edibon

Engineering and Technical
Teaching Equipment

Pumping Storage Power Plants Application,
with SCADA
AEL-GAD-01S

EDIBON PATENT

Teaching Technique used

EDIBON **SCADA** System

②
Software for:
- Computer Control
- Data Acquisition
- Data Management

Computer
(not included in the supply)
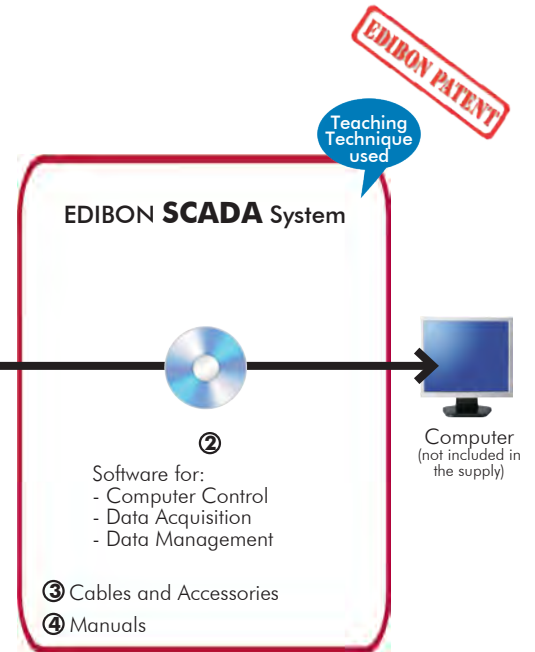
③ Cables and Accessories
④ Manuals

① Unit: AEL-GAD-01S. Pumping Storage Power Plants Application, with SCADA

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

Key features:

➤ **Advanced Real-Time SCADA.**

➤ **Open Control + Multicontrol + Real-Time Control.**

➤ **Specialized EDIBON Control Software based on LabVIEW.**

➤ **National Instruments Data Acquisition board (250 KS/s, kilo samples per second).**

➤ **Calibration exercises, which are included, teach the user how to calibrate a sensor and the importance of checking the accuracy of the sensors before taking measurements.**

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

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

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

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

➤ **Designed and manufactured under several quality standards.**

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

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

OPEN CONTROL
+
MULTICONTROL
+
REAL TIME CONTROL

POWERED BY
NATIONAL INSTRUMENTS
LabVIEW

www.edibon.com
⤷PRODUCTS
 ⤷4.- ELECTRICITY

For more information about Key Features, click here

PDF Adobe   You Tube

INTRODUCTION

Hydroelectric power plants have the purpose of taking advantage of the potential energy, contained in the mass of water by means of a level difference, to convert it into electrical energy through alternators.

The principle of Pumped Hydro Storage (PHS) is to store electrical energy by utilizing the potential energy of water.

In periods of low demand and high availability of electrical energy, the water will be pumped and stored in an upper reservoir/pond. On demand, the energy can be released respectively and transformed into electrical power within a short reaction time. Because of this, PHS can adjust the demand supply to balance respectively reduce the gap between peak and off-peak periods, and play an important role of leveling other power generation plants and stabilizing of the power grid.

GENERAL DESCRIPTION

The Pumping Storage Power Plant Application, with SCADA, "AEL-GAD-01S", has been developed by Edibon to study the pumped storage power stations and their applications.

Pumping Storage Power Plants Applications are a type of hydroelectric energy storage used by electric power systems for load balancing. The method stores energy in the form of gravitational potential energy of water, pumped from a lower elevation reservoir to a higher elevation. Low-cost off-peak electric power is used to run the pumps. During periods of high electrical demand, the stored water is released through turbines to produce electric power. Although the losses of the pumping process makes the plant a net consumer of energy overall, the system increases revenue by selling more electricity during periods of peak demand, when electricity prices are highest.

The AEL-GAD-01S includes all the necessary modules to simulate and study the operation of a hydroelectric pumping power plants and it different elements. This application includes a synchronous generator, a servo machine and an electric motor with dynamic brake.

The generator in combination with the servo machine allows us to simulate and control the generation through the multifunction relay/controller as if it was a real representation of the generation stage of a hydroelectric power plant. Furthermore, the squirrel cage induction motor and the dynamic brake system, in addition to the frequency control we apply over it, allows us to represent the pumping stage of a pumped storage power plant. As a whole, this application permits simulating in a laboratory scale a real pumped storage plant.

The energy produced by the synchronous generator is consumed by a three-phase induction motor with a dynamic brake which in conjunction with the SCADA let us represent simulated energy demand curves as a real portrayal of the energy consumption of a population nucleus or a whole electric system.

Control modules are included in order to accomplish a safe synchronization, protection and accuracy control.

This application includes an SCADA Control Software to simulate how the electrical energy is produced and stored. This software permits understand how the potential energy of water is converted into electrical power which is then fed back into the grid.

In addition, the SCADA control software includes programming functions for optimum management of the pumping station. This software allows the representation of a real demand curve (simulated) for subsequent energy planning from it, thus reproducing the energy management of a real network.

The "GAD-01S-UB" is the base unit of the "AEL-GAD-01S" application.

The "GAD-01S-UB" includes the following elements:

- N-ALI01. Industrial Main Power Supply.

- SERV01. AC Servomotor 1.

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

- N-PSUB2. Power Generation Substation Module 2.

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

- N-EALD/A. Advanced Network Analyzer Module. (4 units).

- EMT7/1K. 1kW/1P Asynchronous Three-Phase Motor of Squirrel Cage. (2 units).

- N-EDDB/3PH. Three-Phase Electrical Drive System with Dynamic Brake. (2 units).

- N-PSM. Power Switch Module. (2 units).

Required element/s to operate with "GAD-01S-UB" unit:

- AEL-PC. Touch Screen and Computer.

Recommended elements and kits of the "GAD-01S-UB" unit:

- N-ASYB. Basic Synchronization Module.
- GAD-01S-K1. 1KVA 3PH RLC Loads Kit.
  - 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.

The application AEL-GAD-01S can be mounted on rack (option A) or on rail (option B):

Option A:

This application needs the following racks:

- N-RACK-B (5 units).

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

Option B:

This application can be mounted on rail.

