Hydroelectric Power Plants Application with Pelton Turbine

AEL-HPPP

Engineering and Technical Teaching Equipment

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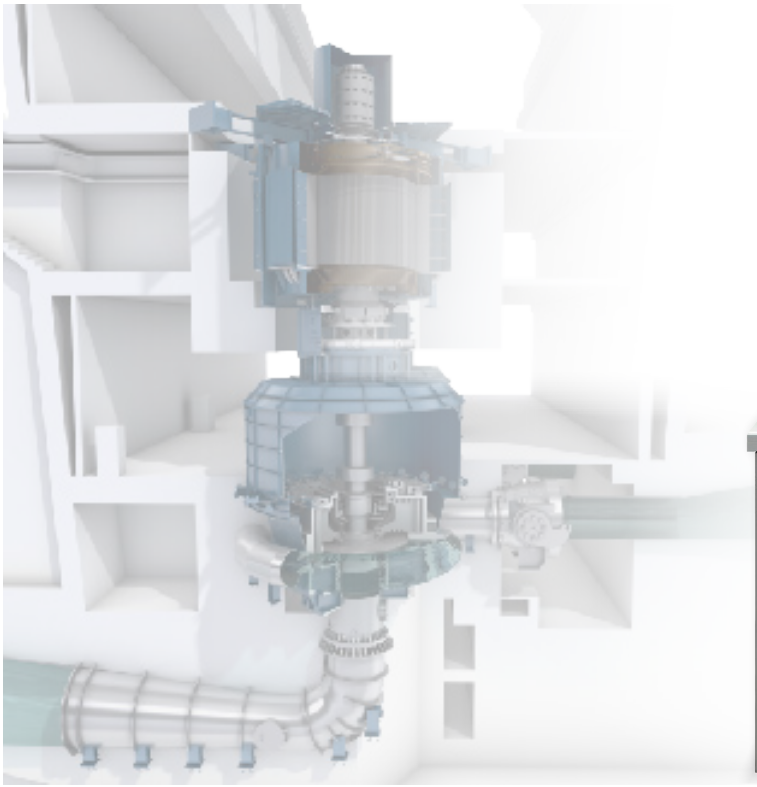
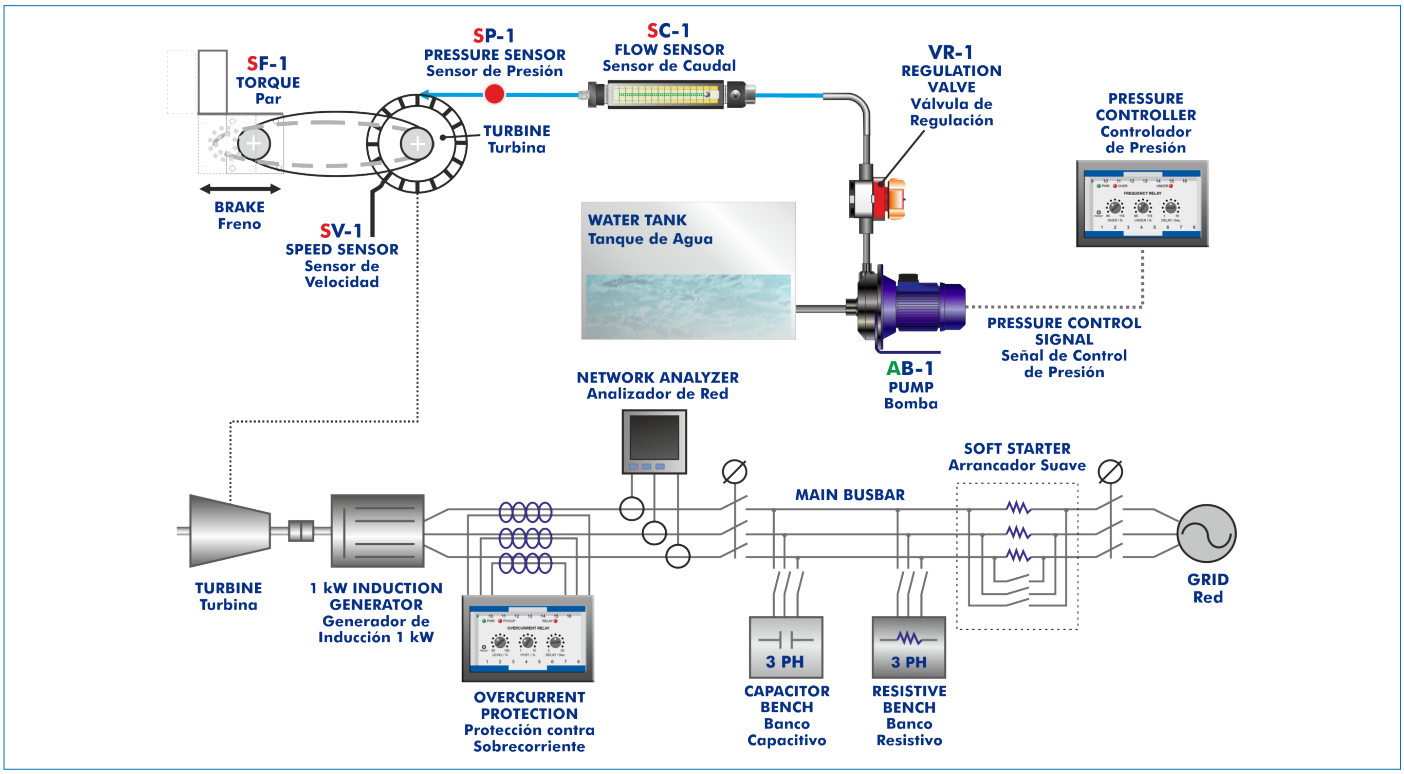


PROCESS DIAGRAM AND UNIT ELEMENTS ALLOCATION



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

European Union Certificate (total safety)

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

"Worlddidac Quality Charter" and Platinum Member of Worlddidac

INTRODUCTION

Hydroelectric Power Plants are great important renewable energy resources in many countries. They are installations which take water bodies in movement of rivers to transform them in electrical energy by mean of electric generators coupled to turbines.

GENERAL DESCRIPTION

The Hydroelectric Power Plants Application 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 application consists of real mechanical and electrical elements (reduced scale) for testing in laboratories.

- Study of mechanical characteristics of the turbine:

  The "AEL-HPPP" Application 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 application 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 application 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 1kW 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 application has a capacitor bench that provides reactive energy to the generator when user works with the application as mini hydroelectric central (stand-alone mode), providing power to a local electric load (included).

El "AEL-HPPP" consists 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.

Optional learning software:

In addition, EDIBON provides optional 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.

SPECIFICATIONS

Industrial rack with three phase power supply with differential and magnetothermal protection:
- Three phase power supply: 400 VAC + N.
- 32A three phase power connector: 3PH + N + GND.

Instrumentation panel:
- Digital network analyzer to measure generator electrical parameters (V, f, P, Q, S, PF, etc.).
- Generator analog voltmeter:
  - Measurement range 0 – 450 VAC.
- Generator analog wattmeter:
  - Measurement range 0 – 1.5 kW.
- Generator analog varmeter:
  - Measurement range 0 – 1 kVAr.
- Water flow and pressure digital meter of the turbine.
- Overcurrent three phase protection relay:
  - Supply voltage: 24 VDC.
  - Nominal Current: 5 A.
  - Maximum Current: 10 A.
  - Set point current range: 50 – 140 %.
  - Hysteresis: 1 – 10 % (max. 1 – 50 %).
  - Delay: 3 – 30 sec. (max. 1 – 360 sec.)
  - Auto Reset: Automatic/manual.
  - Relay Output Contacts:
    - Threshold contacts: 1NO/1NC.
    - Trip contacts: 1NO/1NC

Real electrical diagram panel:
- Water pressure control potentiometer for water injection in the turbine.
- Start/stop turbine switch.
- Generator coupling switch to the main busbar.
- Main busbar coupling switch to the grid.
- Switch for Connecting/Disconnecting the capacitor benches.
- Switch for Connecting/Disconnecting the resistor benches.

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.
- Bench-top unit.
- Anodized aluminum frame and panels made of painted steel.
- Main metallic elements made of stainless steel.
- Diagram in the front panel with distribution of the elements similar to the real one.
- Pelton turbine:
  - Speed range: 0 - 4000 r.p.m.
  - Torque: 4 Nm.
  - Number of buckets: 16.
  - Drum radius: 30 mm.
- Brake:
  - Pulley diameter: 60 mm.
  - Effective radius: 50 mm.
- Water pump, computer controlled:
  - Maximum pressure: 7 bar.
  - Maximum water flow: 80 l/min at 5.4 bar.
- Pressure sensor: 0 to 100 psi (0 to 6.7 bar).
- Load cell - force sensor: 0 - 50N.
- Flow sensor: 2 to 150 l/min.
- Speed sensor: 0 - 20000 r.p.m.
- Water transparent tank, capacity: 130 l approx.

Cables and Accessories, for normal operation.

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

EXERCISES AND PRACTICAL POSSIBILITIES

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.

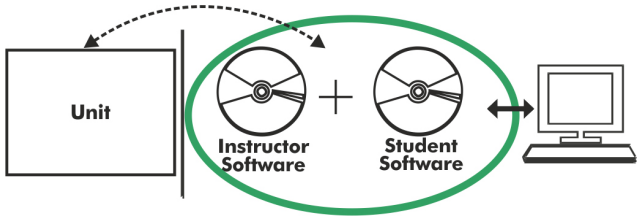
REQUIRED SERVICES

- Electrical supply: three-phase, 380V./50 Hz. or 208V./60 Hz., 20 kW.

DIMENSIONS AND WEIGHTS

AEL-HPPP:
-Dimensions: 600 x 1600 x 1200 mm approx.
(23.62 x 62.99 x 47.24 inches approx.)
-Weight: 100 Kg approx.
(220 pounds approx.)

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



With no physical connection between unit and computer (PC), **this complete software package consists of an Instructor Software (EDIBON Classroom Manager -ECM-SOF) totally integrated with the Student Software (EDIBON Student Labsoft -ESL-SOF)**. Both are interconnected so that the teacher knows at any moment what is the theoretical and practical knowledge of the students.

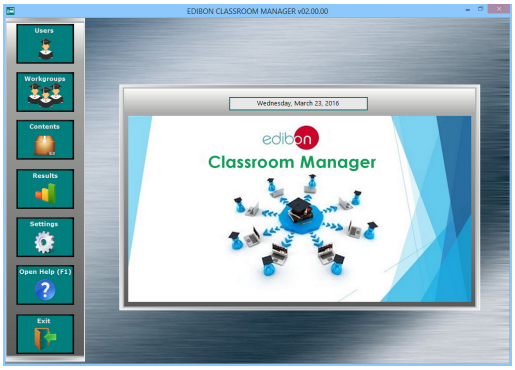
Instructor Software

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

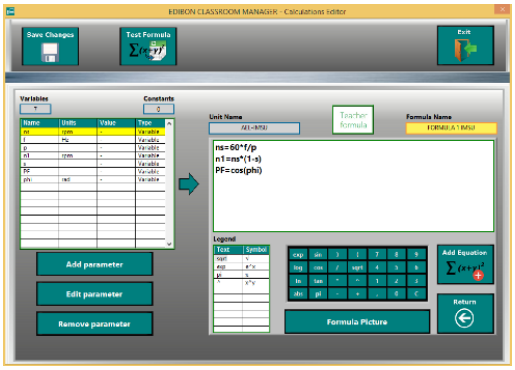
ECM-SOF is the application that allows the Instructor to register students, manage and assign tasks for workgroups, create own content to carry out Practical Exercises, choose one of the evaluation methods to check the Student knowledge and monitor the progression related to the planned tasks for individual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

Innovative features:

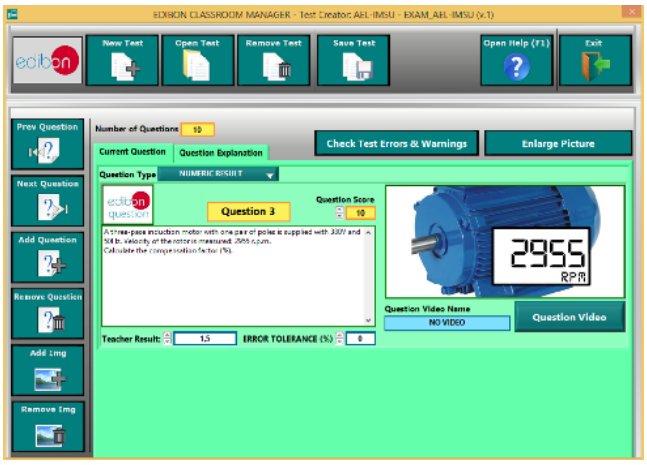
- **User Data Base Management.**
- **Administration and assignment of Workgroup, Task and Training sessions.**
- **Creation and Integration of Practical Exercises and Multimedia Resources.**
- **Custom Design of Evaluation Methods.**
- **Creation and assignment of Formulas & Equations.**
- **Equation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



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



ECAL. EDIBON Calculations Program Package - Formula Editor Screen



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

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

Optional

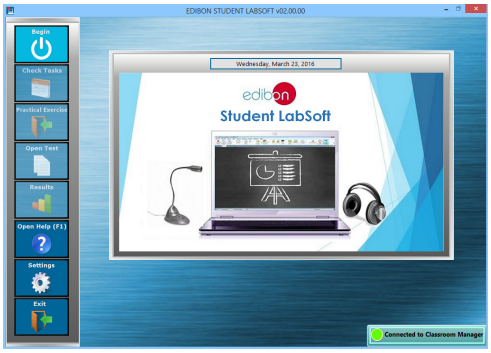
Student Software

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

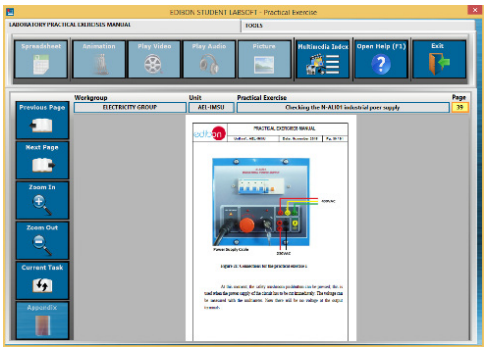
ESL-SOF is the application addressed to the Students that helps them to understand theoretical concepts by means of practical exercises and to prove their knowledge and progression by performing tests and calculations in addition to Multimedia Resources. Default planned tasks and an Open workgroup are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

Innovative features:

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



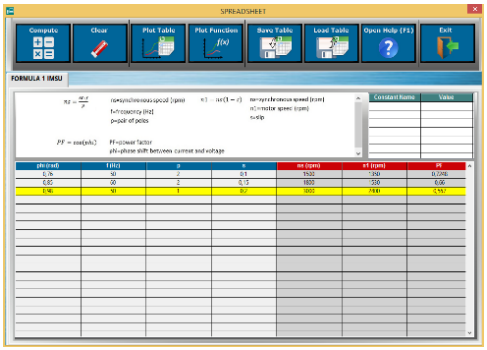
ESL-SOF. EDIBON Student LabSoft (Student Software) Application Main Screen



EPE. EDIBON Practical Exercise Program Package Main Screen

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

ERS. EDIBON Results & Statistics Program Package - Question Explanation



ECAL. EDIBON Calculations Program Package Main Screen

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

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REPRESENTATIVE: