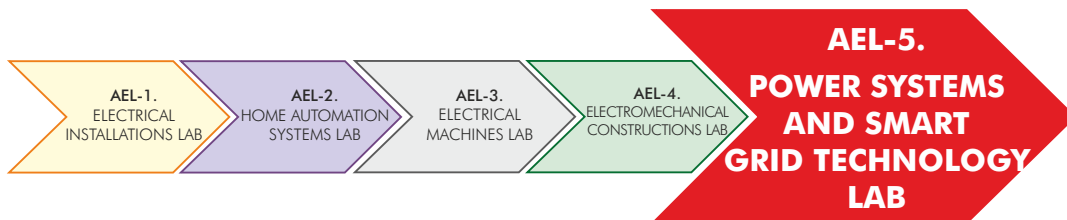




POWER SYSTEMS AND SMART GRID TECHNOLOGY LAB

www.edibon.com
 ↳ PRODUCTS
 ↳ 40.- ELECTRICITY



Key features:

- ▶ **SCADA Control System** for the intelligent control and evaluation of the Power System Trainers, Micro-Grids, Renewable Energy Sources...
- ▶ **Specialized EDIBON Softwares**, based on Labview, for:
 - SCADA Control Software.
 - Data Acquisition Software.
 - Computer Aided Instruction Software.
 - ... and others.
- ▶ **Touch Screens and computers** for a real interaction.
- ▶ **Functional and self contained Electrical Workbench** with instrumentation panel with all the required elements to supply power and control in the workbench.
- ▶ **Intuitive, quick and accurate interaction** of the user with the Electrical Workbench.
- ▶ **Complete and functional training solution** for electricity learning purposes.
- ▶ **Covering all areas of electricity field.**
- ... and others possibilities.



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



European Union Certificate
(total safety)

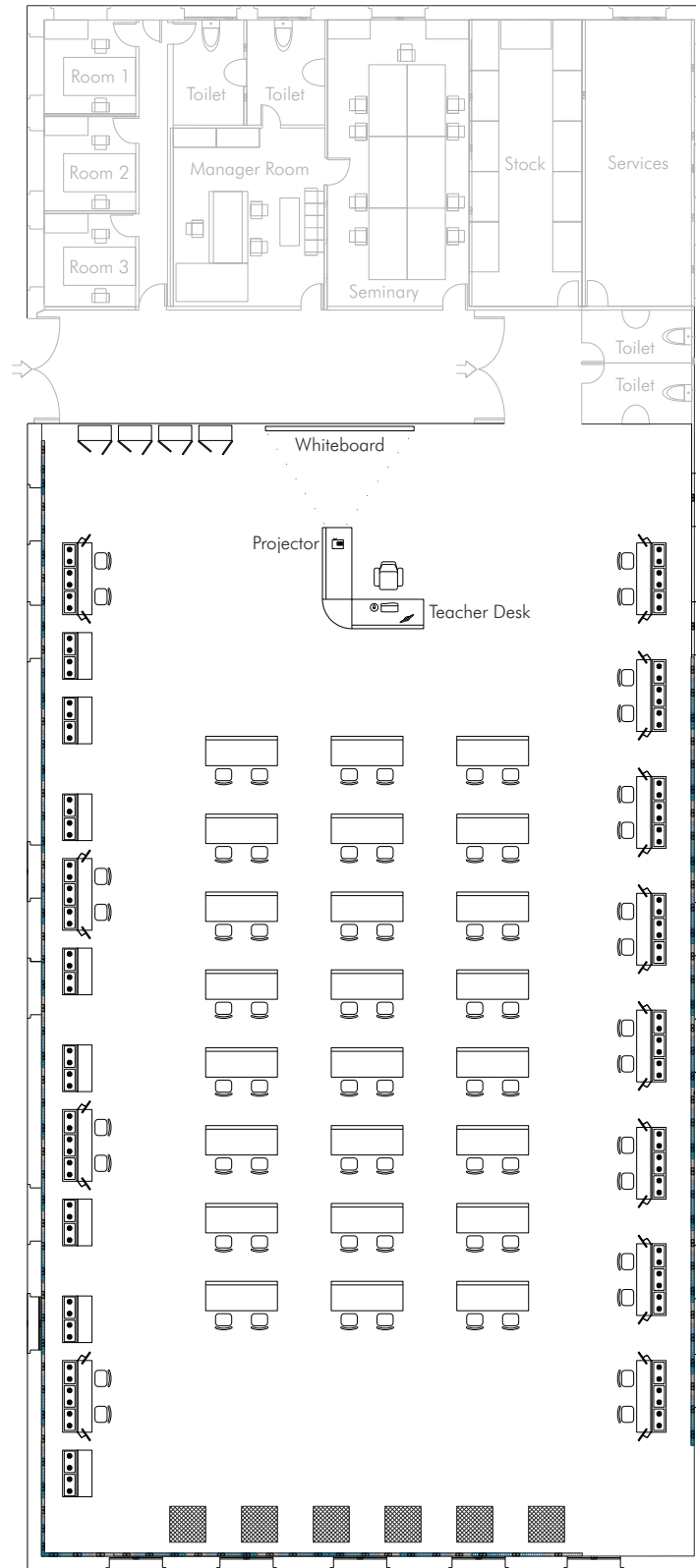







Certificates ISO 14001 and
ECO-Management and Audit Scheme
(environmental management)



Worlddidac Quality Charter
Certificate and
Worlddidac Member

Classroom and Laboratory Lay Out



-  AEL-WTS. Laboratory Workplace Table
-  AEL-WBC. Electrical Workbench (Rail) + 2 x AEL-PC. Two Touchscreen and computers
-  AEL-WBM. Electrical Workbench (Mobile)
-  AEL-MC. Multipurpose Cabinet
-  AEL-WIC. Electrical Installations Cabinet

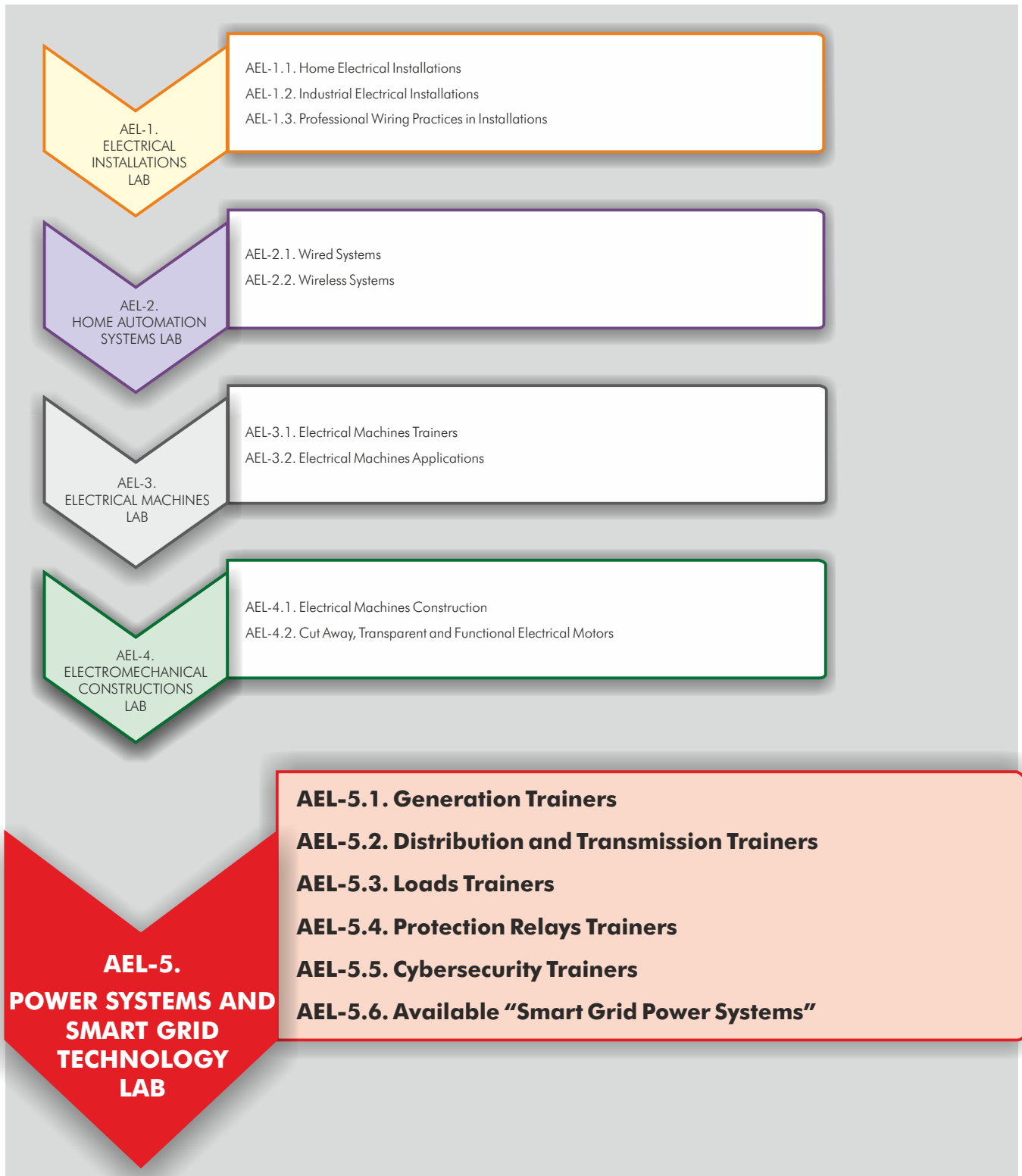
EDIBON, a company with more than 35 years of experience designing and implementing training systems, has a wide variety of applications adapted to 21st century new technologies.

Apart from providing a solid theoretical basis, EDIBON units and trainers are aimed at technical professional training, vocational training, for higher education and even applied research, as well as at the improvement in all fields through advanced systems.

The electricity area includes five great groups that cover Electrical Installations, Home Automation Systems, Electrical Machines, Electromechanical Constructions, **Power Systems and Smart Grid Technology**.

All the units have a modular and intuitive design, with real elements used in the industry and technological market.

In this catalogue we will cover "AEL-5. Power Systems and Smart Grid Technology Lab."



AEL-5. Power Systems and Smart Grid Technology Lab

The AEL-5. Power Systems and Smart Grid Technology Lab is formed by:

AEL-WBC. Electrical Workbench (Rail)



AEL-WBR. Electrical Workbench (Rack)



+

Applications
(to be mounted on rail)



AEL-AD33



AEL-AD3A

...



AEL-AD33 + N-RACK-A



AEL-AD3A + N-RACK-A

...

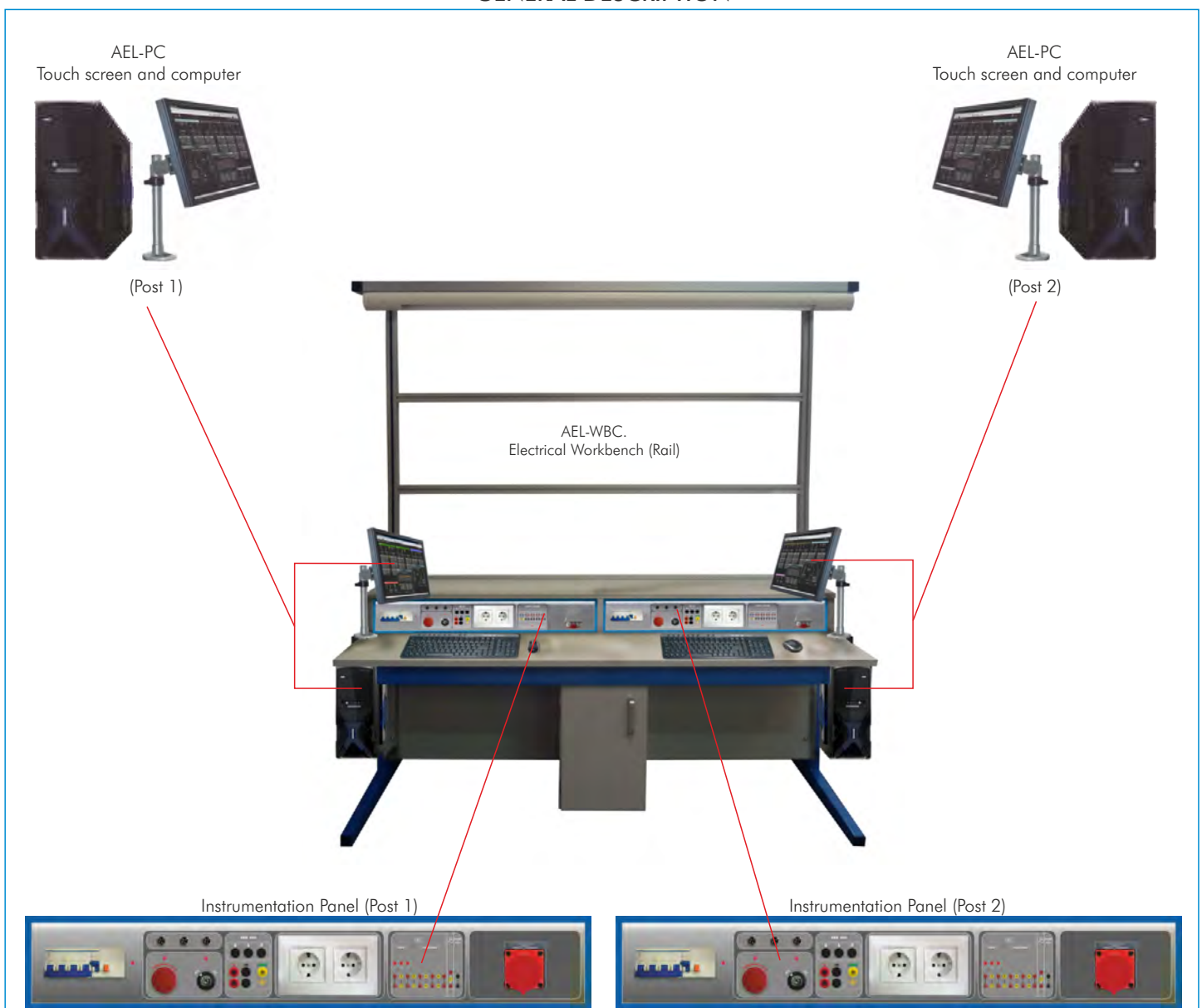
+

Learning Software Packages



Electrical Workbench

GENERAL DESCRIPTION



The Electrical Workbench has been designed to offer the students and teachers the necessary tools to learn and teach about the XXI century technologies.

The Electrical Workbench consists of:

Furniture, itself:

Consists of the frame that allows to locate the applications, lighting fitting, table, supports, etc.

Instrumentation Panel:

The workbench has been designed to be used by one or two students. Each student has access to its own instrumentation panel.

There are two Electrical Workbench versions:

AEL-WBC. Electrical Workbench (Rail).

The AEL-WBC is a workbench designed with rails in order to put and remove all electrical modules free.

AEL-WBR. Electrical Workbench (Rack).

The AEL-WBR is a workbench designed with strong rack in order to fix all electrical modules.

Optional:

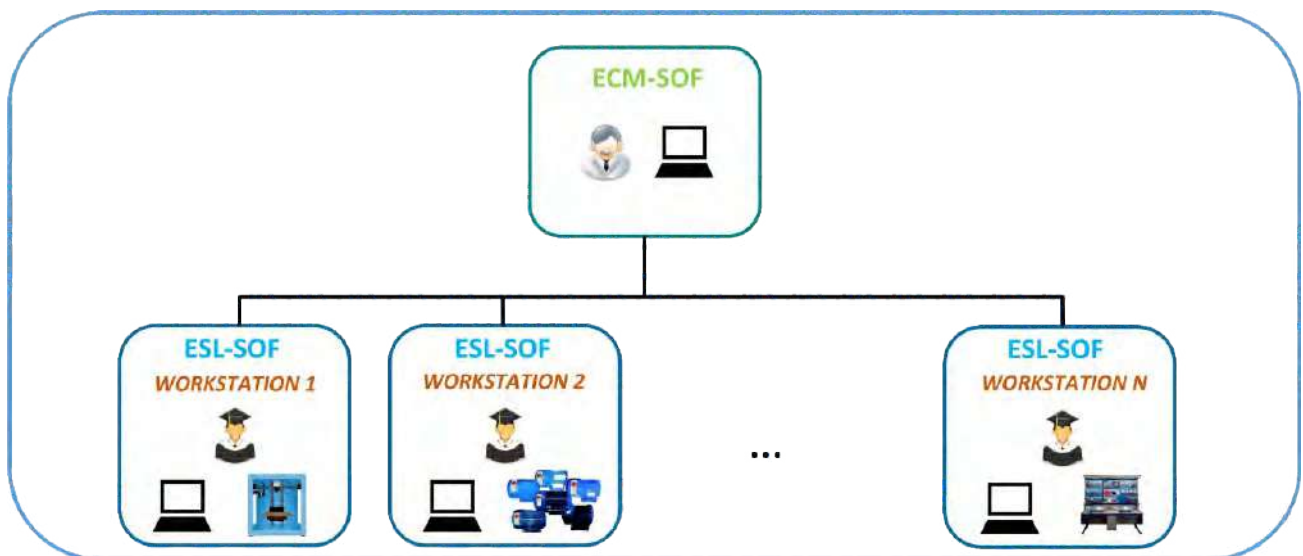
Touch screen and computer (AEL-PC):

The workbench can be supplied with one or two touch screens and computers. Thus, both students and teachers gain quick access to the applications to control them better, obtaining the maximum man-machine interaction.

In summary, technology, quality and aesthetics are combined in this piece of furniture in order to offer the best features for both research and teaching fields.

Learning Software Packages

GENERAL DESCRIPTION



* Contents included for all ECM-SOF and ESL-SOF Workstations.

Example of some Software Screens:

EDIBON has different software packages to provide students the maximum level in training systems.

Interactive Computer Aided Instruction Software System

- 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.



Instructor Software

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

ESL 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.

NOTE: Will be necessary acquire a license per student.



Student Software

List of Applications

AEL-5. POWER SYSTEMS AND SMART GRID TECHNOLOGY LAB

AEL-5.1.

Entrenadores de Generación

Applications

- | | | |
|--|---|--|
| <p>Basic Synchronization Applications</p> <ul style="list-style-type: none"> • AEL-MOSC. Manual Operations of Synchronization Circuits. <p>Advanced Synchronization Applications</p> <ul style="list-style-type: none"> • AEL-EESD. Advanced Digital Synchronization Trainer. <p>Wind Energy</p> <ul style="list-style-type: none"> • AEL-WPR. Wind Power Plants with Double Feed Induction Generator. • AEL-WPT. Wind Power Trainer with Permanent Magnets Synchronous Generator. • AEL-WPPI. Wind Power Plants with Induction Generator. | <p>Photovoltaic Energy</p> <ul style="list-style-type: none"> • AEL-PHVG. Photovoltaic Application with Connection to Grid. <p>Fuel Cell Energy</p> <ul style="list-style-type: none"> • AEL-FCLL. Fuel Cell Energy Trainer. <p>Power Plants</p> <ul style="list-style-type: none"> • AEL-EPP. Energy Power Plants Trainer. • AEL-HPPP. Hydroelectric Power Plants Trainer with Pelton Turbine. • AEL-MEPD. Marine Electrical Power Distribution System. • TDEGC. Computer Controlled Diesel Engine Electricity Generator. | <p>Basic Smart Grid Power Systems</p> <ul style="list-style-type: none"> • AEL-BSG. Basic Smart Grid Trainer. <p>Microgrid Series</p> <ul style="list-style-type: none"> • AEL-MGR. Micro-Grids Power System Series. |
|--|---|--|

AEL-5.2.

Distribution and Transmission Trainers

Applications

Distribution and Transmission Trainers

- | | |
|--|---|
| <ul style="list-style-type: none"> • AEL-AE1A. Aerial Line Model. • AEL-TI-01. Analysis of Three-phase Power Lines. • AEL-TI-02. Distribution Transformer with Motor Regulation. • AEL-TI-03. Arc suppression Coil. • AEL-TI-04. Underground Transmission lines. • AEL-TI-05. Parallel and Series Transmission Lines. • AEL-TI-06. Analysis of Flow Power on Transmission Lines. • AEL-TI-07. Transmission Systems with Synchronous Generator. | <ul style="list-style-type: none"> • AEL-SST-01. Basic Operations in Switching Transmission Substation Trainer. • AEL-SST-02. Switching Substation Protection Trainer. • AEL-HVDC. High Voltage DC Transmission Lines. |
|--|---|

AEL-5.3.

Loads Trainers

Applications

Basic Load Controller Trainers

- AEL-MRPC. Manual Reactive Power Compensation.
- AEL-ARPC. Automatic Reactive Power Compensation.
- AEL-EECFP. Advanced Power Factor Compensation.
- AEL-APFC. Single-phase Automatic Power Factor Compensation.
- AEL-DLT. Dynamic Loads Trainer.

Advanced Loads Control

- AEL-FUSG. Final User Smart Grid Trainer.
- AEL-FUSG-M. Final User Smart Grid-Smart Meter Trainer.
- AEL-FUSG-E. Final User Smart Grid-Smart Energy Trainer.
- AEL-FUSG-N. Final User Smart Grid-Net Metering Trainer.

AEL-5.4.

Protection Relays Trainers

Applications

Fundamental Concepts

- AEL-CTFP. Current Transformer Fundamentals for Protections Devices.
- AEL-VTFP. Voltage Transformer Fundamentals for Protections Devices.

Protection Relays Trainers

- ERP. Protection Relays Test Trainer.
- ERP-CBM. Cybersecurity Module.

Protection Systems for Generators

- AEL-GPRE. Generator Protection Relay Trainer.

Protection Systems for Transmission and Distribution Lines

- AEL-TPT-01. Overcurrent Time Protection Relay for Lines.
- AEL-TPT-02. Directional Overcurrent Protection Relay for Transmission Lines.
- AEL-TPT-03. Overvoltage and Undervoltage Protection Relay.
- AEL-TPT-04. Directional Power Protection Relay.
- AEL-TPT-05. Earth-Fault Voltage Protection Relay.
- AEL-TPT-06. Parallel Transmission Lines Protection Relay.
- AEL-TPT-07. High Speed Distance Protection Relay.

AEL-5.5

Cybersecurity Trainers

Applications

- ERP-CBM. Cybersecurity Module.

AEL-5.6.

Available "Smart Grid Power Systems"

Applications

- APS12. Advanced Mechanical, Electrical and Smart Grid Power Systems (Utilities).
- AEL-MPSS-01. Modular Smart Grid Power Systems Simulator, with Automatic Control Generation, Transmission Line, Loads and Protection Relays, with SCADA.
- AEL-MPSS-02. Modular Smart Grid Power Systems Simulator, with Automatic Control Generation, Transmission Line and Loads, with SCADA.
- AEL-MPSS-03. Modular Smart Grid Power Systems Simulator, with Manual Control Generation, Transmission Line, Loads and Protection Relays, with SCADA.
- AEL-MPSS-04. Modular Smart Grid Power Systems Simulator, with Manual Control Generation, Transmission Line and Loads, with SCADA.
- AEL-CPSS-01S. Smart Grid Power Systems Application, with Automatic Control Generation, Transmission Line and Loads.
- AEL-CPSS-02S. Smart Micro-Grids Power Systems Application, with Automatic Control Generation and Loads.
- AEL-CPSS-03S. Smart Grid Power Systems Application with Two Parallel Generators, Two Distribution Lines and Loads, with SCADA.

Nowadays, smart grids are at the forefront worldwide. Having full control of the electric energy in real time is not a challenge any more, but a fact. The AEL-5. Power Systems and Smart Grid Technology Lab includes a great variety of trainers and applications to study the most revolutionary technologies used nowadays.

EDIBON power systems and smart grid units cover the fields of generation, power transmission and distribution systems and loads control, as well as the most advanced protection relays used in electrical substations.

Applications about smart generation systems allow the student to experiment the operation of current power control systems in generators, being able to directly control the generators excitation, operating cutting-edge synchronization systems and connecting several loads to the system to study the dynamic changes of the machine.

In smart distribution systems, EDIBON covers the study of power transmission networks and distribution systems, focusing on the study of the voltage regulation systems, telemetry, high voltage electrical protection systems, arrangement in parallel of transport lines and DC high voltage transmission systems.

Finally, EDIBON has designed a group of smart loads control systems.

Smart Grid Systems are the present and the future, for this reason EDIBON has designed a series of trainers to show to students and teachers the necessary knowledge about the new smart power systems. Telecommand, telemetry, bidirectional communication systems, power flow control, etc. appear in EDIBON trainers.

On the other hand, in every area described, EDIBON includes cutting-edge smart protection relays trainers used in electricity generation, transport and distribution systems: directional overcurrent protection relays, overvoltage and undervoltage protection relays, distance protection relays, over frequency protection relays, etc.

The complete Power Systems and Smart Grid Technology Lab (AEL-5) includes:

- Electrical Workbench.
- Software packages.
- Applications.

Electrical Workbench:

There are two Electrical Workbench versions:

AEL-WBC. Electrical Workbench (Rail).

The AEL-WBC is a workbench designed with rails in order to put and remove all electrical modules free. The frame consists of three levels to get a maximum space for the modules and applications. Besides, the user can put and remove manually all electrical modules and make free configurations to construct different applications.

The advantage of this workbench is that all modules can be put and removed free and quick, so the student can change quickly to other practical exercises.

AEL-WBR. Electrical Workbench (Rack).

The AEL-WBR is a workbench designed with strong rack in order to fix all electrical modules. Each module will be fixed with screws. The frame consists of three racks to support different applications.

The advantage of this workbench is that all applications are perfectly covered to get a homogeny and strong unit.

The Electrical Workbench is ready to use Specialized EDIBON Softwares, based on Labview, for:

- SCADA Control Software.
- Data Acquisition Software.
- Computer Aided Instruction Software.
- ...others.

It is a complete and functional training solution for electricity learning purposes, with intuitive, quick and accurate interaction of the user with the Electrical Workbench.

It is a functional and self contained Electrical Workbench, with wide working area for several applications, with instrumentation panel including all the required elements to supply power and control in the workbench.

The Electrical Workbench is mainly formed by:

Furniture, itself:

- Formed by the frame that allows to allocate the applications, lighting fitting, table, supports, etc.
- Dimensions: 2000 x 1000 x 1900 mm approx.

Instrumentation Panel:

- 2 x Control and supply panels.
- Three-phase and single-phase power systems.
- Independent Residual Circuit Breaker (RCB).
- Two single-phase sockets.
- Different level control voltages for signals applications.
- Integrated lighting system.

Technical data:

- 1 x Differential Protection, 1 x Emergency Stop Button and 1 x Safety Key.
- Power Terminal Connections: 1 x Three-phase terminals: 380 Vac + N+ GND and 1 x Single-phase terminals: 230 Vac + GND and 2 x Single-phase plugs + 2 x Three-phase plugs.
- Control terminals: 2 x 24 Vac., 2 x (+24) Vdc., 2 x (+12) Vdc., 2 x (-12) Vdc. and 2 x (+5) Vdc.
- Power Supply required: 380 Vac 3PH + N + GND.

Optional:

- Touch screen and computer (AEL-PC).
- The workbench can be supplied with one or two touch screens and computers.



Software packages:**ICAI. Interactive Computer Aided Instruction Software System:****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 Workgroups, Tasks 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.

Instructor Software

ECM-SOF. EDIBON Classroom Manager 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

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

www.edibon.com/en/files/equipment/ICAI-ELEC/catalog

Applications:

AEL-5.1
Generation Trainers

Basic Synchronization Applications

AEL-MOSC. Manual Operations of Synchronization Circuits.

The AEL-MOSC Manual Operations of Synchronization Circuits Application has been designed by Edibon to demonstrate the basic principles and the need for synchronization. With power being generated by multiple sources, there is a need to have this power in sync. The frequencies, phase shifts and voltages may vary greatly. If these outputs are not properly synchronized the grid may be damaged.

The AEL-MOSC consists of a series of modules to teach the students the basic synchronization methods using the "lamps method".

With the AEL-MOSC the student will learn the electricity fundamental laws in order to understand the maneuvers of synchronization. One important module included in this application is the synchronoscope. It compares the frequency and voltage from the grid with generator's one. A network analyzer is provided too. It displays electrical characteristics such as volts, amps, watts, Vars, VA, power factor, and frequency.

The AEL-MOSC includes the following modules:

- N-ALI01. Industrial Main Power Supply.
- EMT7B/1K. 1kVA three-phase Asynchronous motor of squirrel cage.
- EMT6B/1K. 1KVA three-phase Synchronous generator.
- N-WCA/M. AC Motor Speed Controller.
- N-WVCC/M. DC Motor Speed Controller.
- N-ASY/B. Basic Synchronization Module.
- N-EALD. Network Analyzer Unit with Computer Data Acquisition.
- N-REL08. Time Overcurrent Electronic Relay (0.3 - 1.5 A).

Expansion learning software:

In addition, Edibon provides expansion learning software (AEL-MOSC/ICAI) to reinforce knowledge about this field. This software is formed by:

- ECM-SOF. EDIBON Classroom Manager (Instructor Software).
- ESL-SOF. EDIBON Student Labsoft (Student Software).

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

Option A:

This application needs the following racks:

- N-RACK-M. (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.

Some practical exercises possibilities:

- 1.- Commissioning of group generation.
- 2.- Main connections for the synchronization module to perform the appropriate readings of the phases angles.
- 3.- "Dark" synchronising circuit.
- 4.- "Light" synchronising circuit.
- 5.- Active power generation.
- 6.- Inductive reactive power generation.
- 7.- Capacitive reactive power generation.

For more information see **AEL-MOSC** catalogue.

Click on the following link:

www.edibon.com/en/files/equipment/AEL-MOSC/catalog



AEL-MOSC

Applications:

AEL-5.1
Generation Trainers

Advanced Synchronization Applications

AEL-EESD. Advanced Digital Synchronization Trainer.

The AEL-EESD Advanced Digital Synchronization Trainer has been designed by Edibon to study the procedure and need for synchronization of different power generation sources in the same grid. When different energy sources are generating power, it is extremely significant that these work in synchronism. Frequencies, phase shift and voltages can vary substantially and the grid could be damaged if these were not properly synchronized.

The AEL-EESD consists of several modules that allow step by step demonstrating the synchronization procedure of a synchronous generator with the grid. This trainer provides a complete program that extends training in generator synchronization manuevers, control and the most relevant protections used on these systems. This trainer has a synchronous generator-motor group and several modules such as a professional synchroscope module, excitation voltage regulator module of the synchronous generator, speed controller module of the turbine and a power analyzer that measures all electrical parameters of the synchronous generator (V, f, PF, Q, VAR, VA). Through these modules, the user could manually control the speed of the synchronous generator (generator frequency) and the output voltage according to the excitation current. With the synchroscope module, the user could visualize the voltage, frequency and lags between the generator and the grid. Once synchronization conditions are achieved the synchronization module indicates that synchronization circuit breaker can be closed. Hence the user can give permission to synchronize the generator-motor group. When the generator is synchronized with the grid, the main purpose of the excitation and frequency controller is to inject more or less reactive and active power to the grid according to the required power factor.

Optionally, the AEL-EESD trainer provides a Supervisory Control and Data Acquisition Software (AEL-EESD/CCSOF) designed to carry out a remote control over the generator-motor group. Through the SCADA and the PC, the user can control the speed and torque of the turbine, the excitation current and frequency of the generator, enable/disable of the synchronization circuit breaker, monitoring the state of the alarms and protections of the generation group (it is necessary to acquire the optional Protection and Control Relay Unit). In addition, the optional SCADA System allows all the time acquire the electrical variables measured with the power analyzer and to monitor them numerically and graphically.

For further studies about generator control systems, this trainer has the following optional modules: generation protection and control relay unit, three-phase digital bench resistors module and three-phase digital bench of commutable inductances module.

- N-ERP-PGC01. Generator Protection and Control Relay Unit.

In large industrial installations power generation systems require a special device to control automatically the frequency, voltage and power factor of the synchronous generators. This is the goal of the protection and control relay unit. Because constants load fluctuations occur in the demanded energy, it is necessary a precise control of the frequency, current excitation,

torque and power factor of the generators and turbines. With this device, the user can realize a manual control of the generator and transfers, in any moment, the fully control to the protection and control relay unit (automatic control mode).

- N-CAR35T3D. Three-Phase Digital Bench of Resistors Module.
- N-CAR36T3D. Three-Phase Digital Bench of Commutable Inductances Module.

These two three-phase resistive and inductive modules offer the possibility to study the synchronous generator in stand-alone mode. These circumstances occur, for instance in islands, because it is very expensive to interconnect the nearest power generation source and chose stand-alone power generation.

The AEL-EESD includes the following modules:

- N-ALI01. Industrial Main Power Supply.
- N-AVR/P. Automatic Voltage Regulator.
- N-ASY3PH. Three-phase Automatic Synchroscope.
- N-EALD. Network Analyzer Unit with Computer Data Acquisition.
- N-WCA5K. 5 kW Motor Speed Controller.
- GMG4.5K3PH. 4.5 kVA Generator-Motor Group.

Optional modules:

Optionally, the students can carry out advanced operations of synchronization and control of the generator-motor group including in the basic option the following optional modules:

- N-ERP-PGC01. Generator Protection and Control Relay Unit.
- N-CAR35T3D. Three-Phase Digital Bench Resistors Module.
- N-CAR36T3D. Three-Phase Digital Bench of Commutable Inductances Module.
- N-CAR19T3D. Three-phase Digital Bank of Commutable Capacitors Module.

Optional SCADA software:

- AEL-EESD/CCSOF. Computer Control + Data Acquisition + Data Management Software.

Expansion learning software:

In addition, Edibon provides expansion learning software (AEL-EESD/ICAI) to reinforce knowledge about this field. This software is formed by:

- ECM-SOF. EDIBON Classroom Manager (Instructor Software).
- ESL-SOF. EDIBON Student Labsoft (Student Software).

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

Option A:

This application needs the following racks:

- N-RACK-A.
 - N-RACK-B. (3 units if optional modules are acquired)
- 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.



AEL-EESD



GMG4.5K3PH

OPTIONAL MODULES



N-ERP-PGC01



N-CAR35T3D



N-CAR36T3D



N-CAR19T3D

Applications:

AEL-5.1
Generation Trainers

Advanced Synchronization Applications

AEL-EESD. Advanced Digital Synchronization Trainer. (Continuation).

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

Some practical exercises possibilities:

- 1.- Commissioning of generation group and coupling to the electrical grid.
- 2.- Inductive reactive power generation.
- 3.- Capacitive reactive power generation.
- 4.- Coupling operations between generator and electrical grid.
- 5.- Monitoring of voltages and phase angles in order to carry out a correct coupling.
- 6.- Main connections for the synchronization module to perform the appropriate readings of the phases angles.
- 7.- Monitoring of the generator's power flux before and after the synchronization.
- 8.- Search of the optimum point to couple the generator to the grid.
- 9.- Frequency and voltage manual control of the generator to carry out the synchronization to the grid.

Additional practical exercises possibilities with the optional modules:

- 10.- Island grid operations.
- 11.- Parallel grid operations.
- 12.- Manual and automatic voltage regulation operations.
- 13.- Manual and automatic frequency regulation operations.
- 14.- Transference of manual to automatic voltage regulation operations.
- 15.- Transference of manual to automatic frequency regulation operations.
- 16.- Studying of the power factor regulation of synchronous generator in parallel grid operation.
- 17.- Studying of turbine regulation (frequency control) in island mode.
- 18.- Studying of turbine regulation (frequency control) in parallel grid mode.
- 19.- Studying of excitation/voltage regulation in island mode.
- 20.- Studying of excitation/voltage regulation in parallel grid mode.
- 21.- Analysis of active and reactive power.
- 22.- Automatic control of active power.
- 23.- Automatic control of reactive power.
- 24.- Studying of the micro-grids.
- 25.- Setting of Overcurrent protection.
- 26.- Setting of Overvoltage and Undervoltage protection of the synchronous generator.
- 27.- Reverse power protection.

28.- Remote control operation with the SCADA Control System.

Other possibilities to be done with this Unit:

- 29.- Many students view results simultaneously.
To view all results in real time in the classroom by means of a projector or an electronic whiteboard.
- 30.- The Computer Control System with SCADA allow a real industrial simulation.
- 31.- This unit is totally safe as uses mechanical, electrical and electronic, and software safety devices.
- 32.- This unit can be used for doing applied research.
- 33.- This unit 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.

For more information see **AEL-EESD** catalogue. Click on the following link:
www.edibon.com/en/files/equipment/AEL-EESD/catalog



AEL-EESD



GMG4.5K3PH

OPTIONAL MODULES



N-ERP-PGC01



N-CAR35T3D



N-CAR36T3D



N-CAR19T3D

Applications:

AEL-5.1
Generation Trainers

Wind Energy

AEL-WPP. Wind Power Plants with Double Feed Induction Generator.

The AEL-WPP has been designed to investigate the design and operation of modern wind power stations. The AEL-WPP consists of a prime motor that moves a double-feed induction generator (as a generator for the wind power plant).

This power station includes a SCADA Control Systems which allows the following:

In one hand the SCADA allows the user to configure the desired wind curve for the experiment. Once the wind curve is configured and the user starts the experiment, the Software controls automatically the AEL-SERIN/CA-1K motor to generate the same wind curve configured by the user.

In the other hand the SCADA allows to visualize the most important signals of the systems (rotor current, stator current, line voltage, dc bus voltage of the back to back inverter...) and allows to visualize the most important measurements of the system (value of the rotor active power and reactive power, stator active power and reactive power, total active and reactive power, speed of the generator shaft...).

The software also allows the user to save the experiment data, to analyze the results after the test, through a data visualizer included with the software. The data format of the saved files are compatible with Microsoft excel.

This application can be combined with other applications of generation, transmission/distribution and load systems areas.

The AEL-WPP includes the following modules:

- EMT8DF. Double Feed Induction Generator.
- N-DFGC. Double-feed Generator Control Module.
- N-FRT. Fault Ride Through Module.
- N-BTINV. Back to Back Inverter.
- AEL-SERIN/CA-1K. Computer Controlled Advanced Industrial Servo systems Trainer (for AC Motors).
- AEL-WPP/CCSOF. Computer Control+Data Acquisition+Data Management Software.

Expansion software:

- WSS. Wind Sim Software.

Expansion learning software:

In addition, Edibon provides expansion learning software (AEL-WPP/ICAI) to reinforce knowledge about this field. This software is formed by:

- ECM-SOF. EDIBON Classroom Manager (Instructor Software).
- ESL-SOF. EDIBON Student Labsoft (Student Software).

The application AEL-WPP is mounted on the following racks:

- N-RACK-M (3 units).
- N-RACK-B (3 units).

This trainer includes too:

- Touch screen.
- Computer.

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

Some practical exercises possibilities:

- 1.- Identifying elements and devices.
- 2.- Supply and modules signals wiring.
- 3.- Commissioning of trainer.
- 4.- Analyzing the system states: Starting and Loading the DC bus.
- 5.- Identifying modulation inverter start back to back.
- 6.- Stop sequence Double Feed Induction Generator.
- 7.- Study of the double-feed asynchronous machine with subsynchronous speed.
- 8.- Study of the double-feed asynchronous machine with supersynchronous speed.
- 9.- Studying the operating response when there are faults on the grid ("fault ride-through").

Other possibilities to be done with this Unit:

- 10.- Many students view results simultaneously. To view all results in real time in the classroom by means of a projector or an electronic whiteboard.
 - 11.- The Computer Control System with SCADA allow a real industrial simulation.
 - 12.- This unit is totally safe as uses mechanical, electrical and electronic, and software safety devices.
 - 13.- This unit can be used for doing applied research.
 - 14.- This unit 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.

For more information see **AEL-WPP** catalogue. Click on the following link:

www.edibon.com/en/files/equipment/AEL-WPP/catalog



AEL-WPP

Applications:

AEL-5.1
Generation Trainers

Wind Energy

AEL-WPT. Wind Power Trainer with Permanent Magnets Synchronous Generator.

Energy saving and environmental pollution reduction are crucial global issues. Using renewable energies as alternative sources to fossil fuels can address both issues, with great benefits especially in countries where traditional energy sources are scarce.

Considering the above, this trainer enables experimental investigation on the conversion of wind energy into electricity by means of a wind power generator. The system configuration is stand-alone (isolated from the grid). The equipment is manufactured using real components available on the market.

The AEL-WPT Wind Power Trainer with Permanent Magnets Synchronous Generator is an application designed by Edibon to train the students in the main operations of wind turbines.

Using a driver motor that controls on AC Permanent Magnets Synchronous Generator, the student can simulate an actual medium wind turbine with a voltage regulator, inverter and batteries. In order to carry out electric parameters measurements, a network analyzer is included too.

The AEL-WPT includes the following modules:

- N-ALI01. Industrial Main Power Supply.
- EMT6/B. Permanent magnets synchronous three-phase generator.
- EMT7/C. Asynchronous three-phase motor of squirrel cage.
- N-WVCA/M. AC Motor Speed Controller.
- BAT. Battery.
- N-REG02. Voltage Electronic Regulator (300W).
- N-EAL. Network Analyzer Unit.
- N-INV01. Power Inverter (300W).
- N-REV/500. Variable Resistor of 500W.
- N-LAM16. Halogen Lamp Module.
- N-ES20. 12 VDC Load Module.

Optional SCADA software:

- AEL-WPT/CCSOF. Computer Control + Data Acquisition + Data Management Software.

Optional modules:

- PMSWG. Permanent Magnet Small Wind Turbine.
- WTFMS. Wind Turbine Floor Mounting Set.

Expansion learning software:

In addition, Edibon provides expansion learning software (AEL-WPT/ICAI) to reinforce knowledge about this field. This software is formed by:

- ECM-SOF. EDIBON Classroom Manager (Instructor Software).
- ESL-SOF. EDIBON Student Labsoft (Student Software).

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

Option A:

This application needs the following racks:

- N-RACK-A.

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.

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

Some practical exercises possibilities:

- 1.- Voltage-Speed Characteristics of a Wind Turbine Generator.
- 2.- Checking the lamps.
- 3.- Power vs Wind Turbine Speed.
- 4.- Storing Energy from a Wind Turbine into Batteries.
- 5.- Battery charging fundamentals.
- 6.- Drop voltage in the wind generator.
- 7.- Feeding from the wind generator.
- 8.- Feeding from the battery.

Some practical exercises possibilities with the Optional SCADA System:

- 9.- Monitoring and Data Acquisition wind turbine curves.
- 10.- Measurement of energy generation in function of the wind speed.
- 11.- Remote control of the wind turbine.

Other possibilities to be done with this Unit:

- 12.- Many students view results simultaneously. To view all results in real time in the classroom by means of a projector or an electronic whiteboard.
 - 13.- The Computer Control System with SCADA allow a real industrial simulation.
 - 14.- This unit is totally safe as uses mechanical, electrical and electronic, and software safety devices.
 - 15.- This unit can be used for doing applied research.
 - 16.- This unit 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.

For more information see **AEL-WPT** catalogue. Click on the following link:

www.edibon.com/en/files/equipment/AEL-WPT/catalog



AEL-WPT

OPTIONAL MODULES

PMSWG

Applications:

AEL-5.1
Generation Trainers

Wind Energy

AEL-WPPI. Wind Power Plants with Induction Generator.

The AEL-WPPI Wind Power Plants with Induction Generator application has been developed by Edibon to study the wind turbines electrical performance with three-phase induction generators of squirrel cage that inject power in the network.

Wind turbines with induction generator have some characteristics, of great interest to the students, which will be studied working with the machine in different regimes: sub-synchronous, synchronous and super-synchronous. Depending on the working regime of the induction generator, different electrical parameters can be analyzed. To analyze these electrical parameters, the Wind Power Plants with Induction Generator Trainer has an advanced network analyzer to show the student, among others, the following parameters: positive and negative active, reactive and apparent powers (P, Q and S), line and total power factors, line currents, phase and line voltages, current and voltage harmonics, etc.

The wind turbine induction generator is coupled to the three-phase induction motor of squirrel cage in order to simulate different wind speeds. The three-phase induction motor is controlled by mean a frequency variator to vary the wind speed. On this way, the user can simulate different wind speeds and observes the response of the electrical generator coupled to the grid.

The Wind Power Plants Induction Generator Application has a series of sensors which allow the student to measure the wind turbine speed and the applied torque for it in order to calculate electrical and mechanical parameters, through which the student will go in depth about knowledge of wind turbines with induction generator.

This application has a power factor compensation module in order to analyze the effects of the reactive energy in the induction generator and the grid.

This application has all necessary electrical and mechanical safety elements.

The AEL-WPPI includes of the following modules:

- N-ALI01. Industrial Main Power Supply.
- N-CAR19T3. Three-Phase Bank of Commutable Capacitors Module.
- N-WCA2K. 2 kW Motor Speed Controller.
- N-EAL. Network Analyzer Unit.
- N-MPS. Motor Protection (1.6 A - 2.5 A).
- N-ARS. Automatic Resistors Starter.
- GMG1.25K3PH. 1.25 KW Generator-Motor Group.

Optional SCADA software:

- AEL-WPPI/CCSOF. Computer Control + Data Acquisition + Data Management Software.

Expansion learning software:

In addition, Edibon provides expansion learning software (AEL-WPPI/ICAI) to reinforce knowledge about this field. This software is formed by:

- ECM-SOF. EDIBON Classroom Manager (Instructor Software).
- ESL-SOF. EDIBON Student Labsoft (Student Software).

The application AEL-WPPI is mounted on rack:

This application needs the following rack/s:

- N-RACK-M. (2 units)

Optionally can be supplied one of the following workbenches for to place the rack/s.

- AEL-WBR. Electrical Workbench (Rack).
- AEL-WBMP. Electrical Workbench (Small Mobile).

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

Some practical exercises possibilities:

- 1.- Commissioning of the induction generator.
 - 2.- Wiring procedure of the induction generator to the grid.
 - 3.- Study of operation regimes of the wind turbines with three-phase induction generator of squirrel cage.
 - 4.- Analysis of the induction generators coupled to the grid in sub-synchronous state.
 - 5.- Analysis of the induction generators coupled to the grid in synchronous state.
 - 6.- Analysis of the induction generators coupled to the grid in super-synchronous state.
 - 7.- Study of electrical parameters of the induction generator coupled to the grid in sub-synchronous state.
 - 8.- Study of electrical parameters of the induction generator coupled to the grid in synchronous state.
 - 9.- Study of electrical parameters of the induction generator coupled to the grid in super-synchronous state.
 - 10.- Efficiency study of the induction generator comparing the injected power in the grid with the mechanical power shaft of the turbine.
 - 11.- Power factor influence with the speed variations and analysis of the possible solutions to automate the regulation of the power factor.
 - 12.- Active power compensation by mean capacitor banks and electrical measurement of the electrical machine response.
- Other possibilities to be done with this Unit:
- 13.- Many students view results simultaneously. To view all results in real time in the classroom by means of a projector or an electronic whiteboard.
 - 14.- The Computer Control System with SCADA allow a real industrial simulation.
 - 15.- This unit is totally safe as uses mechanical, electrical and electronic, and software safety devices.
 - 16.- This unit can be used for doing applied research.
 - 17.- This unit can be used for giving training courses to Industries even to other Technical Education Institutions.

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

For more information see **AEL-WPPI** catalogue. Click on the following link:

www.edibon.com/en/files/equipment/AEL-WPPI/catalog



AEL-WPPI

Applications:

AEL-5.1
Generation Trainers

Photovoltaic Energy

AEL-PHVG. Photovoltaic Application with Connection to Grid.

Energy saving and environmental pollution reduction are crucial global issues. Using renewable energies as alternative sources to fossil fuels can address both issues, with great benefits especially in countries where traditional energy sources are scarce.

In the last two decades, photovoltaics has evolved from small scale applications towards becoming a mainstream electricity source.

The AEL-PHVG Photovoltaic Application with Connection to Grid has been designed by Edibon to study the energy production by photovoltaic panels and how this energy is injected to the grid.

In order to learn about solar energy production, the AEL-PHVG includes a module which emulates a photovoltaic system and a grid inverter. On the other hand, photovoltaic panels and lamps are included to study real solar energy production systems.

This application can work together other power generation sources to study the energy mix, their advantages and problems developed when alternate sources are interconnected into a power system.

The AEL-PHVG includes the following modules:

- N-ALI01. Industrial Main Power Supply.
- N-INV02. 3kW Grid Inverter.
- N-EALD. Network Analyzer Unit with Computer Data Acquisition.
- PSPS/A. Advanced Panel simulator power supply.
- N-ARR12. Direct Starter.

Optional modules:

- LP3. 3 lamps panel.
- FVP96. 96W Photovoltaic Panel.

Optional SCADA software:

- AEL-PHVG/CCSOF. Computer Control + Data Acquisition + Data Management Software.

Expansion learning software:

In addition, Edibon provides expansion learning software (AEL-PHVG/ICAI) to reinforce knowledge about this field. This software is formed by:

- ECM-SOF. EDIBON Classroom Manager (Instructor Software).
- ESL-SOF. EDIBON Student Labsoft (Student Software).

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

Option A:

This application needs the following racks:

- N-RACK-M.

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.

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

Some practical exercises possibilities:

- 1.- Wiring of photovoltaic system.
- 2.- Checking the photovoltaic system with feed to the power grid.
- 3.- Measurement of energy production by the photovoltaics panel.
- 4.- Finding the Maximum Power Point.
- 5.- Minimum power of the photovoltaic inverter.
- 6.- Losses of the power grid inverter.
- 7.- Control of the power grid inverter.
- 8.- Visualizing the electrical parameters of the photovoltaic panel through SCADA Control System (optional SCADA).
- 9.- System's response in case of power outage on the grid.
- 10.- Lightning protecting for photovoltaic systems.
- 11.- Testing V-I characteristics.

Other possibilities to be done with this Unit:

- 12.- Many students view results simultaneously. To view all results in real time in the classroom by means of a projector or an electronic whiteboard.
- 13.- The Computer Control System with SCADA allow a real industrial simulation.
- 14.- This unit is totally safe as uses mechanical, electrical and electronic, and software safety devices.
- 15.- This unit can be used for doing applied research.
- 16.- This unit 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.

For more information see **AEL-PHVG** catalogue. Click on the following link:

www.edibon.com/en/files/equipment/AEL-PHVG/catalog



AEL-PHVG

Applications:

AEL-5.1
Generation Trainers

Fuel Cell Energy

AEL-FCLL. Fuel Cells Energy trainer.

A fuel cell is a device that converts the chemical energy from a fuel into electricity through a chemical reaction of positively charged hydrogen ions with oxygen or another oxidizing agent. Fuel cells are different from batteries in that they require a continuous source of fuel and oxygen or air to sustain the chemical reaction, whereas in a battery the chemicals present in the battery react with each other to generate an electromotive force (emf). Fuel cells can produce electricity continuously for as long as these inputs are supplied.

Fuel cells have been used in many other applications, such as for primary and backup power for commercial, industrial and residential buildings and in remote or inaccessible areas. They are also used to power fuel cell vehicles, including forklifts, automobiles, buses, boats, motorcycles and submarines.

The AEL-FCLL Fuel Cell Energy has been designed by Edibon in order to show how fuel cell works.

This trainer includes a stack of proton exchange membrane fuel cell (PEM) which is composed of several cells with channeled plate shape that allow the air flow through the membrane. The membrane facilitates the hydrogen flow, generating the electrons release. There are separate plates which conduct electricity, allowing that electrons flow, between each pair of cells. Moreover, solenoid valve, electronic load and protection systems are included. One important part of the AEL-FCLL is the optional Edibon Computer Control System (SCADA) for controlling the process and all parameters involved in the process.

Edibon offers the possibility of include an electrolyser to be independent of hydrogen cylinder.

The AEL-FCLL includes the following modules:

- N-FC/1K. Fuel cell of 1kW Module.
- N-EL/150. Electronic Load of 150W Module.
- N-MHSC. Metal Hydride Storage Cell Module and Solenoid Valve.

Optional SCADA software:

- AEL-FCLL/CCSOF. Computer Control + Data Acquisition + Data Management Software.

Expansion learning software:

In addition, Edibon provides expansion learning software (AEL-FCLL/ICAI) to reinforce knowledge about this field. This software is formed by:

- ECM-SOF. EDIBON Classroom Manager (Instructor Software).
- ESL-SOF. EDIBON Student Labsoft (Student Software).

The application AEL-FCLL is mounted on the following racks:

- N-RACK-M (2 units).

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

Some practical exercises possibilities:

- 1.- Basic operations with the fuel cell
- 2.- Design and operation of a metal hydride storage cell
- 3.- Calculation of the efficiency of a PEM fuel cell.
- 4.- Study of the influence of air consumption and hydrogen consumption in the efficiency of a PEM fuel cell.
- 5.- Study of the power density of a PEM fuel cell .
- 6.- Representation of the polarization curve of a PEM fuel cell.
- 7.- Determination of the voltage and current density characteristics of a PEM fuel cell.
- 8.- Study influence of hydrogen consumption in the electric power generation.
- 9.- Study of the influence of the generated power in the efficiency of PEM a fuel cell.
- 10.- Study of the influence of the reagents' flows in the generation of electrical power.
- 11.- Study voltage conversion
- 12.- Study sensors calibration (with optional SCADA).

Additional practical exercises with the electrolyser:

- 13.- Study of electrolyser.
- 14.- Study the standalone power supply.

Other possibilities to be done with this Unit:

- 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.- The Computer Control System with SCADA allow a real industrial simulation.
- 17.- This unit is totally safe as uses mechanical, electrical and electronic, and software safety devices.
- 18.- This unit can be used for doing applied research.
- 19.- This unit 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.

For more information see **AEL-FCLL** catalogue.

Click on the following link:

www.edibon.com/en/files/equipment/AEL-FCLL/catalog



AEL-FCLL

Applications:

AEL-5.1
Generation Trainers

Power Plants

AEL-EPP. Energy Power Plants Trainer.

Nowadays power generation from different energy sources is essential to get a reliable and robust electrical power system. Hydroelectric, thermal, nuclear and ocean power plants play an important role in the energy mix in a country. Depending on the moment of the day, the climatology, the tides and the total power demanded at any time, the energy production may come from different energy sources. For this reason it is very interesting and important to understand how work these type of energy sources.

The "Energy Power Plants Trainer" AEL-EPP is a modular trainer designed to demonstrate the working principles of different power plants along with automatic governor control so that the students can understand the whole mechanism of them.

Hydroelectric power plant, Thermal Power Plant, Nuclear power Plant and Ocean Energy Power Plant are studied in depth through this complete trainer.

Optionally, "Power Systems SCADA Viewer" PSV-SCADA can be included in order to carry out remote control operations related to the mentioned power plants such as synchronization operations, active power generation, reactive power control, setting of generator controller, simulate different water flows, thermal and ocean (tides) situations under different conditions and many other possibilities which will give the students large knowledge about this issues.

The AEL-EPP includes different modules which allow represent similar situations produced in real power systems, for instance the servomotor module. This module is connected to the PSV-SCADA and it receives different commands according to mathematical models of the power plant previously loaded in the software. On this way, if the user is working, for example, with the hydroelectric power plant, he can change different conditions such as water potential energy (initial height) and to observe how the servomotor speed changes, the active power is increased, etc. Other important module is the automatic voltage and frequency controller. This module allows the user understand how work a real industrial controller used in large power stations. This controller ensures that frequency and voltage are constant for any external or internal condition. Besides, it protects the synchronous generator and governor against over currents, over/under voltages, over/under frequencies, reverse powers, over and under speeds, etc.

The AEL-EPP includes the following modules:

- N-ALI01. Industrial Main Power Supply.
- N-AVR/P. Automatic Voltage Regulator.
- N-ASY/B. Basic Synchronization Module.
- N-SERV1K. 1 kW Servomotor Module.
- N-EALD. Network Analyzer Unit with Computer Data Acquisition.
- N-ERP-PGC-02. Automatic Voltage and Frequency Controller.

Generator:

- EMT6B/1K. 1KVA three-phase Synchronous generator.

Expansions SCADA software:

- PSV-SCADA. Power Systems SCADA Viewer, required as well for working with the following optional simulation software:
 - PSV-NPPS-SOF. Nuclear Power Plants Simulator.
 - PSV-HPPS-SOF. Hydroelectric Power Plants Simulator.
 - PSV-OPPS-SOF. Ocean Energy Power Plants Simulator.
 - PSV-CCPP-SOF. Combined Cycle Power Plants Simulator.
 - PSV-DFPP-SOF. Diesel Fuel Power Plant Simulator.
 - PSV-FFPP-SOF. Fossil Fuel Power Plant Simulator.
 - PSV-GSPP-SOF. Gas Power Plants Simulator.
 - PSV-WPPP-SOF. Wind Powered Power Plant Simulator.
 - PSV-PPP-SOF. Photovoltaic Power Plant Simulator.
 - PSV-BPP-SOF. Biomass Power Plant Simulator.
 - PSV-FCPP-SOF. Fuel Cells Power Plant Simulator.
 - PSV-GPP-SOF. Geothermal Power Plants Simulator.
 - PSV-HSPP-SOF. Heliothermic Solar Power Plant Simulator.
 - PSV-STPP-SOF. Steam Turbine Power Plant Simulator.

Expansion learning software:

In addition, Edibon provides expansion learning software (AEL-EPP/ICAI) to reinforce knowledge about this field. This software is formed by:

- ECM-SOF. EDIBON Classroom Manager (Instructor Software).
- ESL-SOF. EDIBON Student Labsoft (Student Software).

The application AEL-EPP 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.

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



AEL-EPP

Applications:

AEL-5.1

Generation Trainers

Power Plants

AEL-EPP. Energy Power Plants Trainer. (Continuation)

Some practical exercises possibilities:

Operations with electrical generator and governor:

- 1.- Generator island grid operations.
 - 2.- Generator parallel grid operations.
 - 3.- Generator manual voltage regulation operations.
 - 4.- Generator manual frequency regulation operations.
 - 5.- Study of synchronous generator power factor regulation.
 - 6.- Studying of turbine regulation (frequency control) in island mode.
 - 7.- Study of turbine regulation (frequency control) in parallel grid mode.
 - 8.- Study of excitation/voltage regulation in island mode.
 - 9.- Study of excitation/voltage regulation in parallel grid mode.
 - 10.- Analysis of active and reactive power control.
 - 11.- Automatic control of active power.
 - 12.- Automatic control of reactive power.
- Operations with the frequency and voltage controller working as protection:
- 13.- Setting of the overcurrent protection of the generator controller.
 - 14.- Setting of the overvoltage and undervoltage protection of the generator controller.
 - 15.- Setting of the reverser power protection of the generator controller.

Particular practical exercises related to power plants:

Nuclear power plant simulator.

- 16.- Demonstration the working principles and operations of nuclear power plants simulator during varying loads.

Hydroelectric power plant simulator.

- 17.- Demonstration the working principles of mechanism of hydroelectric power plant simulator.
- 18.- Manual water flow control.
- 19.- Automatic water flow control.

Ocean energy power plant simulator.

- 20.- Demonstration of working principles and the way of how energy is stored.

Combined Cycle power plant simulator.

- 21.- Demonstration the working principles of mechanism of combined cycle power plant simulator.
- 22.- Manual water flow control.
- 23.- Automatic water flow control.

Diesel fuel power plant simulator.

- 24.- Demonstration the working principles of mechanism of diesel fuel cycle power plant simulator.
- 25.- Manual fuel flow control.
- 26.- Automatic fuel flow control.

Fossil fuel power plant simulator.

- 27.- Demonstration the working principles of mechanism of fossil fuel power plant simulator.
- 28.- Manual fossil control.
- 29.- Automatic fossil control.

Gas power plant simulator.

- 30.- Demonstration the working principles of mechanism of gas power plant simulator.

- 31.- Manual gas flow control.
 - 32.- Automatic gas flow control.
- Wind powered power plant simulator.*
- 33.- Demonstration the working principles of mechanism of wind powered power plant simulator.
 - 34.- Manual wind flow control.
 - 35.- Automatic wind flow control.
- Photovoltaic power plant simulator.*
- 36.- Demonstration the working principles of mechanism of photovoltaic power plant simulator.
 - 37.- Manual irradiation control.
 - 38.- Automatic irradiation control.
- Biomass power plant simulator.*
- 39.- Demonstration the working principles of mechanism of biomass power plant simulator.

- 40.- Manual biomass control.
 - 41.- Automatic biomass control.
- Fuel cells power plant simulator.*
- 42.- Demonstration the working principles of mechanism of biomass power plant simulator.
 - 43.- Manual hydrogen flow control.
 - 44.- Automatic hydrogen flow control.
- Geothermal power plant simulator.*
- 45.- Demonstration the working principles of mechanism of biomass power plant simulator.

- 46.- Manual water flow control.
 - 47.- Automatic water flow control.
- Heliothermic Solar Power Plant Simulator.*
- 48.- Demonstration the working principles of mechanism of Heliothermic Solar Power Plant Simulator.
 - 49.- Manual solar irradiation control.
 - 50.- Automatic solar irradiation control.
- Steam Turbine Power Plant Simulator.*
- 51.- Demonstration the working principles of mechanism of Steam Turbine Power Plant Simulator
 - 52.- Manual steam flow control.
 - 53.- Automatic steam flow control.

Other possibilities to be done with this Unit:

- 54.- Many students view results simultaneously.
To view all results in real time in the classroom by means of a projector or an electronic whiteboard.
 - 55.- The Computer Control System with PSV-SCADA allows a real industrial simulation.
 - 56.- This unit is totally safe as uses mechanical, electrical and electronic, and software safety devices.
 - 57.- This unit can be used for doing applied research.
 - 58.- This unit 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.

For more information see **AEL-EPP** catalogue. Click on the following link:

www.edibon.com/en/files/equipment/AEL-EPP/catalog



AEL-EPP

Applications:

AEL-5.1
Generation Trainers

Power Plants

AEL-HPPP. Hydroelectric Power Plants Trainer with Pelton Turbine.

The Hydroelectric Power Plants Trainer with Pelton Turbine, "AEL-HPPP", has been designed by EDIBON with a double purpose: in one hand it allows to study the mechanical characteristics of a Pelton turbine (designed by EDIBON) and, on the other hand, it allows to study the operation of real hydroelectric power plants.

This trainer consists of real mechanical and electrical elements (reduced scale) for testing in laboratories.

• Study of mechanical characteristics of the turbine:

The "AEL-HPPP" Trainer consists of a water tank (water reservoir) from which the water is propelled via pipe through a high power water pump (potential energy) up to an injector in which is installed a pressure sensor. Injector injects water into the Pelton turbine, which consists of 16 appreciable vanes from the transparent cover of the turbine. This trainer offers the advantage of controlling the water pressure of the injector via pump speed control (flow/pressure variations). The pipe output of the water pump has a flowmeter that allows measure the water flow injected into the turbine. On this way different pressures can be got to analyze several operation regimes of the Pelton turbine, as well as power generation variations. Thus, it is included a torque sensor, a braking system and a load cell to measure the turbine torque. This allows to obtain the characteristic curves of the turbine.

• Study of hydroelectric power plants:

Because its versatility and flexibility, this trainer permits to study the operation of both large hydroelectric power plants, that provide energy into the grid (parallel operation mode), and mini hydroelectric centers that provide energy to an isolated grid (stand-alone operation mode).

A 1 kW three-phase induction generator is coupled to the Pelton turbine shaft in order to synchronize the generator to the laboratory grid (50 Hz or 60 Hz).

The "AEL-HPPP" has an automatic grid connection device with pre-insertion resistors, to avoid sudden torque changes in the generator and turbine at the time of synchronization.

A network analyzer is connected to the induction generator terminals to monitor the power

generation parameters such as active power, reactive power, apparent power, phase currents, frequency and power factor. In addition, this trainer has a capacitor bench that provides reactive energy to the generator when user works with the trainer as mini hydroelectric central (stand-alone mode), providing power to a local electric load (included).

The "AEL-HPPP" includes of the following elements:

- Industrial rack with three phase power supply with differential and magnetothermal protection.
- Instrumentation panel:
 - Digital network analyzer to measure generator electrical parameters (V, f, P, Q, S, PF, etc.).
 - Generator analog voltmeter.
 - Generator analog wattmeter.
 - Generator analog varmeter.
 - Water flow and pressure digital meter of the turbine.
 - Three phase overcurrent protection relay.
- Real electrical diagram panel.
- Power, control and sensor connections panel.
- Three phase capacitive load bench to provide reactive energy to the generator.
- Three phase resistive load bench for energy consumption in stand-alone operation.
- Soft coupler system of the generator with the grid.
- CWTP. Conjunction of water tank, Pelton Turbine – Generator, injector, sensors and water pump.

Expansion learning software:

In addition, Edibon provides expansion learning software (AEL-HPPP/ICAI) to reinforce knowledge about this field. This software is formed by:

- ECM-SOF. EDIBON Classroom Manager (Instructor Software).
- ESL-SOF. EDIBON Student Labsoft (Student Software).

The application AEL-HPPP requires the following rack/s:

- N-RACK-A.

Optionally the AEL-WBMP. Electrical Workbench (Mobile Small) can be supplied to place the rack/s.



AEL-HPPP

Applications:

AEL-5.1
Generation Trainers

Power Plants

AEL-HPPP. Hydroelectric Power Plants Trainer with Pelton Turbine. (Continuation)

Some practical exercises possibilities:

- 1.- Determination of the operative characteristics of a Pelton Turbine.
- 2.- Obtaining the hydraulic and mechanical powers.
- 3.- Determination of the mechanical efficiency curve.
- 4.- Determination of the efficiency hydraulic curve.
- 5.- Flow calculation.
- 7.- Analysis the influence of the injected flow on the turbines's power.
- 8.- Synchronization of the induction generator with the laboratory grid.
- 9.- Injection of active power in the grid through flow control of the Pelton turbine.
- 10.- Measurement of the generator electrical parameters (S, P, Q, f, PF) injecting power to the grid.
- 11.- Stand-alone power generation. Energy consumption with isolated loads.
- 12.- Measurement of electrical parameters (S, P, Q, f, PF) of the generator injecting power to the isolated load.
- 13.- Calculation of hydroelectric power plant efficiency.
- 14.- Study of several problems that occur during synchronization operation with the grid.
- 15.- Study of generator motorization in synchronism with the grid. Casues and consequences.
- 16.- Study of sudden uncouple of the generator and the grid. Pelton turbine shedding.

For more information see **AEL-HPPP** catalogue.

Click on the following link:

www.edibon.com/en/files/equipment/AEL-HPPP/catalog



AEL-HPPP

Applications:

AEL-5.1
Generation Trainers

Power Plants

AEL-MEPD. Marine Electrical Power Distribution System.

A ship can be considered as a mobile power plant. Most of the machinery is driven electrically, which thus makes for a huge electrical power demand. This makes a shipboard electrical power distribution system very important.

Electricity has to be distributed with minimal losses after generation. Unlike a shore based transmission system, where the lengths of the conductors run throughout a country, a shipboard electrical distribution system is short and simple. Through AEL-MEPD "Marine Electrical Power Distribution System", the general layout of the main electrical distribution system, along with the main switchboard and emergency switchboard arrangements, will be studied.

The AEL-MEPD "Marine Electrical Power Distribution System" has been designed by Edibon for the training at both the theoretical and practical levels in the field of power distribution systems in ships.

This system provides several levels of training to give the user full knowledge and experiences about the operation of Marine Electrical Power Distribution Systems. For this purpose, this application includes a specific manual, which explains at theoretical level the subjects relating to power distribution systems in ships. The thematic of the manual covers topics such as construction and configuration of the main switch distribution board, short circuit protections, protection coordination studies, maintenance operations, charging battery system, essential and non-essential circuits, etc. On the other hand, it is provided a series of distribution panels and optional elements to put into practice all theoretical concepts previously studied in this manual.

This power system consists of three panels (included) that represent the parties of a Marine Electrical Power Distribution System. These parties are the Main Busbar Panel, the Distribution Board Panel and the Emergency Switch-Board Panel.

Optionally, electrical generators can be supplied to form a complete and real Marine Electrical Power Distribution System. On this way, the users can broaden their knowledge learning topics related to management of power generators used in ships such as parallel operation, load sharing, power generators control systems, etc. There are two available optional electrical generators according to the customer requirements:

- The TDEGC "Computer Controlled Diesel Engine Electrical Generator, with SCADA and PID Control". This unit consists of a diesel engine coupled to an electrical generator. It includes manual and automatic control and protection devices for diesel engines and synchronous

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

www.edibon.com/en/files/equipment/TDEGC/catalog

- The AEL-EESD "Advanced Digital Synchronization Trainer". This trainer consists of a three-phase induction motor of squirrel cage that works as a turbine and it is coupled to a synchronous generator. The trainer includes real industrial devices and controllers to manage the generator-motor group to work as a real power generation system. For more information see AEL-EESD catalogue. Click on the following link:

www.edibon.com/en/files/equipment/AEL-EESD/catalog

Basically, the AEL-MEPD consists three panels explained below:

- Main busbar.
 - Distribution boards.
 - Emergency switch-board.
- **Main busbar.**

The main bus bar is found inside the main switch board. Onboard a merchant ship, the supply is usually 440 volts, 60/50 Hertz, however higher voltages of 6.6kV are possible on LNG tankers, special purpose ships, and passenger vessels having electrical propulsion. The rating of the main bus bar is decided by the type of ship. In this System, the operation voltage is always 400-450 VAC to work under safety conditions for the students.

The main bus bar has three heavy, thick bars of conductor, running horizontally throughout the length of the main switch board. Each of the conductors is insulated between each other and wherever it is supported to the switchboard.

The main switchboard is the main power distribution center of the ship. Thus the main bus bars are contained within the switchboard feeding ship board auxiliaries. A ship may contain two or more generators connected to the main bus bar via the circuit breaker. This depend of the diesel generators acquired by the user (one, two or three TDEGC units). Besides, each diesel engine generator has protection like overload, reverse power, etc. which are connected to circuit breaker such that the faulty generator is electrically isolated from the main bus bar. From the main bus bar, the electrical power is supplied to various ship board auxiliaries like pumps, blowers, compressors, etc. The main switch board has various measuring and monitoring devices like ammeters, voltmeters, frequency meters, watt meters, synchroscope, and power factor meters.



AEL-MEPD

+

Optional Trainers



AEL-EESD

+



TDEGC

Applications:

AEL-5.1
Generation Trainers

Power Plants

AEL-MEPD. Marine Electrical Power Distribution System. (Continuation).

• **Distribution boards panel.**

Shipboard machinery may not be connected to the main switchboard directly. There are small motors and other devices that consume very little power and thus they may be grouped together. Instead of providing cables for every such individual motor, a single cable is taken out from the main switch board, supplying the distribution board which has a small bus bar (equivalent to supply the motors). From this small bus bar, the supply is provided for various starters of these motors via the circuit breakers. In this way, the protection for the machinery is also precise, as a small fault in such small motors will not operate the protection devices on the main switch board.

• **Emergency switch-board panel.**

As the name indicates, it supplies to equipment and machinery that are essential during any emergency like fire, flooding, etc. One important aspect about the emergency switch boards is that it is located above the load water line or the upper most continuous deck, where as the main generators and main switchboards are located below the weather deck or the load water line. Thus this ensures that the emergency supply is maintained when the vessel is flooded with water to the weather deck.

Optional Trainers / Generators:

According to the type and number of synchronous generators that the user requires to complete the ship power systems, one of the following unit is required:

- AEL-EESD. Advanced Digital Synchronization Trainer.
- TDEGC. Computer Controlled Diesel Engine Electrical Generator.

Optional SCADA software:

- AEL-EESD/CCSOF. Computer Control + Data Acquisition + Data Management Software.

Expansion learning software:

In addition, Edibon provides expansion learning software (AEL-MEPD/ICAI) to reinforce knowledge about this field. This software is formed by:

- ECM-SOF. EDIBON Classroom Manager (Instructor Software).
- ESL-SOF. EDIBON Student Labsoft (Student Software).

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

Some practical exercises possibilities:

- 1.- Main switch board construction and configuration.
 - 2.- Short circuit protection, fuses, circuit breakers studies.
 - 3.- Generator air circuit breaker operations.
 - 4.- Protection coordination studies.
 - 5.- Distribution bus bar configurations.
 - 6.- Studies of generation and distribution of high voltage on ships
 - 7.- Maintenance operations and repair a marine high voltage system.
 - 8.- Studies of high voltage system advantages.
 - 9.- High voltage circuit breakers.
 - 10.- High voltage cable and fuses
 - 11.- Selection of suitable apparatus for insulation and testing of high voltage equipment.
 - 12.- Studies of how to use High Voltage personal protection equipment (PPE).
- Emergency operations
- 13.- Emergency operation studies.
 - 14.- Emergency power requirements.
 - 15.- Essential and non essential circuits.
 - 16.- Charging battery system.

Other possibilities to be done with this Unit:

- 17.- Many students view results simultaneously. To view all results in real time in the classroom by means of a projector or an electronic whiteboard.
 - 18.- The Computer Control System with PSV-SCADA allows a real industrial simulation.
 - 19.- This unit is totally safe as uses mechanical, electrical and electronic, and software safety devices.
 - 20.- This unit can be used for doing applied research.
 - 21.- This unit 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.

For more information see **AEL-MEPD** catalogue. Click on the following link:

www.edibon.com/en/files/equipment/AEL-MEPD/catalog



AEL-MEPD

+

Optional Trainers



AEL-EESD

+



TDEGC

Applications:

AEL-5.1
Generation Trainers

Power Plants

TDEGC. Computer Controlled Diesel Engine Electrical Generator.

Engine diesel generators play an important role in the World Power Systems. These power machines are used in large amount of applications such as micro-grids, hospitals, shopping centers, ships, energy recover after black-outs and many other situations where the continuity of the power supply is essential.

The TDEGC has been designed by Edibon International to give teachers, students and researchers the most important knowledge about how works a real diesel engine - generator group. With the TDEGC unit the user can study the generator control in stand-alone mode and the synchronization with the grid for any power plant in general and the diesel generator group in particular.

The TDEGC unit can work together with many applications related to Smart Grids, Micro-Grids, Power Plants, Power Systems, etc. For more information about these applications click on the following links:

- AEL-MPSS. Modular Smart Grid Power Systems Simulators (Utilities).
www.edibon.com/en/files/equipment/AEL-MPSS/catalog
- AEL-CPSS-01S. Smart Grid Power Systems Application, with Automatic Control Generation, Transmission Line and Loads.
www.edibon.com/en/files/equipment/AEL-CPSS-01S/catalog
- APS12. Advanced Mechanical, Electrical and Smart Grid Power Systems (Utilities).
www.edibon.com/en/files/equipment/APS12/catalog
- In general with several power systems units.

The TDEGC includes the following elements and modules:

- Diesel Engine-Synchronous Generator Group.
- Control and Supervision Module.
- Instrumentation Module.
- Connection Diagram and SCADA Module.
- Industrial load modules: Three-Phase Resistive Industrial Module, Three-Phase Inductive Industrial Module, Three-Phase Capacitive Industrial Module.

Diesel Engine-Synchronous Generator Group:

Diesel engine has an electronic accelerator which is controlled by an Automatic Speed Controller to keep the speed constant independently of the load. On the other hand, diesel engine is coupled to a three-phase synchronous generator in order to transform chemical energy from a fuel to electrical energy. Synchronous generator has an Automatic Voltage Regulator to generate a constant voltage independently of the load consumption.

Automatic Speed Controller and Automatic Voltage Regulator work as primary control when the diesel engine and synchronous generator are working in stand-alone operation mode (without grid). The goal of these two controllers is to ensure that engine/generator always rotate at 1500 rpm/50 Hz or 1800 rpm/ 60 Hz (depending of the country frequency) and aenerate 400 VAC. However these

two controllers are not enough when diesel engine – generator work in parallel with the grid. In this circumstance the TDEGC unit includes a secondary controller with

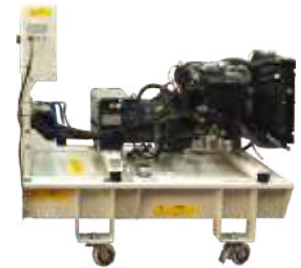
four programmed PIDs: speed, voltage, power factor and active power PIDs. These PIDs allow the users to stabilize the machine in synchronism with the grid.

In addition secondary controller is very important for a complete protection of diesel engine electrical generator to avoid damages in the unit. The most important alarms are listed subsequently: over/undervoltage protection, overcurrent protection, reverse power protection, over/underfrequency protection, low level fuel protection, low oil pressure protection, coolant high temperature protection, dirty filter alarm, etc.

Control and Supervision Module:

This module is the brain of the TDEGC unit and consists of four important parts:

- Speed and voltage controller. It works as secondary controller. When the diesel engine electrical generator works in parallel operation with the grid four PIDs are working at the same time in order to establish the machine in synchronism with the National Grid. These PIDs are the following: speed, voltage, power factor and active power PIDs. The first two (speed and voltage PIDs) can be monitored from the SCADA in order to understand how the controller works.
- Alarms and operating conditions of the TDEGC unit. The speed and voltage controller works as protection relay too. On this way the unit is completely protected and safe. The following are some alarms/protections included in the unit: overvoltage, undervoltage, overfrequency, underfrequency, overcurrent, reverse power protections. In addition, this module shows a series of operating conditions allowing the user to know the operating state of the machine. The following are the operating conditions shown in the control panel: ready for operation, start request, GCB synchronization conditions, remote closing signal for GCB synchronization, mains parallel operation, isolated operation, emergency stop, auxiliary services and starter signals.
- Maintenance operation panel. From this one the user can carry out a basic starting test disabling the secondary controller and working with the primary control alone. This function is very important when users work for the first time with the unit and it has to be checked.
- Back-Up protections panel. This panel consists of a differential protection relay and an overcurrent three-phase protection relay. These two protections give the unit a complete safety and reliability.



TDEGC

Applications:

AEL-5.1
Generation Trainers

Power Plants

TDEGC. Computer Controlled Diesel Engine Electrical Generator. (Continuation).

Instrumentation Module.

This module consist of a field dc power analyzer, an analog ammeter, a three phase generator power analyzer and a three phase grid power analyzer.

- Field DC Power Analyzer: field voltage, current and power measurements.
- Analog ammeter for field current excitation measurements.
- Synchronous generator power analyzer: three-phase output voltage, line currents, power factors, active power, reactive power, apparent powers, frequency, harmonics measurements.
- Grid power analyzer: three-phase output voltage, line currents, power factors, active powers, reactive powers, apparent powers, frequency, harmonics, measurements.

Connection Diagram and SCADA Module.

This module includes all power and signal connectors, bus bars voltage indicator lamps, synchronization lamps and real diagram of generator, circuit breakers, grid and loads.

SCADA Control System:

The TDEGC unit includes a SCADA Control System with which the user will manage and monitor a large amount of signals both manually and automatically. For example, start and stop diesel engine signals, fuel valve control signal, engine speed/frequency PID control signal, generator excitation PID control signal, opening and closing maneuvers of circuit breakers, etc.

Through the TDEGC's SCADA Control System the user can control and study the engine-generator group in stand-alone operation or in synchronism with the grid. For isolated operation the unit includes a series of commutable resistive, inductive and capacitive loads. On this way, the user can vary the active and reactive power to study the behavior of the engine and synchronous

generator. For synchronization operation with the grid, the unit detects the presence of this; hence the speed and voltage secondary controller adjusts phase voltage angles and engine frequency in order to get synchronization conditions with the national grid. Other important characteristic is that the user can take the full control over the speed and excitation signals to manage the diesel engine-generator group manually.

On the other hand, through the TDEGC's SCADA System it is possible to acquire all electrical parameters such us generator output voltages, line currents, power factors, active powers, reactive powers, apparent powers, excitation voltage, excitation current, generator speed and frequency, PID speed and voltage signals, etc. Besides, the SCADA includes an oscilloscope that allows visualize generator voltage, current, active power and speed waves in order to carry out different analysis of the machine.

Industrial load modules: Three-Phase Resistive Industrial Module, Three-Phase Inductive Industrial Module, Three-Phase Capacitive Industrial Module.

These modules allows user to simulate different industrial energy consumptions in order to study the generator and engine behavior in isolated operation mode.

Expansion learning software:

In addition, Edibon provides expansion learning software (TDEGC/ICAI) to reinforce knowledge about this field. This software is formed by:

- ECM-SOF. EDIBON Classroom Manager (Instructor Software).
- ESL-SOF. EDIBON Student Labsoft (Student Software).

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



TDEGC

Applications:

AEL-5.1
Generation Trainers

Power Plants

TDEGC. Computer Controlled Diesel Engine Electrical Generator. (Continuation).

Some practical exercises possibilities:

- 1.- Automatic speed control of the engine and generator in island.
- 2.- Manual speed control of the engine in island.
- 3.- Automatic excitation control of the three-phase synchronous generator.
- 4.- Manual excitation control of the three-phase synchronous generator.
- 5.- Automatic speed control of the engine in parallel with the grid.
- 6.- Manual speed control of the engine in parallel with the grid.
- 7.- Automatic excitation control of the synchronous generator in parallel with the grid.
- 8.- Manual excitation control of the synchronous generator in parallel with the grid.
- 9.- Control of the engine and generator in parallel generation mode (working with other generators).
- 10.- Coordination of energy needs and generating capacity in stand-alone grids.
- 11.- Active power waves measurement in real time and comparison with PID speed signal and engine.
- 12.- Smart Meter to measure the generated energy by the generator.
- 13.- Manual control of voltage, frequency, power factor and torque.
- 14.- Manual control of voltage and frequency of the generator in a stand-alone and in parallel operation (with any other generator).
- 15.- Automatic control of voltage and frequency of the generator/engine in a stand-alone or in parallel operation (with any other generator).
- 16.- Study of energy requirements and energy generation in stand-alone grid.
- 17.- Studying of synchronous generator/engine response when a change in load is produced.
- 18.- Synchronization operations of the one synchronous generator and the grid.

Other optional practical exercises:

- 19.- Synchronization operations with two synchronous generators and grid (with any other generator).
- 20.- Load sharing between two synchronous generators (with any other generator).

Other possibilities to be done with this Unit:

- 21.- Many students view results simultaneously.

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

- 22.- 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.

- 23.- The Computer Control System with SCADA and PID Control allow a real industrial simulation.

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

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

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

- 27.- Visualization of all the sensors values used in the TDEGC unit process.

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

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

www.edibon.com/en/files/equipment/TDEGC/catalog



TDEGC

Applications:

AEL-5.1
Generation Trainers

Basic Smart Grid Trainer Power Systems

AEL-BSG. Basic Smart Grid Trainer.

A Smart Grid is an electrical grid that includes a variety of operational and energy measures, including smart meters, smart appliances, renewable energy sources and energy efficiency resources. Control production and distribution of electricity are important aspects of Smart Grids that are studied with the AEL-BSG, Basic Smart Grid Trainer.

The AEL-BSG, Basic Smart Grid Trainer, has been designed to study the Smart Grids in the generation, transmission, distribution and load consumption fields.

Students and teachers of universities and vocational schools can easily study how a real Smart Grid works since electrical energy is produced till it is consumed, analyzing problems and solutions in each part of the process or as a whole.

This trainer includes by the following elements:

- 1 kVA Three-Phase Synchronous Generator-Motor group. It is used to study the production of electricity. The synchronous generator is coupled to a three-phase induction motor of squirrel cage controlled through a variable frequency drive. With the frequency controller the user can control the induction motor speed and simulate any power generation condition. In addition, the generator excitation is controlled by an AVR (automatic voltage regulator) that allows user to control the current excitation of the synchronous generator.
- Transmission line module. With this module it is possible to study in a simple way how electrical energy is transported and distributed along hundreds of kilometers. The transmission line module is designed according to the concentrated parameters theory with variable inductances, capacitances and resistances. This module allows change the lines length, the capacitive effect with the ground and the capacitive effect between the lines. On this way students will understand how the line parameters affect in the transported energy.
- Two network analyzers for bidirectional smart metering (Smart Meter Simulators). The AEL-BSG Trainer includes two network analyzers through which the user can study energy losses in the transmission lines, measuring upstream and downstream voltages, active powers, reactive powers, power factor, line currents and many other electrical parameters.
- Resistive, inductive and capacitive load modules. The AEL-BSG trainer includes a series of loads to simulate different load conditions. The resistances allow to change the active power consumption as it occurs in real situations. On the other hand, the inductances and capacitances allow to change the reactive energy consumption and to study the power factor compensation.
- Advanced Speed and Voltage Controller. This module allows to study the operation of a real speed and voltage controller. The user can configure speed and voltage PIDs in order to study the stability of a synchronous generator-motor group. In power generation systems it is very important to maintain speed and voltage constants to avoid possible damages due to frequency or voltage oscillations. With this trainer students will learn how set and operate with an actual speed/voltage controller.

Expansion learning software:

In addition, Edibon provides expansion learning software (AEL-BSG/ICAL) to reinforce knowledge about this field. This software is formed by:

- ECM-SOF. EDIBON Classroom Manager (Instructor Software).
- ESL-SOF. EDIBON Student Labsoft (Student Software).

Some practical exercises possibilities:

- 1.- Basic concepts of Smart Isolated Grids.
- 2.- Manual control of voltage and frequency of the generator in a Smart Stand-Alone Grid.
- 3.- Automatic control of voltage and frequency of the generator in a Smart Stand-Along Grid.
- 4.- Study of energy requirements and energy generation in a Smart 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.- Study of energy losses in transmission lines.

For more information see **AEL-BSG** catalogue. Click on the following link:

www.edibon.com/en/files/equipment/AEL-BSG/catalog



AEL-BSG

Applications:

AEL-5.1
Generation Trainers

Basic Smart Grid Trainer Power Systems

AEL-BSGC. Basic Smart Grid Trainer, with SCADA.

A Smart Grid is an electrical grid that includes a variety of operational and energy measures including smart meters, smart appliances, renewable energy sources, and energy efficiency resources. Control production and distribution of electricity are important aspects of Smart Grids that are studied with the AEL-BSGC. Basic Smart Grid Trainer with SCADA.

The AEL-BSGC Basic Smart Grid Trainer with SCADA has been designed to study the Smart Grids in the generation, transmission, distribution and load consumption fields.

Students and teachers of universities and vocational schools can easily study how a real Smart Grid works since electrical energy is produced till it is consumed, analyzing problems and solutions in each part of the process or as the whole.

This trainer includes by the following elements:

- 1 kVA Three-Phase Synchronous Generator-Motor group. It is used to study the production of electricity. The synchronous generator is coupled to a three-phase induction motor of squirrel cage controlled through a variable frequency drive. With the frequency controller the user can control the induction motor speed and simulate any power generation condition. In addition, the generator excitation is controlled by an AVR (automatic voltage regulator) that allows user to control the current excitation of the synchronous generator.
- Transmission line module. With this module it is possible to study in a simple way how electrical energy is transported and distributed along hundreds of kilometers. The transmission line module is designed according to the concentrated parameters theory with variable inductances, capacitances and resistances. This module allows change the lines length, the capacitive effect with the ground and the capacitive effect between the lines. On this way students will understand how the line parameters affect in the transported energy.
- Two network analyzers for bidirectional smart metering (Smart Meter Simulators). The AEL-BSGC Trainer includes two network analyzers through which the user can study energy losses in the transmission lines, measuring upstream and downstream voltages, active powers, reactive powers, power factor, line currents and many other electrical parameters.
- Resistive, inductive and capacitive load modules. The AEL-BSGC trainer includes a series of loads to simulate different load conditions. The resistances allow to change the active power consumption as it occurs in real situations. On the other hand, the inductances and capacitances allow to change the reactive energy consumption and to study the power factor compensation.
- Advanced Speed and Voltage Controller. This module allows to study the operation of a real speed and voltage controller. The user can configure speed and voltage PIDs in order to study the stability of a synchronous generator-motor group. In power generation systems it is very important to maintain speed and voltage constants to avoid possible damages due to frequency or voltage oscillations. With this trainer students will learn how set and operate with an actual speed/voltage controller.

- Data Acquisition System. SCADA System allows visualize all electrical parameters measured in the network analyzers: active power waves, reactive power waves, line current waves, etc. All this information can be used for viewing data reports, comparing upstream and downstream electrical parameters of the transmission lines, calculating energy balances and many other possibilities.

Expansion learning software:

In addition, Edibon provides expansion learning software (AEL-BSGC/ICAI) to reinforce knowledge about this field. This software is formed by:

- ECM-SOF. EDIBON Classroom Manager (Instructor Software).
- ESL-SOF. EDIBON Student Labsoft (Student Software).

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.

Some practical exercises possibilities:

- 1.- Basic concepts of Smart Isolated Grids.
- 2.- Manual control of voltage and frequency of the generator in a Smart Stand-Alone Grid.
- 3.- Automatic control of voltage and frequency of the generator in a Smart Stand-Along Grid.
- 4.- Study of energy requirements and energy generation in a Smart 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.- Study of energy losses in transmission lines.

Practical exercises possibilities with SCADA:

- 11.- Representation of power generation waves through the Data Acquisition System.
 - 12.- Comparison of energy losses according to the line length.
 - 13.- Visualization and comparison of the reactive load curves with and without power factor compensation.
 - 14.- Display of measured values of the synchronous generator.
 - 15.- Display of measured values upstream and downstream of the transmission line for different line lengths and energy losses compantion.
 - 16.- Plotting of measured values vs.
 - 17.- Data processing, analyzing and exporting of generation, lines and load electrical parameters.
- Several other exercises can be done and designed by the user.

For more information see **AEL-BSGC** catalogue.

Click on the following link:

www.edibon.com/en/files/equipment/AEL-BSGC/catalog



AEL-BSGC

Applications:

AEL-5.1
Generation Trainers

Microgrid Series

AEL-MGR. Micro-Grids Power System Series.

Micro Grids play an important role for the progress of the world. Conventional energy sources are being depleted due to their overuse. It is very important to have in mind that renewable energies are the present and, especially, the future. They are of vital importance to reduce the pollution and the environment impact of non-renewable energy sources. Thus, there is a massive urgency to accelerate the utilization of distributed energy resources. In the future great power plants that supply important amounts of energy to everywhere will not be necessary. A future without great transmission lines and power plants will be possible, with clean cities and countries without pollution. All these facts may come true if we reach a future where photovoltaic energy, wind energy, DC storage energy, etc. work together. It is very important that everyone understand the importance of micro-grids and renewable energy sources for the world's sustainable future. For this purpose EDIBON International has designed a series of applications in order to demonstrate how micro grids work. Complete system AEL-MGR consists of the following applications which can work separately or together:

- AEL-MGR-1. Stand-Alone and Parallel Generator Operations Application.

Complementary micro-grids applications to AEL-MGR-1:

- AEL-MGR-2. Isolated-Parallel Generator Operation Application.
 - AEL-WPT. Wind Power Trainer with Permanent Magnets Synchronous Generator.
 - AEL-PHVG. Photovoltaic Application with Connection to Grid.
 - TDEGC. Computer Controlled Diesel Engine Electrical Generator.
- AEL-MGR-1. Stand-Alone and Parallel Generator Operations Application.

The "AEL-MGR-1" has been developed to show how carry out basic operations to control a generator, which supplies power to a micro-grid: voltage stabilization, frequency control, synchronization both generator and the grid for load sharing, etc.

This application includes an advanced frequency and voltage controller that allows a perfect control over the synchronous generator. By changing a series of automatic switches the user can set between a manual or automatic frequency and voltage control of the synchronous generator. On this way, the user can be a simple supervisor of the electrical system, observing how current excitation and frequency change automatically, or he can take the whole control of the energy production.

For more information see **AEL-MGR** catalogue. Click on the following link:
www.edibon.com/en/files/equipment/AEL-MGR/catalog

Complementary micro-grids applications to AEL-MGR-1:

- AEL-MGR-2. Isolated-Parallel Generator Operation Application.

The "AEL-MGR-2" has been developed as a complement to the "AEL-MGR-1" in order to show how carry out the control of multiple generators in parallel operation. With two parallel generators it is possible to supply power to a micro-grid as more realistic way, studying the voltage stabilization of the generators, frequency control, load sharing, etc.

For more information see **AEL-MGR** catalogue. Click on the following link:

www.edibon.com/en/files/equipment/AEL-MGR/catalog

- AEL-WPT. Wind Power Trainer with Permanent Magnets Synchronous Generator.

Renewable energies play an important role in the micro-grids field. For this reason, the "AEL-WPT" is a perfect complement to work together with the rest of micro-grid applications. The Wind Power Trainer with Permanent Magnets Synchronous Generator (AEL-WPT) is an application designed to train the students in the main operations of wind turbines. The wind speed is simulated through a three-phase squirrel cage of induction motor controlled through a frequency controller. This motor is coupled to a permanent magnet synchronous generator for energy production.

For more information see **AEL-WPT** catalogue. Click on the following link:

www.edibon.com/en/files/equipment/AEL-WPT/catalog

- AEL-PHVG. Photovoltaic Application with Connection to Grid.

The "AEL-PHVG" is an application designed to study the energy production by photovoltaic panels and how this energy is injected to the grid or to a micro-grid. This application can work together with other power generation sources to study the energy mix, their advantages and problems present when alternate sources are interconnected into a power system.

For more information see **AEL-PHVG** catalogue. Click on the following link:

www.edibon.com/en/files/equipment/AEL-PHVG/catalog

- TDEGC. Computer Controlled Diesel Engine Electrical Generator.

The TDEGC has been designed by EDIBON International to give teachers, students and researchers the most important knowledge about how works a real diesel engine-generator group. With the TDEGC unit the user can study the generator control in stand-alone mode and the synchronization with the grid for any power plant in general and the diesel generator group in particular.

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

www.edibon.com/en/files/equipment/TDEGC/catalog



AEL-MGR-1



AEL-MGR-2



AEL-WPT

Applications:

AEL-5.1
Generation Trainers

Microgrid Series

AEL-MGR. Micro-Grids Power System Series. (Continuation).

Some practical exercises possibilities with AEL-MGR-1:

- 1.- Basic concepts of isolated, stand-alone 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 stand-alone grids.
- 5.- Smart Metering of the generated energy.
- 6.- Studying of synchronous generator response when a load change is produced.
- 7.- Programming of synchronous generator controller working mode.
- 8.- Synchronization operations with synchronous generator and grid.

Some practical possibilities with AEL-MGR-1S (SCADA option):

- 9.- Remote manual control of voltage and frequency of the generator in a stand-alone grid.
- 10.- Remote automatic control of voltage and frequency of the generator in a stand-alone micro-grid.
- 11.- Real time measurement of generator electrical parameters.
- 12.- Remote control of open and close circuit breakers.
- 13.- Remote synchronization operation with synchronous generator and grid.

Some practical exercises possibilities with AEL-MGR-2:

- 14.- Control of multiple generators in a standalone grid.
- 15.- Control of multiple generators in parallel generation mode.
- 16.- Coordination of energy needs and generating capacity in stand-alone grids.
- 17.- Smart Metering of the generated energy by the generators.
- 18.- Manual control of voltage, frequency, power factor and torque.
- 19.- Manual control of voltage and frequency of the generator in a stand-alone and in parallel operation.
- 20.- Automatic control of voltage and frequency of the generator in a stand-alone and in parallel operation.
- 21.- Study of energy requirements and energy generation in stand-alone grids.
- 22.- Studying of synchronous generator response when a changing load is produced.
- 23.- Programming of synchronous generator controller working mode: base load and peak load coverage.
- 24.- Synchronization operations with two synchronous generators and grid.
- 25.- Synchronization operations with one synchronous generator and grid.
- 26.- Load sharing between two synchronous generators.

Some practical possibilities with AEL-MGR-2S (SCADA option):

- 27.- Remote control of multiple generators in a stand-alone grid.
- 28.- Remote control of multiple generators in parallel generation mode.
- 29.- Remote coordination of energy needs and generating capacity in stand-alone grids.
- 30.- Remote Smart Metering of the generated energy by the generators.
- 31.- Remote manual control of voltage, frequency, power factor and torque.
- 32.- Remote manual control of voltage and frequency of the generator in a stand-alone and in parallel operation.
- 33.- Remote automatic control of voltage and frequency of the generator in a stand-alone and in parallel operation.
- 34.- Remote synchronization operations with two synchronous generators and grid.
- 35.- Remote synchronization operations with one synchronous generator and grid.

Some practical exercises possibilities with AEL-WPT:

- 36.- Voltage-Speed Characteristics of a Wind Turbine Generator.
- 37.- Checking the lamps.
- 38.- Power vs Wind Turbine Speed.
- 39.- Storing Energy from a Wind Turbine into Batteries.
- 40.- Battery charging fundamentals.
- 41.- Drop voltage in the wind generator.
- 42.- Feeding from the wind generator.
- 43.- Feeding from the battery.

Some practical exercises possibilities with the Optional SCADA System:

- 44.- Monitoring and Data Acquisition wind turbine curves.
- 45.- Measurement of energy generation in function of the wind speed.
- 46.- Remote control of the wind turbine.

Some practical exercises possibilities with AEL-PHVG:

- 47.- Wiring of photovoltaic system.
- 48.- Checking the photovoltaic system with feed to the power grid.
- 49.- Measurement of energy production by the photovoltaics panel.
- 50.- Finding the Maximum Power Point.
- 51.- Minimum power of the photovoltaic inverter.
- 52.- Losses of the power grid inverter.
- 53.- Control of the power grid inverter.
- 54.- Visualizing the electrical parameters of the photovoltaic panel through SCADA Control System.
- 55.- System's response in case of power outage on the grid.
- 56.- Lightning protecting for photovoltaic systems.
- 57.- Testing V-I characteristics.



AEL-PHVG



TDEGC

Applications:

AEL-5.1
Generation Trainers

Microgrid Series

AEL-MGR. Micro-Grids Power System Series. (Continuation).

Some practical exercises possibilities with TDEGC:

- 58.- Automatic speed control of the engine and generator in island.
- 59.- Manual speed control of the engine in island.
- 61.- Automatic excitation control of the three-phase synchronous generator.
- 62.- Manual excitation control of the three-phase synchronous generator.
- 63.- Automatic speed control of the engine in parallel with the grid.
- 64.- Manual speed control of the engine in parallel with the grid.
- 65.- Automatic excitation control of the synchronous generator in parallel with the grid.
- 65.- Manual excitation control of the synchronous generator in parallel with the grid.
- 66.- Control of the engine and generator in parallel generation mode (working with other generators).
- 67.- Coordination of energy needs and generating capacity in stand-alone grids.
- 68.- Active power waves measurement in real time and comparison with PID speed signal and engine.
- 69.- Smart Meter to measure the generated energy by the generator.
- 70.- Manual control of voltage, frequency, power factor and torque.
- 71.- Manual control of voltage and frequency of the generator in a stand-alone and in parallel operation (with any other generator).
- 72.- Automatic control of voltage and frequency of the generator/engine in a stand-alone or in parallel operation (with any other generator).
- 73.- Study of energy requirements and energy generation in stand-alone grid.
- 74.- Studying of synchronous generator/engine response when a change in load is produced.
- 75.- Synchronization operations of the one synchronous generator and the grid.

Other optional practical exercises:

- 76.- Synchronization operations with two synchronous generators and grid (with any other generator).
- 77.- Load sharing between two synchronous generators (with any other generator).

Other possibilities to be done with TDEGC this Unit:

- 78.- Many students view results simultaneously.
To view all results in real time in the classroom by means of a projector or an electronic whiteboard.

- 79.- 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.

- 80.- The Computer Control System with SCADA and PID Control allow a real industrial simulation.

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

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

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

- 84.- Visualization of all the sensors values used in the TDEGC unit process.

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

For more information see **AEL-MGR** catalogue. Click on the following link:

www.edibon.com/en/files/equipment/AEL-MGR/catalog



AEL-PHVG



TDEGC

Applications:

AEL-5.2

Distribution and Transmission Trainers

Basic Distribution and Transmission Trainers

AEL-AE1A. Aerial Line Model.

The Aerial Line Model, AEL-AE1A has been designed by Edibon to study the basics concept of power systems in the field of the power generation, transmission, distribution and load consumption.

The AEL-AE1A consists of a series of modules that represent, in a reduced scale, a real power system.

Through these modules, the student will understand the main concepts of Transport Lines: drop voltages, reactive energy compensation, measurement of currents, voltages, active and reactive power, power losses at the transmission lines, etc.

In order to simulate the energy transport, the student will work with the transmission line simulation module. This module represents basic concepts of the Electric Energy high-voltage three-phase transmission lines operation. It simulates a value modifying concentrated parameter line that allows different configurations and consists of three conductor line (R, S, T) and a Neutral or return line (N).

Each one of the phases is represented following the concentrated parameters theoretical model, through a resistance series association and inductances, along with a parallel association between each one of them in a capacitance effect.

In addition, this unit includes a three phase power supply to simulate power generation. On the other hand, three-phase resistive, inductive and capacitive load modules are included to simulate different energy consumption profiles to analyze the load effect in the transmission line.

The AEL-AE1A includes the following modules:

- N-ALI01. Industrial Main Power Supply.
- N-AE1. Transmission Lines Simulation Module.
- N-REFT. Three-phase Resistor Load with commutator.
- N-INDT. Three-phase Variable Inductive Load with commutator.
- N-CONT. Three-phase Variable Capacitor Load with commutator.
- N-EAL. Network Analyzer Unit. (2 units)

Optional SCADA software:

- AEL-AE1A/CCSOF. Computer Control + Data Acquisition + Data Management Software.

Expansion learning software:

In addition, Edibon provides expansion learning software (AEL-AE1A/ICAI) to reinforce knowledge about this field. This software is formed by:

- ECM-SOF. EDIBON Classroom Manager (Instructor Software).
- ESL-SOF. EDIBON Student Labsoft (Student Software).

The application AEL-AE1A can be mounted on rack (option A) or on rail (option B):

Option A:

This application needs the following racks:

- N-RACK-A.
- N-RACK-B.

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.

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

Some practical exercises possibilities:

- 1.- Studying of the energy power losses on the transport lines.
- 2.- Theoretical calculation of drops voltage on the transport lines and comparison y networks analyzer values.
- 3.- Voltage increases on open-circuit lines.
- 4.- Studying the unbalanced power systems.
- 5.- Studying the balanced power systems.
- 6.- Directly measure of energy losses on the electrical grid and comparison with theory calculus.
- 7.- Variation of type of loads and visualizing the power factor of the grid.
- 8.- Study of power factor compensation and the effects in the energy losses.

Other possibilities to be done with this Unit:

- 9.- Many students view results simultaneously.
To view all results in real time in the classroom by means of a projector or an electronic whiteboard.
 - 10.- The Computer Control System with SCADA allow a real industrial simulation.
 - 11.- This unit is totally safe as uses mechanical, electrical and electronic, and software safety devices.
 - 12.- This unit can be used for doing applied research.
 - 13.- This unit 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.

For more information see **AEL-AE1A** catalogue. Click on the following link:

www.edibon.com/en/files/equipment/AEL-AE1A/catalog



AEL-AE1A

Applications:

AEL-5.2
Distribution and Transmission Trainers

Distribution and Transmission Trainers

AEL-TI-01. Analysis of Three-phase Power Lines.

Electricity is transmitted at high voltages to reduce the energy losses in long-distance transmission. Power is usually transmitted through overhead power lines. Underground power transmission has a significantly higher cost and greater operational limitations but is sometimes used in urban areas or sensitive locations.

Power line is a structure used in electric power transmission and distribution to transmit electrical energy along large distances. It consists of one or more conductors (commonly multiples of three) suspended by towers or poles. Since most of the insulation is provided by air, overhead power lines are generally the lowest-cost method of power transmission for large quantities of electric energy.

This application consists of a series of modules such as configurable transmission line, network analyzers, electronic time overcurrent relay and resistive, inductive and capacitive loads modules.

All these modules together the special transmission line module allow the students carry out important investigations about power transmission and distribution lines: capacitive effects between the lines and the ground, energy losses depending on the load, power factor compensation and electrical values comparison, one or two phase shifts in a line, etc.

In addition, the AEL-TI-01 is the base unit of other expansion trainers designed to increase the student's knowledge in different materials of the power transmission and distribution.

The AEL-TI-01 includes the following modules:

- N-VPS01. AC 3PH Variable Power Supply.
- N-AE1/1K. 1KVA Transmission Line Simulator Module
- N-REVT/1K. 1kW Three-Phase Resistors Module.
- N-CONT/1K. 1kVA Three-Phase Capacitors Module.
- N-INDT/1K. 1kVA Three-Phase inductances Module.
- N-EALD. Network Analyzer Unit with Computer Data Acquisition. (2 units).
- N-PSM. Power Switch Module.
- N-CON02. 3-Pole Contactor.
- N-REL09. Time Electronic Relay against Overcurrents (1.2 - 7 A).

Optional SCADA software:

- PSV-SCADA. Power Systems SCADA Viewer.

Expansion learning software:

In addition, Edibon provides expansion learning software (AEL-TI-01/ICAI) to reinforce knowledge about this field. This software is formed by:

- ECM-SOF. EDIBON Classroom Manager (Instructor Software).
- ESL-SOF. EDIBON Student Labsoft (Student Software).

This application can be extended with the following applications:

- AEL-TI-02. Distribution Transformer with Motor Regulation.
- AEL-TI-03. Arc Suppression Coil.

- AEL-TI-04. Underground Transmission Lines.
- AEL-TI-05. Parallel and Series Transmission Lines.
- AEL-TI-06. Analysis of Flow Power on Transmission Lines
- AEL-TI-07. Transmission Systems with Synchronous Generator.

The application AEL-TI-01 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 (4 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.

Optionally this unit is supplied with the Power Systems SCADA Viewer (PSV-SCADA), and includes: The unit itself + Computer Control, Data Acquisition and Data Management Software Packages, for controlling the process and all parameters involved in the process.

Some practical exercises possibilities:

- 1.- Checking the variable power supply.
- 2.- Study of voltage increases on transmission lines without load.
- 3.- Study of voltage drop in transmission lines with different length.
- 4.- Study of voltage drop in transmission lines with different power factors.
- 5.- Reactive power losses in transmission lines as a function of U and I.
- 6.- Study of phase shift on transmission lines.
- 7.- Resistive, inductive and resistive-inductive mixed loads.
- 8.- Power factors Compensation for a resistive-inductive load.

Other possibilities to be done with this Unit:

- 9.- Many students view results simultaneously. To view all results in real time in the classroom by means of a projector or an electronic whiteboard.
 - 10.- The Computer Control System with PSV-SCADA allows a real industrial simulation.
 - 11.- This unit is totally safe as uses mechanical, electrical and electronic, and software safety devices.
 - 12.- This unit can be used for doing applied research.
 - 13.- This unit 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.

For more information see **AEL-TI-01** catalogue. Click on the following link:

www.edibon.com/en/files/equipment/AEL-TI-01/catalog



AEL-TI-01

Applications:

AEL-5.2
Distribution and Transmission Trainers

Distribution and Transmission Trainers

AEL-TI-02. Distribution Transformer with Motor Regulation.

Electric utilities aim to provide service to customers at a specific voltage level, for example, 220V or 240V. However, due to Kirchhoff's Laws, the voltage magnitude and thus the service voltage to customers will in fact vary along the length of a transmission line.

Depending on the amount of power demanded the voltage drop along the lines may be more or less. The goal of the utilities is to maintain the constant voltages. In order to maintain voltage within a tolerance under changing load conditions, are used voltage regulators in the distribution transformers.

An electric power distribution system is the final stage in the delivery of electric power; it carries electricity from the transmission system to individual consumers. Distribution substations connect to the transmission system and reduce the transmission voltage to medium voltage with the use of transformers. Primary distribution lines carry this medium voltage power to distribution transformers located near of customer's premises. Distribution transformers again reduce the voltage to the utilization voltage of household appliances and typically feed several customers through secondary distribution lines at this voltage.

This trainer has been developed as a complement to AEL-TI-01 in order to study how distribution lines response to changes of load. In order to compensate the voltage fluctuations when the load changes, three-phase power transformer with motor regulation is included.

Required Basic equipment:

- AEL-TI-01. Analysis of Three-phase Power Lines.

The AEL-TI-02 includes the following modules:

- N-TRANS3R/1K. Three-phase transformer with motor voltage regulator.

Optional SCADA software:

- PSV-SCADA. Power Systems SCADA Viewer.

Expansion learning software:

In addition, Edibon provides expansion learning software (AEL-TI-02/ICAI) to reinforce knowledge about this field. This software is formed by:

- ECM-SOF. EDIBON Classroom Manager (Instructor Software).
- ESL-SOF. EDIBON Student Labsoft (Student Software).

The application AEL-TI-02 can be mounted on rack (option A) or on rail (option B):

Option A:

This application need the following rack:

- N-RACK-B.

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.

Optionally this unit is supplied with the Power Systems SCADA Viewer (PSV-SCADA), and includes: The unit itself + Computer Control, Data Acquisition and Data Management Software Packages, for controlling the process and all parameters involved in the process.

Some practical exercises possibilities of basic equipment (AEL-TI-01):

- 1.- Checking the variable power supply.
- 2.- Study of voltage increases on transmission lines without load.
- 3.- Study of voltage drop in transmission lines with different length.
- 4.- Study of voltage drop in transmission lines with different power factors.
- 5.- Reactive power losses in transmission lines as a function of U and I.
- 6.- Study of phase shift on transmission lines.
- 7.- Resistive, inductive and resistive-inductive mixed loads.
- 8.- Power factors Compensation for a resistive-inductive load.

Some practical exercises possibilities with the specific modules of AEL-TI-02:

- 9.- Automatic voltage compensation with the three-phase transformer.
- 10.- Calculation of equivalent circuit parameters through vacuum test.
- 11.- Study of increase voltage through Step-up transformer.
- 12.- Study of decrease voltage through Step-down transformer.

Other possibilities to be done with this Unit:

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

For more information see **AEL-TI-02** catalogue.

Click on the following link:

www.edibon.com/en/files/equipment/AEL-TI-02/catalog



AEL-TI-02

Applications:

AEL-5.2
Distribution and Transmission Trainers

Distribution and Transmission Trainers

AEL-TI-03. Arc suppression Coil.

Petersen coils are used in ungrounded three-phase systems to limit arcing currents during earth faults. When a phase-to-earth fault occurs in these systems, the phase voltage of the faulty phase is reduced to the earth potential as the capacitance of the faulty line is discharged at the fault location, the phase-to-earth voltage of the other two phases rises by $\sqrt{3}$ times. The consequence is that charging current "IC" is three times the charging current of each phase-to-earth.

A modern Petersen coil consists of an iron-cored reactor connected between the star point of the substation transformer and earth in a three-phase system. In the event of a fault, the capacitive earth fault current (IC) is now neutralized by the current in the reactor as this is equal in magnitude, but 180 degrees out-of-phase.

The AEL-TI-03 Arc Suppression Coil application has been designed by Edibon in order to show the students how earth fault current can be neutralized thanks to Petersen coil.

This trainer has been developed as a complement to AEL-TI-01 in order to study how Petersen coil work. In order to realize it, a Petersen coil module is included. Thanks to the other modules like variable power supply or the transmission line simulator module, the student can realize different earth fault conditions.

Required Basic equipment:

- AEL-TI-01. Analysis of Three-phase Power Lines.

The AEL-TI-03 includes the following modules:

- N-ASC. Arc Suppression Coil module.

Optional SCADA software:

- PSV-SCADA. Power Systems SCADA Viewer.

Expansion learning software:

In addition, Edibon provides expansion learning software (AEL-TI-03/ICAI) to reinforce knowledge about this field. This software is formed by:

- ECM-SOF. EDIBON Classroom Manager (Instructor Software).
- ESL-SOF. EDIBON Student Labssoft (Student Software).

The application AEL-TI-03 can be mounted on rack (option A) or on rail (option B):

Option A:

This application needs the following racks:

- N-RACK-B.

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.

Optionally this unit is supplied with the Power Systems SCADA Viewer (PSV-SCADA), and includes: The unit itself + Computer Control, Data Acquisition and Data Management Software Packages, for controlling the process and all parameters involved in the process.

Some practical exercises possibilities of basic equipment (AEL-TI-01):

- 1.- Checking the variable power supply.
- 2.- Study of voltage increases on transmission lines without load.
- 3.- Study of voltage drop in transmission lines with different length.
- 4.- Study of voltage drop in transmission lines with different power factors.
- 5.- Reactive power losses in transmission lines as a function of U and I.
- 6.- Study of phase shift on transmission lines.
- 7.- Resistive, inductive and resistive-inductive mixed loads.
- 8.- Power factors Compensation for a resistive-inductive load.

Some practical exercises possibilities with the specific modules of AEL-TI-03:

- 9.- Earth fault on a line with an isolated star point.
- 10.- Response to earth faults.
- 11.- Earth-fault compensation.

Other possibilities to be done with this Unit:

- 12.- Many students view results simultaneously.
To view all results in real time in the classroom by means of a projector or an electronic whiteboard.
- 13.- The Computer Control System with PSV-SCADA allows a real industrial simulation.
- 14.- This unit is totally safe as uses mechanical, electrical and electronic, and software safety devices.
- 15.- This unit can be used for doing applied research.
- 16.- This unit 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.

For more information see **AEL-TI-03** catalogue. Click on the following link:

www.edibon.com/en/files/equipment/AEL-TI-03/catalog



AEL-TI-03

Applications:

AEL-5.2
Distribution and Transmission Trainers

Distribution and Transmission Trainers

AEL-TI-04. Underground Transmission lines.

Power is usually transmitted through overhead power lines. Underground power transmission has a significantly higher cost and greater operational limitations but is sometimes used in urban areas or sensitive locations.

Underground cables take up less than overhead lines, have lower visibility, and are less affected by bad weather. However, costs of insulated cable and excavation are much higher than overhead construction. Faults in buried transmission lines take longer to locate and repair. Underground lines are strictly limited by their thermal capacity, which permits fewer overloads than overhead lines. Long underground AC cables have significant capacitance, which may reduce their ability to provide useful power to loads located to long distances.

This trainer has been developed as a complement to AEL-TI-01 in order to study the underground transmission lines' characteristics. The student will learn about their critical length, capacity, characteristic impedance, compare overheads an underground power lines, how they are connected and how different loads affect in these systems.

Required Basic equipment:

- AEL-TI-01. Analysis of Three-phase Power Lines.

The AEL-TI-04 includes the following modules:

- N-TRANS03. Three-Phase Autotransformer Module.
- N-UTL. Underground Transmission Line module.
- N-EALD. Network Analyzer Unit with Computer Data Acquisition.

Optional SCADA software:

- PSV-SCADA. Power Systems SCADA Viewer.

Expansion learning software:

In addition, Edibon provides expansion learning software (AEL-TI-04/ICAI) to reinforce knowledge about this field. This software is formed by:

- ECM-SOF. EDIBON Classroom Manager (Instructor Software).
- ESL-SOF. EDIBON Student Labsoft (Student Software).

The application AEL-TI-04 can be mounted on rack (option A) or on rail (option B):

Option A:

This application needs the following racks:

- 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.

Optionally this unit is supplied with the Power Systems SCADA Viewer (PSV-SCADA), and includes: The unit itself + Computer Control, Data Acquisition and Data Management Software Packages, for controlling the process and all parameters involved in the process.

Some practical exercises possibilities of basic equipment (AEL-TI-01):

- 1.- Checking the variable power supply.
- 2.- Study of voltage increases on transmission lines without load.
- 3.- Study of voltage drop in transmission lines with different length.
- 4.- Study of voltage drop in transmission lines with different power factors.
- 5.- Reactive power losses in transmission lines as a function of U and I.
- 6.- Study of phase shift on transmission lines.
- 7.- Resistive, inductive and resistive-inductive mixed loads.
- 8.- Power factors Compensation for a resistive-inductive load.

Some practical exercises possibilities with the specific modules of AEL-TI-04:

- 9.- Study of the capacity's cable.
- 10.- Calculation of critical length in cables.
- 11.- Determining characteristic impedance.
- 12.- Symmetric and asymmetric shorts.
- 13.- Dealing with star points and shorts to earth.
- 14.- Study of the differences between underground and overhead power lines.
- 15.- Losses each part of power system.

Other possibilities to be done with this Unit:

- 16.- Many students view results simultaneously. To view all results in real time in the classroom by means of a projector or an electronic whiteboard.
- 17.- The Computer Control System with PSV-SCADA allows a real industrial simulation.
- 18.- This unit is totally safe as uses mechanical, electrical and electronic, and software safety devices.
- 19.- This unit can be used for doing applied research.
- 20.- This unit 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.

For more information see **AEL-TI-04** catalogue. Click on the following link:

www.edibon.com/en/files/equipment/AEL-TI-04/catalog



AEL-TI-04

Applications:

AEL-5.2
Distribution and Transmission Trainers

Distribution and Transmission Trainers

AEL-TI-05. Parallel and Series Transmission Lines.

The power distribution is dependent of the lines impedance. The distribution may be rather inefficient, if impedances are extremely different.

This trainer has been developed as a complement to AEL-TI-01 in order to study the consequences to operate with series and parallel transmission lines (real power system). The student will understand the main concepts of Transport Lines, working in series and parallel configurations. In order to study the concepts mentioned above, a second transmission line is included. In this way, the student can connect the transmission lines in parallel or series and he can see the consequences in the power distribution through the network analyzers.

Required Basic equipment:

- AEL-TI-01. Analysis of Three-phase Power Lines.

The AEL-TI-05 includes the following modules:

- N-AE1/1K. 1KVA Transmission Line Simulator Module.

Optional SCADA software:

- PSV-SCADA. Power Systems SCADA Viewer.

Expansion learning software:

In addition, Edibon provides expansion learning software (AEL-TI-05/ICAI) to reinforce knowledge about this field. This software is formed by:

- ECM-SOF. EDIBON Classroom Manager (Instructor Software).
- ESL-SOF. EDIBON Student Labsoft (Student Software).

The application AEL-TI-05 can be mounted on rack (option A) or on rail (option B):

Option A:

This application need the following rack:

- N-RACK-B.

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.

Optionally this unit is supplied with the Power Systems SCADA Viewer (PSV-SCADA), and includes: The unit itself + Computer Control, Data Acquisition and Data Management Software Packages, for controlling the process and all parameters involved in the process.

Some practical exercises possibilities of basic equipment (AEL-TI-01):

- 1.- Checking the variable power supply.
- 2.- Study of voltage increases on transmission lines without load.
- 3.- Study of voltage drop in transmission lines with different length.
- 4.- Study of voltage drop in transmission lines with different power factors.
- 5.- Reactive power losses in transmission lines as a function of U and I.
- 6.- Study of phase shift on transmission lines.
- 7.- Resistive, inductive and resistive-inductive mixed loads.
- 8.- Power factors Compensation for a resistive-inductive load.

Some practical exercises possibilities with the specific modules of AEL-TI-05:

- 9.- Measurement of the most important electrical parameters with parallel lines of equal length.
- 10.- Measurement of the most important electrical parameters with parallel lines of unequal length.
- 11.- Measurement of the most important electrical parameters with series lines of equal length.
- 12.- Measurement of the most important electrical parameters with series lines of unequal length.

Other possibilities to be done with this Unit:

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

For more information see **AEL-TI-05** catalogue.

Click on the following link:

www.edibon.com/en/files/equipment/AEL-TI-05/catalog



AEL-TI-05

Applications:

AEL-5.2
Distribution and Transmission Trainers

Distribution and Transmission Trainers

AEL-TI-06. Analysis of Power Flow in Transmission Lines.

The AEL-TI-06 has been designed to demonstrate that the distribution may be rather inefficient, if the impedances of power transmission lines are extremely different.

This trainer has been developed as a complement to AEL-TI-01 in order to study how the troubles caused by parallel lines can be corrected. This is possible thanks to a Phase-Shifting-Transformer included in this trainer. The student will understand the main concepts of Transport Lines, working in series and parallel configurations.

In order to study the concepts mentioned above, this application includes two transmission line simulator modules, network analyzers and resistive, inductive and capacitive loads.

Required Basic equipment:

- AEL-TI-01. Analysis of Three-phase Power Lines.

The AEL-TI-06 includes the following modules:

- N-AE1/1K. 1KVA Transmission Line Simulator Module.
- N-PST/1K. 1kVA Phase Shifting Transformer.
- N-EALD. Network Analyzer Unit with Computer Data Acquisition.

Optional SCADA software:

- PSV-SCADA. Power Systems SCADA Viewer.

Expansion learning software:

In addition, Edibon provides expansion learning software (AEL-TI-06/ICAI) to reinforce knowledge about this field. This software is formed by:

- ECM-SOF. EDIBON Classroom Manager (Instructor Software).
- ESL-SOF. EDIBON Student Labssoft (Student Software).

The application AEL-TI-06 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.

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.

Optionally this unit is supplied with the Power Systems SCADA Viewer (PSV-SCADA), and includes: The unit itself + Computer Control, Data Acquisition and Data Management Software Packages, for controlling the process and all parameters involved in the process.

Some practical exercises possibilities of basic equipment (AEL-TI-01):

- 1.- Checking the variable power supply.
- 2.- Study of voltage increases on transmission lines without load.
- 3.- Study of voltage drop in transmission lines with different length.
- 4.- Study of voltage drop in transmission lines with different power factors.
- 5.- Reactive power losses in transmission lines as a function of U and I.
- 6.- Study of phase shift on transmission lines.
- 7.- Resistive, inductive and resistive-inductive mixed loads.
- 8.- Power factors Compensation for a resistive-inductive load.

Some practical exercises possibilities with the specific modules of AEL-TI-06:

- 9.- Measurement of the most important electrical parameters with parallel lines of equal length.
- 10.- Measurement of the most important electrical parameters with parallel lines of unequal length.
- 11.- Measurement of the most important electrical parameters with series lines of equal length.
- 12.- Measurement of the most important electrical parameters with series lines of unequal length.
- 13.- Study of control voltage in phase with main winding voltage.
- 14.- Study of control voltage perpendicular to main winding voltage.
- 15.- Study of control voltage out of phase with main winding voltage.

Other possibilities to be done with this Unit:

- 16.- Many students view results simultaneously.
To view all results in real time in the classroom by means of a projector or an electronic whiteboard.
 - 17.- The Computer Control System with PSV-SCADA allows a real industrial simulation.
 - 18.- This unit is totally safe as uses mechanical, electrical and electronic, and software safety devices.
 - 19.- This unit can be used for doing applied research.
 - 20.- This unit 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.

For more information see **AEL-TI-06** catalogue. Click on the following link:

www.edibon.com/en/files/equipment/AEL-TI-06/catalog



AEL-TI-06

Applications:

AEL-5.2
Distribution and Transmission Trainers

Distribution and Transmission Trainers

AEL-TI-07. Transmission Systems with Synchronous Generators.

An electrical grid is an interconnected network for delivering electricity from suppliers to consumers. It consists of generating stations that produce electrical power, high-voltage transmission lines that carry power from distant sources to demand centers, and distribution lines that connect individual customers.

The AEL-TI-07 is designed to train the students in the different operations performed in actual electrical grids, such as parallel operations of a generator and line via the network, control of reactive and active power, control of energy production, synchronization operations, etc.

With this trainer, the students will learn about all process of the grid: Generation, transmission and consumption. Moreover, the generator performance can be studied in depth changing the demanded energy from the loads. The generator is driven through a servomotor with which the user will be able to control the speed of the machine.

In addition, it is included a voltage controller to control the current excitation of synchronous generator.

Required Basic equipment:

- AEL-TI-01. Analysis of Three-phase Power Lines.

The AEL-TI-07 includes the following modules:

- N-AVR/P. Automatic Voltage Regulator.
- N-ASYB. Basic Synchronization Module.
- N-SERV1K. 1 kW Servomotor Module.
- EMT6B/1K. 1 kVA three-phase Synchronous generator.

Optional module:

Optionally, the students can carry out advanced

operations of synchronization and control of the generator-motor group including in the basic option the following module:

- N-ERP-PGC-01. Generator Protection and Control Relay Unit.

Optional SCADA software:

- PSV-SCADA. Power Systems SCADA Viewer.

Expansion learning software:

In addition, Edibon provides expansion learning software (AEL-TI-07/ICAI) to reinforce knowledge about this field. This software is formed by:

- ECM-SOF. EDIBON Classroom Manager (Instructor Software).
- ESL-SOF. EDIBON Student Labsoft (Student Software).

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-B (4 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.

Optionally this unit is supplied with the Power Systems SCADA Viewer (PSV-SCADA), and includes: The unit itself + Computer Control, Data Acquisition and Data Management Software Packages, for controlling the process and all parameters involved in the process.



AEL-TI-07

Applications:

AEL-5.2
Distribution and Transmission Trainers

Distribution and Transmission Trainers

AEL-TI-07. Transmission Systems with Synchronous Generators. (Continuation).

Some practical exercises possibilities of basic equipment (AEL-TI-01):

- 1.- Checking the variable power supply.
- 2.- Study of voltage increases on transmission lines without load.
- 3.- Study of voltage drop in transmission lines with different length.
- 4.- Study of voltage drop in transmission lines with different power factors.
- 5.- Reactive power losses in transmission lines as a function of U and I.
- 6.- Study of phase shift on transmission lines.
- 7.- Resistive, inductive and resistive-inductive mixed loads.
- 8.- Power factors Compensation for a resistive-inductive load.

Some practical exercises possibilities with the specific modules of AEL-TI-07:

- 9.- Power distribution in a line network fed by a generator.
- 10.- Parallel operation of a generator and line via the network.
- 11.- Control of active power feed.
- 12.- Control of reactive power feed.
- 13.- Manual synchronization operations.
- 14.- Manual speed control of synchronous generator.
- 15.- Manual current excitation of synchronous generator.

Additional practical exercises possibilities with the optional module "N-ERP-PGC-01":

This module allows the students to make operations carried out in the large electrical generators:

- 16.- Island grid operations.
- 17.- Parallel grid operations.
- 18.- Manual voltage regulation operations.
- 19.- Manual frequency regulation operations.
- 20.- Transference of manual to automatic voltage regulation operations.
- 21.- Transference of manual to automatic frequency regulation operations.
- 22.- Studying of the power factor regulation of synchronous generator in parallel grid operation.
- 23.- Studying of turbine regulation (frequency control) in island mode.
- 24.- Studying of turbine regulation (frequency control) in parallel grid mode.
- 25.- Studying of excitation/voltage regulation in island mode.

26.- Studying of excitation/voltage regulation in parallel grid mode.

27.- Analysis of active and reactive power.

28.- Automatic control of active power.

29.- Automatic control of reactive power.

30.- Studying of the micro-grids.

31.- Setting of Overcurrent protection.

32.- Setting of Overvoltage and undervoltage protection of the synchronous generator.

33.- Setting of Reverser power protection.

Other possibilities to be done with this Unit:

34.- Many students view results simultaneously.

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

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

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

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

38.- This unit 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.

For more information see **AEL-TI-07** catalogue.

Click on the following link:

www.edibon.com/en/files/equipment/AEL-TI-07/catalog



AEL-TI-07

Applications:

AEL-5.2

Distribution and Transmission Trainers**Distribution and Transmission Trainers****AEL-SST-01. Basic Operations in Switching Transmission Substation Trainer.**

An electric power distribution system is the final stage in the delivery of electric power; it carries electricity from the transmission system to individual consumers. A switching substation is a substation without transformers and operating only at a single voltage level. Switching substations are sometimes used as collector and distribution stations. Sometimes they are used for switching the current to back-up lines or for parallelizing circuits in case of failure.

The AEL-SST-01 Switching Substation Trainer has been designed by Edibon to study the operations which can be carried out in this kind of substations.

This trainer shows several procedures in switching substations. The students will be able to realize the busbar changeover without interruption of the branch and they will do algorithms for various switching operations.

The AEL-SST-01 Basic Operations in Switching Transmission Substation Trainer includes the following modules:

- N-VPS01. AC 3PH Variable Power Supply.
- N-EALD. Network Analyzer Unit with Computer Data Acquisition.
- N-BUS08. Distribution Busbar Module (4 units)
- N-BUS09. Coupling Busbar Module.
- N-REVT/1K. 1kW Three-Phase Resistors Module.
- N-INDT/1K. 1 kVA T h r e e - P h a s e inductances module.
- N-CON02. 3-Pole Contactor.
- N-REL09. Time Electronic Relay against Overcurrents (1.2 - 7 A).

Optional modules:

- N-AE1/1K. 1KVA Transmission Line Simulator Module
- EMT7B/1K. 1 kVA t h r e e - p h a s e Asynchronous motor of squirrel cage.

Optional SCADA software:

- PSV-SCADA. Power Systems SCADA Viewer.

Expansion learning software:

In addition, Edibon provides expansion learning software (AEL-SST-01/ICAI) to reinforce knowledge about this field. This software is formed by:

- ECM-SOF. EDIBON Classroom Manager (Instructor Software).
- ESL-SOF. EDIBON Student Labsoft (Student Software).

The application AEL-SST 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 (3 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.

Optionally this unit is supplied with the Power Systems SCADA Viewer (PSV-SCADA), and includes: The unit itself + Power Systems SCADA Viewer, for controlling the process and all parameters involved in the process.

Some practical exercises possibilities with AEL-SST-01:

- 1.- Basic wiring with double busbar.
- 2.- Analyzing of double busbar connected to load.
- 3.- Busbar changeover without interruption
- 4.- Busbar operations with circuit breakers and disconnectors.

Some practical exercises possibilities with optional modules:

- 5.- Busbar coupling
- 6.- Voltage increases on open-circuit lines.
- 7.- Voltage drop as a function of line length.
- 8.- Voltage drop as a function of $\cos\phi$.
- 9.- Capacitive and inductive power losses on a line as a function of U and I.
- 10.- Remote control operations in switching substations (with PSV-SCADA).
- 11.- Remote electrical measurements in several points of switching substation (with PSV-SCADA).

Other possibilities to be done with this Unit:

- 12.- Many students view results simultaneously. To view all results in real time in the classroom by means of a projector or an electronic whiteboard.
 - 13.- The Computer Control System with PSV-SCADA allows a real industrial simulation.
 - 14.- This unit is totally safe as uses mechanical, electrical and electronic, and software safety devices.
 - 15.- This unit can be used for doing applied research.
 - 16.- This unit 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.

For more information see **AEL-SST-01** catalogue.

Click on the following link:

www.edibon.com/en/files/equipment/AEL-SST-01/catalog



AEL-SST-01

Applications:

AEL-5.2
Distribution and Transmission Trainers

Distribution and Transmission Trainers

AEL-SST-02. Switching Substation Protection Trainer.

The AEL-SST-02 Switching Substation Protection Trainer has been designed as complement to AEL-SST-01 in order to study the performance of the protection relays most used on these types of electrical substations.

This trainer consists of a series of modules, which allow carrying out three-phase, two-phase and single-phase short circuits to analyze the performance of the time overcurrent protection relay. Besides, the AEL-SST-02 allows to study the response of this relay against these short circuits and the configuration procedure to achieve an optimum behavior and a properly selectivity.

In addition, the AEL-SST-02 has a transmission line optional module that allows studying the interconnection maneuvers between the transmission lines and switching substations.

Required Basic equipment:

- AEL-SST-01. Basic Operations in Switching Transmission Substation Trainer

The AEL-SST-02 includes the following modules:

- N-TOPR. Time Overcurrent Protection Relay.
- N-BCT. Balancing Transformer Module.
- N-PSM. Power Switch Module.

Optional module:

- N-AE1/1K. 1KVA Transmission Line Simulator Module.

Optional SCADA software:

- PSV-SCADA. Power Systems SCADA Viewer.

Expansion learning software:

In addition, Edibon provides expansion learning software (AEL-SST-02/ICAI) to reinforce knowledge about this field. This software is formed by:

- ECM-SOF. EDIBON Classroom Manager (Instructor Software).
- ESL-SOF. EDIBON Student Labsoft (Student Software).

The application AEL-SST-02 can be mounted on rack (option A) or on rail (option B):

Option A:

This application needs the following racks:

- N-RACK-B (3 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.

Optionally this unit is supplied with the Power Systems SCADA Viewer (PSV-SCADA), and includes: The unit itself + Power Systems SCADA Viewer, for controlling the process and all parameters involved in the process.

Some practical exercises possibilities with AEL-SST-01:

- 1.- Basic wiring with double busbar.
- 2.- Analyzing of double busbar connected to load.
- 3.- Busbar changeover without interruption
- 4.- Busbar operations with circuit breakers and disconnectors.

Some practical exercises possibilities with optional modules:

- 5.- Busbar coupling.
- 6.- Voltage increases on open-circuit lines.
- 7.- Voltage drop as a function of line length.
- 8.- Voltage drop as a function of $\cos\phi$.
- 9.- Capacitive and inductive power losses on a line as a function of U and I.
- 10.- Remote control operations in switching substations (with PSV-SCADA).
- 11.- Remote electrical measurements in several points of switching substation (with PSV-SCADA).

Additional practical exercises possibilities with AEL-SST-02:

- 12.- Phase shift on a line.
 - 13.- Setting of the overcurrent relay.
 - 14.- Double-pole short circuit.
 - 15.- Single-pole short circuit.
 - 16.- Triple-pole short circuit.
- Other possibilities to be done with this Unit:
- 17.- Many students view results simultaneously.
To view all results in real time in the classroom by means of a projector or an electronic whiteboard.
 - 18.- The Computer Control System with PSV-SCADA allows a real industrial simulation.
 - 19.- This unit is totally safe as uses mechanical, electrical and electronic, and software safety devices.
 - 20.- This unit can be used for doing applied research.
 - 21.- This unit 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.

For more information see **AEL-SST-02** catalogue. Click on the following link:

www.edibon.com/en/files/equipment/AEL-SST-02/catalog



AEL-SST-02

Applications:

AEL-5.2
Distribution and Transmission Trainers

Distribution and Transmission Trainers

AEL-HVDC. High Voltage DC Transmission Lines.

The AEL-HVDC trainer has been designed to study the most important concepts and advantages of High Voltage DC Transmission Lines. The advantages of DC transmission lines versus AC transmission lines is the ability to transfer large amount of power on long distances with lower losses.

DC technology is better in situations such as undersea connections, power transmission and stabilization between unsynchronized AC distribution systems, remote connection of generating plants from power grid – stabilization of AC grid, connection between countries with different current frequency/voltage.

The AEL-HVDC includes the following modules:

- N-VPS01. AC 3PH Variable Power Supply.
- N-AE1/1K. 1KVA Transmission Line Simulator Module
- N-DCTL1. Outgoins DC Transmission Line.
- N-DCTL2. Ingoins DC Transmission Line.
- N-REVT/1K. 1kW Three-Phase Resistors Module.

Optional module:

- N-FRT. Fault Ride Through Module.

Optional SCADA software:

- AEL-HVDC/CCSOF.Computer Control + Data Acquisition + Data Management Software.

Expansion learning software:

In addition, Edibon provides expansion learning software (AEL-HVDC/ICAI) to reinforce knowledge about this field. This software is formed by:

- ECM-SOF. EDIBON Classroom Manager (Instructor Software).
- ESL-SOF. EDIBON Student Labsoft (Student Software).

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

Option A:

This application needs the following racks:

- N-RACK-B. (3 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.

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

Some practical exercises possibilities:

- 1.- Study of power losses in DC Transmission Lines according to different length lines.
- 2.- Advantages of High Voltage DC Transmission Lines.
- 3.- Relation between length of line and costs in AC and DC lines.
- 4.- Measurement of every losses with different load consumption.

Other possibilities to be done with this Unit:

- 5.- Many students view results simultaneously.

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

- 6.- 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.

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

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

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

- 10.- This unit 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.

For more information see **AEL-HVDC** catalogue.

Click on the following link:

www.edibon.com/en/files/equipment/AEL-HVDC/catalog



AEL-HVDC

Applications:

AEL-5.3
Loads Trainers

Basic Load Controller Trainers

AEL-MRPC. Manual Reactive Power Compensation.

Reactive Power can be described as the quantity of "unused" power that is developed by reactive components, such as inductors or capacitors in an AC circuit or system. The power factor (PF) is defined as the ratio between the active power in watts and the apparent power in volt-amperes and indicates how effectively electrical power is being used.

In the power supply points of the electrical distribution grids to which big industries are connected, there are important reactive energy consumptions that could overload the distribution lines as well as the utilities' transformers. In order to solve this problem, there are power factor compensators installed in the industries.

The Manual Reactive Power Compensation AEL-MRPC is an application designed to study the reactive power effects in AC circuits due to the reactive loads.

The AEL-MRPC includes all type of static loads (resistive, inductive and capacitive) to show how they can be connected and study the power factor compensation. With this purpose, the AEL-MRPC includes variable loads to change how much resistance, inductance and capacitance can be used. Moreover, it is included a network analyzer which allows analyzing the first and second power maxima and studying the maximum power in the event of asymmetric load.

The AEL-MRPC requires the following modules:

- N-ALI01. Industrial Main Power Supply.
- N-REVT/1K. 1kW Three-Phase Resistors Module.
- N-CONT/1K. 1 kVA Three-Phase Capacitors Module.
- N-INDT/1K. 1 kVA Three-Phase inductances module.
- N-EALD. Network Analyzer Unit with Computer Data Acquisition.
- N-PSM. Power Switch Module.
- N-CON02. 3-Pole Contactor.
- N-REL09. Time Electronic Relay against Overcurrents (1.2 - 7 A).

Optional SCADA software:

- AEL-MRPC/CCSOF. Computer Control + Data Acquisition + Data Management Software.

Expansion learning software:

In addition, Edibon provides expansion learning software (AEL-MRPC/ICAI) to reinforce knowledge about this field. This software is formed by:

- ECM-SOF. EDIBON Classroom Manager (Instructor Software).
- ESL-SOF. EDIBON Student Labsoft (Student Software).

Recommended complementary applications :

- AEL-ARPC. Automatic Reactive Power Compensation.
- AEL-EFCFP. Advanced Power Factor Compensation

The application AEL-MRPC 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 (3 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.

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

Some practical exercises possibilities:

- 1.- Wiring star and delta connection with resistive, capacitive and inductive load.
- 2.- Calculating of necessary capacitive load in order to carry out the adequate power factor correction.
- 3.- Studying different classes of reactive compensation methods: general compensation, local compensation, etc.
- 4.- Measurement of active power consumed by a receiver (resistive circuit).
- 5.- Measurement of the inductance of a coil.
- 6.- Measurement of the reactance XL considering RL.
- 7.- Measurement of reactive power consumed by a receiver (inductive circuit).
- 8.- Measurement of reactive power consumed by a receiver (capacitive circuit).
- 9.- Measurement of apparent power consumed by a receiver.
- 10.- Measurement of power factor of a receiver.
- 11.- Measurement of active energy consumed by a receiver.
- 12.- Measurement of reactive energy consumed by a receiver.
- 13.- Compensation of reactive energy (improvement of the power factor).
- 14.- Comparison of the active energy consumed after the compensation.
- 15.- Comparison of the reactive energy consumed after the compensation.
- 16.- Measurement of power factor after the compensation.
- 17.- Determination of the first and second power maxima.
- 18.- Determination of the power maximum in the event of an asymmetric load.

Some Practical exercises possibilities with SCADA:

- 19.- Recording of load profiles.
- 20.- Real Time electrical parameters visualization.
- 21.- Remote active power display.
- 22.- Remote reactive power display.
- 23.- Monitoring of energy waves and data logging.

Other possibilities to be done with this Unit:

- 24.- Many students view results simultaneously.

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

- 25.- The Computer Control System with SCADA allows a real industrial simulation.
- 26.- This unit is totally safe as uses mechanical, electrical and electronic, and software safety devices.
- 27.- This unit can be used for doing applied research.
- 28.- This unit 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.

For more information see **AEL-MRPC** catalogue.

Click on the following link:

www.edibon.com/en/files/equipment/AEL-MRPC/catalog



AEL-MRPC

Applications:

AEL-5.3
Loads Trainers

Basic Load Controller Trainers

AEL-ARPC. Automatic Reactive Power Compensation.

The AEL-ARPC Automatic Reactive Power Compensation application has been developed as a complement to "AEL-MRPC. Manual Reactive Power Compensation" in order to study how the installations compensate the reactive power automatically.

The AEL-ARPC includes an advanced power factor controller module. This module measures the voltage and current values of the grid and calculates the power factor. Such module enables the connection of six stages of capacitors, which enable the regulation of the power factor according to the set value.

Required Basic equipment:

- AEL-MRPC. Manual Reactive Power Compensation.

The AEL-ARPC requires the following modules:

- N-CFP. Advanced Power Factor Controller Module.
- N-CAR19T4D. Three-Phase Digital Capacitor Banks Module.

Optional SCADA software:

- AEL-ARPC/CCSOF. Computer Control + Data Acquisition + Data Management Software..

Expansion learning software:

In addition, Edibon provides expansion learning software (AEL-ARPC/ICAI) to reinforce knowledge about this field. This software is formed by:

- ECM-SOF. EDIBON Classroom Manager (Instructor Software).
- ESL-SOF. EDIBON Student Labsoft (Student Software).

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

Option A:

This application need the following rack:

- N-RACK-B.

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.

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

Some practical exercises possibilities of basic equipment (AEL-MRPC):

- 1.- Wiring star and delta connection with resistive, capacitive and inductive load.
- 2.- Calculating of necessary capacitive load in order to carry out the adequate power factor correction.
- 3.- Studying different classes of reactive compensation methods: general compensation, local compensation, etc.
- 4.- Measurement of active power consumed by a receiver (resistive circuit).
- 5.- Measurement of the inductance of a coil.
- 6.- Measurement of the reactance XL considering RL.

- 7.- Measurement of reactive power consumed by a receiver (inductive circuit).
 - 8.- Measurement of reactive power consumed by a receiver (capacitive circuit).
 - 9.- Measurement of apparent power consumed by a receiver.
 - 10.- Measurement of power factor of a receiver.
 - 11.- Measurement of active energy consumed by a receiver.
 - 12.- Measurement of reactive energy consumed by a receiver.
 - 13.- Compensation of reactive energy (improvement of the power factor).
 - 14.- Comparison of the active energy consumed after the compensation.
 - 15.- Comparison of the reactive energy consumed after the compensation.
 - 16.- Measurement of power factor after the compensation.
 - 17.- Determination of the first and second power maxima.
 - 18.- Determination of the power maximum in the event of an asymmetric load.
- Some Practical exercises possibilities with SCADA:
- 19.- Recording of load profiles.
 - 20.- Real Time electrical parameters visualization.
 - 21.- Remote active power display.
 - 22.- Remote reactive power display.
 - 23.- Monitoring of energy waves and data logging.
- Some practical exercises possibilities with the specific modules of AEL-ARPC:
- 24.- Automatic compensation of reactive energy (improvement of the power factor).
 - 25.- Comparison of the active energy consumed after the automatic compensation.
 - 26.- Comparison of the reactive energy consumed after the automatic compensation.
 - 27.- Measurement of power factor after the automatic compensation.
 - 28.- Results comparison between manual and automatic compensation.
 - 29.- Setting of the automatic power factor controller.

Other possibilities to be done with this Unit:

- 30.- Many students view results simultaneously.
To view all results in real time in the classroom by means of a projector or an electronic whiteboard.
- 31.- The Computer Control System with SCADA allows a real industrial simulation.
- 32.- This unit is totally safe as uses mechanical, electrical and electronic, and software safety devices.
- 33.- This unit can be used for doing applied research.
- 34.- This unit 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.

For more information see **AEL-ARPC** catalogue. Click on the following link:

www.edibon.com/en/files/equipment/AEL-ARPC/catalog



AEL-ARPC

Applications:

AEL-5.3
Loads Trainers

Basic Load Controller Trainers

AEL-EECFP. Advanced Power Factor Controller.

Industrial customers use three-phase power consumption with different power factors. If their power factor drops below a prescribed value, power losses in transmission lines increase. For this reason, the customers have to pay a penalty. In order to avoid these troubles, industrial customer installs power factor correction capacitors.

The AEL-EECFP Advanced Power Factor Controller has been developed as a complement to AEL-MRPC in order to study in depth the power factor compensation when there is a dynamic load.

The three-phase induction motor is the most used motor in the industry. For this reason, a group servomotor and induction motor is included in this application. With this group, the user can cause different motor load conditions modifying the power factor.

Power factor compensation (when the induction motor is working) is necessary to avoid excess reactive energy. For this purpose the user can realize it manually through the three-phase capacitors module or automatically with advanced power factor controller module together three-phase digital capacitor banks module. The first module measures the voltage and current values of the grid and calculates the power factor. Such module enables the connection of six stages of capacitors, which enable the regulation of the power factor according to the desired value.

Required Basic equipment:

- AEL-MRPC. Manual Reactive Power Compensation.

The AEL-EECFP requires the following modules:

- EMT7B/1K. 1 kVA three-phase Asynchronous motor of squirrel cage.

- N-SERV1K. 1 kW Servomotor Module.
- N-ARR01. Manual Star-Delta Starter.
- N-TRANS03. Three-phase Autotransformer.
- N-CFP. Advanced power factor controller module.
- N-MPS. Motor Protection.
- N-CAR19T4D. Three-Phase Digital Capacitor Banks Module.

Optional SCADA software:

- AEL-EECFP/CCSOF. Computer Control + Data Acquisition + Data Management Software.

Expansion learning software:

In addition, Edibon provides expansion learning software (AEL-EECFP/ICAI) to reinforce knowledge about this field. This software is formed by:

- ECM-SOF. EDIBON Classroom Manager (Instructor Software).
- ESL-SOF. EDIBON Student Labsoft (Student Software).

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

Option A:

This application needs the following racks.

- N-RACK-B. (3 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.

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



AEL-EECFP

Applications:

AEL-5.3
Loads Trainers

Basic Load Controller Trainers

AEL-EFCFP. Advanced Power Factor Controller. (Continuation).

Some practical exercises possibilities of basic equipment (AEL-MRPC):

- 1.-Wiring star and delta connection with resistive, capacitive and inductive load.
- 2.-Calculating of necessary capacitive load in order to carry out the adequate power factor correction.
- 3.-Studying different classes of reactive compensation methods: general compensation, local compensation, etc.
- 4.-Measurement of active power consumed by a receiver (resistive circuit).
- 5.-Measurement of the inductance of a coil.
- 6.-Measurement of the reactance XL considering RL.
- 7.-Measurement of reactive power consumed by a receiver (inductive circuit).
- 8.-Measurement of reactive power consumed by a receiver (capacitive circuit).
- 9.-Measurement of apparent power consumed by a receiver.
- 10.- Measurement of power factor of a receiver.
- 11.- Measurement of active energy consumed by a receiver.
- 12.- Measurement of reactive energy consumed by a receiver.
- 13.- Compensation of reactive energy (improvement of the power factor).
- 14.- Comparison of the active energy consumed after the compensation.
- 15.- Comparison of the reactive energy consumed after the compensation.
- 16.- Measurement of power factor after the compensation.
- 17.- Determination of the first and second power maxima.
- 18.- Determination of the power maximum in the event of an asymmetric load.

Some practical exercises possibilities with the specific modules of AEL-EFCFP:

- 19.- Measuring the maximum and minimum reactive power levels of the grid.
- 20.- Studying the manual reactive power compensation for dynamic loads: induction motor coupled to servomotor.
- 21.- Measuring the reactive power consumed by a capacitive receptor.
- 22.- Comparison of the reactive energy before and after of manual power factor compensation.

- 23.-Optimum configuration of the reactive power controller.
- 24.-Checking the compensation control unit applying different reactive power levels.
- 25.- Automatic compensation of reactive energy (improvement of the power factor).
- 26.- Comparison of the active energy consumed after the automatic compensation.
- 27.- Comparison of the reactive energy consumed after the automatic compensation.
- 28.- Measurement of power factor after the automatic compensation.
- 29.- Results comparison between manual and automatic compensation.

Some Practical exercises possibilities with SCADA:

- 30.- Recording of load profiles.
- 31.- Real Time electrical parameters visualization.
- 32.- Remote active power display.
- 33.- Remote reactive power display.
- 34.- Monitoring of energy waves and data logging.

Other possibilities to be done with this Unit:

- 35.- Many students view results simultaneously.
To view all results in real time in the classroom by means of a projector or an electronic whiteboard.
- 36.- The Computer Control System with SCADA allows a real industrial simulation.
- 37.- This unit is totally safe as uses mechanical, electrical and electronic, and software safety devices.
- 38.- This unit can be used for doing applied research.
- 39.- This unit 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.

For more information see **AEL-EFCFP** catalogue.

Click on the following link:

www.edibon.com/en/files/equipment/AEL-EFCFP/catalog



AEL-EFCFP

Applications:

AEL-5.3
Loads Trainers

Basic Load Controller Trainers

AEL-APFC. Single-phase Automatic Power Factor Compensation.

The AEL-APFC Single-phase Automatic Power Factor Compensation is an application designed to study the single phase automatic power factor controllers installed in the energy utilization points. In some places where the reactive energy consumption is high, distribution lines may be overload and it is necessary to install power factor compensators.

The AEL-APFC consists of a single phase automatic power factor controller of six compensation steps that work together resistor and inductor loads.

The AEL-APFC includes the following modules:

- N-ALI02. Domestic Main Power Supply.
- N-CFPS. Single-phase Automatic Power Factor Controller.
- N-CAR19S4D. Single-Phase Digital Capacitor Banks Module.
- N-IND. Variable Inductive Load with commutator. (2 units)
- N - REF. Resistor Load with commutator.

Optional learning software:

In addition, Edibon provides optional software (AEL-APFC/ICAI) to reinforce knowledge about this field. This software is formed by:

- ECM-SOF. EDIBON Classroom Manager (Instructor Software).
- ESL-SOF. EDIBON Student Labssoft (Student Software).

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

Option A:

This application needs the following racks:

- 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.

Some practical exercises possibilities:

- 1.- Studying the reactive power compensation for static loads.
- 2.- Comparison of the reactive energy before and after of power factor compensation.
- 3.- Optimum configuration of the reactive power controller.
- 4.- Checking the compensation control unit applying different reactive power levels.
- 5.- Practical case in which the user carries out manually the reactive energy compensation.

For more information see **AEL-APFC** catalogue.

Click on the following link:

www.edibon.com/en/files/equipment/AEL-APFC/catalog



AEL-APFC

Applications:

AEL-5.3
Loads Trainers

Basic Load Controller Trainers

AEL-DLT. Dynamic Loads Trainer.

The power factor of induction motors varies with load, typically from around 0.85 or 0.90 at full load to as low as 0.12 without load, due to stator and rotor leakage and magnetizing reactance. Power factor can be improved by connecting capacitors either on an individual motor basis or, by preference, on a common bus covering several motors. For economic and other considerations, power systems are rarely power factor corrected to unity power factor.

The Dynamic Loads Trainer AEL-DLT is a complete application designed to study the behavior of the dynamic loads in the field of the electrical generation, the electrical transmission and loads.

The AEL-DLT includes all necessary to study the behavior of the AC circuit with a three-phase induction motor. In order to study in depth the motor power factor is included a servomotor. Moreover, the student will train the star-delta start.

The AEL-DLT requires the following modules:

- N-SERV1K. 1 kW Servomotor Module.
- N-ALI01. Industrial Main Power Supply.
- N-EALD. Network Analyzer Unit with Computer Data Acquisition.
- EMT7B/1K. 1kVA three-phase Asynchronous motor of squirrel cage.
- N-ALI03. AC Auxiliary Power Supply.
- N-ARR01. Manual Star-Delta Starter.
- N-TRANS03. Three-phase Autotransformer.
- N-MPS. Motor Protection.
- N-PSM. Power switch Module.

Optional SCADA software:

- AEL-DLT/CCSOF. Computer Control + Data Acquisition + Data Management Software.

Expansion learning software:

In addition, Edibon provides expansion learning software (AEL-DLT/ICAI) to reinforce knowledge about this field. This software is formed by:

- ECM-SOF. EDIBON Classroom Manager (Instructor Software).
- ESL-SOF. EDIBON Student Labsoft (Student Software).

Option A:

This application needs the following racks:

- N-RACK-M. (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.

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

Some practical exercises possibilities:

- 1.- Studying dynamic loads (three-phase induction motor).
- 2.- Power measurements depending on the braking load.
- 3.- Active power measurement depending on the braking conditions.
- 4.- Reactive power measurement according to the induction motor conditions.
- 5.- Reverse active power measurement and switch-off induction motor.

Some practical exercises possibilities with optional SCADA:

- 6.- Studying load curve of Star-Delta starter maneuver of three-phase induction motor.

Other possibilities to be done with this Unit:

- 7.- Many students view results simultaneously.

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

- 8.- The Computer Control System with SCADA allows a real industrial simulation.
- 9.- This unit is totally safe as uses mechanical, electrical and electronic, and software safety devices.
- 10.- This unit can be used for doing applied research.
- 11.- This unit 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.

For more information see **AEL-DLT** catalogue.

Click on the following link:

www.edibon.com/en/files/equipment/AEL-DLT/catalog



AEL-DLT

Applications:

AEL-5.3
Loads Trainers

Advanced Loads Control

AEL-FUSG. Final User Smart Grid Trainer.



A smart grid is an electrical grid that uses information and communications technology to gather and act on information about the behaviours of suppliers and consumers, in an automated fashion to improve the efficiency, reliability, economics, and sustain ability of the production and distribution of electricity.

Why using a Smart Grid?

Reliability, flexibility, efficiency, load adjustment, sustain ability and demand response are the main factors that allow a better control over the electrical energy parameters.

The AEL-FUSG. Final User Smart Grid Trainer, developed by EDIBON, reflects all these characteristics and will allow the user to carry out real appliances related to current Smart Grids.

Key features:

Managing real Smart Grid devices used by prestigious utilities.

Learning about what are the operations between the utilities and the final user.

Real time monitoring, remote management and verification of the network quality.

Bidirectional communication between the Utility (the student) and the Smart Meter.

The final customer can carry out an optimal consumption at home. Learning how to use an actual Home Energy Management System.

Scheduling switching schemes, visualizing and comparing the consumption with different loads.

Configuring virtual scenes with different sensors and actuators to achieve the optimal consumption and other possibilities to automate the consumption.

Remote controlling of smart devices from programming software.

Simulating electric heating and programming optimal consumption by scheduling of the temperature sensor.

Simulation of selling electricity to the grid.

Measuring the input and output power flows generated by the wind turbine (generator-motor group).

Network Analyzer Unit with oscilloscope display to perform an advanced Net Metering.

Possibility to use additional smart meters and optional accessories.

The AEL-FUSG Trainer consists of three main trainers and a set of static and dynamic loads.

The complete system consist of:

- a) AEL-FUSG-M. Final User Smart Grid - Smart Meter Trainer.
- b) AEL-FUSG-E. Final User Smart Grid - Smart Energy Trainer.
- c) AEL-FUSG-N. Final User Smart Grid - Net Metering Trainer.
- d) AEL-FUSG-LO. Smart Grid Loads.
- e) Optional accessories.

For more information see **AEL-FUSG** catalogue. Click on the following link:

www.edibon.com/en/files/equipment/AEL-FUSG/catalog

Applications:

AEL-5.3
Loads Trainers

Advanced Loads Control

AEL-FUSG-M. Final User Smart Grid-Smart Meter Trainer.

To understand how current utilities work in the Electrical Grids, EDIBON offers the Final User Smart Grid - Smart Meter Trainer (AEL-FUSG-M), a real Smart Grid System where the user can manage an actual Smart Meter.

AEL-FUSG-M is a trainer that reflects the real operation of current Smart Grids. The purpose of the AEL-FUSG-M is to make the user understand how utilities work in a real smart grid environment.

The complete system consists of:

- a) AEL-FUSG-M. Final User Smart Grid - Smart Meter Trainer.
 - b) Required accessories.
 - c) Optional accessories.
- a) AEL-FUSG-M. Final User Smart Grid - Smart Meter Trainer, consist of the following modules:
 - N-ALI01. Industrial Main Power Supply.
 - N-CTT. Data Concentrator Module.
 - N-SM. Smart Meter Module.
 - Configuration and control software (platform web).

- b) Required accessories:

In order to simulate different real consumptions and to carry out all the practical possibilities proposed, AEL-FUSG-M Trainer requires a set of static and dynamic loads.

The following loads must be acquired:

AEL-FUSG-LO. Smart Grid Loads, formed by:

- N-REV. Variable Resistor.
- N-LAM16. Halogen Lamp.
- N-IND. Variable Inductive Load with commutator.
- N-CAR19. Single-Phase Commutable Capacitor Load.
- N-LAM32. LED Lamp.
- N-WVCC/M. DC Motor Speed Controller.
- N-REF. Resistor Load with commutator. (4 units)
- EMT12. Universal Motor.
- FRECP. Eddy Current Brake.
- EH. Electric Heating Module.

- c) Optional accessories:

For AEL-FUSG-M. Final User Smart Grid-Smart Meter Trainer:

OSM. Additional Smart Meter with AEL-FUSG-LO. Smart Grid Loads.

For AEL-FUSG-LO. Smart Grid Loads:

AEL-APFC. Single-phase Automatic Power Factor Compensation.

For more information see **AEL-APFC** catalogue. Click on the following link:
www.edibon.com/es/files/equipment/AEL-APFC/catalog

Some practical exercises possibilities:

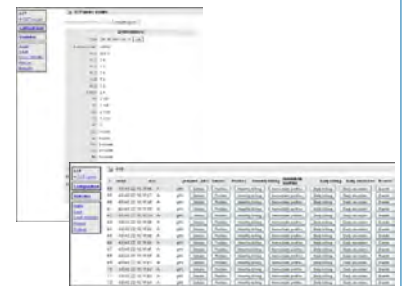
- 1.- Communication process with the data concentrator.
- 2.- Remote control of the smart meter relay.
- 3.- Real time monitoring of the energy consumed by the loads.
- 4.- Power factor comparison with different load combinations using the data concentrator web server.
- 5.- Comparison of the energy consumption from the utility point of view (with the platform integrated in the data concentrator) and from the final user point of view (using the smart meter display).
- 6.- Power factor correction using capacitor banks. The student can configure different loads and analyze the quality of energy in real time.
- 7.- Instantaneous measurement of the current, voltage, active power and power factor.

NOTE: All practical exercises can be done remotely, as actual utilities do with real Smart Grids.

For more information see **AEL-FUSG-M** catalogue.

Click on the following link:

www.edibon.com/en/files/equipment/AEL-FUSG-M/catalog



AEL-FUSG-M

Applications:

AEL-5.3
Loads Trainers

Advanced Loads Control

AEL-FUSG-E. Final User Smart Grid-Smart Energy Trainer.

The Final User Smart Grid - Smart Energy Trainer (AEL-FUSG-E) is a trainer that reflects the real operation of actual Home Energy Management Systems. The purpose of this trainer is to make the user understand how smart devices work in a smart home or industrial environment, controlling the most significant loads. Through the AEL-FUSG-E Trainer the user will manage the monitoring, programming of consumptions and visualization of the load profile through smart devices. A great characteristic is that all smart devices use ZigBee communication protocol (wireless communication).

The complete system consists of:

- a) AEL-FUSG-E. Final User Smart Grid - Smart Energy Trainer.
 - b) Required accessories.
 - c) Optional accessories.
- a) AEL-FUSG-E. Final User Smart Grid - Smart Energy Trainer, consist of the following modules:
 - N-HPM. Home Power Module.
 - N-WLSM. Wireless Light Sensor Module.
 - N-WSM. Wireless Switches Module.
 - N-IOWM. Wireless Outputs Module. (4 units)
 - N-CON02. 3-Pole Contactor. (4 units)
 - Control and programming software.

b) Required accessories:

In order to simulate different real consumptions and to carry out all the practical possibilities proposed AEL-FUSG-E trainer requires a set of static and dynamic loads.

The following loads must be acquired:

AEL-FUSG-LO. Smart Grid Loads, formed by:

- N-REV. Variable Resistor.
- N-LAM16. Halogen Lamp.
- N-IND. Variable Inductive Load with commutator.
- N-CAR19. Single-Phase Commutable Capacitor Load.
- N-LAM32. LED Lamp.
- N-WVCC/M. DC Motor Speed Controller.
- N-REF. Resistor Load with commutator. (4 units)
- EMT12. Universal Motor.
- FRECP. Eddy Current Brake.
- EH. Electric Heating Module.

c) Optional accessories:

For AEL-FUSG-E. Final User Smart Grid-Smart Energy Trainer:

It can be included a series of home automation modules to complete the knowledge about smart control systems:

The user can acquire three different modules:

- AEL-HP-EM. Home Emergency Module.
- AEL-HP-SE. Home Security Module.
- AEL-HE-EN. Home Energy Module.

For AEL-FUSG-LO. Smart Grid Loads:

- AEL-APFC. Single-phase Automatic Power Factor Compensation.

For more information see **AEL-APFC** catalogue. Click on the following link:

www.edibon.com/es/files/equipment/AEL-APFC/catalog

Some practical exercises possibilities:

- 1.- Studying the energy efficiency increase by using capacitor banks to compensate the reactive power of loads.
- 2.- Real time monitoring of local consumptions with induction, resistor or capacitive loads.
- 3.- Simulation of different consumptions and scheduling of the Home Energy Management System devices by the final customer.
- 4.- Study of the optimal load demand and programming the smart devices according to different programming schemes.
- 5.- Controlling and programming the loads maximum accumulated consumption.
- 6.- Programming the panel's inputs and outputs.
- 7.- Illumination control.
- 8.- Temperature control system.
- 9.- Programming the moment of the activating of an electrical motor.
- 10.- Remote scheduling of smart devices (Smart relays, thermostat, different sensors, etc.).
- 11.- Developing switching schemes for appliances connected to the smart relays or thermostat with the management platform.

Practical exercises of AEL-FUSG-E Trainer with AEL-FUSG-M Trainer:

- 12.- Measurement of energy consumption at home or by an industrial consumer and comparison of this measurement with the utility's register (smart meter).
- 13.- Simulation of different consuming periods and scheduling of the Home Energy Management System devices.
- 14.- Telemetering of the energy consumed by the loads using the data concentrator platform.

For more information see **AEL-FUSG-E** catalogue. Click on the following link:

www.edibon.com/en/files/equipment/AEL-FUSG-E/catalog



AEL-FUSG-E

Applications:

AEL-5.3
Loads Trainers

Advanced Loads Control

AEL-FUSG-N. Final User Smart Grid-Net Metering Trainer.

Through the Final User Smart Grid-Net Metering Trainer (AEL-FUSG-N) the user can simulate the sale or consumption of the generated energy. Thus, the user will learn different simulations, such as selling electricity to the grid, Net Metering and measuring the input and output power flows generated by the Renewable Energy simulators. The AEL-FUSG-N is a trainer that reflects actual operations about Net-Metering, auto-consumption and electricity selling.

The complete system consists of:

- a) AEL-FUSG-N. Final User Smart Grid - Net Metering Trainer.
- b) Required accessories.
- c) Optional accessories.

a) AEL-FUSG-N. Final User Smart Grid - Net Metering Trainer.

It consists of the following modules:

- N-ALI01. Industrial Main Power Supply.
- N-PFD. Power Flow Distribution Module.
- N-EALDG. Network Analyzer Unit with Computer Data Acquisition + Oscilloscope Display.
- N-VREG. Voltage Regulator Module.
- N-ASY. Synchronoscope Module.
- N-REL46. Thermal Electric Motor Protection Module.
- N-WCA4K. 4 kW Motor Controller Module.
- GMG4K. 4 KW Generator-Group.

b) Required accessories:

In order to simulate different real consumptions and to carry out all the practical possibilities proposed AEL-FUSG-N trainer requires a set of static and dynamic loads.

The following loads must be acquired:

AEL-FUSG-LO. Smart Grid Loads, formed by:

- N-REV. Variable Resistor.
- N-LAM16. Halogen Lamp.
- N-IND. Variable Inductive Load with commutator.
- N-CAR19. Single-Phase Commutable Capacitor Load.
- N-LAM32. LED Lamp.
- N-WCC/M. DC Motor Speed Controller.
- N-REF. Resistor Load with commutator. (4 units)
- EMT12. Universal Motor.
- FRECP. Eddy Current Brake.
- EH. Electric Heating Module.

c) Optional accessories:

For AEL-FUSG-N. Final User Smart Grid-Net Metering Trainer:

It can be included a set of modules to simulate different renewable energy power generation:

- PPINV. Photovoltaic Panel with Inverter.
- SWTI. Small Wind Turbine with Inverter.

For AEL-FUSG-LO. Smart Grid Loads:

AEL-APFC. Single-phase Automatic Power Factor Compensation.

For more information see **AEL-APFC** catalogue. Click on the following link:

www.edibon.com/es/files/equipment/AEL-APFC/catalog

Some practical exercises possibilities:

- 1.- Synchronization operations of the generator.
- 2.- Real time monitoring of local consumptions with induction, resistor or capacitive loads.
- 3.- Simulation of renewable energy generation through Generator-Motor Group (wind energy).
- 4.- Measurement of the energy generated by the Generator-Motor Group.
- 5.- Net Metering. Measuring the energy consumed and the energy injected to the grid and, finally, measuring the positive or negative energy balance.
- 6.- Measuring of the energy consumption by the loads without generator.
- 7.- Measuring the energy consumption by the loads with the generator and the grid controlling the power flows from the generator.
- 8.- Net-Metering operations: selling energy to the grid.

Additional practical possibilities:

If the user acquires the AEL-FUSG-M. Final User Smart Grid - Smart Meter Trainer and AEL-FUSG-E. Final User Smart Grid - Smart Energy Trainer, then he can perform, among many others, the following practical exercises:

- 9.- Measurement of energy consumption at home or by an industrial consumer and comparison of this measurement with the utility's register (smart meter).
- 10.- Remote scheduling of Smart devices (Smart plug, Smart relays, thermostat, different sensors, etc.) according to the tariff proposed by the utilities.
- 11.- Development of switching schemes through the management platform for appliances connected to the smart plugs, smart relays or the thermostat.
- 12.- Scheduling the energy consumption for optimal periods of sunlight.

For more information see **AEL-FUSG-N** catalogue. Click on the following link:

www.edibon.com/en/files/equipment/AEL-FUSG-N/catalog



AEL-FUSG-N



PPINV



SWTI

Applications:

AEL-5.4

Protection Relays Trainers

Fundamental Concepts

AEL-CTFP. Current Transformer Fundamentals for Protections Devices.

Transformers are electrical machines widely used in different applications with several purposes. Basically, there are two types of transformers: power transformers and instrument transformers. Within instrument transformers, there are two types: voltage instrument transformer and current instrument transformer. A current transformer (CT) is an electric device that produces an alternating current (AC) in its secondary which is proportional to the AC in its primary. Current transformers, together with voltage transformers (VTs) or potential transformers (Pts), which are designed for measurement, are known as instrumentation transformers.

When a current is too high to measure directly, a current transformer can be used to provide an isolated lower current in its secondary which is proportional to the current in the primary circuit. The induced secondary current is then suitable for measuring instruments or processing in electronic equipment. Current transformers are used in electronic equipment and are widely used for metering and protective relays in the electrical power industry.

The AEL-CTFP Current Transformer Fundamentals for Protections Devices has been designed by Edibon to demonstrate the students which the main functions of current transformers are and which the parameters that must be considered in order to choose the adequate current transformer are.

This trainer allows the students to check the transformation ratio and how it changes if the load varies. With this trainer, the student will study the zero residual current, the rated overcurrent factor, how change the current ratio error in function of the load and how work the current transformers.

The AEL-CTFP consists of a series of modules in order to carry out all exercises and practical possibilities related to current instrument transformers. These modules are, for instance, the three-phase AC variable power supply, the network analyzer, the digital multimeter, the overcurrent time electronic relay, the variable resistor and the three-phase current transformer modules.

The AEL-CTFP includes the following modules:

- N-TRTC. Three-Phase Current Transformer.
- N-TRBC. Three-Phase Balancing transformer.
- N-REV/CT. Variable Resistor for Current Transformer.

Required modules:

- N-VPS01. AC 3PH Variable Power Supply.
- N-EALD. Network Analyzer Unit with Computer Data Acquisition (2 units).
- N-MED65. Digital Multimeter.
- N-REVT/1K. 1kW Three-Phase Resistors Module.
- N-CON02. 3-Pole Contactor.
- N-REL09. Time Electronic Relay against Overcurrents (1.2 - 7 A).

Optional SCADA software:

- AEL-CTFP/CCSOF. Computer Control + Data Acquisition + Data Management Software.

Expansion learning software:

In addition, Edibon provides expansion learning software (AEL-CTFP/ICAI) to reinforce knowledge about this field. This software is formed by:

- ECM-SOF. EDIBON Classroom Manager (Instructor Software).
- ESL-SOF. EDIBON Student Labsoft (Student Software).

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

Option A:

This application needs the following racks:

- N-RACK-A.
- N-RACK-B.

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.

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

Some practical exercises possibilities:

- 1.- Analyzing the secondary current transformer as a function of the primary current.
- 2.- Checking the effect of the load on current ratio error.
- 3.- Checking rated overcurrent factor.
- 4.- Analyzing the transformer circuit in three-wire system.
- 5.- Analyzing the transformer in four-wire system.
- 6.- Determination of zero residual current.

Other possibilities to be done with this Unit:

- 7.- Many students view results simultaneously. To view all results in real time in the classroom by means of a projector or an electronic whiteboard.
 - 8.- The Computer Control System with SCADA allows a real industrial simulation.
 - 9.- This unit is totally safe as uses mechanical, electrical and electronic, and software safety devices.
 - 10.- This unit can be used for doing applied research.
 - 11.- This unit 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.

For more information see **AEL-CTFC** catalogue.

Click on the following link:

www.edibon.com/en/files/equipment/AEL-CTFC/catalog



AEL-CTFP

Applications:

AEL-5.4

Protection Relays Trainers**Fundamental Concepts****AEL-VTFP. Voltage Transformer Fundamentals for Protections Devices.**

Voltage transformers (VT) are a parallel connected type of instrument transformer. When a voltage is too high to measure directly, a voltage transformer can be used to provide an isolated lower voltage in its secondary which is proportional to the voltage in the primary circuit. The secondary voltage is then suitable for measuring instruments or processing in electronic equipment. Voltage transformers are used in electronic equipment and are widely used for metering and protective relays in the electrical power industry.

The AEL-VTFP has been designed by Edibon to intend to demonstrate the students which the main functions of voltage transformers are and which the parameters that must be considered in order to choose the adequate voltage transformer are.

The AEL-VTFP allows the student to check the transformation ratio of the voltage transformer and checking the class of accuracy. These maneuvers can be realized with or without earth fault on the primary side.

The AEL-VTFP includes the following modules:

- N-REV/VT. Variable Resistor for Voltage Transformer.
- N-TRTV. Three-Phase Voltage Transformer.

Required modules:

- N-VPS01. AC 3PH Variable Power Supply.
- N-EALD. Network Analyzer Unit with Computer Data Acquisition (2 units).
- N-MED65. Digital Multimeter.
- N-REVT/1K. 1kW Three-Phase Resistors Module.
- N-CON02. 3-Pole Contactor.
- N-REL09. Time Electronic Relay against Overcurrents (1.2 - 7 A).

Optional SCADA software:

- AEL-VTFP/CCSOF. Computer Control + Data Acquisition + Data Management Software.

Expansion learning software:

In addition, Edibon provides expansion learning software (AEL-VTFP/ICAI) to reinforce knowledge about this field. This software is formed by:

- ECM-SOF. EDIBON Classroom Manager (Instructor Software).
- ESL-SOF. EDIBON Student Labsoft (Student Software).

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

Option A:

This application needs the following racks:

- N-RACK-A.
- N-RACK-B.

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.

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

Some practical exercises possibilities:

- 1.- Voltage transformer characteristics.
- 2.- Calculation of class of accuracy.
- 3.- Effects of load on the transformation ratio.
- 4.- Three-Phase voltage transformer in healthy grid.
- 5.- Three-Phase voltage transformer in a grid with earth-fault on the primary side.

Other possibilities to be done with this Unit:

- 6.- Many students view results simultaneously.

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

- 7.- The Computer Control System with SCADA allows a real industrial simulation.
 - 8.- This unit is totally safe as uses mechanical, electrical and electronic, and software safety devices.
 - 9.- This unit can be used for doing applied research.
 - 10.- This unit 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.

For more information see **AEL-VTFP** catalogue. Click on the following link:

www.edibon.com/en/files/equipment/AEL-VTFP/catalog



AEL-VTFP

Applications:

AEL-5.4
Protection Relays Trainers

Protection Relays Trainers

ERP. Protection Relays Test Trainer:

It is formed by:

- ERP-UB. Protection Relays Test Unit. (common for all protection relays type “ERP”, and can work with one or several relays).

Protection Relays modules: (to use with the Protection Relays Test Unit (ERP-UB):

- ERP-SFT. Overcurrent and Earth Fault Protection Relay Module.
- ERP-SDND. Directional/Non Directional Overcurrent Protection Relay Module.
- ERP-PDF. Differential Protection Relay Module.
- ERP-MA. Feeders Management Relay Module.
- ERP-PD. Distance Protection Relay Module.
- ERP-GMGPT. Motor-Generator relés de protección y regulación automática.

•ERP-UB. Protection Relays Test Unit.

This is a teaching unit which gives students theoretical and practical experience with several industrial application relays.

The numerous devices, inputs and outputs, along with a modular structure, allow to use the ERP-UB for a wide range of protection applications simulation and real test of industrial application numerical relay system.

It includes experiments investigating earth fault, overcurrent, differential, directional, feeder management, overvoltage, undervoltage and distance numerical protection. The unit uses real industrial protection equipment and techniques.

This unit also covers relay setting and tripping characteristics, as well as grading and discrimination under fault conditions, and it allows students to compare individual relays characteristics and simultaneous comparison of any two relays to introduce the topic of discrimination and protection coordination.

Instrumentation, power supplies, power transformers, current transformers, voltage transformers and load resistors are incorporated in the unit and has an user-friendly desk space for users to work on.

The relays are housed in modern, portable enclosures.

The test unit will support up to two relays at once. These can be different relays or both the same type.

The relays are programmed either directly or using software, because this unit includes relays support software which enables users to program the relays modules on a suitable computer (computer no included)using software.

•ERP-SFT. Overcurrent and Earth Fault Protection Relay Module.

For use with the Protection Relays Test Unit (ERP-UB), this relay enables investigations into protection and monitoring of transformers, transmission lines and distribution schemes.

The module mounts on the desk area of the Protection Relays Test Unit and by using a multi-core cable and safety leads connects to the test unit.

The relay is housed in a modern and robust enclosure (steel box) with carrying handles.

The relay module is based on the SEL-551/SEL-551C relay, enabling the students to set up different fault circuits on the Protection Relays Test Unit. Students will use the keypad and display on the relay module to programme it to the setting needed for the tests. They can also use the relay support software (supplied with the Protection Relays Test Unit) and computer (available separately, not included in the supply) to programme the relay module. The relay module is then connected to the fault circuits so test can be performed.

Facility to test two relay modules at the same time because there are enough connections on the Protection Relays Test Unit.

The students connect the relays to the console by plugging leads into terminals on the front panels, thus perform experiments and practices using the unit to set test conditions and control and monitor relay behaviour.

The unit and relay front panels have schematic diagrams which help users carry out and understand the experiments.

Each part of the ERP-UB is correctly identified in order to facilitate the operation and fast identification of installations problems.

The base unit includes the following modules:

- ERP-UB. Protection Relays Test Unit.
- AE1. Transmission Lines Simulation Unit.
- ERP-MF. Fault Injection Module.

Optionally, the following modules can be included with the base unit:

- ERP-SFT. Overcurrent and Earth Fault Protection Relay Module.
- ERP-SDND. Directional/Non Directional Overcurrent Protection Relay Module.
- ERP-PDF. Differential Protection Relay Module.
- ERP-MA. Feeders Management Relay Module.
- ERP-PD. Distance Protection Relay Module.
- ERP-GMGPT. Motor-Generator with protection relays and automatic regulation.



ERP-UB

Some practical exercises possibilities:

- 1.-Verification of Overcurrent Protection functionality.
- 2.-Verification of Phase Overcurrent Elements.
- 3.-Verification of Residual Ground Overcurrent Elements.
- 4.-Verification of Phase Instantaneous Overcurrent Protection.
- 5.-Verification of Phase Time-Overcurrent Protection.
- 6.-Verification of Neutral Ground Instantaneous Overcurrent Protection.
- 7.-Verification of Neutral Ground Time-Overcurrent Protection.
- 8.-Verification of Residual Ground Instantaneous Overcurrent Protection.
- 9.-Verification of Residual Ground Time-Overcurrent Protection.
- 10.- Verification of Current Transformer Measurement accuracy.
- 11.- Power Transformer Overcurrent Protection.
- 12.- Power Transmission Line Overcurrent Protection.
- 13.- Load Feeder Overcurrent Protection.
- 14.- Distribution System Overcurrent Protection.
- 15.- Power Transmission System Overcurrent Protection.



ERP-SFT

Applications:

AEL-5.4

Protection Relays Trainers**Protection Relays Trainers****ERP. Protection Relays Test Trainer:** (Continuation)**•ERP-PDF. Differential Protection Relay Module.**

This ERP-PDF. Differential Protection Relay Module has to be used with the Protection Relays Test Unit (ERP-UB), and it enables investigations into protection of transformers, autotransformers, generators, Bus Bar and other apparatus with two windings.

A digital differential protection relay presented in an educational and teaching format.

The relay clearly demonstrates the characteristics of three-phase differential protection, and includes high stability during 'out-of-zone' faults, high-speed operation, zero-sequence current filtering for each winding, magnetising inrush restraint, amplitude and vector matching.

The module mounts on the desk area of the Protection Relays Test Unit and by using a multi-core cable and safety leads connects to the test unit.

The relay is housed in a modern and robust enclosure (steel box) with carrying handles.

The relay module is based on the SEL-587 industrial application relay, enabling the students to set up different fault circuits on the Protection Relay Test Unit. Students will use the keypad and display on the relay module to program it to the setting needed for the tests. They can also use the software (supplied with the Protection Relays Test Unit) and computer (available separately, not included in the supply) to program the relay module. The relay module is then connected to the fault circuits so test can be performed.

Most tests are performed using single relays. However, there are enough connections on the Protection Relays Test Unit to test two relay modules at the same time.

Some practical exercises possibilities:

- 1.-Verification of Differential Protection functionality.
- 2.-Transformer Differential Protection with variable TAP's voltage regulation.
- 3.-Transformer Differential Protection with different transformer connection diagrams.
- 4.-Verification of Phase Instantaneous Overcurrent Protection for Winding 1.
- 5.-Verification of Phase Definite Time-Overcurrent Protection for Winding 1.
- 6.-Verification of Phase Inverse Time-Overcurrent Protection for Winding 1.
- 7.-Verification of Phase Instantaneous Overcurrent Protection for Winding 2.
- 8.-Verification of Phase Definite Time-Overcurrent Protection for Winding 2.
- 9.-Verification of Phase Inverse Time-Overcurrent Protection for Winding 2.
- 10.- Verification of Current Transformers Measurement accuracy.
- 11.- Power Transformer Overcurrent Protection.
- 12.- Distribution Substation Bus-Bar Differential Protection.
- 13.- Transmission Substation Bus-Bar Differential Protection.
- 14.- Analysis of Event Reports and Human Machine Interface.



ERP-PDF

•ERP-SDND. Directional/Non Directional Overcurrent Protection Relay Module.

A directional/non-directional overcurrent relay presented in an educational and teaching format.

For use with the Protection Relays Test Unit (ERP-UB), this relay enables investigations into protection and monitoring of generator and transformer schemes, overhead lines, underground cables and backup on high-voltage systems.

The module mounts on the desk area of the Protection Relays Test Unit and by using a multi/core cable and safety leads connects to the test unit.

The relay is housed in a modern and robust enclosure (steel box) with carrying handles.

The relay module is based on the SEL-351 industrial application relay, enabling the students to set up different fault circuits on the Protection Relays Test Unit. Students will use the keypad and display on the relay module to program it to the setting needed for the tests. They can also use the software (supplied with the Protection Relays Test Unit) and computer (available separately, not included in the supply) to program the relay module. The relay module is then connected to the fault circuits so test can be performed.

Tests are performed using single relay, but there is the facility to test two relay modules at the same time because there are enough connections on the Protection Relays Test Unit.

Some practical exercises possibilities:

- 1.-Verification of Directional Protection functionality.
- 2.-Directional Protection with different measurement circuit.
- 3.-Directional Protection application to Transmission Line under different load conditions.
- 4.- Forward Directional Protection.
- 5.- Reverse Directional Protection.
- 6.- Non-Directional Overcurrent Protection.
- 7.-Residual Ground Time-Overcurrent Protection.
- 8.-Residual Ground Instantaneous Overcurrent Protection.
- 9.-Verification of Cable Undervoltage Protection.
- 10.- Verification of Cable Overvoltage Protection.
- 11.- Verification of Current Transformers Measurements accuracy.
- 12.- Verification of Voltage Transformers Measurements accuracy.
- 13.- Distribution System Directional Protection.



ERP-SDND

Applications:

AEL-5.4

Protection Relays Trainers**Protection Relays Trainers****ERP. Protection Relays Test Trainer:** (Continuation)**•ERP-MA. Feeders Management Relay Module.**

Feeders Management Relay Module for use with Protection Relays Test Unit (ERP-UB), which enables investigations into protection and monitoring of overhead lines, underground cables and feeders.

The module mounts on the desk area of the Protection Relays Test Unit and by using a multi-core cable and safety leads connects to the test unit.

The relay is housed in a modern and robust enclosure (steel box) with carrying handles.

The relay module is based on the SEL-751 industrial application relay, enabling the students to set up different fault circuits on the Protection Relays Test Unit. Students will use the keypad and display on the relay module to program it to the setting needed for the tests. They can also use the software (supplied with the Protection Relays Test Unit) and computer (available separately, not included in the supply) to program the relay module. The relay module is then connected to the fault circuits so test can be performed.

Tests are performed using single relay, but there is the facility to test two relay modules at the same time because there are enough connections on the Protection Relays Test Unit.

Some practical exercises possibilities:

- 1.-Verification of the Feeder Management Relay functionality.
- 2.- Phase Overcurrent Element of the Feeder Management Relay.
- 3.- Residual Ground Overcurrent Element of the Feeder Management Relay.
- 4.- Overvoltage Element of the Feeder Management Relay.
- 5.- Undervoltage Element of the Feeder Management Relay.
- 6.-Verification of Phase Instantaneous Overcurrent Protection.
- 7.-Verification of Phase Time-Overcurrent Protection.
- 8.-Verification of Residual Overcurrent Element.
- 9.-Verification of Residual Time-Overcurrent Element.
- 10.- Verification of Neutral Overcurrent Element.
- 11.- Verification of Overfrequency Protection Element.
- 12.- Verification of Underfrequency Protection Element.
- 13.- Verification of Positive (forward) Power Flow Protection Element.
- 14.- Verification of Negative (reverse) Power Flow Protection Element.
- 15.- Protection of Distribution Feeder Example.
- 16.- Protection of Overhead Transmission Line Example.



ERP-MA

•ERP-PD. Distance Protection Relay Module.

Distance Protection Relay Module (ERP-PD), for use with the Protection Relays Test Unit (ERP-UB), enables investigations into protection and monitoring of overhead transmission lines and underground cables.

The module mounts on the desk area of the Protection Relays Test Unit and by using a multi-core cable and safety leads connects to the test unit.

The relay is housed in a modern and robust enclosure (steel box) with carrying handles.

The relay module is based on the SEL-311 industrial application relay, enabling the students to set up different fault circuits on the Protection Relays Test Unit. Students will use the keypad and display on the relay module to programme it to the setting needed for the tests. They can also use the software (supplied with the Protection Relays Test Unit) and computer (available separately, not included in the supply) to programme the relay module. The relay module is then connected to the fault circuits so test can be performed.

Some practical exercises possibilities:

- 1.-Verification of Line Distance Protection functionality.
- 2.-Line Distance Protection with different measurement circuit conditions.
- 3.-Line Distance Protection with different Line Loads conditions.
- 4.-Verification of Phase Instantaneous Overcurrent Element.
- 5.-Verification of Ground Instantaneous Overcurrent Element.
- 6.-Verification of Phase Time-Overcurrent Protection Element.
- 7.-Verification of Ground Time-Overcurrent Protection Element.
- 8.-Verification of Current Transformer Measurement accuracy.
- 9.-Verification of Current Transformers Connection Diagram.
- 10.- Verification of Voltage Transformers Measurement Accuracy and Connection Diagram for Distance Protection.
- 11.- Overhead Transmission Line Parameters Estimation for Distance Protection.
- 12.- Overhead Transmission Line Distance Protection.
- 13.- Distance Protection Event Reports Analysis.
- 14.- Distance Protection Relay Human Machine Interface.
- 15.- Distance Protection Relay Configuration.
- 16.- Distance Protection of Simple Power System Example.



ERP-PD

Applications:

AEL-5.4

Protection Relays Trainers

Protection Relays Trainers

ERP. Protection Relays Test Trainer: (Continuation)**•ERP-GMGPT. Motor-Generator with Protection Relays and Automatic Regulation.**

It consists of a driving motor coupled to three-phase synchronous generator with independent excitation. This unit simulates a power plant with one turbine and one synchronous generator. Besides the ERP-GMGPT unit includes an advanced frequency and voltage controller used in real power plants.

With this controller the user has complete control over the turbine and the synchronous generator. The turbine-generator can work in automatic or manual control. On this way, in manual mode, the user will control the frequency of the turbine and the current excitation of the synchronous generator, taking decisions about how much active power give to the grid, what is the working frequency of the turbine, when is the adequate moment for synchronization with the grid, etc. On the other hand, the frequency and voltage controller can take the control, being previously set to work in automatic mode.

Besides, the frequency and voltage controller includes a management software that allows to configure different protections thresholds for the synchronous generator and the turbine such as unbalanced load protection, overcurrent protection, over/under voltage protection, over/under frequency protection, reverse power protection, etc.

Some practical exercises possibilities:

- 1.- Working of motor protection switch.
- 2.- Motor protection relay.
- 3.- Thermistor protection.
- 4.- Investigation of time overcurrent protection.
- 5.- Unbalanced load protection.
- 6.- Reverse power protection.
- 7.- Overvoltage and undervoltage protection.
- 8.- Stator earth-fault protection.
- 9.- Generator differential protection (optional with ERP-PDF).
- 10.- Rotor earth-fault protection.
- 11.- Parallel operation of synchronous generator.
- 12.- Isolated operation of synchronous generator.



ERP-GMGPT

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

www.edibon.com/en/files/equipment/ERP/catalog

Applications:

AEL-5.4

Protection Relays Trainers

Protection Relays Trainers

ERP-CBM. Cybersecurity Module.

The ERP-CBM Cybersecurity module has been designed by edibon to allow the student to understand how substations are protected against cyber attacks.

Power engineers demand the most reliable services for their control and protection systems. Settings cannot be disturbed, cables cannot be switched, and significant latency cannot be tolerated. Engineers must have full control of their critical systems and maintain full access to control their equipment 24 hours a day, 365 days a year. Cybersecurity must protect these assets and enable power engineers to accomplish their work efficiently.

The ERP-CBM secures all Ethernet communications between your private networks and interoperates with existing business IT and control systems over an Internet Protocol Security (IPsec) virtual private network (VPN). The ERP-CBM has been designed to protect power protection relays network from malicious traffic with an integrated firewall and strong access authentication control.

Protective meters, protective relays, programmable logic controllers (PLC), remote terminals unit (RTUs), and computers, are communicated through EIA-232, also known as RS-232 (standard for serial communication transmission of data).

The ERP-CBM allows the students to study how prevent unauthorized access, control, monitoring, and malicious attacks by authenticating and optionally encrypting all data along the communications path.

This module has been designed as complement of ERP-UB. Protection Relays Test Unit, AEL-MPSS. Modular Smart Grid Power Systems Simulators and APS12. Advanced Mechanical, Electrical and Smart Grid Power Systems.

In order to see these units, click in the following links:

- ERP-UB: www.edibon.com/en/files/equipment/ERP/catalog
- AEL-MPSS: www.edibon.com/en/files/equipment/AEL-MPSS/catalog
- APS12: www.edibon.com/en/files/equipment/APS12/catalog

Expansion learning software:

In addition, Edibon provides expansion learning software (ERP-CBM/ICAI) to reinforce knowledge about this field. This software is formed by:

- ECM-SOF. EDIBON Classroom Manager (Instructor Software).
- ESL-SOF. EDIBON Student Labsoft (Student Software).

Some practical exercises possibilities:

- 1.- Study of the Cybersecurity devices connection.
- 2.- Step by step Software installation.
- 3.- User accounts management.
- 4.- Study the cybersecurity Virtual Private Network (VPN).
- 5.- Study of Password management.
- 6.- Analysis and study of firewall configuration.
- 7.- Getting results.

For more information see **ERP-CBM** catalogue.

Click on the following link:

- www.edibon.com/en/files/equipment/ERP-CBM/catalog



ERP-CBM

Applications:

AEL-5.4

Protection Relays Trainers

Protection Systems for Generators

AEL-GPRE. Generator Protection Relay Trainer.

Power generators represent the fundamental part of a power system. These machines supply power along hundreds of kilometers up to the demanded point. They are subject to all kind of abnormal conditions that may reduce its service time, with these machines are used different protection systems. In order to avoid possible excessive wear and irreversible damages.

The Generator Protection Relay Trainer, AEL-GPRE has been designed by Edibon for the training at both the theoretical and practical levels in the field of high power generators with control and protection systems.

This trainer presents several levels of training to give the user full knowledge and experiences about the operation of advanced protection systems used in large power plants with electrical generators: a specific manual is included to study all theoretically aspects related to electrical generators such as electrical generators types, basic principles of generators operation, control and stand-alone generator operation, parallel generator operation with the national grid, types of protections used to protect these machines, sizing and protection relay settings. On the other hand, they are provided a series of modules for putting students' acquired knowledge into practice.

The AEL-GPRE trainer includes a series of modules that make it leadership in the market:

- The Generator Protection and Control Relay Unit: it is an industrial control and protection device of power generator groups with more than 150 configurable variables. The Relay Unit allows the user different access levels for the relay configuration. For example, the user can adjust the protection thresholds of overcurrent (50/51), over/under-voltage, over/under-frequency (81), inverse power, over/under-speed of the turbine (12), number of poles of the machine, nominal power, etc. In addition, for more advanced settings, it is possible to set the PID control system parameters under different operation conditions of the turbine-generator group. For example, when the generator is working in stand-alone or in parallel operation modes are used different PIDs. During commissioning of generator the provided software allows monitoring voltage and frequency PID signals, perturbations, analysis and real time settings.

Due to the versatility of the Generator Protection and Control Relay Unit, Edibon provides configured this device to work properly from scratch with the generator-motor group. In addition, it is provided a relay setting file to restore the relay to the initial configuration. On this way, the user can change any relay parameter and recovery the initial setting.

- Turbine Speed Controller: the trainer includes an advanced speed controller that can be controlled manually or automatically. After manual control is selected, the user can control the turbine speed through a potentiometer provided in this module. If the user selects automatic control mode, the Generator Protection and Control Relay will control the turbine with an analog signal of 0-10V. On this way, the user can study the operation of the complete system working autonomously, as a real power station works, or he can take the control of the installation to study the effects of the speed change of the turbine in the electrical system.

- Automatic voltage regulator: this device is designed for manual and automatic control of the current excitation of the synchronous generator. The regulator has a switch that allows the user to select the control mode. If manual control mode is selected, the current excitation of the synchronous generator can be controlled manually with a potentiometer and the effects of the generator output voltage can be seen.

Automatic control mode allows the Generator Protection and Control Relay Unit to take the control of the current excitation. On this way, the user can study the operation of the complete system working autonomously, as a real power station works, or he can take the control of the installation to study the effects of the excitation change of the synchronous generator in the electrical system.

- Faults simulation module: this module allows injecting real short circuits in the electrical generator to study the effects of these short circuits in the machine. Thus can be analyzed the response of the Generator Protection and Control Relay. The faults module has a selector, which allows the user to configure previously the kind of the fault to be injected: three-pole, two-pole, two-pole to ground and single-pole short circuits. All these faults can be configured with and without fault impedance. Finally, this module has a push-button to inject the fault.

- Network Analyzer Unit with Data Acquisition: This device allows measuring all electrical parameters of the synchronous generator such as phase and line voltages, line currents, active, reactive and apparent powers, frequency, harmonics, etc.

- Three-Phase bench of Commutable Resistors Module: this module is designed in order to carry out local consumption of the generated energy by the synchronous generator.

The AEL-GPRE includes the following modules:

- N-ALI01. Industrial Main Power Supply.
- N-ERP-PGC-01. Generator Protection and Control Relay Unit.
- N-WCA5K. 5 kW Motor Speed Controller.
- N-AVR/P. Automatic Voltage Regulator.
- N-EALD. Network Analyzer Unit with Computer Data Acquisition.
- N-CAR35T3. Three-Phase Bank of Commutable Resistors Module.
- N-ERP-MF01. Digital Fault Simulation Module.
- GMG4.5K3PH. 4.5 kVA Generator-Motor Group.

Recommended additional protection modules:

- N-ERP-PDF01. Differential Protection Relay Module.
- N-REP. Rotor earth-fault protection module.

Recommended additional generation group:

The following modules and units are required to extend the practical possibilities for load sharing studies (parallel operations with two synchronous generator).

- N-ERP-PGC-01. Generator Protection Relay Module.
- N-WCA5K. 5 kW Motor Speed Controller.
- N-AVR/P. Automatic Voltage Regulator.
- GMG4.5K3PH. 4.5 kVA Generator-Motor Group.

Optional SCADA software:

- AEL-GPRE/CCSOF. Computer Control + Data Acquisition + Data Management Software.

Expansion learning software:

In addition, Edibon provides expansion learning software (AEL-GPRE/ICAI) to reinforce knowledge about this field. This software is formed by:

- ECM-SOF. EDIBON Classroom Manager (Instructor Software).
- ESL-SOF. EDIBON Student Labsoft (Student Software).



AEL-GPRE

Applications:

AEL-5.4

Protection Relays Trainers

Protection Systems for Generators

AEL-GPRE. Generator Protection Relay Trainer. (Continuation)

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

Option A:

This application needs the following racks:

- N-RACK-A.
- N-RACK-B. (4 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.

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

Some practical exercises possibilities:

- 1.- Study of generation power systems.
- 2.- Analysis of the measurements of the power flows of the synchronous generator.
- 3.- Analysis of the active and reactive power of the synchronous generator.
- 4.- Automatic synchronization maneuvers of synchronous generator with the mains.
- 5.- Study of the synchronous generator in island operation mode.
- 6.- Study of the synchronous generator in grid parallel operation mode.
- 7.- Study of excitation/voltage regulation of synchronous generator in island mode.
- 8.- Study of turbine regulation (frequency control) in island mode.
- 9.- Study of excitation/voltage regulation of synchronous generator in parallel grid operation mode.
- 10.- Study of turbine regulation (frequency control) in parallel grid operation mode.
- 11.- Study of the power factor regulation of synchronous generator in parallel grid operation mode.
- 12.- Setting of time overcurrent protection.
- 13.- Setting of unbalance load protection.
- 14.- Setting of reverse power protection.
- 15.- Setting of overvoltage and undervoltage protection.
- 16.- Setting of PID voltage.
- 17.- Setting of PID frequency voltage.

Additional practical exercises possibilities with the optional modules:

For differential protection relay studies (with optional module "N-ERP-PDF01"):

- 18.- Calculating protection operating values.
- 19.- Fault recognition within the protection range.
- 20.- Testing tripping and reset for faults occurring inside and outside the protection range.
- 21.- Disconnection and de-excitation of the generator.
- 22.- Measurement of the operating (pick-up) currents of the protection device for symmetrical and asymmetrical faults.
- 23.- Comparison of measured values to set values.

For rotor earth-fault relay studies (with optional module "N-REP"):

24.- Connection and testing of earth-fault relay.

25.- Setting different rotor earth-faults.

Additional practical exercises possibilities with the optional SCADA (AEL-GPRE/CCSOF).

- 26.- Remotely control of generation power systems.
- 27.- Analysis with the SCADA software of synchronous generator power flows.
- 28.- Analysis with SCADA software of active and reactive power of synchronous generator.
- 29.- Remotely control of manual synchronization of synchronous generator with the mains.
- 30.- Remotely control of automatic synchronization of synchronous generator with the mains.
- 31.- Remotely control of synchronous generator in island grid operation mode.
- 32.- Remotely control of synchronous generator in parallel grid operation mode.
- 33.- Remotely control of excitation/voltage regulation of synchronous generator in island mode.

Other possibilities to be done with this Unit:

34.- Many students view results simultaneously.

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

- 35.- The Computer Control System with SCADA allows a real industrial simulation.
- 36.- This unit is totally safe as uses mechanical, electrical and electronic, and software safety devices.
- 37.- This unit can be used for doing applied research.
- 38.- This unit 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.

For more information see **AEL-GPRE** catalogue. Click on the following link:

www.edibon.com/en/files/equipment/AEL-GPRE/catalog



AEL-GPRE

Applications:

AEL-5.4

Protection Relays Trainers

Protection Systems for Transmission and Distribution Lines

AEL-TPT-01. Overcurrent Time Protection Relay for Lines.

Transmission and distribution lines require efficient protection systems to provide safety, reliability and quality to the power. An overcurrent relay is a type of protective relay which operates when the load current exceeds a pickup value. The ANSI device number is 50 for an instantaneous over current (IOC) or a Definite Time Overcurrent (DTOC). In a typical application the over current relay is connected to a current transformer and calibrated to operate at or above a specific current level. When the relay operates, one or more contacts will operate and energize to trip (open) a circuit breaker.

The AEL-TPT-01 Overcurrent Time Protection Relay for Lines has been designed by Edibon to show the students how overcurrent time protection relays work.

This trainer allows the student inject different faults safely thanks to the relay test unit while the unit is protected by the time overcurrent relay. The user can study the effects of this faults on transmission lines measuring the most important electric parameters through several measuring instruments.

The AEL-TPT-01 includes the following modules:

- N-VPS01. AC 3PH Variable Power Supply.
- N-MED65. Digital Multimeter.
- N-REVT/1K. 1kW Three-Phase Resistors Module.
- N-EALD. Network Analyzer Unit with Computer Data Acquisition.
- N-AE1/1K. 1KVA Transmission Line Simulator Module
- N-PSM. Power Switch module.
- N-TOPR. Time Overcurrent Protection Relay.
- N-RELT. Relay test module.
- N-CON02. 3-Pole Contactor.
- N-REL09. Time Electronic Relay against Overcurrents (1.2 - 7 A).

Optional SCADA software:

- PSV-SCADA. Power Systems SCADA Viewer.

Expansion learning software:

In addition, Edibon provides expansion learning software (AEL-TPT-01/ICAI) to reinforce knowledge about this field. This software is formed by:

- ECM-SOF. EDIBON Classroom Manager (Instructor Software).
- ESL-SOF. EDIBON Student Labsoft (Student Software).

Recommended additional applications:

- AEL-TPT-02. Overvoltage and Undervoltage Protection Relay.
- AEL-TPT-03. Directional Power Protection Relay.
- AEL-TPT-04. Earth Fault Voltage Protection Relay.
- AEL-TPT-05. Protection Relay of Parallel-Connected Lines.
- AEL-TPT-06. Parallel Transmission Lines Protection.
- AEL-TPT-07. High Speed Distance Protection Relay.

The application AEL-TPT-01 can be mounted on rack (option A) or on rail (option B):

Option A:

This application needs the following racks:

- N-RACK-A.
- 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.

Optionally, this unit is supplied with the Power Systems SCADA Viewer (PSV-SCADA), and includes: The unit itself + Computer Control, Data Acquisition and Data Management Software Packages, for controlling the process and all parameters involved in the process.

Some practical exercises possibilities:

- 1.- Configuration of overcurrent time protection relay.
- 2.- Parameterization of overcurrent time protection relay.
- 3.- Commissioning of overcurrent time protection relay.
- 4.- Configuration of different protection thresholds.
- 5.- Generation of different current levels for tripping operations.
- 6.- Analysis of different wave forms in real time.
- 7.- Determining rise and fall time.
- 8.- Determining the reset ratio.
- 9.- Setting and testing various characteristics.
- 10.- Checking circuit breaker's release behavior in the event of a failure.

Other possibilities to be done with this Unit:

- 11.- Many students view results simultaneously. To view all results in real time in the classroom by means of a projector or an electronic whiteboard.
 - 12.- The Computer Control System with PSV-SCADA allows a real industrial simulation.
 - 13.- This unit is totally safe as uses mechanical, electrical and electronic, and software safety devices.
 - 14.- This unit can be used for doing applied research.
 - 15.- This unit 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.

For more information see **AEL-TPT-01** catalogue. Click on the following link:

www.edibon.com/en/files/equipment/AEL-TPT-01/catalog



AEL-TPT-01

Applications:

AEL-5.4

Protection Relays Trainers

Protection Systems for Transmission and Distribution Lines

AEL-TPT-02. Directional Overcurrent Protection Relay for Transmission Lines.

Directional relays (ANSI 50/ 51 and 67) are used for overcurrent or earth fault protection when selectivity is required, for example, due to parallel lines meshed networks or networks being supplied from a number of directions.

Tripping characteristics can be independently (definite) or dependently (inverse) time delayed. Three phase assemblies are used primarily when extra dependability is required against two phase short-circuits.

The AEL-TPT-02 application has been developed as a complement to AEL-TPT-01 in order to study how protect a transmission line with a directional overcurrent protection.

The student will learn to protect against forward and reverse overcurrents thanks to the time directional overcurrent relay. The user can configure it and he will be able to determine the reset ratio in the event of single, double and triple-pole short circuit.

Required Basic equipment:

- AEL-TPT-01. Overcurrent Time Protection Relay for Lines.

The AEL-TPT-02 includes the following modules:

- N-TDOPR. Time Directional Overcurrent Protection relay.

Optional SCADA software:

- PSV-SCADA. Power Systems SCADA Viewer.

Expansion learning software:

In addition, Edibon provides expansion learning software (AEL-TPT-02/ICAI) to reinforce knowledge about this field. This software is formed by:

- ECM-SOF. EDIBON Classroom Manager (Instructor Software).
- ESL-SOF. EDIBON Student Labsoft (Student Software).

The application AEL-TPT-02 can be mounted on rack (option A) or on rail (option B):

Option A:

This application needs the following racks:

- N-RACK-B.

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.

Optionally this unit is supplied with the Power Systems SCADA Viewer (PSV-SCADA), and includes: The unit itself + Computer Control, Data Acquisition and Data Management Software Packages, for controlling the process and all parameters involved in the process.

Some practical exercises possibilities of basic equipment (AEL-TPT-01):

- 1.- Configuration of overcurrent time protection relay.
- 2.- Parameterization of overcurrent time protection relay.
- 3.- Commissioning of overcurrent time protection relay.
- 4.- Configuration of different protection thresholds.
- 5.- Generation of different current levels for tripping operations.
- 6.- Analysis of different wave forms in real time.
- 7.- Determining rise and fall time.
- 8.- Determining the reset ratio.
- 9.- Setting and testing various characteristics.
- 10.- Checking circuit breaker's release behavior in the event of a failure.

Some practical exercises possibilities with the specific modules of AEL-TPT-02:

- 11.- Designing and parametrizing overcurrent time protection
 - 12.- Determining the reset ratio in the case of single-, double and triple-pole short circuit
 - 13.- Forward and reverse protection.
- Other possibilities to be done with this Unit:
- 14.- Many students view results simultaneously.
To view all results in real time in the classroom by means of a projector or an electronic whiteboard.

- 15.- The Computer Control System with PSV-SCADA allows a real industrial simulation.
- 16.- This unit is totally safe as uses mechanical, electrical and electronic, and software safety devices.
- 17.- This unit can be used for doing applied research.
- 18.- This unit can be used for giving training courses to Industries even to other Technical Education Institutions.

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

For more information see **AEL-TPT-02** catalogue. Click on the following link:

www.edibon.com/en/files/equipment/AEL-TPT-02/catalog



AEL-TPT-02

Applications:

AEL-5.4

Protection Relays Trainers

Protection Systems for Transmission and Distribution Lines

AEL-TPT-03. Overvoltage and Undervoltage Protection Relay.

27/59 under/overvoltage relays are general purpose three phase relays designed to be used wherever protection is required against abnormal voltage conditions. They are generally used for incoming line protection. An important application is in co-generation schemes to create an acceptable voltage window for the generator.

The AEL-TPT-03 trainer has been developed as a complement to AEL-TPT-01 in order to study how protect a transmission line against overvoltage and undervoltage.

The user can train with the over/undervoltage relay and thus obtain a complete knowledge about this type of protections. He can set parameter and start up this relay. Moreover, the user can determinate the rise and fall time and the reset ratio.

Required Basic equipment:

- AEL-TPT-01. Overcurrent Time Protection Relay for Lines.

The AEL-TPT-03 includes the following modules:

- N-TOUPR. Time Over/Undervoltage Protection relay.

Optional SCADA software:

- PSV-SCADA. Power Systems SCADA Viewer.

Expansion learning software:

In addition, Edibon provides expansion learning software (AEL-TPT-03/ICAI) to reinforce knowledge about this field. This software is formed by:

- ECM-SOF. EDIBON Classroom Manager (Instructor Software).
- ESL-SOF. EDIBON Student Labsoft (Student Software).

The application AEL-TPT-03 can be mounted on rack (option A) or on rail (option B):

Option A:

This application needs the following racks:

- N-RACK-B.

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.

Optionally this unit is supplied with the Power Systems SCADA Viewer (PSV-SCADA), and includes: The unit itself + Computer Control, Data Acquisition and Data Management Software Packages, for controlling the process and all parameters involved in the process.

Some practical exercises possibilities of basic equipment (AEL-TPT-01):

- 1.- Configuration of overcurrent time protection relay.
- 2.- Parameterization of overcurrent time protection relay.
- 3.- Commissioning of overcurrent time protection relay.
- 4.- Configuration of different protection thresholds.
- 5.- Generation of different current levels for tripping operations.
- 6.- Analysis of different wave forms in real time.
- 7.- Determining rise and fall time.
- 8.- Determining the reset ratio.
- 9.- Setting and testing various characteristics.
- 10.- Checking circuit breaker's release behavior in the event of a failure.

Some practical exercises possibilities with the specific modules of AEL-TPT-03:

- 11.- Setting of over/under voltage protection relay.
- 12.- Parameterization of over/under voltage protection relay.
- 13.- Commissioning of over/under voltage protection relay.
- 14.- Testing the over/under voltage relay against overvoltage situations and undervoltage.

Other possibilities to be done with this Unit:

- 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.- The Computer Control System with PSV-SCADA allows a real industrial simulation.
 - 17.- This unit is totally safe as uses mechanical, electrical and electronic, and software safety devices.
 - 18.- This unit can be used for doing applied research.
 - 19.- This unit 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.

For more information see **AEL-TPT-03** catalogue.

Click on the following link:

www.edibon.com/en/files/equipment/AEL-TPT-03/catalog



AEL-TPT-03

Applications:

AEL-5.4

Protection Relays Trainers

Protection Systems for Transmission and Distribution Lines

AEL-TPT-04. Directional Power Protection Relay.

The overcurrent protection can be given directional feature by adding directional element in the protection system. Directional overcurrent protection responds to overcurrents for a particular direction flow. If power flow is in the opposite direction, the directional overcurrent protection remains un-operative.

Directional overcurrent protection comprises overcurrent relay and power directional relay in a single relay casing. The power directional relay does not measure the power but is arranged to respond to the direction of power flow. Directional operation of relay is used where the selectivity can be achieved by directional relaying. The directional relay recognizes the direction in which fault occurs, relative to the location of the relay. It is set such that it actuates for faults occurring in one direction only. It does not act for faults occurring in the other direction.

The AEL-TPT-04 trainer has been developed as a complement to AEL-TPT-01 in order to study how protect a system against revers power.

The student can cause a fault and see how work the directional protection work. The student can train the selectivity connecting correctly the directional protection and the time overcurrent protection relay. This unit has a great potential because the user can configure and parametrize the protections as he wants.

Required Basic equipment:

- AEL-TPT-01. Overcurrent Time Protection Relay for Lines.

The AEL-TPT-04 includes the following modules:

- N-PPR. Power Protection Relay.

Optional SCADA software:

- PSV-SCADA. Power Systems SCADA Viewer.

Expansion learning software:

In addition, Edibon provides expansion learning software (AEL-TPT-04/ICAI) to reinforce knowledge about this field. This software is formed by:

- ECM-SOF. EDIBON Classroom Manager (Instructor Software).
- ESL-SOF. EDIBON Student Labs of (Student Software).

The application AEL-TPT-04 can be mounted on rack (option A) or on rail (option B):

Option A:

This application needs the following racks:

- N-RACK-B.

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.

Optionally this unit is supplied with the Power Systems SCADA Viewer (PSV-SCADA), and includes: The unit itself + Computer Control, Data Acquisition and Data Management Software Packages, for controlling the process and all parameters involved in the process.

Some practical exercises possibilities of basic equipment (AEL-TPT-01):

- 1.- Configuration of overcurrent time protection relay.
- 2.- Parameterization of overcurrent time protection relay.
- 3.- Commissioning of overcurrent time protection relay.
- 4.- Configuration of different protection thresholds.
- 5.- Generation of different current levels for tripping operations.
- 6.- Analysis of different wave forms in real time.
- 7.- Determining rise and fall time.
- 8.- Determining the reset ratio.
- 9.- Setting and testing various characteristics.
- 10.- Checking circuit breaker's release behavior in the event of a failure.

Some practical exercises possibilities with the specific modules of AEL-TPT-04:

- 11.- Configuration of directional power protection relay.
- 12.- Parameterization of directional power protection relay.
- 13.- Commissioning of directional power protection relay.
- 14.- Configuration of directional power protection relay thresholds.

Other possibilities to be done with this Unit:

- 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.- The Computer Control System with PSV-SCADA allows a real industrial simulation.
- 17.- This unit is totally safe as uses mechanical, electrical and electronic, and software safety devices.
- 18.- This unit can be used for doing applied research.
- 19.- This unit 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.

For more information see **AEL-TPT-04** catalogue. Click on the following link:

www.edibon.com/en/files/equipment/AEL-TPT-04/catalog



AEL-TPT-04

Applications:

AEL-5.4

Protection Relays Trainers

Protection Systems for Transmission and Distribution Lines

AEL-TPT-05. Earth-Fault Voltage Protection Relay.

The available fault current for single-phase to ground faults is very limited for ungrounded systems and systems that are grounded through a high resistance. This current limiting reduces the possibility of extensive equipment damage, and eliminates the need for a neutral breaker by reducing the fault current below the level required to sustain an arc. But it remains important to detect and isolate single-phase to ground faults in order to prevent their evolution into more dangerous faults such as phase to phase to ground and three-phase to ground faults. Sensitive voltage relays can be used to detect ground faults where the fault current is very small. The earth fault voltage relay included in this trainer is especially suited to the task.

The AEL-TPT-05 trainer has been developed as a complement to AEL-TPT-01 in order to study how protect a transmission line with a earth fault voltage relay.

This application allows the student to acquire depth knowledge about earth fault protection for undergrounded systems and systems that are grounded through a high resistance. This is possible thanks to the earth fault voltage relay and the three phase voltage transformer included in this trainer

Required Basic equipment:

- AEL-TPT-01. Overcurrent Time Protection Relay for Lines.

The AEL-TPT-05 includes the following modules:

- N-EFVR. Earth fault voltage Relay.
- N-TRTV. Three-Phase Voltage Transformer.

Optional SCADA software:

- PSV-SCADA. Power Systems SCADA Viewer.

Expansion learning software:

In addition, Edibon provides expansion learning software (AEL-TPT-05/ICAL) to reinforce knowledge about this field. This software is formed by:

- ECM-SOF. EDIBON Classroom Manager (Instructor Software).
- ESL-SOF. EDIBON Student Labsoft (Student Software).

The application AEL-TPT-05 can be mounted on rack (option A) or on rail (option B):

Option A:

This application needs the following racks:

- N-RACK-B.

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.

Optionally this unit is supplied with the Power Systems SCADA Viewer (PSV-SCADA), and includes: The unit itself + Computer Control, Data Acquisition and Data Management Software Packages, for controlling the process and all parameters involved in the process.

Some practical exercises possibilities of basic equipment (AEL-TPT-01):

- 1.- Configuration of overcurrent time protection relay.
- 2.- Parameterization of overcurrent time protection relay.
- 3.- Commissioning of overcurrent time protection relay.
- 4.- Configuration of different protection thresholds.
- 5.- Generation of different current levels for tripping operations.
- 6.- Analysis of different wave forms in real time.
- 7.- Determining rise and fall time.
- 8.- Determining the reset ratio.
- 9.- Setting and testing various characteristics.
- 10.- Checking circuit breaker's release behavior in the event of a failure.

Some practical exercises possibilities with the specific modules of AEL-TPT-05:

- 11.- Measuring voltages in a sound, three-phase network
 - 12.- Measuring voltages in a three-phase network experiencing earth faults.
 - 13.- Determining rise and fall times.
 - 14.- Determining the inherent time of a fault.
- Other possibilities to be done with this unit:
- 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.- The Computer Control System with PSV-SCADA allows a real industrial simulation.
 - 17.- This unit is totally safe as uses mechanical, electrical and electronic, and software safety devices.
 - 18.- This unit can be used for doing applied research.
 - 19.- This unit 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.

For more information see **AEL-TPT-05** catalogue. Click on the following link:

www.edibon.com/en/files/equipment/AEL-TPT-05/catalog



AEL-TPT-05

Applications:

AEL-5.4

Protection Relays Trainers

Protection Systems for Transmission and Distribution Lines

AEL-TPT-06. Parallel Transmission Lines Protection Relay.

Transmission and distribution lines require efficient protection systems to provide safety, reliability and quality to the power. In the event of meshed grids are necessary some types of protections. The overcurrent protection can be given directional feature by adding directional element in the protection system. Directional overcurrent protection responds to overcurrents for a particular flow direction. If power flow is in the opposite direction, the directional overcurrent protection remains un-operative.

The AEL-TPT-06 trainer has been developed as a complement to AEL-TPT-01 in order to study how protect a system with parallel transmission lines.

The AEL-TPT-06 offers to students a wide knowledge about selectivity on transmission lines. The student can configure and parametrize the protection relays in order to see how they protect the system when there are parallel or series transmission lines.

Required Basic equipment:

- AEL-TPT-01. Overcurrent Time Protection Relay for Lines.

The AEL-TPT-06 includes the following modules:

- N-TDOPR. Time Directional Overcurrent Protection relay.
- N-AE1/1K. 1KVA Transmission Line Simulator Module.
- N-PSM. Power Switch Module. (2 units)

Optional SCADA software:

- PSV-SCADA. Power Systems SCADA Viewer.

Expansion learning software:

In addition, Edibon provides expansion learning software (AEL-AEL-TPT-06/ICAI) to reinforce knowledge about this field. This software is formed by:

- ECM-SOF. EDIBON Classroom Manager (Instructor Software).
- ESL-SOF. EDIBON Student Labsoft (Student Software).

The application AEL-TPT-06 can be mounted on rack (option A) or on rail (option B):

Option A:

This application needs the following racks:

- N-RACK-B. (3 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.

Optionally, this unit is supplied with the Power Systems SCADA Viewer (PSV-SCADA), and includes: The unit itself + Computer Control, Data Acquisition and Data Management Software Packages, for controlling the process and all parameters involved in the process.

Some practical exercises possibilities of basic equipment (AEL-TPT-01):

- 1.- Configuration of overcurrent time protection relay.
- 2.- Parameterization of overcurrent time protection relay.
- 3.- Commissioning of overcurrent time protection relay.
- 4.- Configuration of different protection thresholds.
- 5.- Generation of different current levels for tripping operations.
- 6.- Analysis of different wave forms in real time.
- 7.- Determining rise and fall time.
- 8.- Determining the reset ratio.
- 9.- Setting and testing various characteristics.
- 10.- Checking circuit breaker's release behavior in the event of a failure.

Some practical exercises possibilities with the specific modules of AEL-TPT-06:

- 11.- Configuration of directional protection relay.
- 12.- Parameterization of directional protection relay.
- 13.- Commissioning of directional protection relay.
- 14.- Configuration of directional protection relay thresholds.
- 15.- Combining of directional protection relay and overcurrent protection relay for selectivity studies.

16.- Determining the inherent time of a fault.

Other possibilities to be done with this Unit:

- 17.- Many students view results simultaneously.

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

- 18.- The Computer Control System with PSV-SCADA allows a real industrial simulation.
- 19.- This unit is totally safe as uses mechanical, electrical and electronic, and software safety devices.
- 20.- This unit can be used for doing applied research.
- 21.- This unit 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.

For more information see **AEL-TPT-06** catalogue. Click on the following link:

www.edibon.com/en/files/equipment/AEL-TPT-06/catalog



AEL-TPT-06

Applications:

AEL-5.4

Protection Relays Trainers

Protection Systems for Transmission and Distribution Lines

AEL-TPT-07. High Speed Distance Protection Relay.

Since the impedance of a transmission line is proportional to its length, for distance measurement it is appropriate to use a relay capable of measuring the impedance of a line up to a predetermined point (the reach point). Such a relay is described as a distance relay and is designed to operate only for faults occurring between the relay location and the selected reach point, thus giving discrimination for faults that may occur in different line sections.

The basic principle of distance protection involves the division of the voltage at the relaying point by the measured current. The apparent impedance so calculated is compared with the reach point impedance. If the measured impedance is less than the reach point impedance, it is assumed that a fault exists on the line between the relay and the reach point.

The AEL-TPT-07 application has been developed as a complement to AEL-TPT-01 in order to study how protect a system with high speed distance protection relay.

The AEL-TPT-07 allows the student training the protection of transmission lines with a high speed distance protection relay. Thanks to this module, the user can Set and test distance protection, overcurrent time protection and voltage protection characteristic.

Required Basic equipment:

- AEL-TPT-01. Overcurrent Time Protection Relay for Lines.

The AEL-TPT-07 includes the following modules:

- N-HSDPR. High Speed Distance Protection Relay.
- N-TRTC. Three-Phase Current Transformer.
- N-TRTV. Three-Phase Voltage Transformer.
- N-AE1/1K. 1KVA Transmission Line Simulator Module.

Optional SCADA software:

- PSV-SCADA. Power Systems SCADA Viewer.

Expansion learning software:

In addition, Edibon provides expansion learning software (AEL-TPT-07/ICAI) to reinforce knowledge about this field. This software is formed by:

- ECM-SOF. EDIBON Classroom Manager (Instructor Software).
- ESL-SOF. EDIBON Student Labssoft (Student Software).

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

Option A:

This application needs the following racks:

- N-RACK-B. (4 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.

Optionally, this unit is supplied with the Power Systems SCADA Viewer (PSV-SCADA), and includes: The unit itself + Computer Control, Data Acquisition and Data Management Software Packages, for controlling the process and all parameters involved in the process.

Some practical exercises possibilities of basic equipment (AEL-TPT-01):

- 1.- Configuration of overcurrent time protection relay.
- 2.- Parameterization of overcurrent time protection relay.
- 3.- Commissioning of overcurrent time protection relay.
- 4.- Configuration of different protection thresholds.
- 5.- Generation of different current levels for tripping operations.
- 6.- Analysis of different wave forms in real time.
- 7.- Determining rise and fall time.
- 8.- Determining the reset ratio.
- 9.- Setting and testing various characteristics.
- 10.- Checking circuit breaker's release behavior in the event of a failure.

Some practical exercises possibilities with the specific modules of AEL-TPT-07:

- 11.- Configuration of distance protection relay.
- 12.- Parameterization of distance protection relay.
- 13.- Commissioning of distance protection relay.
- 14.- Configuration of distance protection relay thresholds.
- 15.- Setting and testing Distance protection characteristic.
- 16.- Setting and testing Overcurrent time protection characteristic.
- 17.- Setting and testing Voltage protection characteristic.

Other possibilities to be done with this Unit:

- 18.- Many students view results simultaneously. To view all results in real time in the classroom by means of a projector or an electronic whiteboard.
- 19.- The Computer Control System with PSV-SCADA allows a real industrial simulation.
- 20.- This unit is totally safe as uses mechanical, electrical and electronic, and software safety devices.
- 21.- This unit can be used for doing applied research.
- 22.- This unit 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.

For more information see **AEL-TPT-07** catalogue. Click on the following link:

www.edibon.com/en/files/equipment/AEL-TPT-07/catalog



AEL-TPT-07

Applications:

AEL-5.5
Cybersecurity Trainers

ERP-CBM. Cybersecurity Module.

The ERP-CBM Cybersecurity module has been designed by edibon to allow the student to understand how substations are protected against cyber attacks.

Power engineers demand the most reliable services for their control and protection systems. Settings cannot be disturbed, cables cannot be switched, and significant latency cannot be tolerated. Engineers must have full control of their critical systems and maintain full access to control their equipment 24 hours a day, 365 days a year. Cybersecurity must protect these assets and enable power engineers to accomplish their work efficiently.

The ERP-CBM secures all Ethernet communications between your private networks and interoperates with existing business IT and control systems over an Internet Protocol Security (IPsec) virtual private network (VPN). The ERP-CBM has been designed to protect power protection relays network from malicious traffic with an integrated firewall and strong access authentication control.

Protective meters, protective relays, programmable logic controllers (PLC), remote terminals unit (RTUs), and computers, are communicated through EIA-232, also known as RS-232 (standard for serial communication transmission of data).

The ERP-CBM allows the students to study how prevent unauthorized access, control, monitoring, and malicious attacks by authenticating and optionally encrypting all data along the communications path.

This module has been designed as complement of ERP-UB. Protection Relays Test Unit, AEL-MPSS. Modular Smart Grid Power Systems Simulators and APS12. Advanced Mechanical, Electrical and Smart Grid Power Systems.

In order to see these units, click in the following links:

- ERP-UB: www.edibon.com/en/files/equipment/ERP/catalog
- AEL-MPSS: www.edibon.com/en/files/equipment/AEL-MPSS/catalog
- APS12: www.edibon.com/en/files/equipment/APS12/catalog



ERP-CBM

Expansion learning software:

In addition, Edibon provides expansion learning software (ERP-CBM/ICAI) to reinforce knowledge about this field. This software is formed by:

- ECM-SOF. EDIBON Classroom Manager (Instructor Software).
- ESL-SOF. EDIBON Student Labsoft (Student Software).

Some practical exercises possibilities:

- 1.- Study of the Cybersecurity devices connection.
- 2.- Step by step Software installation.
- 3.- User accounts management.
- 4.- Study the cybersecurity Virtual Private Network (VPN).
- 5.- Study of Password management.
- 6.- Analysis and study of firewall configuration.
- 7.- Getting results.

For more information see **ERP-CBM** catalogue.

Click on the following link:

www.edibon.com/en/files/equipment/ERP-CBM/catalog

Applications:

AEL-5.6

Available "Smart Grid Power Systems"

AEL-CPSS-01S Smart Grid Power Systems Application, with Automatic Control Generation, Transmission Line and Loads.

The Smart Grid Power System Application, with Automatic Control Generation, Transmission Line and Loads, AEL-CPSS-01S has been designed by Edibon for the training at both the theoretical and practical levels in the field of Power Generation, Transmission, Distribution, Consumption, protections relays and Micro-Grids Power Systems.

The AEL-CPSS-01S application provides several levels of training to give the user full knowledge and experiences about the most important principles of control, operation and functioning of Generation, Transmission, Distribution and Load Consumption. For this purpose, this application includes a specific manual, which explains at theoretical level the subjects relating to high voltage power systems. The thematic of the manual covers from basic principles of functioning, control and operation of electric generators and energy transmission up to energy consumption. On the other hand, it is provided a series of modules and units to put into practice all theoretical concepts previously studied in this manual.

One of the advantages of this application is its modularity and flexibility. This allows carry out different real power systems configurations. For example, the user can configure the classical power system formed by "Generation + Transmission/Distribution + Consumption" or he can configure a Micro-Grid with "Generation + Consumption" working in stand-alone too. At any moment the user can synchronize the electric generator with the laboratory mains and he can develop a real energy distribution network.

In functional terms the whole system can be controlled either locally through the operation of switches, breakers and signals, and remotely through the Data Acquisition and Control Software offered optionally.

The AEL-CPSS-01S optionally offers both a Data Control and Data Acquisition Software (AEL-CPSS-01S/CCSOF) and a PLC control module that allow the user carries out the remote control of the power system. The SCADA control system allows carrying out the most important operations of real power systems such as speed and voltage control of the turbine and synchronous generator, coupling maneuvers of the generator with the mains (synchronization), stand-alone operations with the generator, loads commutation, current and voltage measurements in different points of the system, etc.

The following is a description of the most important modules included in this application:

- Generator Protection and Control Relay Unit: it is an industrial control and protection device of power generator groups with more than 150 configurable variables. The Relay Unit provides different levels of access to be configured. For example, the user can adjust the protection thresholds of overcurrent (50/51), over/under-voltage, over/under-frequency (81), inverse power, over/underspeed of the turbine (12), number of poles of the machine, nominal power, etc. In addition, for more advanced settings, it is possible to set the PID control system parameters under different operation conditions of the turbine-generator group. For example, when the generator is working in stand-alone or in parallel operation modes are used different PIDs. During commissioning of generator the provided software allows monitoring voltage and frequency PID signals, perturbations, analysis and real time settings.

During motor-generator group start-up, it is possible to monitor the PID signals, to analyze the generator disturbances and to remake real time setting adjustments through the provided relay configuration software.

Due to the versatility of the Generator Protection

and Control Relay Unit, Edibon provides configured this device to work properly from scratch with the generator-motor group. In addition, it is provided a relay setting file to restore the relay to the initial configuration. On this way, the user can change any relay parameter and recovery the initial setting.

- Turbine Speed Controller: this device allows controlling manually and automatically the turbine speed. Manual control allows the user to manage the turbine speed through a potentiometer included in this module. On the other hand, automatic control function is carried out by the Generator Protection and Control Relay unit with an analog signal of 0-10V. On this way, the user can either study the whole system operations working autonomously, as a real power station works, or taking the manual control of the system to study the effects of the turbine speed changes in the electrical system.

- Automatic Voltage Regulator: this device is designed for manual and automatic control of the current excitation of the synchronous generator. The regulator has a switch that allows the user to select the control mode. If manual control mode is selected, the current excitation of the synchronous generator can be controlled manually with a potentiometer and the effects of the generator output voltage can be seen. Automatic control mode allows the Generator Protection and Control Relay Unit to take the control of the current excitation.

On this way, the user can study the operation of the complete system working autonomously, as a real power station works, or he can take the control of the installation to study the effects of the excitation change of the synchronous generator in the electrical system.

- Transmission Line Simulation Digital Unit: This module represents basic concepts of the electric energy high-voltage three-phase transmission lines operation. It consists of resistors, inductances and capacitances that can be configured to simulate different transmission lines. Each one of the phases is represented following the concentrated parameters theoretical model, through a resistance series association and inductances, along with a parallel association between each one of them in a capacitance effect. In addition this module has several switches to provoke one, two or three broken lines to study unbalance effects in the electrical system.

- Network Analyzer Unit with Data Acquisition: This device allows measuring all electrical parameters of the synchronous generator such as phase and line voltages, line currents, active, reactive and apparent powers, frequency, harmonics, etc.

- Three-Phase bench of Commutable Resistors Module: this module is designed in order to carry out local consumption of the generated energy by the synchronous generator. This module has three switches to introduce three active power consumption stages.

- Three-Phase bench of Commutable Inductances Module: this module is designed in order to carry out local consumption of the generated energy by the synchronous generator. This module has three switches to introduce three reactive power consumption stages.

- Three-Phase bench of Commutable Inductances Module: this module is designed in order to carry out local consumption of the generated energy by the synchronous generator. This module has three switches to introduce three reactive power consumption stages.

- DC Generator Analyzer. This module allows measuring electrical parameters of the current excitation of the synchronous generator (V, I, P).



AEL-CPSS-01S

Applications:

 AEL-5.6
 Available "Smart Grid Power Systems"

AEL-CPSS-01S Smart Grid Power Systems Application, with Automatic Control Generation, Transmission Line and Loads.

The AEL-CPSS-01S includes the following modules:

- N-ALI01. Industrial Main Power Supply.
- N-WCA5K. 5KW Motor Speed Controller.
- N-EALDC/G. DC Generator Analyzer.
- N-AVR/P. Automatic Voltage Regulator.
- N-ERP-PGC01. Generator Protection and Control Relay Module.
- N-AE1CD. Commutable Transmission Line Simulator.
- N-EALD. Network Analyzer Unit with Computer Data Acquisition. (2 Units)
- N-CAR35T3D. Three-Phase Digital Bank of Commutable Resistors Module.
- N-CAR36T3D. Three-Phase Digital Bank of Commutable Inductances Module.
- N-CAR19T3D. Three-Phase Digital Bank of Commutable Capacitors Module.
- GMG4.5K3PH. 4.5KW Generator-Motor Group.

Required module if the optional SCADA is acquired:

- N-PLC04. PLC04 Control Module.

Required PC if optional SCADA is acquired:

- AEL-PC. Touch Screen and Computer. (to work with the optional SCADA Control System).

Optional SCADA software:

- AEL-CPSS-01S/CCSOF. Computer Control + Data Acquisition + Data Management Software.

Expansion learning software:

In addition, Edibon provides expansion learning software (AEL-CPSS-01S/ICAI) to reinforce knowledge about this field. This software is formed by:

- ECM-SOF. EDIBON Classroom Manager (Instructor Software).
- ESL-SOF. EDIBON Student Labsoft (Student Software).

The application AEL-CPSS-01S is mounted on rack.

This application required the following racks:

- N-RACK-A. (3 units).
- N-RACK-M.
- N-RACK-B (4 units).

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

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

Some practical exercises possibilities:

- 1.-Study of generation power systems.
- 2.-Analysis of the measurements of the power flows of the synchronous generator.
- 3.-Analysis of the active and reactive power of the synchronous generator.
- 4.-Automatic synchronization maneuvers of synchronous generator with the mains.
- 5.-Study of the synchronous generator in island operation mode.
- 6.- Study of the Micro-Grids.
- 7.-Study of the synchronous generator in grid parallel operation mode.
- 8.- Study of excitation/voltage regulation of synchronous generator in island mode.

9.- Study of turbine regulation (frequency control) in island mode.

10.-Study of excitation/voltage regulation of synchronous generator in parallel grid operation mode.

11.-Study of turbine regulation (frequency control) in parallel grid operation mode.

12.-Study of the power factor regulation of synchronous generator in parallel grid operation mode.

Some practical exercises possibilities with the optional SCADA:

13.-Remotely control of generation power systems.

14.-Analysis with the SCADA software of synchronous generator power flows.

15.-Analysis with SCADA software of active and reactive power of synchronous generator.

16.-Remotely control of manual synchronization of synchronous generator with the mains.

17.-Remotely control of automatic synchronization of synchronous generator with the mains.

18.- Remotely control of synchronous generator in island grid operation mode.

19.- Study of Micro-Grids.

20.- Remotely control of synchronous generator in parallel grid operation mode.

21.- Remotely control of excitation/voltage regulation of synchronous generator in island mode.

Other possibilities to be done with this Unit:

22.- Many students view results simultaneously.

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

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

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

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

26.- This unit 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.

For more information see **AEL-CPSS-01S** catalogue. Click on the following link:

www.edibon.com/en/files/equipment/AEL-CPSS-01S/catalog



AEL-CPSS-01S

Applications:

AEL-5.6
Available "Smart Grid Power Systems"

AEL-CPSS-02S. Smart Micro-Grids Power Systems Application, with Automatic Control Generation and Loads.

Micro-grids are modern, small-scale versions of the centralized electricity system. They active specific local goals, such as reliability, carbón emission reduction, diversification of energy sources, and cost reduction, established by the community being served. Like the bulk power

grid, smart micro-grids generate, distribute, and regulate the flow of electricity to consumers, but do so locally. Smart micro-grids are an ideal way to integrate renewable resources on the community level and allow for customer participation in the electricity enterprise.

The Smart Micro-Grids Power System Application, with Automatic Control Generation and Loads, AEL-CPSS-02S has been designed by Edibon for the training at both the theoretical and practical levels in the field of Smart Micro-Grids Energy Systems.

The AEL-CPSS-02S application provides several levels of training to give the user full knowledge and experiences about the most important principles of micro-grid in the context of control, distribution and energy consumption.

For this purpose, this application includes a specific manual, which explains at theoretical level the subjects relating to Micro-Grids Power Systems. The thematic of the manual covers from the coordination of different energy sources working in the same distribution grid up to issues as the protection relays coordination, electric generators control and system response against a black-out to maintain the electricity supply. On the other hand, it is provided a series of modules and options to put into practice all theoretical concepts previously studied in this manual.

One of the advantages of this application is its modularity and flexibility. This allows carry out different Micro-Grids configurations. For example, the user can configure the power system as "Generation + Distribution + Consumption" working with the generator in stand-alone mode or the can be configured with the generator connected to the grid for parallel operation purposes. Electrical generator can be synchronized with the laboratory network to establish an energy delivery network in order to develop a Micro-Grid with one or more energy generation sources.

In functional terms the whole system can be controlled either locally through the operation of switches, breakers and signals, and remotely through the Data Acquisition and Control Software offered optionally.

The AEL-CPSS-02S optionally offers both a Data Control and Data Acquisition Software (AEL-CPSS-02S/CCSOF) and a PLC control module that allow the user carries out the remote control of the Micro-Grid. The SCADA control system allows carrying out the most important operations of real power systems such as speed and voltage control of the turbine and synchronous generator, coupling maneuvers of the generator with the mains (synchronization), stand-alone operations with the generator (micro-grid concept), loads commutation, current and voltage measurements in different points of the system, etc.

In addition the AEL-IOP-01S can be optionally acquired. This application consists of a second motor-generator group with its respective control and measurement modules for parallel operations with several power generation sources. This allows

the user load sharing studies with several generators connected in parallel to supply Micro-Grid.

The following is a description of the most important modules included in this application:

- Generator Protection and Control Relay Unit: it is an industrial control and protection device of power generator groups with more than 150 configurable variables. The Relay Unit provides different levels of access to be configured. For example, protection thresholds such as overcurrent (50/51), over/under-voltage, over/under-frequency (81), inverse power, over/underspeed of the turbine (12), number of poles of the machine and nominal power can be set. In addition, for more advanced settings, it is possible to set the PID control system parameters under different operation conditions of the turbine-generator group.

During motor-generator group start-up, it is possible to monitor the PID signals, to analyze the generator disturbances and to remake real time setting adjustments through the provided relay configuration software.

Due to the versatility of the Generator Protection and Control Relay Unit, Edibon provides configured this device to work properly from scratch with the generator-motor group. In addition, it is provided a relay setting file to restore the relay to the initial configuration. On this way, the user can change any relay parameter and recovery the initial setting.

This device offers the advantage of managing the generator-motor group to supply power autonomously to the micro-grid and, at the same time, it allows synchronizing the generator with the grid to work as a support system.

- Automatic Voltage Regulator: this device is designed for manual and automatic control of the current excitation of the synchronous generator. The regulator has a switch that allows the user to select the control mode. If manual control mode is selected, the current excitation of the synchronous generator can be controlled manually with a potentiometer and the effects of the generator output voltage can be seen. Automatic control mode allows the Generator Protection and Control Relay Unit to take the control of the current excitation.
- Three-Phase bank of Commutable Resistors Module: this module is designed in order to carry out local consumption of the generated energy by the synchronous generator. This module has three switches to introduce three active power consumption stages.
- DC Generator Analyzer. This module allows measuring electrical parameters of the current excitation of the synchronous generator (V, I, P).
- Turbine Speed Controller: this device allows controlling manually and automatically the turbine speed. Manual control allows the user to manage the turbine speed through a potentiometer included in this module. On the other hand, automatic control function is carried out by the Generator Protection and Control Relay unit with an analog signal of 0-10V. On this way, the user can either study the whole system operations working autonomously, as a real power station works, or taking the manual control of the system to study the effects of the turbine speed changes in the electrical system.



AEL-CPSS-02S

Applications:

 AEL-5.6
Available "Smart Grid Power Systems"
AEL-CPSS-02S. Smart Micro-Grids Power Systems Application, with Automatic Control Generation and Loads. (Continuation).

The AEL-CPSS-02S includes the following modules:

- N-AL101. Industrial Main Power Supply.
- N-WVCA5K. 5KW Motor Speed Controller.
- N-EALDC/G. DC Generator Analyzer.
- N-AVR/P. Automatic Voltage Regulator.
- N-ERP-PGC01. Generator Protection and Control Relay Module.
- N-EALD. Network Analyzer Unit with Computer Data Acquisition.
- N-CAR35T3D. Three-Phase Digital Bank of Commutable Resistors Module.
- GMG4.5K3PH. 4.5KW Generator-Motor Group.

Required module if the optional SCADA is acquired:

- N-PLC04. PLC04 Control Module.

Required PC if optional SCADA is acquired:

- AEL-PC. Touch Screen and Computer. (to work with the optional SCADA Control System).

Optional SCADA software:

- AEL-CPSS-02S/CCSOF. Computer Control + Data Acquisition + Data Management Software.

Expansion learning software:

In addition, Edibon provides expansion learning software (AEL-CPSS-02S/ICA) to reinforce knowledge about this field. This software is formed by:

- ECM-SOF. EDIBON Classroom Manager (Instructor Software).
- ESL-SOF. EDIBON Student Labsoft (Student Software).

Optional application:

The AEL-IOP-01S Isolated Parallel Operation application, with SCADA can be acquired as a supplement to AEL-CPSS-02S to study isolated parallel operations with two generators in a Micro-Grid.

The AEL-IOP-01S includes the following modules:

- N-WVCA5K. 5KW Motor Speed Controller.
- N-EALDC/G. DC Generator Analyzer.
- N-AVR/P. Automatic Voltage Regulator.
- N-ERP-PGC01. Generator Protection and Control Relay Module.
- N-EALD. Network Analyzer Unit with Computer Data Acquisition.
- GMG4.5K3PH. 4.5KW Generator-Motor Group.

Required module if the optional SCADA is acquired:

- N-PLC05. PLC05 Control Module.

Required PC if optional SCADA is acquired:

- AEL-PC. Touch Screen and Computer. (to work with the optional SCADA Control System).

The application AEL-CPSS-02S is mounted on rack.

This application required the following racks:

- N-RACK-A.
- N-RACK-M.
- N-RACK-B (4 units).

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

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

Some practical exercises possibilities:

- 1.- Study of generation power systems in Micro-Grids.
- 2.- Analysis of the measurements of the power flows of the synchronous generator in the Micro-Grids.
- 3.- Analysis of the active and reactive power of the generator in the Micro-Grids.
- 4.- Automatic synchronization maneuvers of synchronous generator with the mains.
- 5.- Study of the synchronous generator in island operation mode in Micro-Grids.
- 6.- Study of excitation/voltage regulation of synchronous generator in island mode in Micro-Grids.
- 7.- Study of turbine regulation (frequency control) in the Micro-Grids.
- 8.- Study of excitation/voltage regulation of synchronous in Micro-Grids.
- 9.- Study of the power factor regulation of the synchronous generator in Micro-Grids.

Some practical exercises possibilities with the optional SCADA:

- 10.- Remotely control of generation power systems in Micro-Grids.
 - 11.- Analysis with the SCADA software of synchronous generator power flows in Micro-Grids.
 - 12.- Analysis with SCADA software of active and reactive power of synchronous generator in Micro-Grids.
 - 13.- Remotely control of synchronous generator in Micro-Grids.
- Additional practical exercises possibilities with the Optional Application "AEL-IPO-01S":
- 14.- Control of multiple generator in a standalone network.
 - 15.- Control of multiple generator in parallel generation mode.
 - 16.- Manual/Automatic frequency control of synchronous generators.
 - 17.- Manual/Automatic voltage control of synchronous generators.
 - 18.- Power factor control generator in island mode.

Other possibilities to be done with this Unit:

- 19.- Many students view results simultaneously. To view all results in real time in the classroom by means of a projector or an electronic whiteboard.
 - 20.- The Computer Control System with SCADA allows a real industrial simulation.
 - 21.- This unit is totally safe as uses mechanical, electrical and electronic, and software safety devices.
 - 22.- This unit can be used for doing applied research.
 - 23.- This unit 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.

For more information see **AEL-CPSS-02S** catalogue. Click on the following link:

www.edibon.com/en/files/equipment/AEL-CPSS-02S/catalog



AEL-CPSS-02S

Applications:

AEL-5.6
Available "Smart Grid Power Systems"

AEL-CPSS-03S. Smart Grid Power Systems Application with Two Parallel Generators, Two Distribution Lines and Loads, with SCADA.



AEL-CPSS-03S

A Smart Grid is an advanced electrical grid that uses analog information, digital information and communications technology to gather and act on information about the behavior of suppliers and consumers, in an automated way to improve the efficiency, reliability, economics, and sustain ability of the production and distribution of electricity.

The AEL-CPSS-03S is an application that reflects the most important operations carried out in the actual Smart Grids Power Systems.

- Generation:

Parallel operations with different renewable energy sources.

Real time monitoring and control the demanded energy and the energy production.

Automatic control operations of synchronization.

Parallel operations of hydroelectric, two synchronous generators.

- Transmission:

Transmission and distribution flow powers. Energy losses.

Distribution transformer with voltage regulator.

Parallel distribution lines.

- Consumption:

Active, capacitive and inductive loads.

Automatic power factor compensation.

Feeder protection relay.

This application shows different operations of an entire power system, from the energy is generated until it reaches the final consumer.

In the generation field, the students will learn how work different generation systems from three different sources: conventional energy source like carbon, fuel, gas, etc.; hydroelectric source, wind source.

The AEL-CPSS-03S includes a SCADA Control System that will allows the users supervise, control and manage the generation, transmission and consumption electrical system:

- Disconnecter and circuit breakers control.
- Data Acquisition of all electrical parameters of the system.
- Manual and automatic control of the generators.

The AEL-CPSS-03S includes the following modules:

- N-ALI01. Industrial Main Power Supply.
- N-TRANS3/1KR. Three-Phase Regulation Transformer. (2 units)
- N-ERP-MA01. Feeder Management Relay Module.
- N-ERP-MF01. Digital Fault Simulator Module.
- N-AE1/1K. 1KVA Transmission Line Simulator Module (2 units)
- N-EALD. Network Analyzer Unit with Data Acquisition Unit.(3 units)
- N-PSM. Power Switch Module. (4 units).

- N-ERP-PGC01. Generator Protection Relay Module.
- N-AVR/P. Automatic Voltage Regulator.
- N-SERV1K. 1 kW Servomotor Module.(2 units)
- N-EALDC/G. DC Generator Analyzer.
- EMT6B/1K. 1 kW three-phase Synchronous generator.
- EMT7B/1K. 1 kW three-phase Asynchronous motor of squirrel cage.
- N-CFP. Advanced Power Factor Controller.
- N-CAR19T4D. Three-Phase Digital Capacitor Banks Module.
- N-CAR35T3/1.2K. 1.2 kW Three-Phase Step-Variable Resistor Load Module.
- N-CAR36T3/0.9K. 0.9 kW Three-Phase Step-Variable Inductive Load Module.
- N-CAR35T3/0.8K. 0.8 kW Three-Phase Step-Variable Capacitive Load Module.
- N-GINV300. 300W Three-Phase Grid Inverter.
- LP3. 3 lamps panel.
- FVP96. 96W Photovoltaic Panel.
- AEL-WBR. Electrical Workbench (Rack).
- AEL-WBMG. Electrical Mobile Workbench (2 units).
- AEL-PC. Touch Screen and Computer.
- SCADA (Supervision, Control and Data Acquisition).

Expansion learning software:

In addition, Edibon provides expansion learning software (AEL-CPSS-03S/ICA1) to reinforce knowledge about this field. This software is formed by:

- ECM-SOF. EDIBON Classroom Manager (Instructor Software).
- ESL-SOF. EDIBON Student Labsoft (Student Software).

The application AEL-CPSS-03S is mounted on rack.

This application required the following racks:

- N-RACK-A. (9 units)

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

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

Applications:

AEL-5.6
Available "Smart Grid Power Systems"

AEL-CPSS-03S. Smart Grid Power Systems Application with Two Parallel Generators, Two Distribution Lines and Loads, with SCADA. (Continuation).

Some practical exercises possibilities:

- 1.- Study of synchronous machine in stand-alone operation mode.
- 2.- Study of parallel operation with one synchronous generator and the grid.
- 3.- Study of parallel operation with two synchronous generators and the grid.
- 4.- Study of parallel operation with two synchronous generators: load sharing.
- 5.-Study of micro-grids.
- 6.-Study of manual power factor compensation.
- 7.-Study of automatic power factor compensation.
- 8.-Study of brushless motors.
- 9.-Study of transformers: step-up voltage transformer, step-down voltage transformer, energy losses, voltage regulation.
- 10.-Study of drop voltages in transmission lines according to the line lengths.
- 11.-Study of the main operations of the protection relay: phase instantaneous overcurrent element 50P, negative sequence overcurrent element 50Q, Time-overcurrent element 51P, overvoltage element 59P and many other parameters.
- 12.-Study of different short circuit tests: single pole, two pole, two pole to ground and three-phase short circuits.
- 13.-Wiring of photovoltaic system.
- 14.-Checking the photovoltaic system with feed to the power grid.
- 15.-Measurement of energy production by the photovoltaics panel.
- 16.-Finding the Maximum Power Point.
- 17.-Minimum power of the photovoltaic inverter.
- 18.-Losses of the power grid inverter.
- 19.-Visualizing the electrical parameters of the photovoltaic panel through SCADA Control System.
- 20.-System's response in case of power outage on the grid.

Other possibilities to be done with this Unit:

- 21.-Many students view results simultaneously.

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

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

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

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

25.-This unit 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.

For more information see **AEL-CPSS-03S** catalogue. Click on the following link:

www.edibon.com/en/files/equipment/AEL-CPSS-03S/catalog



AEL-CPSS-03S

Applications:

AEL-5.6
Available "Smart Grid Power Systems"

- APS12. **Advanced Mechanical, Electrical and Smart Grid Power Systems (Utilities).**
www.edibon.com/en/files/equipment/APS12/catalog
- AEL-MPSS-01. **Modular Smart Grid Power Systems Simulator, with Automatic Control Generation, Transmission Line, Loads and Protection Relays, with SCADA.**
www.edibon.com/en/files/equipment/AEL-MPSS/catalog
- AEL-MPSS-02. **Modular Smart Grid Power Systems Simulator, with Automatic Control Generation, Transmission Line and Loads, with SCADA.**
www.edibon.com/en/files/equipment/AEL-MPSS/catalog
- AEL-MPSS-03. **Modular Smart Grid Power Systems Simulator, with Manual Control Generation, Transmission Line, Loads and Protection Relays, with SCADA.**
www.edibon.com/en/files/equipment/AEL-MPSS/catalog
- AEL-MPSS-04. **Modular Smart Grid Power Systems Simulator, with Manual Control Generation, Transmission Line and Loads, with SCADA.**
www.edibon.com/en/files/equipment/AEL-MPSS/catalog

ALL Advanced Electrical Laboratories (AEL-LABS)

AEL-1. ELECTRICAL INSTALLATIONS LAB		
AEL-1.1. Home Electrical Installations	AEL-1.2. Industrial Electrical Installations	AEL-1.3. Professional Wiring Practices in Installations
<p style="text-align: center;"><u>Applications</u></p> <p style="text-align: center;">Lighting and Control</p> <ul style="list-style-type: none"> • AEL-AD13. Audio Door Entry System. • AEL-AD14. Audio and Video Door Entry System. • AEL-AD6A. Luminosity Control Station. • AEL-AD6B. Basic Luminosity Control Station. • AEL-AD24. Position Switch. • AEL-AD5. Stair Lights Timing. • AEL-AI13-E. Modular Trainer for Electrotechnics (Lighting). <p style="text-align: center;">Climatization</p> <ul style="list-style-type: none"> • AEL-AD9A. Heating Control Station. • AEL-AD9B. Basic Heating Control Station. 	<p style="text-align: center;"><u>Applications</u></p> <p style="text-align: center;">Industrial Control Engineering</p> <ul style="list-style-type: none"> • AEL-CM1. Manual Control Operations. • AEL-CM2. Operations with Manual Commutators. • AEL-CM3. Automatic Control Operations. • AEL-CM4. Automatic Control Operations with contactors and sensors. <p style="text-align: center;">Fault Simulators</p> <ul style="list-style-type: none"> • AEL-AD33. Single-Phase Installations Faults Simulator. • AEL-AD33T. Three-Phase Installations Faults Simulator. <p style="text-align: center;">Relays Trainer</p> <ul style="list-style-type: none"> • AEL-AE4. Test Unit for Differential Automatic Switches. • AEL-AE5. Relay Control Station. • AEL-PRTS. Protective Relaying Training System. <p style="text-align: center;">Loads</p> <ul style="list-style-type: none"> • AEL-AI13-A. Modular Trainer for Electrotechnics (RLC Circuits). • AEL-MED. Industrial Measurement Technology. 	<p style="text-align: center;"><u>Applications</u></p> <p style="text-align: center;">Cubicle Wiring Installations</p> <ul style="list-style-type: none"> • AEL-AEBI. Assembly Exercises in Building Installations. • AEL-AEBM. Assembly Exercises on Building Mains Feeds and Meter Cabinets. • AEL-AESI. Assembly Exercises for Signals Electrical Installations. • AEL-AESU. Assembly Exercises on Switching Units.
<div style="border: 1px solid black; padding: 5px; display: inline-block;"> See catalogue of: AEL-1. Electrical Installations Lab www.edibon.com/en/files/equipment/AEL-1/catalog </div>		

AEL-2. HOME AUTOMATION SYSTEMS LAB	
AEL-2.1. Wired Systems	AEL-2.2. Wireless Systems
<p style="text-align: center;"><u>Applications</u></p> <p style="text-align: center;">General Wired Home Automation Systems</p> <ul style="list-style-type: none"> • AEL-AD1A. Robbery Alarm Station. • AEL-AD1B. Basic Robbery Alarm Station. • AEL-AD3A. Fire Alarm Station. • AEL-AD3B. Basic Fire Alarm Station. • AEL-AD15A. Position Control Station. • AEL-AD15B. Basic Position Control Station. • AEL-AD25A. Control Station for Home Electric Service through the telephone. • AEL-AD22. Flooding Control Station. • AEL-AD30. Gas Control Station. • AEL-AD31. Movement and Sound Detection and Control. • AEL-AD40. Remote Control Station Via Telephone. <p style="text-align: center;">KNX/EIB Systems</p> <ul style="list-style-type: none"> • AEL-KNX1. KNX/EIB Lighting and Shutter Control System. • AEL-KNX2. KNX/EIB Heating Control System. • AEL-KNX3. KNX/EIB Robbery Alarm System. • AEL-KNX4. KNX/EIB Fire Alarm System. • AEL-BCS. BacNet Systems. 	<p style="text-align: center;"><u>Applications</u></p> <p style="text-align: center;">General Wired Home Automation Systems</p> <ul style="list-style-type: none"> • AEL-AD28A. Integral Control Station of Home Electric Systems. • AEL-AD28B. Basic Control Station of Home Electric Systems. • AEL-AD28C. Elementary Control Station of Home Electric Systems. • AEL-AD23. Wireless Basic Control Station (RF).
<div style="border: 1px solid black; padding: 5px; display: inline-block;"> See catalogue of: AEL-2. Home Automation Systems Lab www.edibon.com/en/files/equipment/AEL-2/catalog </div>	

AEL-3. ELECTRICAL MACHINES LAB

<p style="text-align: center;">AEL-3.1. Electrical Machines Trainers</p>	<p style="text-align: center;">AEL-3.2. Electrical Machines Applications</p>
<p style="text-align: center;"><u>Applications</u></p> <p style="text-align: center;">Transformers Trainers</p> <ul style="list-style-type: none"> • AEL-SPTT. Single-Phase Transformer Trainer. • AEL-TPTT. Three-Phase Transformer Trainer. • AEL-AI13-D. Modular Trainer for Electrotechnics (Transformers). <p style="text-align: center;">Generators/Motors Trainers</p> <p style="text-align: center;"><u>General Trainers</u></p> <ul style="list-style-type: none"> • AEL-EEEM. Energy Efficiency in Electrical Motors. • AEL-EMSS. Electrical Machines Soft Starter. • AEL-EMCF. Electrical Machines Control through Frequency Controller. • AEL-AI13. Modular Trainer for Electrotechnics (RLC Circuits, Electrostatics, Motors, Transformers, Lighting). • AEL-AI13-C. Modular Trainer for Electrotechnics (Motors). • AEL-EMRP. Electrical Machines Relays Protection Trainer. • AEL-SERIN/CA-1k. Computer Controlled Advanced Industrial Servo systems Trainer- 1 kW (for AC Motors). • AEL-MMRT. Motor Management Relays Trainer. • AEL-AI12. Modular Application (AC Motors). • AEL-IMSU. General Applications of AC Induction Motors • AEL-PRTS. Protective Relaying Training System. <p style="text-align: center;"><u>AC Machines</u></p> <p style="text-align: center;">Synchronous Machines</p> <ul style="list-style-type: none"> • AEL-EEA. Alternator Study Unit. • AEL-EGMG24. Motor-Generator Group. <p style="text-align: center;">Asynchronous Machines</p> <ul style="list-style-type: none"> • AEL-ACEMT. AC Electrical Motors Trainer. - Option 1 (EMT7): Study of Three-Phase Asynchronous Motor of Squirrel cage. - Option 2 (EMT8): Study of Three-Phase Asynchronous Motor of wound rotor. - Option 3 (EMT9): Study of Three-Phase Dahlander Motor. - Option 4 (EMT10): Study of Asynchronous three-phase motor of two independent speeds. - Option 5 (EMT11): Study of Asynchronous single-phase motor with starting capacitor. - Option 6 (EMT12): Study of Universal Motor - Option 7 (EMT16): Study of Asynchronous single-phase motor with starting and running capacitor. - Option 8 (EMT20): Study of Asynchronous single-phase motor with split phase. - Option 9 (EMT21): Study of Three-Phase Reluctance Motor. <p style="text-align: center;"><u>DC Machines</u></p> <ul style="list-style-type: none"> • AEL-DCEMT. DC Electrical Motors Trainer. - Option 1 (EMT1): Study of DC Machine with independent excitation. - Option 2 (EMT2): Study of DC Machine with Series excitation. - Option 3 (EMT3): Study of DC Machine with shunt excitation. - Option 4 (EMT4): Study of DC Machine with Compound excitation. - Option 5 (EMT5): Study of all types of DC Machines. <p style="text-align: center;">Faults Trainers</p> <ul style="list-style-type: none"> • AEL-ESAM. Faults Simulation Trainer in Electrical Motors. • AEL-ESAT. Faults Simulation Trainer in Transformers. 	<p style="text-align: center;"><u>Applications</u></p> <p style="text-align: center;">Generators/Motors Applications</p> <ul style="list-style-type: none"> • AEL-ACINA. Applications of AC Three-Phase Induction Motors of Squirrel Cage. • AEL-ACDHA. Applications of AC Dahlander Three-Phase Induction Motors. • AEL-ACWRA. Applications of AC Three-Phase Induction Motors of Wound Rotor. • AEL-ACLA. Applications of AC Linear Motor Operations. • AEL-DCSEA. Applications of DC Series Motors. • AEL-DCSHA. Applications of DC Shunt Motors. • AEL-DCCOA. Applications of DC Compound Motors. • AEL-DCSPA. Applications of DC Separately Excited Motors. • AEL-DCGEA. Applications of DC Generators. • AEL-UMA. Applications of Universal Motors. • AEL-STMA. Applications of Stepper Motors. • AEL-DCPMA. Applications of DC Permanent Magnet Motors. • AEL-DCBRA. Applications of DC Brushless Motors. • AEL-ACRLA. Applications of AC Three-Phase Reluctance Motors. • AEL-ACSPA. Applications of Asynchronous Single-Phase Motor with Split Phase. • AEL-AI12. Modular Application (AC Motors). • AEL-IMSU. General Applications of AC Induction Motors. <p style="text-align: center;"><u>AC Machines</u></p> <p style="text-align: center;">Synchronous Machines</p> <ul style="list-style-type: none"> • AEL-EEA. Alternator Study Unit. • AEL-EGMG24. Motor-Generator Group. <p style="text-align: center;">Asynchronous Machines</p> <ul style="list-style-type: none"> • AEL-ACEMA. AC Electrical Motors Application - Option 1 (EMT7): Study of Three-Phase Asynchronous Motor of Squirrel cage. - Option 2 (EMT8): Study of Three-Phase Asynchronous Motor of wound rotor. - Option 3 (EMT9): Study of Three-Phase Dahlander Motor. - Option 4 (EMT10): Study of Asynchronous three-phase motor of two independent speeds. - Option 5 (EMT11): Study of Asynchronous single-phase motor with starting capacitor. - Option 6 (EMT12): Study of Universal Motor - Option 7 (EMT16): Study of Asynchronous single-phase motor with starting and running capacitor. - Option 8 (EMT20): Study of Asynchronous single-phase motor with split phase. - Option 9 (EMT21): Study of Three-Phase Reluctance Motor. <p style="text-align: center;"><u>DC Machines</u></p> <ul style="list-style-type: none"> • AEL-DCEMA. DC Electrical Motors Application - Option 1 (EMT1): Study of DC Machine with independent excitation - Option 2 (EMT2): Study of DC Machine with Series excitation - Option 3 (EMT3): Study of DC Machine with shunt excitation - Option 4 (EMT4): Study of DC Machine with Compound excitation - Option 5 (EMT5): Study of all types of DC Machines. - Option 6: (EMT15): Study of Permanent Magnet DC Motor. - Option 7: (EMT1): Study of DC Generator. • AEL-STMA. Applications of Stepper Motors. • AEL-DCBRA. Applications of DC Brushless Motors.
<p>See catalogue of: AEL-3. Electrical Machines Lab www.edibon.com/en/files/equipment/AEL-3/catalog</p>	

AEL-4. ELECTROMECHANICAL CONSTRUCTIONS LAB

**AEL-4.1.
Electrical Machines Construction**

Applications

Dissectible and Configurable Electrical Motors Application

- AEL-EMT-KIT. Advanced Dissectible and Configurable Electrical Machines.

Wiring & Construction of Motors, Generators and Transformers

- AEL-MGTC. Motors, Generators and Transformers Construction Application.
- AEL-TPTC. Three-Phase Transformer Construction Kit.

Disassembly Motors

- AEL-DMG-KIT. Disassembly Motors-Generators Kit.
- AEL-DIM-KIT. 4 Disassembly Induction Motors Kit.

**AEL-4.2.
Electrical Motors Construction**

Applications

Cut Away Electrical Motors

- EMT1 -S. Cut away DC independent excitation motor-generator.
- EMT2-S. Cut away DC series excitation motor-generator.
- EMT3-S. Cut away DC shunt excitation motor-generator.
- EMT4-S. Cut away DC compound excitation motor-generator.
- EMT5-S. Cut away DC shunt-series compound excitation motor.
- EMT6-S. Cut away AC synchronous three-phase motor alternator.
- EMT7-S. Cut away asynchronous three-phase motor of squirrel cage.
- EMT8-S. Cut away asynchronous three-phase motor with wound rotor.
- EMT9-S. Cut away Dahlander three-phase motor.
- EMT10-S. Cut away asynchronous three-phase motor of two independent speeds.
- EMT11-S. Cut away asynchronous single-phase motor with starting capacitor.
- EMT12-S. Cut away universal motor.
- EMT14-S. Cut away repulsion motor, single-phase with short circuited brushes.
- EMT15-S. Cut away DC permanent magnet motor.
- EMT16-S. Cut away asynchronous single-phase motor with starting and running capacitor.
- EMT17-S. Cut away asynchronous three-phase motor of squirrel cage with "Y" connection.
- EMT18-S. Cut away DC Brushless motor.
- EMT19-S. Cut away stepper motor.
- EMT20-S. Cut away asynchronous single-phase motor with split phase.
- EMT21-S. Cut away three-phase reluctance motor.
- EMT22-S. Cut away single-phase shaded pole motor.

Transparent and Functional Electrical Motors

- AEL-FTM. Transparent and Functional Motors Application
- AEL-EMT1-T. Transparent and functional DC independent excitation motor-generator.
- AEL-EMT2-T. Transparent and functional DC series excitation motor-generator.
- AEL-EMT3-T. Transparent and functional DC shunt excitation motor-generator.
- AEL-EMT4-T. Transparent and functional DC compound excitation motor-generator.
- AEL-EMT5-T. Transparent and functional DC shunt-series compound excitation motor-generator.
- AEL-EMT6-T. Transparent and functional AC synchronous three-phase motor alternator.
- AEL-EMT7-T. Transparent and functional asynchronous three-phase motor of squirrel cage.
- AEL-EMT8-T. Transparent and functional asynchronous three-phase motor with wound rotor.
- AEL-EMT9-T. Transparent and functional Dahlander three-phase motor.
- AEL-EMT10-T. Transparent and functional asynchronous three-phase motor of two independent speeds.
- AEL-EMT11-T. Transparent and functional asynchronous single-phase motor with starting capacitor.
- AEL-EMT12-T. Transparent and functional universal motor.
- AEL-EMT14-T. Transparent and functional repulsion motor, single-phase with short circuited brushes.
- AEL-EMT16-T. Transparent and functional asynchronous single-phase motor with starting and running capacitor.
- AEL-EMT17-T. Transparent and functional asynchronous three-phase motor of squirrel cage with "Y" connection.
- AEL-EMT20-T. Transparent and functional asynchronous single-phase motor with split phase.
- AEL-EMT21-T. Transparent and functional three-phase reluctance motor.
- AEL-EMT22-T. Transparent and functional single-phase shaded pole motor.

See catalogue of: **AEL-4. Electromechanical Constructions Lab**
www.edibon.com/en/files/equipment/AEL-4/catalog

AEL-5. POWER SYSTEMS AND SMART GRID TECHNOLOGY LAB

AEL-5.1.

Generation Trainers

Applications

Basic Synchronization Applications

- AEL-MOSC. Manual Operations of Synchronization Circuits.

Advanced Synchronization Applications

- AEL-EESD. Advanced Digital Synchronization Trainer.

Wind Energy

- AEL-WPP. Wind Power Plants with Double Feed Induction Generator.
- AEL-WPT. Wind Power Trainer with Permanent Magnets Synchronous Generator.
- AEL-WPPI. Wind Power Plants with Induction Generator.

Photovoltaic Energy

- AEL-PHVG. Photovoltaic Application with Connection to Grid.

Fuel Cell Energy

- AEL-FCLL. Fuel Cell Energy Trainer.

Power Plants

- AEL-EPP. Energy Power Plants Trainer.
- AEL-HPPP. Hydroelectric Power Plants Trainer with Pelton Turbine.
- AEL-MEPD. Marine Electrical Power Distribution System.
- TDEGC. Computer Controlled Diesel Engine Electricity Generator.

Basic Smart Grid Power Systems

- AEL-BSG. Basic Smart Grid Trainer.
- AEL-BSGC. Basic Smart Grid Trainer, with SCADA.
- AEL-MGR. Micro-Grids Power System Series.

Microgrid Series

AEL-5.2.

Distribution and Transmission Trainers

Applications

Distribution and Transmission Trainers

- AEL-AE1A. Aerial Line Model.
- AEL-TI-01. Analysis of Three-phase Power Lines.
- AEL-TI-02. Distribution Transformer with Motor Regulation.
- AEL-TI-03. Arc suppression Coil.
- AEL-TI-04. Underground Transmission lines.
- AEL-TI-05. Parallel and Series Transmission Lines.
- AEL-TI-06. Analysis of flow power on Transmission Lines.
- AEL-TI-07. Transmission Systems with Synchronous Generator.
- AEL-SST-01. Basic Operations in Switching Transmission Substation Trainer.
- AEL-SST-02. Switching Substation Protection Trainer.
- AEL-HVDC. High Voltage DC Transmission Lines.

AEL-5.3.

Loads Trainers

Applications

Basic Load Controller Trainers

- AEL-MRPC. Manual Reactive Power Compensation.
- AEL-ARPC. Automatic Reactive Power Compensation.
- AEL-EECFP. Advanced Power Factor Compensation.
- AEL-APFC. Single-phase Automatic Power Factor Compensation.
- AEL-DLT. Dynamic Loads Trainer.

Advanced Loads Control

- AEL-FUSG. Final User Smart Grid Trainer.
- AEL-FUSG-M. Final User Smart Grid-Smart Meter Trainer.
- AEL-FUSG-E. Final User Smart Grid-Smart Energy Trainer.
- AEL-FUSG-N. Final User Smart Grid-Net Metering Trainer.

AEL-5.4.

Protection Relays Trainers

Applications

Fundamental Concepts

- AEL-CTFP. Current Transformer Fundamentals for Protections Devices.
- AEL-VTFP. Voltage Transformer Fundamentals for Protections Devices.

Protection Trainers Relays

- ERP. Protection Relays Test Trainer.
- ERP-CBM. Cybersecurity Module.

Protection Systems for Generators

- AEL-GPRE. Generator Protection Relay Trainer.

Protection Systems for Transmission and Distribution Lines

- AEL-TPT-01. Overcurrent Time Protection Relay for Lines.
- AEL-TPT-02. Directional Overcurrent Protection Relay for Transmission Lines.
- AEL-TPT-03. Overvoltage and Undervoltage Protection Relay.
- AEL-TPT-04. Directional Power Protection Relay.
- AEL-TPT-05. Earth-Fault Voltage Protection Relay.
- AEL-TPT-06. Parallel Transmission Lines Protection Relay.
- AEL-TPT-07. High Speed Distance Protection Relay.

AEL-5.5

Cybersecurity Trainers

Applications

- ERP-CBM. Cybersecurity Module.

AEL-5.6.

Available "Smart Grid Power Systems"

Applications

- APS12. Advanced Mechanical, Electrical and Smart Grid Power Systems (Utilities).
- AEL-MPSS-01. Modular Smart Grid Power Systems Simulator, with Automatic Control Generation, Transmission Line, Loads and Protection Relays, with SCADA.
- AEL-MPSS-02. Modular Smart Grid Power Systems Simulator, with Automatic Control Generation, Transmission Line and Loads, with SCADA.
- AEL-MPSS-03. Modular Smart Grid Power Systems Simulator, with Manual Control Generation, Transmission Line, Loads and Protection Relays, with SCADA.
- AEL-MPSS-04. Modular Smart Grid Power Systems Simulator, with Manual Control Generation, Transmission Line and Loads, with SCADA.
- AEL-CPSS-01S. Smart Grid Power Systems Application, with Automatic Control Generation, Transmission Line and Loads.
- AEL-CPSS-02S. Smart Micro-Grids Power Systems Application, with Automatic Control Generation and Loads.
- AEL-CPSS-03S. Smart Grid Power Systems Application with Two Parallel Generators, Two Distribution Lines and Loads, with SCADA.

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



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