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

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

PROCESS DIAGRAM AND UNIT ELEMENTS ALLOCATION
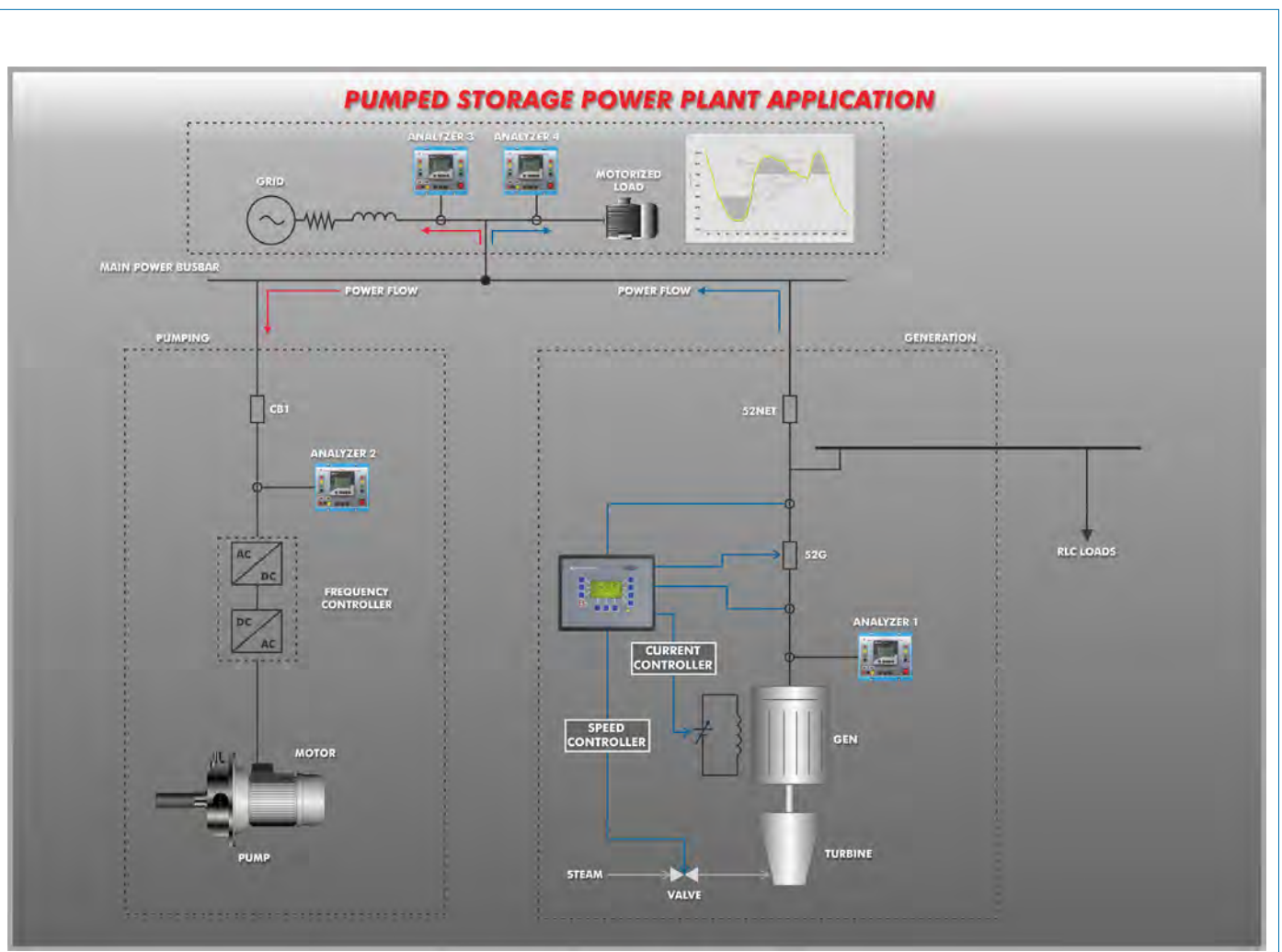
With this unit there are several options and possibilities:
  - Main items: 1, 2, 3 and 4.
  - Optional items: 5, 6 and 7.
Let us describe first the main items (1 to 4):

① **AEL-GAD-01S Application.**

• N-ALI01. **Industrial Main Power Supply.**
   Supply voltage: 400 VAC, 3PH+N+G.
   ON-OFF removable key.
   Output voltage connections:
      Three-Phase + Neutral: 400 VAC.
      Single-Phase: 230 VAC.
   Three-Phase supply hose with IP44 3PN+E 32A 400 V connecting plug.
   Differential magnetothermal, 4 poles, 25 A, 300 mA AC 6 KA.
   Emergency stop push button.
   GND terminal.

N-ALI01

• SERV01. **AC Servomotor 1.**
   Nominal power: 2000 W.
   Nominal voltage: 400V AC.
   Nominal speed: 3000 rpm.
   Nominal current: 5 A.

SERV01

• EMT6/1K. **1kW/1P Three-Phase Synchronous Generator.**
   Nominal power: 1000 VA.
   Power factor: 0.8.
   Nominal Voltage: 3x 400 VAC.
   Terminals for connection configuration: Δ/Y
   Terminals to connect DC excitation.
   Frequency: 50/60 Hz.
   RPM: 3000 rpm.
   Nominal Current: 0.8 A.
   Excitation Current: 5 A.

EMT6/1K

• N-PSUB2. **Power Generation Substation Module 2.**
   Supply voltage: 400 VAC, 3PH+N+G.
   ON/OFF switch.
   Power and signals connection:
      Auxiliary connection.
      Three-phase turbine supply hose with IP44 3PN+E 32A 400V connecting plug.
      Three-phase generator supply hose with IP44 3PN+E 32A 400V connecting plug.
   Three switches to choose between the different modes:
      Local and remote control mode.
      Manual and automatic speed control.
      Manual and automatic excitation control
   Three control switches to:
      Start and stop the turbine.
      Give permission to synchronize the generator with the grid.
      Give permission to close 52NET circuit breaker.
   Two potentiometers to regulate:
      Turbine speed.
      Generator excitation.
   Emergency stop button.
   Two circuit breakers for synchronization and stand-alone operations.
   Different terminals to measure.
   Ethernet connection: RJ45 communication port for SCADA remote control.

N-PSUB2

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

    Automatic speed and voltage controller (easygen):

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

        Enables to connect a generator in parallel with the grid.

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

        Analogical outputs to control voltage and frequency regulators.

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

        Three-phase measurement of the generator intensity and power.

        Single-phase measurement of the grid intensity.

    Protection system.

    Generator:

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

    Network:

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

    Six alarms:

        Alarm 1: Reverse power.

        Alarm 2: Overcurrent.

        Alarm 3: Over/undervoltage.

        Alarm 4: Inverse Time Overcurrent.

        Alarm 5: Over/under frequency.

        Alarm 6: Shutdown Alarms.

    Four operation signals:

        Ready for operation.

        Start request.

        Synchronization conditions.

        Permission for synchronization.

    Back-up protections:

        Current relay.

        Reverse Power relay.

    Ethernet connection: RJ45 communication port.

N-PPCM1

• N-EALD/A. **Advanced Network Analyzer Module (4 units).**

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

    Features:

        Multifunctional three-phase power meter:

            Single and three-phase voltage. Up to 690 VAC L-L.

            Phase and line current. Current range up to 200%. Measurement from 0-10 A.

            Active, reactive and apparent power.

            Suitable frequencies: 25 Hz, 50 Hz, 60 Hz y 400 Hz.

            Display of the V-I vector diagram.

            Supply voltage: 85-265 VAC.

        Energy quality control:

            Current and voltage individual harmonics measurement. Up to the 40th harmonic.

            THD voltage and current, TDD and K-factor.

            Maximums and minimums display.

            Waveforms display, 128 samples/sec.

        Events and data storage.

        Harmonics analyzer:

            THD voltage and current, TDD current and K-factor, up to the 40th harmonic.

            Current and voltage harmonic spectrum and angles.

        Tariff programming:

            Class 0.5S IEC 62053-22, active and reactive power in four quadrants.

            Measurement of the total and per phase three-phase active, reactive and apparent powers.

            Usage time, 4 energy/demand records of total tariffs.

            8 tariffs, 4 seasons, 4 types of days.

            Automatic daily report of energy consumption maximums and minimums.

        Communications:

            Modbus TCP communication protocol with Ethernet interface.

N-EALD/A

Complete Technical Specifications (for main items)

- **EMT7/1K. 1kW/1P Asynchronous Three-Phase Motor of Squirrel Cage (2 units).**
  Nominal power: 1100 W.
  Nominal voltage: 3 x 230/400 VAC Δ/Y.
  Frequency: 50/60 Hz
  Number of poles: 2.
  Speed: 2730 rpm.
  Nominal current: 2.52 / 1.45 A

EMT7/1K

- **N-EDDB/3PH. Three-Phase Electrical Drive System with Dynamic Brake (2 units).**
  Controller:
    ON/OFF Switch.
    Supply voltage: 230 VAC.
    Nominal power: 750 W.
    Power output terminals:
      230 VAC/PWM VAC.
    Potentiometer for the induction motor control speed.
    Potentiometer for the dynamic brake control braking torque.
    Setting and visualization display of the machine parameters.
    GND terminal.
  Dynamic Brake:
    Nominal Torque: 5 Nm.
    Maximum Power Dissipation: 100 W.
    Maximum output current adjustment.
    Operating modes "freewheel "and "blocking".
    Maximum power consumed: 70 W.

N-EDDB/3PH

- **N-PSM. Power Switch Module (2 units).**
  Supply voltage: single-phase 230V AC.
  Power terminals:
    Four power input terminals (3PH+N).
    Four power output terminals (3PH+N).
  Auxiliary contacts:
    One "NO" contact.
    One "NC" contact.
  Two push-buttons to open / close the power terminals and auxiliary contacts.
  Two control contacts of 24V DC.
  Two voltage supply outputs of 24V DC.

N-PSM

- **AEL-PC. Touch Screen and Computer.**
  Touch Screen:
    Energy efficiency class: A.
    Screen diagonal: 68.6 cm (27 inch (s)).
    Power consumption (operating): 26 watts.
    Annual energy consumption: 38 kWh.
    Power consumption (standby / off) 0.49 watts.
    Screen resolution: 1920 x 1080 pixels.
  Computer:
    Processor Number: Intel Core i7-6600U Processor (4M Cache, up to 3,40 GHz).
    Cache: 4 MB Intel Smart Cache.
    Clock speed: 2.6 GHz.
    # Of Cores/# of Threads: 2/4.
    Max. TDP/Power: 15 W.
    Memory Types: DDR4-2133, LPDDDR3-1866, DDR3L-1600.
    Graphics: Intel HD Graphics 530.Slot for PCI Express.

AEL-PC

Complete Technical Specifications (for main items)

- N-ASYB. **Basic Synchronization Module.**
    Supply voltage: 230 VAC.
    Input terminals:
        Generation input terminals L1, L2, L3 and N.
    Output terminals:
        Network input terminals L1, L2, L3 and N.
    Synchronization switch:
        2x 24 VDC connections.
    Digital synchroscope.
    Double frequency meter.
    Double voltmeter.
    400 VAC Lamps.
    GND terminal.

N-ASYB

- N-CAR35T3D. **Three-Phase Digital Bank of Commutable Resistors Module.**
    Nominal Voltage: 400 VAC.
    Supply Voltage: 230 VAC.
    Resistors: 3x (3 x 150) Ohms.
    Nominal power: 3x (3 x 300) W.
    Fuses: 6x 5 A.
    GND terminal.

N-CAR35T3D

- N-CAR36T3D. **Three-Phase Digital Bank of Commutable Inductances Module.**
    Nominal Voltage: 400 VAC.
    Supply Voltage: 230 VAC.
    Configurable connections: Y and Δ.
    Commutable Inductances: 3x (3x5) H.
    Nominal power: 3x (3 x 300) Var.
    Fuses: 6x 5 A.
    Ethernet Connection.
    GND terminal.

N-CAR36T3D

- N-CAR19T3D. **Three-phase Digital Banks of Commutable Capacitors Module.**
    Configurable Star and Delta connection.
    Three Banks with three-phase capacitors of 2 μF each one.
    Nominal voltage: 400 VAC.
    Nominal power: 3 x (3 x 300) VAr.

N-CAR19T3D

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

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② **AEL-GAD-01S/CCSOF. Computer Control + Data Acquisition + Data Management Software:**

The three softwares are part of the SCADA system.

Compatible with actual Windows operating systems. Graphic and intuitive simulation of the process in screen. **Compatible with the industry standards.**

Registration and visualization of all process variables in an automatic and simultaneous way.

Flexible, open and multicontrol software, developed with actual windows graphic systems, acting simultaneously on all process parameters.

Management, processing, comparison and storage of data.

It allows the registration of the alarms state and the graphic representation in real time.

Comparative analysis of the obtained data, after the process and modification of the conditions during the process.

Open software, allowing the teacher to modify texts, instructions. Teacher's and student's passwords to facilitate the teacher's control on the student, and allowing the access to different work levels.

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

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

④ **Manuals:**

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

∗ References 1 to 4 are the main items: AEL-GAD-01S + AEL-GAD-01S/CCSOF + Cables and Accessories + Manuals are included in the minimum supply for enabling normal and full operation.

AEL-GAD-01S/CCSOF

EXERCISES AND PRACTICAL POSSIBILITIES TO BE DONE WITH THE MAIN ITEMS

1.- How pumping storage power plants operate.

2.- Characteristic curves and electrical machines performances.

3.- Hydropower plant functioning as generator.

4.- Hydropower plant functioning as pumped storage plant.

5.- Study of the power consumption curves and the regulation of a hydroelectric plant involves in the grid.

6.- Start and synchronization of synchronous generator.

7.- Power regulation: both in generator and motor modes.

8.- Semi-automatic active and reactive power control.

9.- Smart grid integration of pumped storage power plants.

10.- Fully-automatic compensation for externally measured active and reactive power.

11.- SCADA open and closed-loop system control.

12.- Transference of manual to automatic voltage regulation operations.

13.- Transference of manual to automatic frequency regulation operations.

14.- Studying of the power factor regulation of synchronous generator in parallel grid operation.

15.- Studying of turbine regulation (frequency control) in parallel grid mode.

16.- Analysis of active and reactive power.

17.- Automatic control of active power.

18.- Studying of the micro-grids.

19.- Overcurrent protection.

20.- Overvoltage and undervoltage protection of the synchronous generator.

21.- Reverse power protection.

22.- Plotting of the demand curve forecast with SCADA software for the subsequent planning of the production capacity of a pumping hydroelectric plant.

23.- Operations as a power grid manager for demand/generation planning. Parameterization of the maximum and minimum power thresholds of the hydroelectric plant for energy injection at peak times and for pumping at off-peak times.

24.- Smart energy management for monitoring changes in the actual demand curve. Regulation performed by the pumping hydroelectric plant in the system for changes in the demand curve.

Some practical exercises possibilities with the base unit GAD-01S-UB and the basic synchroscope:

25.- Visualization of parameters through a synchroscope for the study of the synchronism condition between the generator and the grid.

Some practical exercises possibilities with the base unit GAD-01S-UB and GAD-01S-K1:

26.- Study of the consumption of isolated loads from the three stages of a resistive commutable load.

27.- Study of the consumption of isolated loads from the three stages of an inductive commutable load.

28.- Study of the consumption of isolated loads from the three stages of a capacitive commutable load.

29.- Compensation of reactive power and adjustment of the power factor by means of a capacitive commutable load bank.

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.

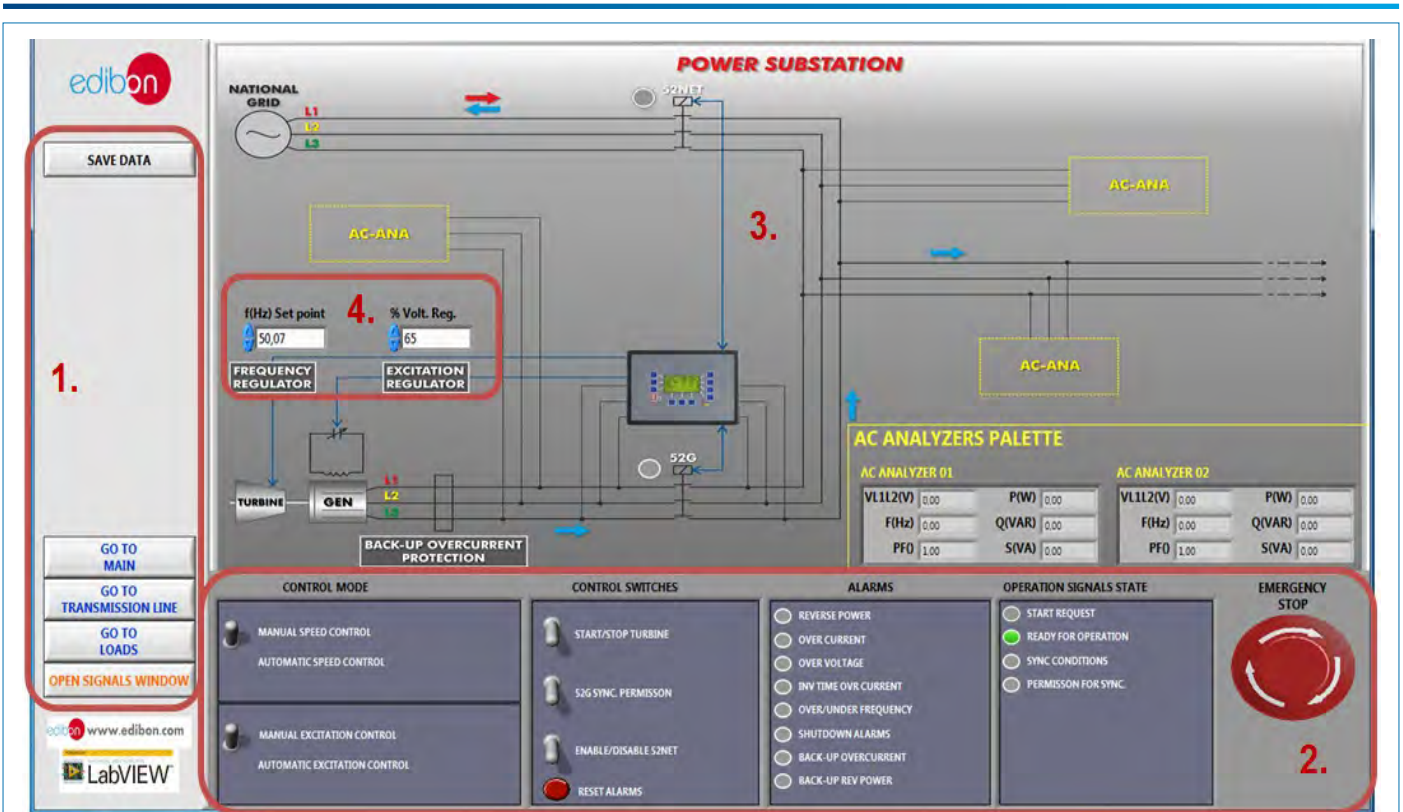- Several other exercises can be done and designed by the user.

REQUIRED SERVICES

- Electrical supply: three-phase, 380 VAC – 400 VAC/50 Hz or 190 VAC – 240 VAC/60 Hz, 1 kW.
- Computer.

DIMENSIONS AND WEIGHTS

AEL-GAD-01S:
- Dimensions: 2000 x 400 x 2000 mm approx.
  (78.74 x 15.75 x 78.74 inches approx.)
- Weight: 85 Kg approx.
  (187 pounds approx.)

① Navigation menu and save data button.

② **Power substation control panel:** - Manual / Automatic Speed Control switch. - Manual / Automatic Excitation Control switch. - Control switches group: Start/Stop turbine, 52G synchronization permission, Enable/Disable 52NET and reset alarms. - Alarms monitoring: Revers power, over current, over voltage, inverse time over current, over frequency, shutdown alarms, back-up over current and back-up reverse power. - Operation signals state: start request, ready for operation, sync conditions, permission for sync. - Emergency stop.

③ **Diagram of the power substation.** In the right of the screen has an "AC analyzers palette" with the measures of the network analyzers. These analyzers can be moved to different positions.

④ **Manual speed and voltage control regulators.**

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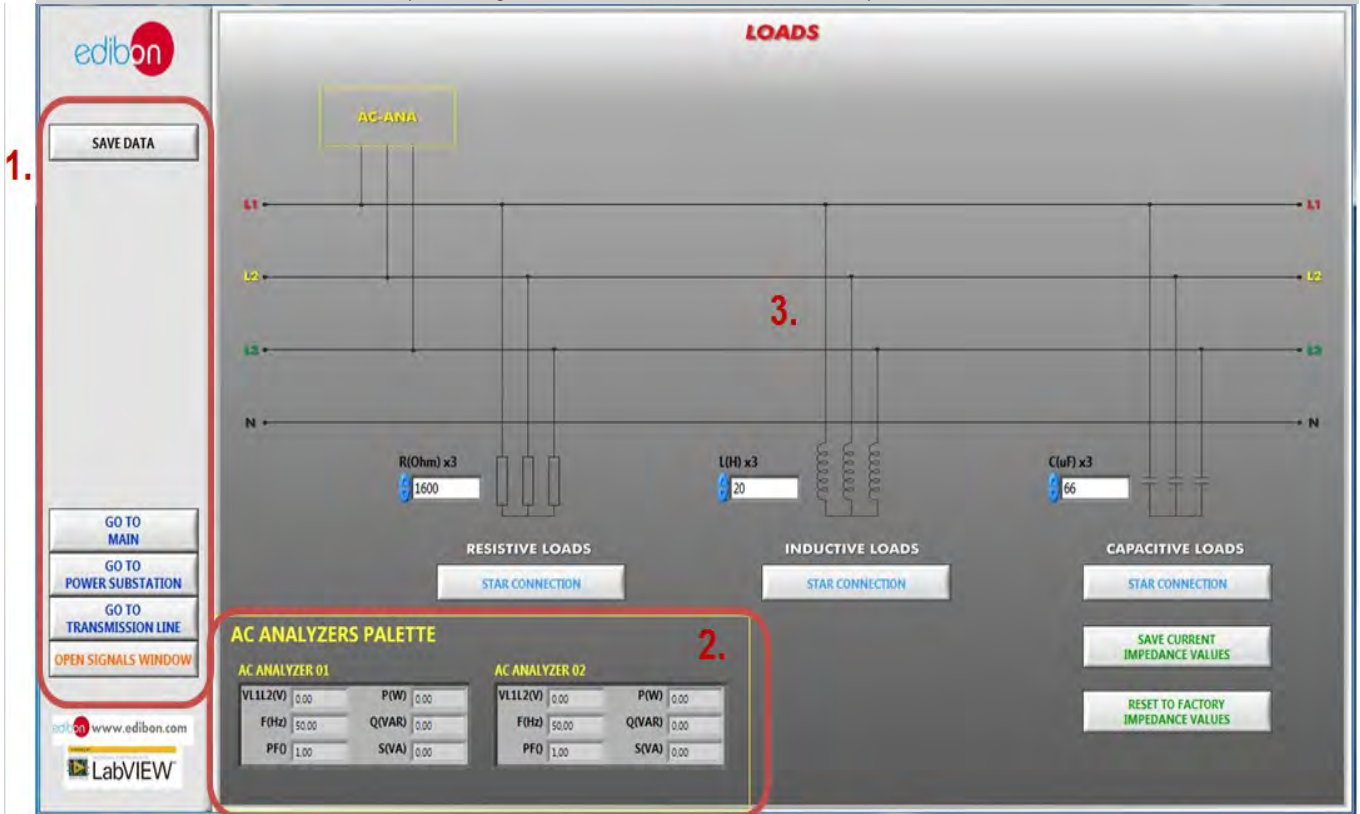

① Navigation menu and save data button.

② **AC analyzers palette.** It shows the measures taken by the analyzers. The analyzers can be moved to the positions named as AC-ANA in the three-phase diagram.

③ **Diagram of the loads.** It has nine push-buttons for remote control of resistive, inductive and capacitive loads commutation.

Some **real** results obtained from this Unit

Waveform plot of the real time currents and voltages measured by the analyzer, showing the angular, maximum, minimum and RMS values, and the phasors corresponding to such electrical parameters.
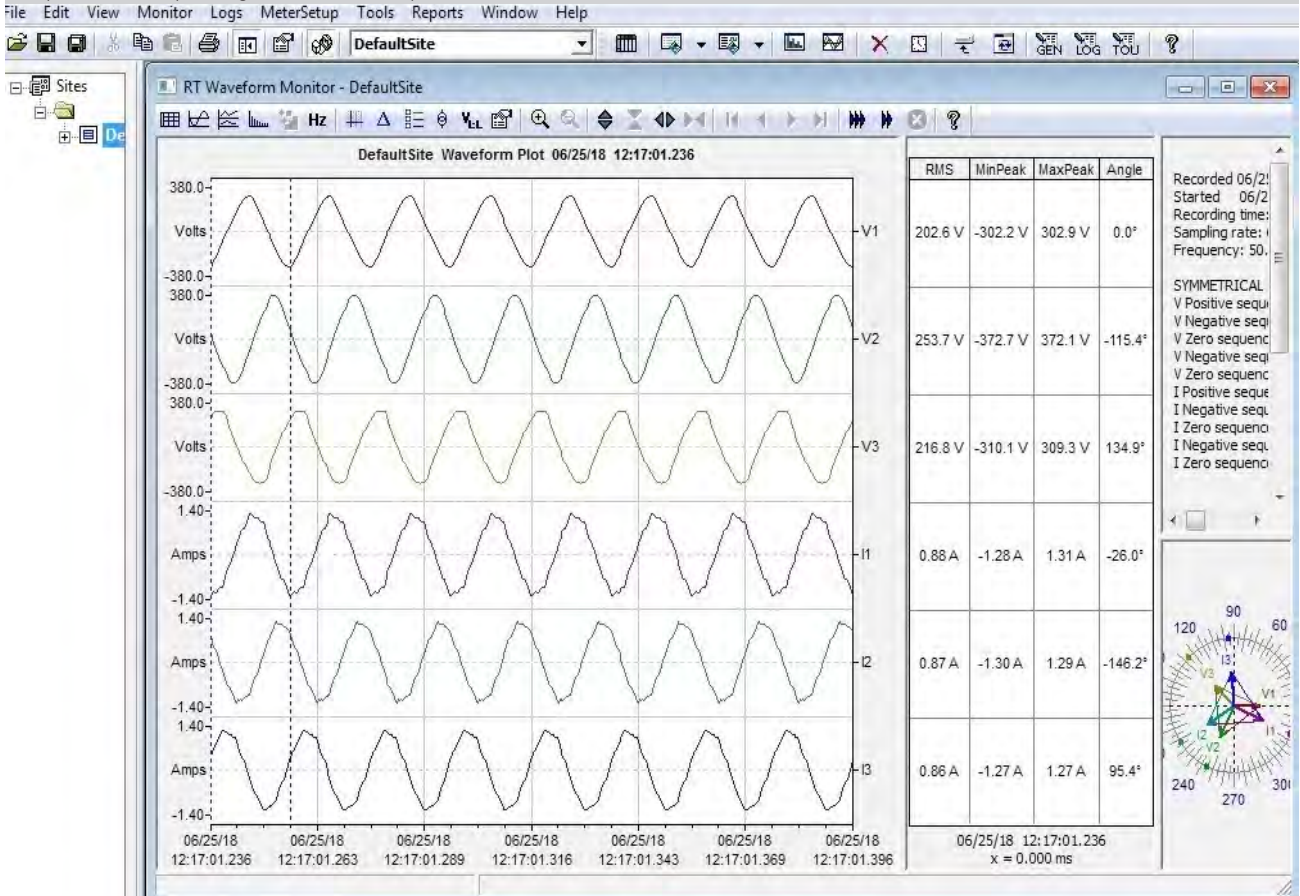
Representation of the torque-speed curve for the Three-Phase Asynchronous Squirrel Cage Motor. Notice that the motor nominal speed and the maximum torque can be appreciated.
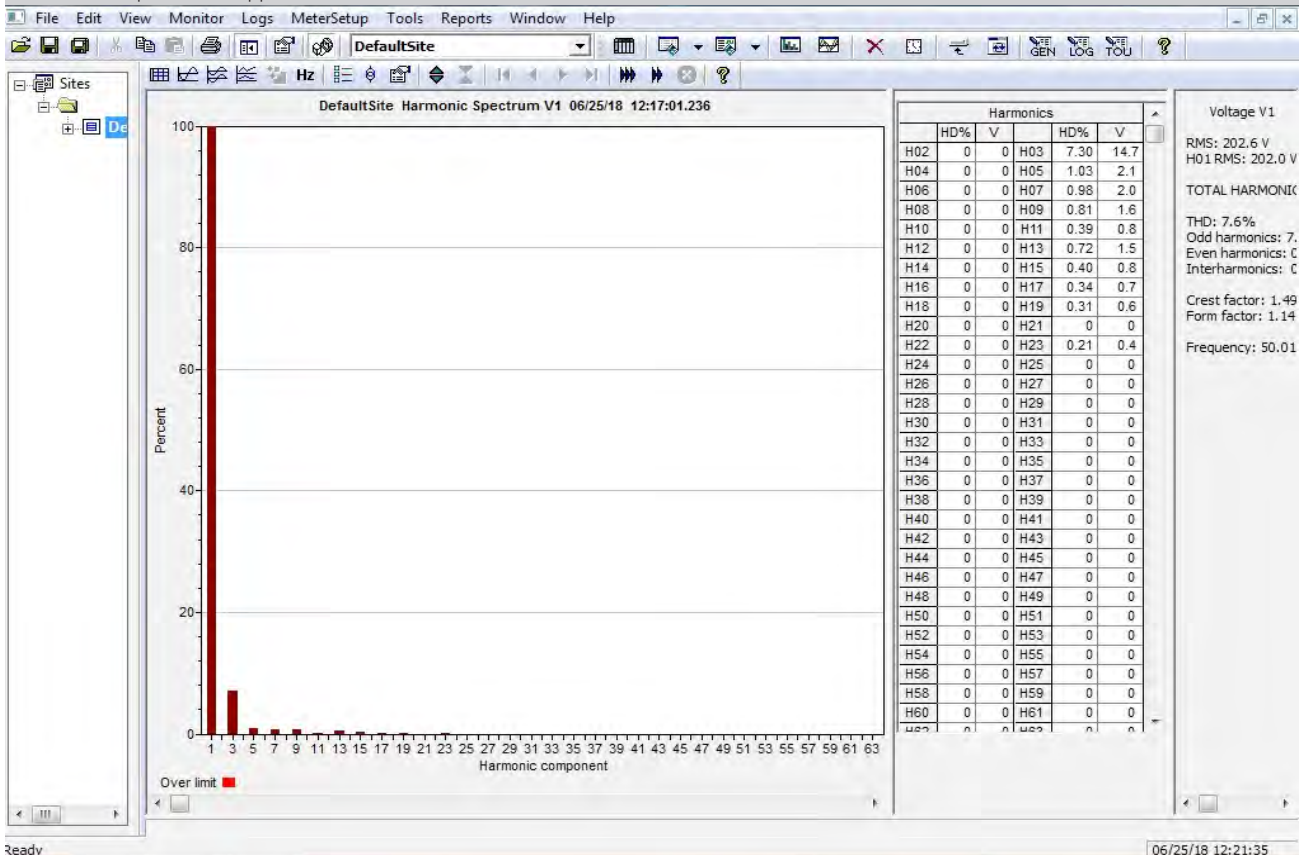
Some **real** results obtained from this Unit

Programming of the demand curve by manually plotting the curve. Subsequently, the behavior of the dynamic brake and the induction motor will be adapted to the shape of the curve.

① Starting command signal of the pumping system to increase the power consumption as a base load.

② Stop command signal of the pumping system when exceeding the minimum level of power demand.

③ Starting command signal of the hydroelectric plant. At peak loads the value of the energy is higher and the injection of electrical power is carried out to cover the demand.

④ Stop command signal of the generation system when exceeding the minimum level of power demand.

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

All these items try to give more possibilities for:

    a) Technical and Vocational Education configuration. (ICAI)

    b) Multipost Expansions options. (MINI ESN and ESN)

<u>a) Technical and Vocational Education configuration</u>

⑤ **AEL-GAD-01S/ICAI. Interactive Computer Aided Instruction Software System.**

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

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

<u>Instructor Software</u>

- 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.

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

ECAL. EDIBON Calculations Program Package - Formula Editor Screen

Innovative features:

• **User Data Base Management.**

• **Administration and assignment of Workgroup, Task and Training sessions.**

• **Creation and Integration of Practical Exercises and Multimedia Resources.**

• **Custom Design of Evaluation Methods.**

• **Creation and assignment of Formulas & Equations.**

• **Equation System Solver Engine.**

• **Updatable Contents.**

• **Report generation, User Progression Monitoring and Statistics.**

ERS. EDIBON Results & Statistics Program Package - Student Scores Histogram
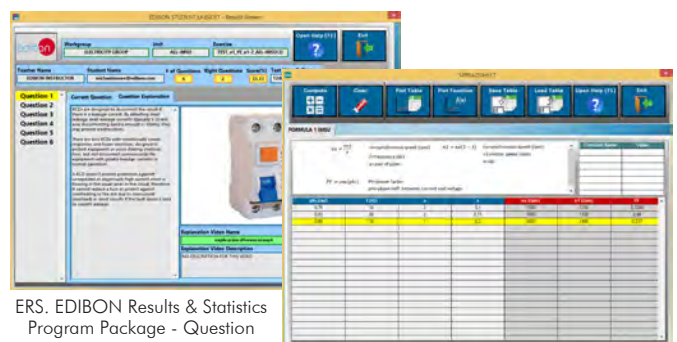
ETTE. EDIBON Training Test & Exam Program Package - Main Screen with Numeric Result Question

- 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.

<u>Student Software</u>

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

EPE. EDIBON Practical Exercise Program Package Main Screen

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.**

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/expansion/ICAI/catalog

Complete Technical Specifications (for optional items)

<u>b) Multipost Expansions options</u>

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

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

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

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

<u>Main characteristics:</u>

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

<u>Main advantages:</u>

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

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

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

MINI ESN. EDIBON Mini Scada-Net System

1 UNIT= up to 30 STUDENTS can work simultaneously

Pumping Storage Power Plants Application, with SCADA (AEL-GAD-01S)

Software for:
- Computer Control
- Data Acquisition
- Data Management

Instructors' Central Computer

Mini Scada-Net Software

LOCAL NET FOR 30 STUDENTS

OPEN CONTROL + MULTICONTROL + REAL TIME CONTROL + MULTI STUDENT POST

Note: The MINI ESN system can be used with any EDIBON computer controlled unit

⑦ **ESN. EDIBON Scada-Net Systems.**

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

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

www.edibon.com/en/files/expansion/ESN/catalog
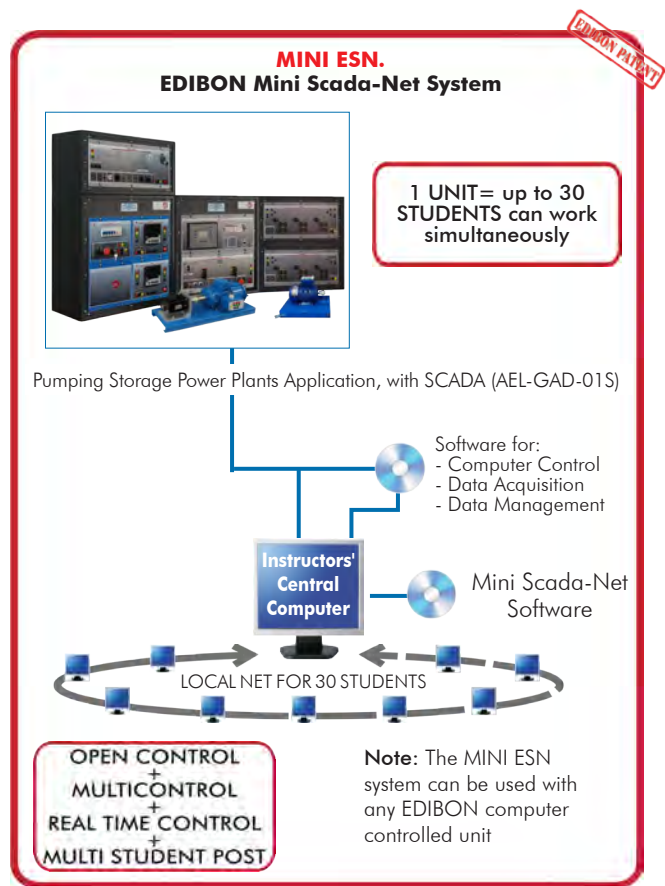
Main items (always included in the supply)

Minimum supply always includes:

① Unit: AEL-GAD-01S. Pumping Storage Power Plants Application, with SCADA.

② AEL-GAD-01S/CCSOF. Computer Control + Data Acquisition + Data Management Software.

③ Cables and Accessories, for normal operation.

④ Manuals.

*IMPORTANT: Under AEL-GAD-01S we always supply all the elements for immediate running as 1, 2, 3 and 4.

Optional items (supplied under specific order)

a) Technical and Vocational Education configuration

⑤ AEL-GAD-01S/ICAI. Interactive Computer Aided Instruction Software System.

b) Multipost Expansions options

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

⑦ ESN. EDIBON Scada-Net Systems.

①**AEL-GAD-01S Application.**
   • N-ALI01. Industrial Main Power Supply.
      Supply voltage: 400 VAC, 3PH+N+G.
      ON-OFF removable key.
      Output voltage connections:
         Three-Phase + Neutral: 400 VAC.
         Single-Phase: 230 VAC.
      Three-Phase supply hose with IP44 3PN+E 32A 400 V connecting plug.
      Differential magnetothermal, 4 poles, 25 A, 300 mA AC 6 KA.
      Emergency stop push button.
      GND terminal.
   • SERV01. AC Servomotor 1.
      Nominal power: 2000 W.
      Nominal voltage: 400V AC.
      Nominal speed: 3000 rpm.
      Nominal current: 5 A.
   • EMT6/1K. 1kW/1P Three-Phase Synchronous Generator.
      Nominal power: 1000 VA.
      Power factor: 0.8.
      Nominal Voltage: 3x 400 VAC.
      Terminals for connection configuration: Δ/Y
      Terminals to connect DC excitation.
      Frequency: 50/60 Hz.
      RPM: 3000 rpm.
      Nominal Current: 0.8 A.
      Excitation Current: 5 A.
   • N-PSUB2. Power Generation Substation Module 2.
      Supply voltage: 400 VAC, 3PH+N+G.
      ON/OFF switch.
      Power and signals connection:
         Auxiliary connection.
         Three-phase turbine supply hose with IP44 3PN+E 32A 400V connecting plug.
         Three-phase generator supply hose with IP44 3PN+E 32A 400V connecting plug.
      Three switches to choose between the different modes:
         Local and remote control mode.
         Manual and automatic speed control.
         Manual and automatic excitation control
      Three control switches to:
         Start and stop the turbine.
         Give permission to synchronize the generator with the grid.
         Give permission to close 52NET circuit breaker.
      Two potentiometers to regulate:
         Turbine speed.
         Generator excitation.
      Emergency stop button.
      Two circuit breakers for synchronization and stand-alone operations.
      Different terminals to measure.
      Ethernet connection: RJ45 communication port for SCADA remote control.
   • N-PPCM1. Control and Protection of Turbine-Generator Group Module 1.
      Automatic speed and voltage controller (easygen):
         Enables to connect up to 16 electric generators in parallel-island with distribution of active and reactive load and start/stop in function of the load demand.
         Enables to connect a generator in parallel with the grid.
         Enables different switches control modes, such as opening, closing and synchronization.
         Analogical outputs to control voltage and frequency regulators.
         Three-phase measurement of the grid and the generator voltage.
         Three-phase measurement of the generator intensity and power.
         Single-phase measurement of the grid intensity.
      Protection system.
      Generator:
         Maximum/minimum voltage (59/27), maximum/minimum frequency (81O/U), voltage asymmetry, detection of dead busbars, overvoltage (32), load unbalance (46), negative sequence power/reduced power (32R/F), overcurrent by defined curve (50/51), inverse time overcurrent (IEC255), measured ground fault (50N/51N), phase rotation, switches faults.
      Network:
         Maximum/minimum voltage (59/27), maximum/minimum frequency (81O/U), vector jump, phase rotation.
      Six alarms:
         Alarm 1: Reverse power.
         Alarm 2: Overcurrent.
         Alarm 3: Over/undervoltage.
         Alarm 4: Inverse Time Overcurrent.
         Alarm 5: Over/under frequency.
         Alarm 6: Shutdown Alarms.
      Four operation signals:
         Ready for operation.
         Start request.
         Synchronization conditions.
         Permission for synchronization.
      Back-up protections:
         Current relay.
         Reverse Power relay.
      Ethernet connection: RJ45 communication port.

Tender Specifications (for main items)

- N-EALD/A. Advanced Network Analyzer Module (4 units).
  The network analyzer module allows fulfilling measurements, displaying and analyzing all the parameters of the AC electrical networks. It has an LCD screen and push-buttons for the navigation through the different menus. It includes specific software for monitoring current and voltage curves, harmonics display, tariffs programming, alarms programming and electrical parameters storage.
  Features:
  - Multifunctional three-phase power meter:
    - Single and three-phase voltage. Up to 690 VAC L-L.
    - Phase and line current. Current range up to 200%. Measurement from 0-10 A.
    - Active, reactive and apparent power.
    - Suitable frequencies: 25 Hz, 50 Hz, 60 Hz y 400 Hz.
    - Display of the V-I vector diagram.
    - Supply voltage: 85-265 VAC.
  - Energy quality control:
    - Current and voltage individual harmonics measurement. Up to the 40th harmonic.
    - THD voltage and current, TDD and K-factor.
    - Maximums and minimums display.
    - Waveforms display, 128 samples/sec.
  - Events and data storage.
  - Harmonics analyzer:
    - THD voltage and current, TDD current and K-factor, up to the 40th harmonic.
    - Current and voltage harmonic spectrum and angles.
  - Tariff programming:
    - Class 0.5S IEC 62053-22, active and reactive power in four quadrants.
    - Measurement of the total and per phase three-phase active, reactive and apparent powers.
    - Usage time, 4 energy/demand records of total tariffs.
    - 8 tariffs, 4 seasons, 4 types of days.
    - Automatic daily report of energy consumption maximums and minimums.
  - Communications:
    - Modbus TCP communication protocol with Ethernet interface.
- EMT7/1K. 1kW/1P Asynchronous Three-Phase Motor of Squirrel Cage (2 units).
  - Nominal power: 1100 W.
  - Nominal voltage: 3 x 230/400 VAC Δ/Y.
  - Frequency: 50/60 Hz
  - Number of poles: 2.
  - Speed: 2730 rpm.
  - Nominal current: 2.52 / 1.45 A.
- N-EDDB/3PH. Three-Phase Electrical Drive System with Dynamic Brake (2 units).
  - Controller:
    - ON/OFF Switch.
    - Supply voltage: 230 VAC.
    - Nominal power: 750 W.
    - Power output terminals:
      - 230 VAC/PWM VAC.
    - Potentiometer for the induction motor control speed.
    - Potentiometer for the dynamic brake control braking torque.
    - Setting and visualization display of the machine parameters.
    - GND terminal.
  - Dynamic Brake:
    - Nominal Torque: 5 Nm.
    - Maximum Power Dissipation: 100 W.
    - Maximum output current adjustment.
    - Operating modes "freewheel "and "blocking".
    - Maximum power consumed: 70 W.
- N-PSM. Power Switch Module (2 units).
  - Supply voltage: single-phase 230V AC.
  - Power terminals:
    - Four power input terminals (3PH+N).
    - Four power output terminals (3PH+N).
  - Auxiliary contacts:
    - One "NO" contact.
    - One "NC" contact.
  - Two push-buttons to open / close the power terminals and auxiliary contacts.
  - Two control contacts of 24V DC.
  - Two voltage supply outputs of 24V DC.
- AEL-PC. Touch Screen and Computer.
  - Touch Screen:
    - Energy efficiency class: A.
    - Screen diagonal: 68.6 cm (27 inch (s)).
    - Power consumption (operating): 26 watts.
    - Annual energy consumption: 38 kWh.
    - Power consumption (standby / off) 0.49 watts.
    - Screen resolution: 1920 x 1080 pixels.
  - Computer:
    - Processor Number: Intel Core i7-6600U Processor (4M Cache, up to 3,40 GHz).
    - Cache: 4 MB Intel Smart Cache.
    - Clock speed: 2.6 GHz.
    - # Of Cores/# of Threads: 2/4.
    - Max. TDP/Power: 15 W.
    - Memory Types: DDR4-2133, LPDDDR3-1866, DDR3L-1600.
    - Graphics: Intel HD Graphics 530.Slot for PCI Express.

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- N-ASYB. Basic Synchronization Module.
    Supply voltage: 230 VAC.
    Input terminals:
        Generation input terminals L1, L2, L3 and N.
    Output terminals:
        Network input terminals L1, L2, L3 and N.
    Synchronization switch:
        2x 24 VDC connections.
    Digital synchroscope.
    Double frequency meter.
    Double voltmeter.
    400 VAC Lamps.
    GND terminal.
- N-CAR35T3D. Three-Phase Digital Bank of Commutable Resistors Module.
    Nominal Voltage: 400 VAC.
    Supply Voltage: 230 VAC.
    Resistors: 3x (3 x 150) Ohms.
    Nominal power: 3x (3 x 300) W.
    Fuses: 6x 5 A.
    GND terminal.
- N-CAR36T3D. Three-Phase Digital Bank of Commutable Inductances Module.
    Nominal Voltage: 400 VAC.
    Supply Voltage: 230 VAC.
    Configurable connections: Y and Δ.
    Commutable Inductances: 3x (3x5) H.
    Nominal power: 3x (3 x 300) Var.
    Fuses: 6x 5 A.
    Ethernet Connection.
    GND terminal.
- N-CAR19T3D. Three-phase Digital Banks of Commutable Capacitors Module.
    Configurable Star and Delta connection.
    Three Banks with three-phase capacitors of 2 μF each one.
    Nominal voltage: 400 VAC.
    Nominal power: 3 x (3 x 300) VAr.
- All necessary cables to realize the practical exercises are included.

The complete unit includes as well:

Advanced Real-Time SCADA.

Open Control + Multicontrol + Real-Time Control.

Specialized EDIBON Control Software based on LabVIEW.

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

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

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

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

Designed and manufactured under several quality standards.

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

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

④**AEL-GAD-01S/CCSOF. Computer Control +Data Acquisition+Data Management Software:**
The three softwares are part of the SCADA system.
Compatible with the industry standards.
Flexible, open and multicontrol software, developed with actual windows graphic systems, acting simultaneously on all process parameters.
Management, processing, comparison and storage of data.
It allows the registration of the alarms state and the graphic representation in real time.
Open software, allowing the teacher to modify texts, instructions. Teacher's and student's passwords to facilitate the teacher's control on the student, and allowing the access to different work levels.
This unit allows the 30 students of the classroom to visualize simultaneously all the results and the manipulation of the unit, during the process, by using a projector or an electronic whiteboard.

⑤**Cables and Accessories**, for normal operation.

⑥**Manuals:**
This unit is supplied with 7 manuals: Required Services, Assembly and Installation, Control Software, Starting-up, Safety, Maintenance & Practices Manuals.

Exercises and Practical Possibilities to be done with the Main Items

1.- How pumping storage power plants operate.

2.- Characteristic curves and electrical machines performances.

3.- Hydropower plant functioning as generator.

4.- Hydropower plant functioning as pumped storage plant.

5.- Study of the power consumption curves and the regulation of a hydroelectric plant involves in the grid.

6.- Start and synchronization of synchronous generator.

7.- Power regulation: both in generator and motor modes.

8.- Semi-automatic active and reactive power control.

9.- Smart grid integration of pumped storage power plants.

10.- Fully-automatic compensation for externally measured active and reactive power.

11.- SCADA open and closed-loop system control.

12.- Transference of manual to automatic voltage regulation operations.

13.- Transference of manual to automatic frequency regulation operations.

14.- Studying of the power factor regulation of synchronous generator in parallel grid operation.

15.- Studying of turbine regulation (frequency control) in parallel grid mode.

16.- Analysis of active and reactive power.

17.- Automatic control of active power.

18.- Studying of the micro-grids.

19.- Overcurrent protection.

20.- Overvoltage and undervoltage protection of the synchronous generator.

21.- Reverse power protection.

22.- Plotting of the demand curve forecast with SCADA software for the subsequent planning of the production capacity of a pumping hydroelectric plant.

23.- Operations as a power grid manager for demand/generation planning. Parameterization of the maximum and minimum power thresholds of the hydroelectric plant for energy injection at peak times and for pumping at off-peak times.

24.- Smart energy management for monitoring changes in the actual demand curve. Regulation performed by the pumping hydroelectric plant in the system for changes in the demand curve.

Some practical exercises possibilities with the base unit GAD-01S-UB and the basic synchroscope:

25.- Visualization of parameters through a synchroscope for the study of the synchronism condition between the generator and the grid.

Some practical exercises possibilities with the base unit GAD-01S-UB and GAD-01S-K1:

26.- Study of the consumption of isolated loads from the three stages of a resistive commutable load.

27.- Study of the consumption of isolated loads from the three stages of an inductive commutable load.

28.- Study of the consumption of isolated loads from the three stages of a capacitive commutable load.

29.- Compensation of reactive power and adjustment of the power factor by means of a capacitive commutable load bank.

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.

<u>a) Technical and Vocational Education configuration</u>

⑤ **AEL-GAD-01S/ICAI. Interactive Computer Aided Instruction Software System.**

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

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

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

Innovative features:

• User Data Base Management.

• Administration and assignment of Workgroup, Task and Training sessions.

• Creation and Integration of Practical Exercises and Multimedia Resources.

• Custom Design of Evaluation Methods.

• Creation and assignment of Formulas & Equations.

• Equation System Solver Engine.

• Updatable Contents.

• Report generation, User Progression Monitoring and Statistics.

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

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

Innovative features:

• Student Log-In & Self-Registration.

• Existing Tasks checking & Monitoring.

• Default contents & scheduled tasks available to be used from the first session.

• Practical Exercises accomplishment by following the Manual provided by EDIBON.

• Evaluation Methods to prove your knowledge and progression.

• Test self-correction.

• Calculations computing and plotting.

• Equation System Solver Engine.

• User Monitoring Learning & Printable Reports.

• Multimedia-Supported auxiliary resources.

<u>b) Multipost Expansions options</u>

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

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

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Main characteristics:

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- Any user/student can work doing "real time" control/multicontrol and visualisation.

- Instructor can see in the computer what any user/student is doing in the unit.

- Continuous communication between the instructor and all the users/students connected.

Main advantages:

- It allows an easier and quicker understanding.

- This system allows you can save time and cost.

- Future expansions with more EDIBON Units.

The system basically will consist of:

This system is used with a Computer Controlled Unit.

- Instructor's computer.

- Students' computers.

- Local Network.

- Unit-Control Interface adaptation.

- Unit Software adaptation.

- Webcam.

- MINI ESN Software to control the whole system.

- Cables and accessories required for a normal operation.

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

REPRESENTATIVE: