Engineering and Technical Teaching Equipment

Power Flux Protection Application

AEL-AE9

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PRODUCTS
4.- ELECTRICITY

Example configuration of the AEL-AE9 with additional recommended loads and analog instrumentation

INTRODUCTION

When we talk about power-system protection we are referring to the integrity of the facilities and infrastructure in which the electrical installation is located and the electrical systems that surround them. The importance of the power-system protection is innate to its design, since if the power supply and the integrity of equipment and people are not assured, it would be inconceivable the integration of a complex electrical system as it exists nowadays.

Protection devices are installed with the aims of protection of assets and ensuring continued supply of energy, as well as the protection of the people. In particular, the protection devices controlling the power flow of the network, as well as the power factor are important for detecting and dissipating electrical faults and analyzing how the power flow behaves in response to different events in an electrical system.

GENERAL DESCRIPTION

The Power Flux Protection Application, "AEL-AE9", has been designed by EDIBON to study the protection devices that deal with the resolution of network events involving reverse power flow and power factor alteration. This application allows the user to understand the operation of the protection devices during power factor detection below established limits and detection of a reverse power flow, as well as the incidents that may be caused.

The "AEL-AE9" application consists of a power factor protection relay and a reverse power flow protection relay, with their correspondent power switch, to study the operation of these protection devices when these circumstances are detected in the grid. Two squirrel-cage three-phase asynchronous motors are also included to produce a reverse power flow, creating the circumstances to study the protection devices operation.

One of the motor works as prime mover and it is controlled by a frequency controller. The second motor works as an electricity generator and it is coupled to the prime mover. Analog meters are included too to study the operation of the electrical machines. Additionally it is included a network analyzer which displays all the parameters involved in the grid. Finally, this application includes resistive, inductive and capacitive loads that cause different consumption conditions for the study of the influence of each one on the power factor, and the response of the correspondent protection devices.

The "AEL-AE9" application includes the following elements:

- N-ALI01. Industrial Main Power Supply Module.
- N-EALD. Electrical Network Analyzer Module with Oscilloscope and Data Acquisition.
- N-REL51. Reverse Power Relay Module.
- N-REL52. Power Factor Protection Relay Module.
- N-PSM. Power Switch Module (2 units).
- EMT7. 3PH Squirrel-Cage Motor (2 units).
- N-VVCA/M. AC Motor Speed Controller (Intermediate option) Module.
- N-REFT. Three-phase Commutable Resistor Load Module.

Additional recommended elements (Not included):

- N-INDT. Three-phase Commutable Inductive Load Module.
- N-CONT. Three- phase Commutable Capacitive Load Module (2 units).
- N-MED10. AC Ammeter Module (0-5 A).
- N-MED82. AC Voltmeter Module (0-500 V).
- AEL-SERIN/CA-1KW. 1 kW AC Industrial Servomotor Application.
  - N-SERV1K. 1 kW Servomotor Module.
  - N-ALI01. Industrial Main Power Supply Module.
  - N-DMC01. Torque and Speed Measurement Module 1.
- EM-SCADA. Control and Data Acquisition System Software for Electrical Machines.

The application "AEL-AE9" 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).

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

Option B:

This application can be mounted on rail.

Optionally the AEL-WBC, Electrical workbench (rail) can be supplied to mount the modules.

SPECIFICATIONS

The "AEL-AE9" application includes the following elements:

N-ALI01

- N-ALI01. **Industrial Main Power Supply Module.**
  - Supply voltage: 400 VAC, 3PH + N.
  - ON / OFF removable key.
  - Output voltage connections:
    - Three-phase + Neutral: 400 VAC.
    - Single-phase: 230 VAC.
  - Three-phase supply hose with IP44 3PN + E 32 A 400 V connecting plug.
  - Differential magnetothermal 4 poles, 25 A, 30 mA AC 6 KA.
  - Emergency stop push-button.

N-EALD

- N-EALD. **Electrical Network Analyzer Module with Oscilloscope and Data Acquisition.**
  - 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:
      - Three-phase and single-phase voltage. Up to 690 VAC L-L.
      - Line and neutral nominal current: 10 A.
      - Active, reactive and apparent power.
      - Suitable frequencies: 25 Hz, 50 Hz, 60 Hz and 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.
      - Voltage and current THD, TDD and K-Factor.
      - Maximums and minimums display.
      - Waveforms display, 128 samples/sec.
    - Events and data storage:
      - Harmonics analyzer:
        - Voltage and current THD, current TDD 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, four energy/demand records of total tariffs.
        - Eight tariffs, four seasons and four types of days.
        - Automatic daily report of energy consumption maximums and minimums.
      - Communications:
        - RS – 485 communication port.

N-REL51

- N-REL51. **Reverse Power Relay Module.**
  - Supply voltage: 24 VDC.
  - Input voltage: 63 – 690 VAC.
  - Nominal current: 5 A.
  - Maximum current: 10 A.
  - Frequency permissible range: 35 – 75 %.
  - Set point current range:
    - Reverse power: (2 – 20 %, max. 2 – 50 %).
    - Forward power: (50 – 140 %, max. 50 – 150 %).
  - 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.

N-REL52

- N-REL52. **Power Factor Protection Relay Module.**
  - Supply voltage: 90 – 690 VAC.
  - Input voltage: 90 – 690 VAC.
  - Delay: 0.1 – 20 seg.
  - Auto reset: automatic/manual.
  - Relay output contacts:
    - Trip contacts: 1NO / 1NC.

- N-PSM. **Power Switch Module (2 units).**
  - Supply voltage: single-phase 230 VAC.
  - 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 24 VDC.
  - Two voltage supply outputs of 24 VDC.

N-PSM

- EMT7. **3PH Squirrel-Cage Motor (2 units).**
  - Nominal power: 370 W.
  - Nominal voltage: 3 x 230 / 400 VAC Δ/Y.
  - Frequency: 50 / 60 Hz.
  - Number of poles: 2.
  - Speed: 2730 rpm.
  - Nominal current: 1.67 / 0.97 A.
  - Shaft height: 71 mm.

EMT7

- N-VVCA/M. **AC Motor Speed Controller (Intermediate option) Module.**
  - ON / OFF switch.
  - Supply voltage: 230 VAC.
  - Nominal power: 750 W.
  - PWM output voltage connections:
    - Three-Phases: 230 VAC.
  - 10 K, potentiometer for the induction motor control speed.
  - Setting and visualization display of the machine parameters.

N-VVCA/M

- N-REFT. **Three-phase Commutable Resistor Load Module.**
  - Nominal voltage: 400 VAC.
  - Resistance: 3 x 150 Ohm.
  - Nominal current: 1.6 A.
  - Manual switch to turn activate/deactivate resistors.
  - Fuses: 3 x 2 A.
  - Terminals:
    - Four input terminals (3PH + N).
    - Four output terminals (3PH + N).

N-REFT

Additional recommended elements (Not included):

- N-INDT. **Three-phase Commutable Inductive Load Module.**
  - Nominal voltage: 400 VAC.
  - Inductance: 1.4 H.
  - Nominal current: 1.6 A.
  - Manual switch to turn activate/deactivate inductances.
  - Fuses: 3 x 2 A.
  - Terminals:
    - Four input terminals (3PH + N).
    - Four output terminals (3PH + N).

N-INDT

- N-CONT. **Three- phase Commutable Capacitive Load Module (2 units).**
  - Nominal voltage: 400 VAC.
  - Capacitance: 3 x 7 μF.
  - Manual switch to turn activate/deactivate capacitors.
  - Fuses: 3 x 4 A.
  - Terminals:
    - Four inputs terminals (3PH + N).
    - Four outputs terminals (3PH + N).

N-CONT

- N-MED10. **AC Ammeter Module (0-5 A).**
  - Measurement range: 0 – 5 A.
  - Terminals:
    - Measurement terminals.

N-MED10

- N-MED82. **AC Voltmeter Module (0-500 V).**
  Measurement range: 0 – 500 VAC.
  Terminals:
  Measurement terminals.

N-MED82

- AEL-SERIN/CA-1KW. **1 kW AC Industrial Servomotor Application.**
  - N-SERV1K. **1 kW Servomotor Module.**
    Dynamic and static operating regime in four quadrants.
    Speed and torque signals.
    Power supply terminals: 3 x 400 VAC.
    Frequency: 50 / 60 Hz.
    Nominal power: 1 kW.
    Maximum power: 3 kW.
    Maximum speed: 5000 rpm.
    Nominal torque: 3.18 Nm.
    Maximum torque: 9.55 Nm.
    Temperature control.
    Speed control potentiometer.
    Torque control potentiometer.
    Mode selection switch: torque/speed control.
    Motor turning reversal switch.

AEL-SERIN/CA-1KW

  - N-ALI01. **Industrial Main Power Supply Module.**
    Supply voltage: 400 VAC, 3PH + N.
    ON / OFF removable key.
    Output voltage connections:
    Three-phase + Neutral: 400 VAC.
    Single-phase: 230 VAC.
    Three-phase supply hose with IP44 3PN + E 32 A 400 V connecting plug.
    Differential magnetothermal 4 poles, 25 A, 30 mA AC 6 KA.
    Emergency stop push button.

  - N-DMC01. **Torque and Speed Measurement Module 1.**
    Digital torque meter:
    Torque signal connector.
    Auxiliary contact NO.
    Digital speed meter:
    Speed signal connector.
    Auxiliary contact NO.
    IP66 protection.

- EM-SCADA. **Control and Data Acquisition System Software for Electrical Machines.**
  Power supply: 230 VAC.
  Input signals:
  Current signal (x2).
  RMS current signal (x2).
  Voltage signal (x2).
  RMS voltage signal (x2).
  Torque and speed signals.
  Output signals:
  Torque control signal for the servomotor.
  Speed control signal for the servomotor.
  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.
  Management, processing, comparison and storage of data.
  It allows graphic representation in real time.
  Comparative analysis of the obtained data, after the process and modification of the conditions during the process.
  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.

EM-SCADA

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

Cables and accessories, for normal operation.

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

EXERCISES AND PRACTICAL POSSIBILITIES

1.- Manual regulation of the speed of an asynchronous electric machine to generate an over-slip and cause an inverse power flow. Operation both in generator mode and in motor mode.
2.- Analysis of active and reactive power and their influence on the operation of the protection relays to provoke a response from them.
3.- Setting of the reverse power protection.
4.- Testing of the reverse power protection response to a reverse power flow.
5.- Setting of the power factor protection.
6.- Testing of the power factor protection response to below established limits power factor.
7.- Calculation of the power factor when there is a resistive load variation and consequent response of the power factor protection.
8.- Calculation of the power factor when there is an inductive load variation and consequent response of the power factor protection.
9.- Calculation of the power factor when there is a capacitive load variation and consequent response of the power factor protection.

Some possible practices with additional recommended EM-SCADA and AEL-SERIN/CA-1kW:

10.- Wiring and starting up the AC servomotor.
11.- Start/stop operations of the servomotor.
12.- Speed control operation.
13.- Torque control operation.
14.- Warnings through alarm.

Some practical possibilities in case of acquiring at least one electrical machine application:

15.- Start-up of the electrical machine coupled to the servomotor.
16.- Introducing the braking torque.
17.- Monitoring of the electrical and mechanical parameters of the rotating machine under different operating conditions.
18.- Electrodynamic study of the machine.
19.- Obtaining the characteristic curves of the machine by means of manually controlled braking tests (torque-speed, torque-current etc).

Practical exercises with the additional recommended software, "EM-SCADA":

20.- Real time torque monitoring.
21.- Real time speed monitoring.
22.- Real time monitoring of current and voltage RMS values.
23.- Real time monitoring of current and voltage waveforms.
24.- Advanced electrodynamic study of the machine.
25.- Automatic braking test and monitoring of the results.
26.- Obtaining the characteristic curves of the machine (torquespeed, torque-current etc).
27.- Saving and comparison of results.

REQUIRED SERVICES

- Electrical supply: three-phase, 380 VAC – 400 VAC/50 Hz or 190 VAC – 240 VAC/60 Hz, 2 kW.

DIMENSIONS AND WEIGHTS

AEL-AE9:

- Dimensions: 1280 x 320 x 920 mm approx.
  (25.19 x 12.59 x 32.22 inches approx.)
- Weight: 70 Kg approx.
  (132 pounds approx.)

ADDITIONAL RECOMMENDED ELEMENTS (Not included)

- N-INDT. Three-phase Commutable Inductive Load Module.
- N-CONT. Three- phase Commutable Capacitive Load Module.
- N-MED10. AC Ammeter Module (0-5 A).
- N-MED82. AC Voltmeter Module (0-500 V).
- AEL-SERIN/CA-1KW. 1 kW AC Industrial Servomotor Application.
- EM-SCADA. Control and Data Acquisition System Software for Electrical Machines.

SIMILAR UNITS AVAILABLE

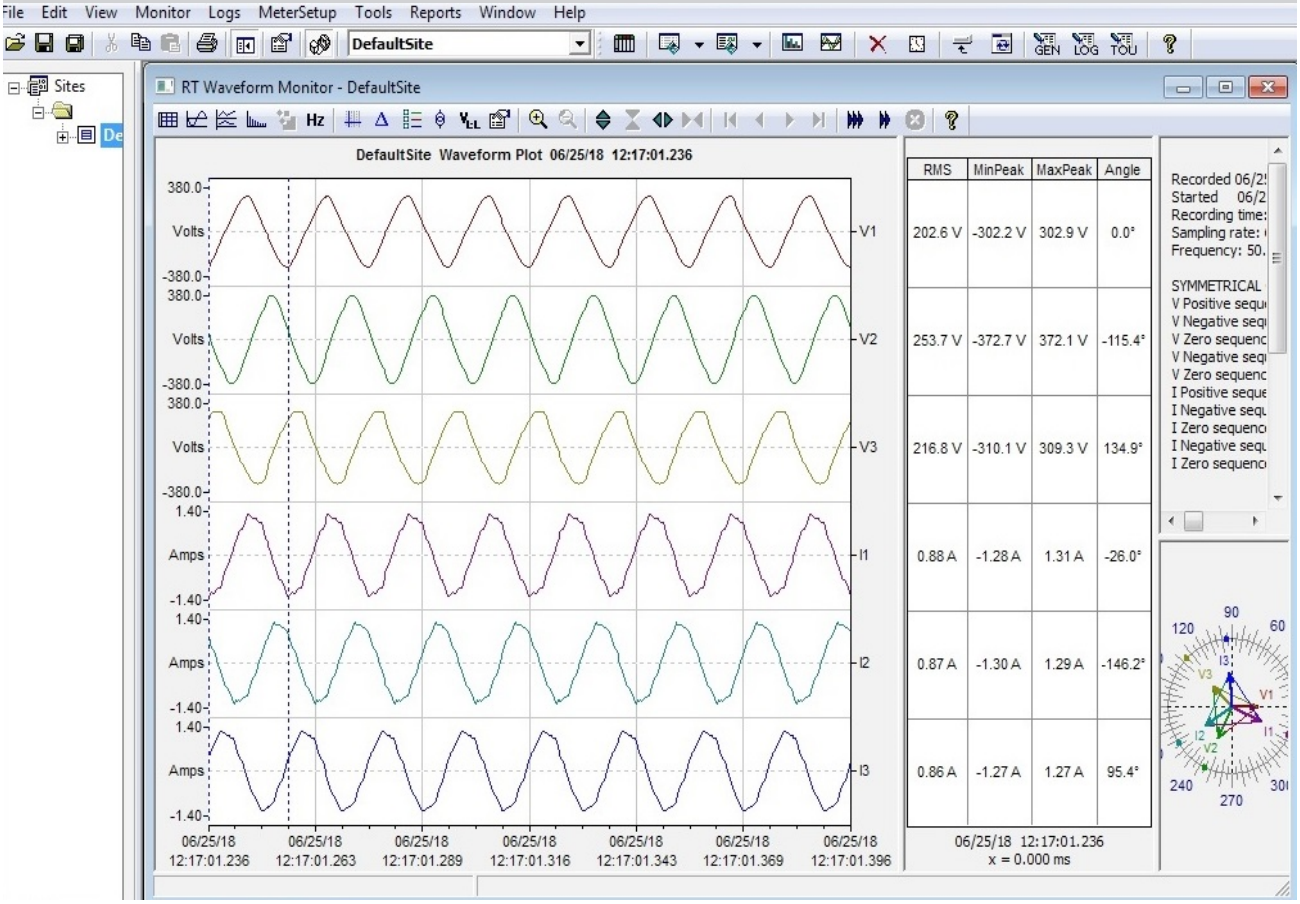
Offered in this catalog:

- AEL-AE9. Power Flux Protection Application.

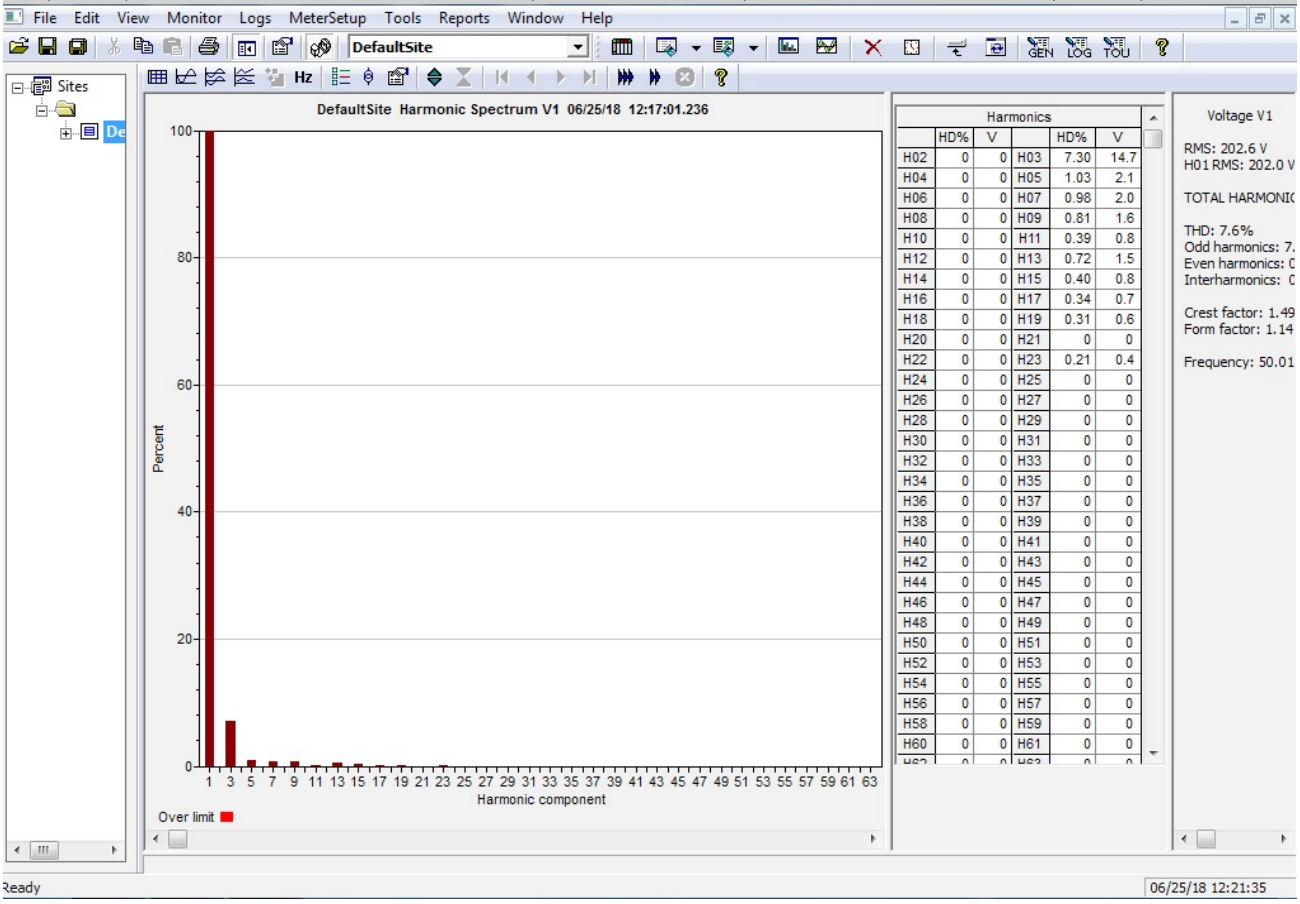
Offered in other catalog:

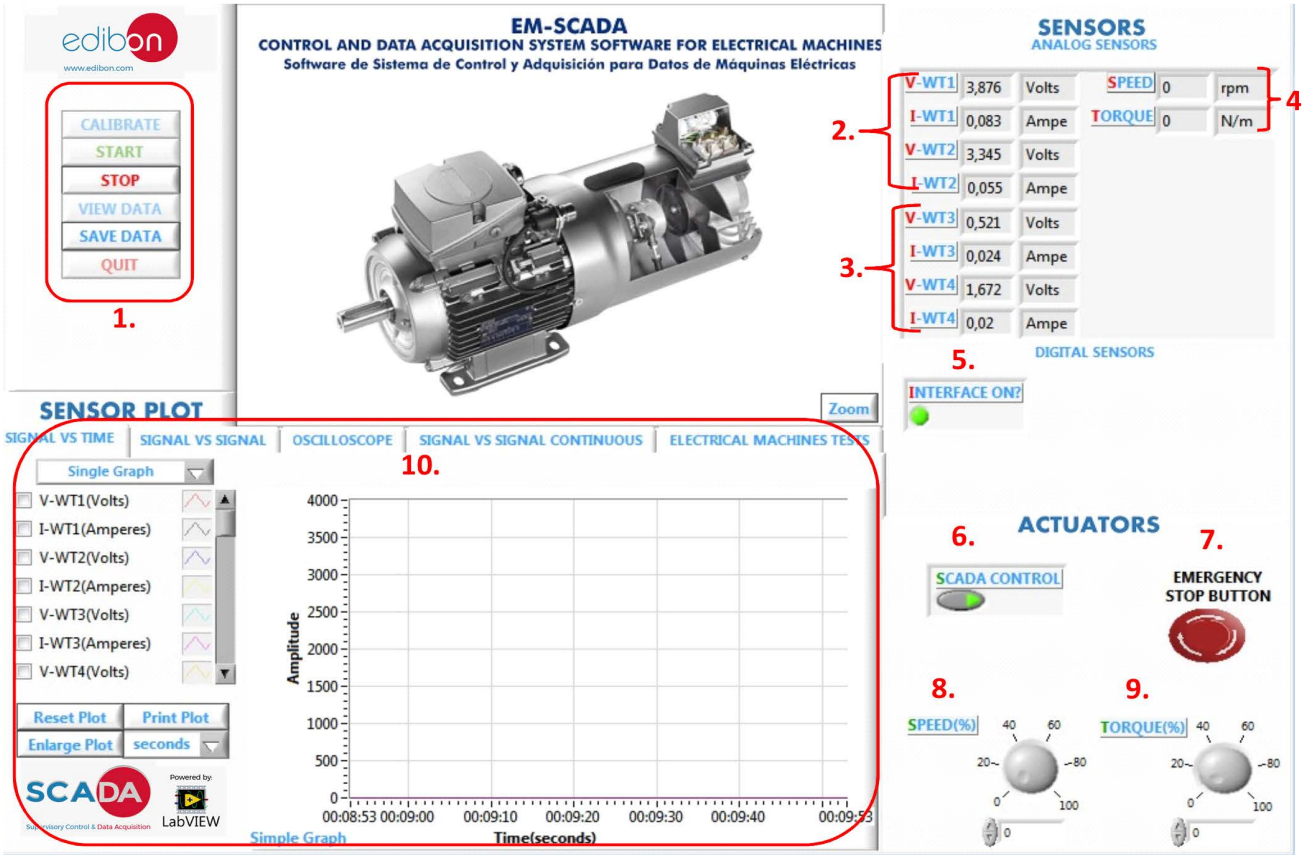
- AEL-AE5. Protection Relays Control Application.

Graphical representation of the waveform of the currents and voltages measured in real time by the analyser, showing the angular, maximum, minimum and effective (RMS) values, and the phasors corresponding to such electrical parameters.



Graphical representation and data table of the harmonic spectrum of the selected parameter measured in real time by the analyzer.





① **Main menu.** Start-up, stop, view data, save data and quit.

② **RMS voltages and currents measurements.** It shows the effective values for the real time measured voltages and currents.

③ **Real voltages and currents measurements.** It shows the exact values for the real time measured voltages and currents.

④ **Torque and speed measurements.** It shows the machine torque and speed real time values.

⑤ **Interface connected warning switch.** The green pilot means the right operation of the control-interface box.

⑥ **SCADA control switch.** To enable the actuators control from the software.

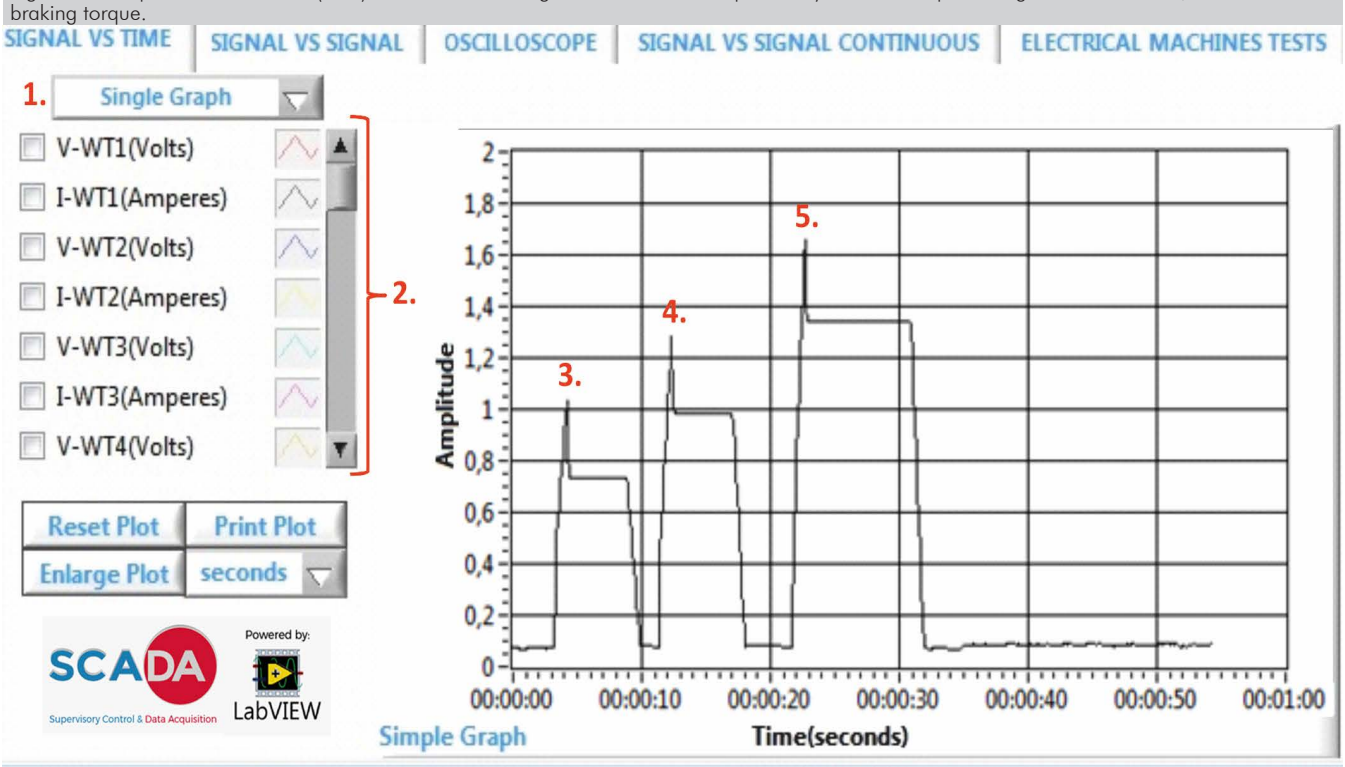
⑦ **Emergency stop button.**

⑧ **Speed actuator.** In order to set the desired speed value through the potentiometer or entering the exact value.

⑨ **Torque actuator.** In order to set the desired torque value through the potentiometer or entering the exact value.

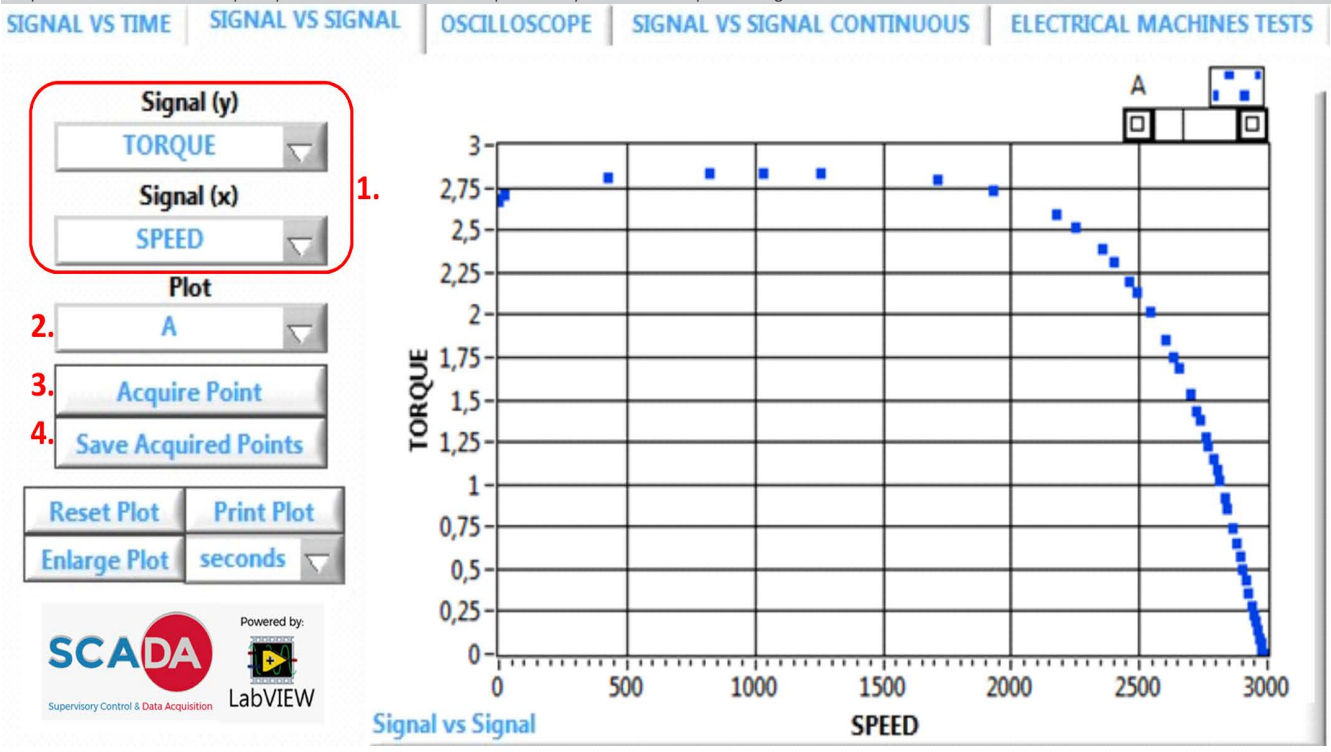
⑩ **Screen selector.**

Signal vs time plot of the effective (RMS) value of the starting current of the three-phase asynchronous squirrel-cage motor for 10 %, 20 % and 30 % braking torque.



① **Type of graph selector.** Simple or several signals overlapping.
② **Parameters selection.** It allows choosing the parameters to be displayed and the setting for its display.
③ **Starting current with 10 % of brake torque.**
④ **Starting current with 20 % of brake torque.**
⑤ **Starting current with 30 % of brake torque.**

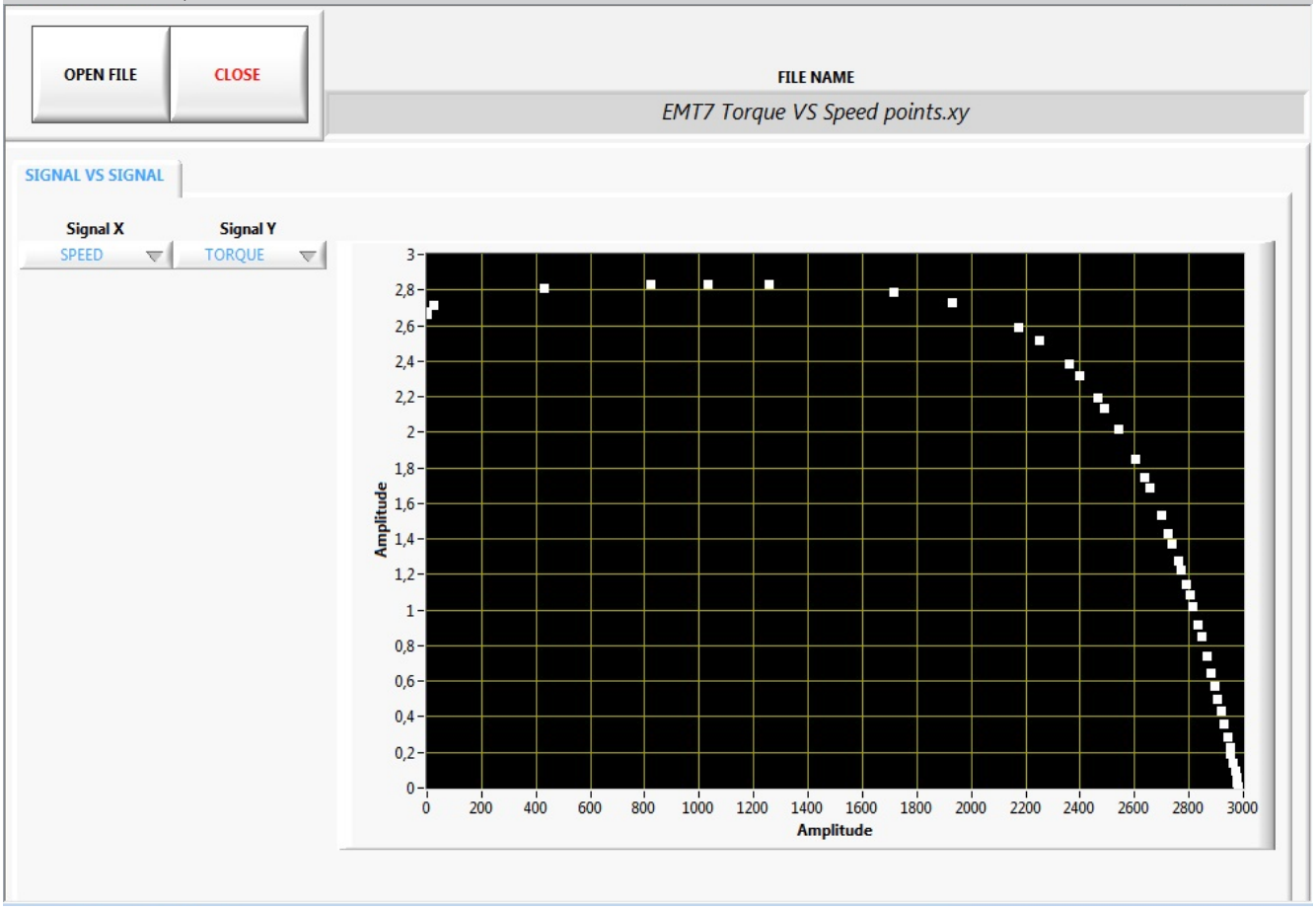
Representation of the torque-speed curve for the three-phase asynchornous squirrel cage motor.



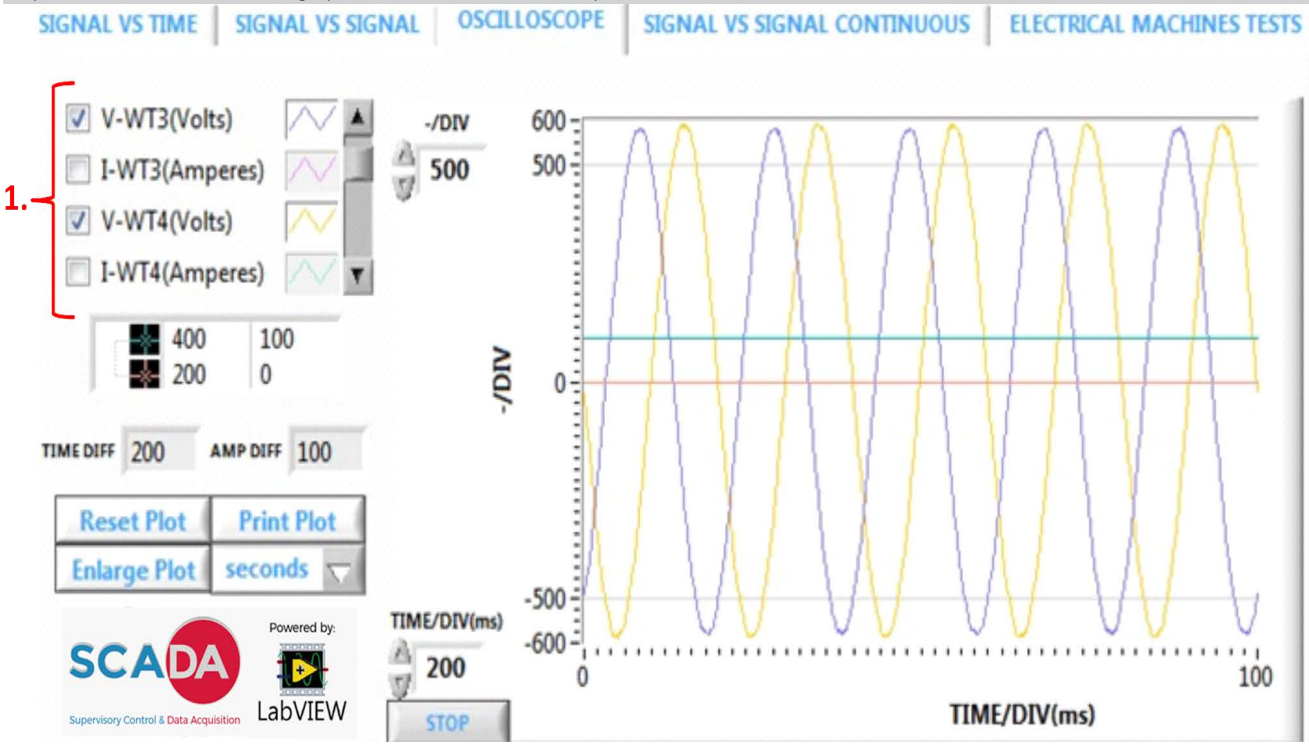
① **Axis signal selector.** It allows selecting the parameter to be monitored in each axis.
② **Type of graph selector.**
③ **Acquire points.** It allows displaying in the graph the point corresponding to the time when it is pressed.
④ **Save acquired points.** It allows saving the acquired points, which will start erasing automatically after 500 samples.

Some **real** results obtained from this unit with the software **EM-SCADA** (recommended)

Visualisation and representation of saved data.



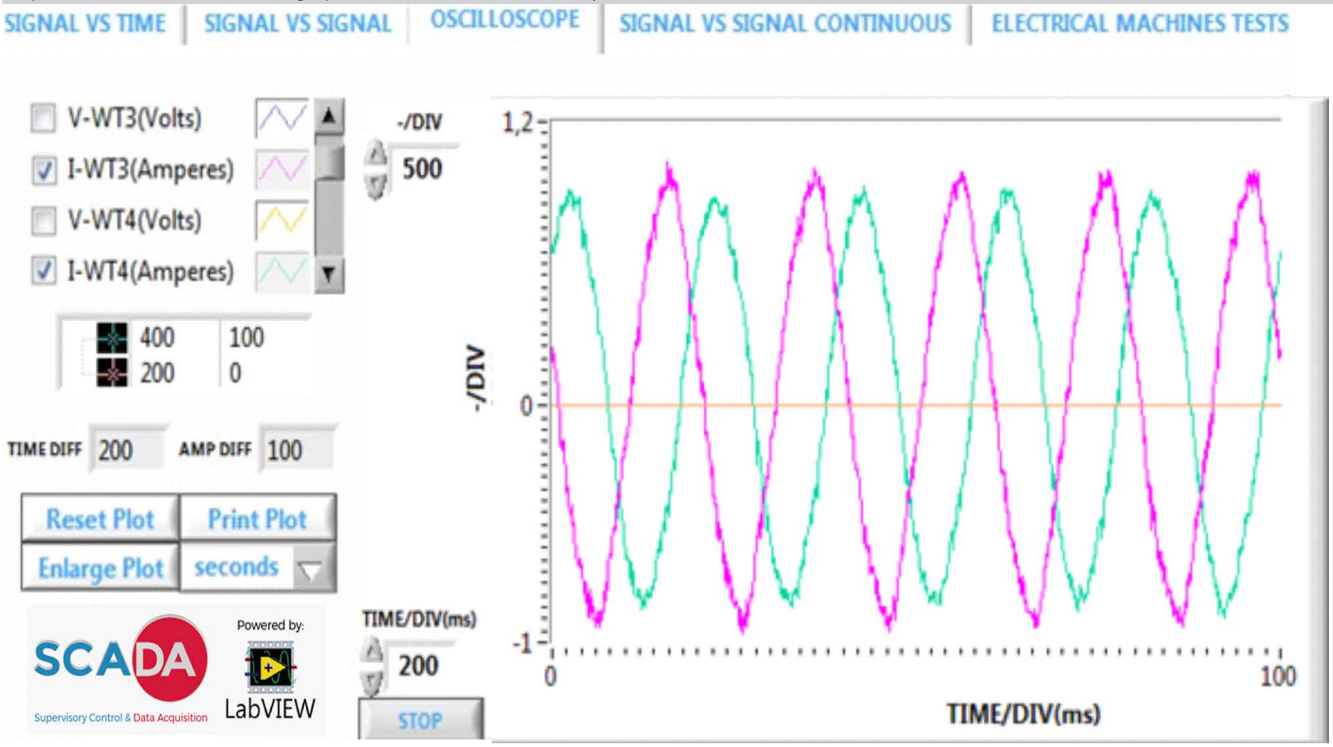
Representation of the waveform graph of the currents measured by the interface in real time.



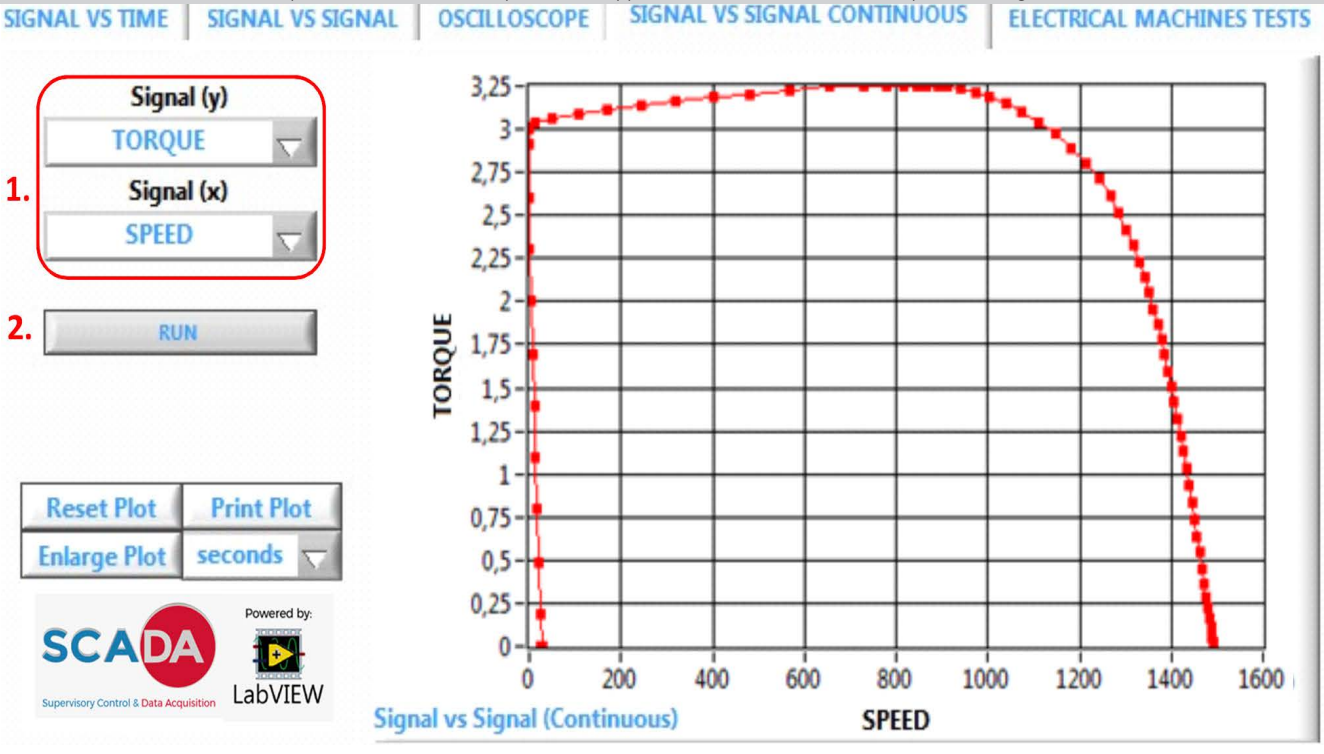
ⓘ **Parameters selector.** It allows choosing the parameters whose waveforms want to be displayed.

Some **real** results obtained from this unit with the software **EM-SCADA** (recommended)

Representation of the waveform graph of the currents measured by the interface in real time.



Representation of the torque-speed curve of the manual braking test with the two-speed three-phase asynchronous motor, first speed (1500 rpm). Notice that the motor nominal speed and maximum torque can be appreciated, as well as motor complete braking.

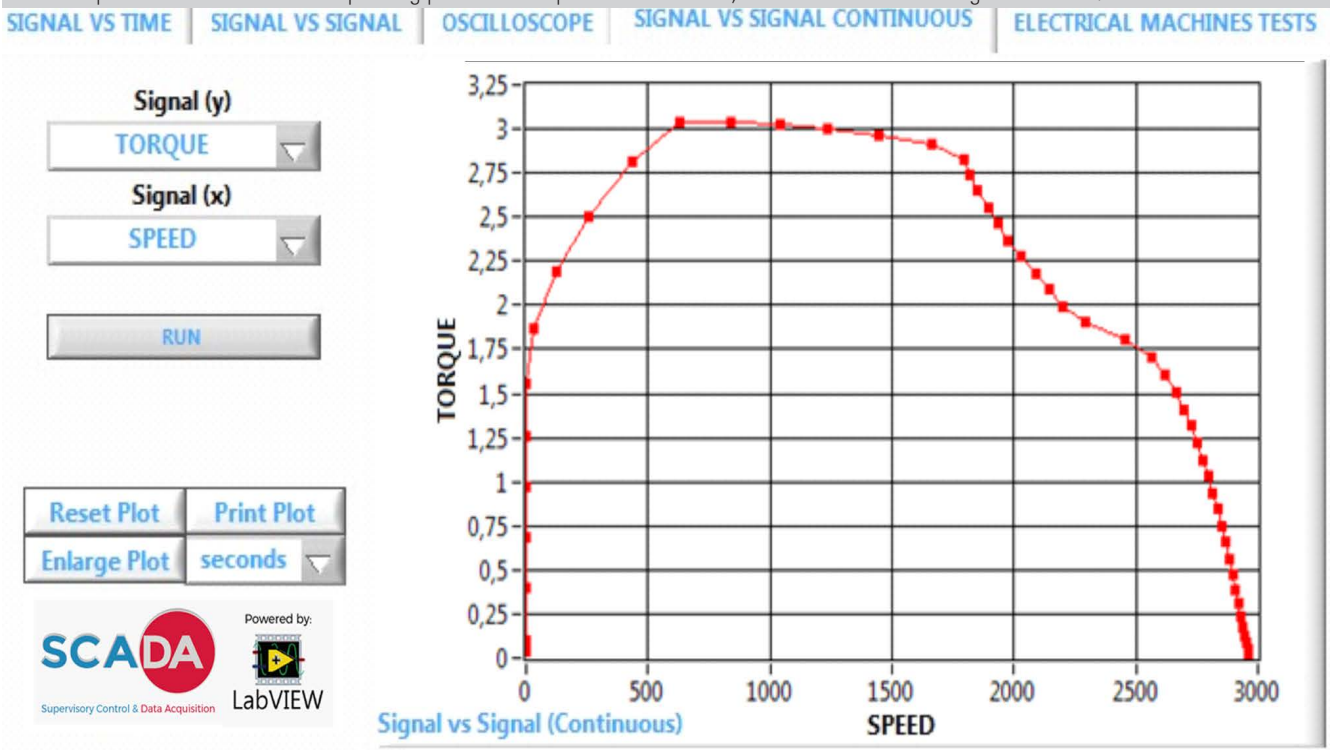


① **Axis signal selector.** It allows selecting the parameter to be monitored in each axis.

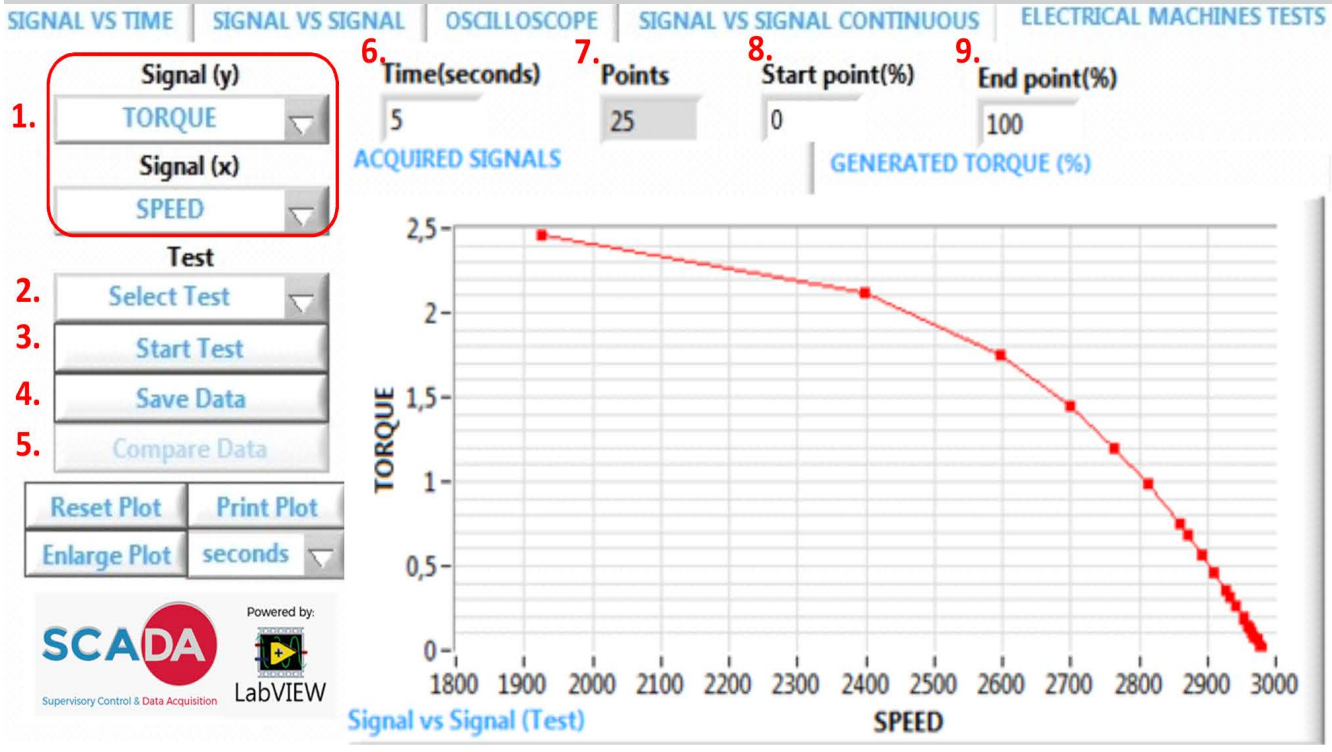
② **Run.** It allows starting the manual braking test.

Some **real** results obtained from this unit with the software **EM-SCADA** (recommended)

Representation of the torque-speed curve of the manual braking test with the single phase motor with starting and running capacitor. Notice the nominal speed of the motor and the operating point of the capacitor can be seen, as well as the total braking of the motor.



Obtained results for the automatic braking test with the three-phase asynchronous squirrel cage motor with delta connection, from 0 to 100 % and exponetial braking ramp. Notice the nominal speed of the motor and how the exponential braking ramp is not sufficient for total braking of the electric motor.



① **Axis signal selector.** It allows selecting the parameter to be monitored in each axis.

② **Type of test selector.** It allows selecting the type of automatic braking test to be fulfilled: lineal, constant or exponential ramp.

③ **Iniciar test.**

④ **Save data.** It allows saving the obtained test results.

⑤ **Compare data.** It allows up to three different tests to be compared on the same graph, for which the user must have previously saved these results.

⑥ **Test time.** It allows selecting the length of the test to be fulfilled.

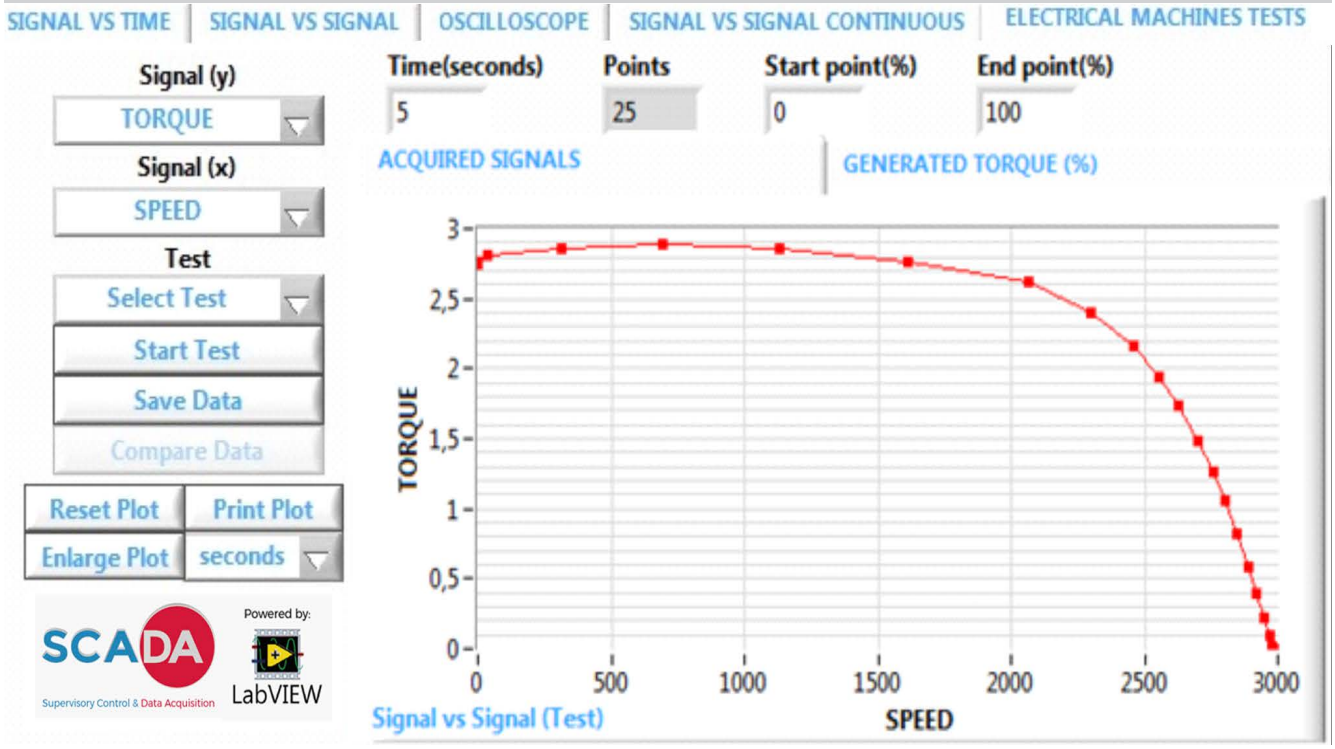
⑦ **Points.** It shows the number of points that will define the resulting plot.

⑧ **Start point.** It allows selecting (as a percentage) the start point for the test to be fulfilled.

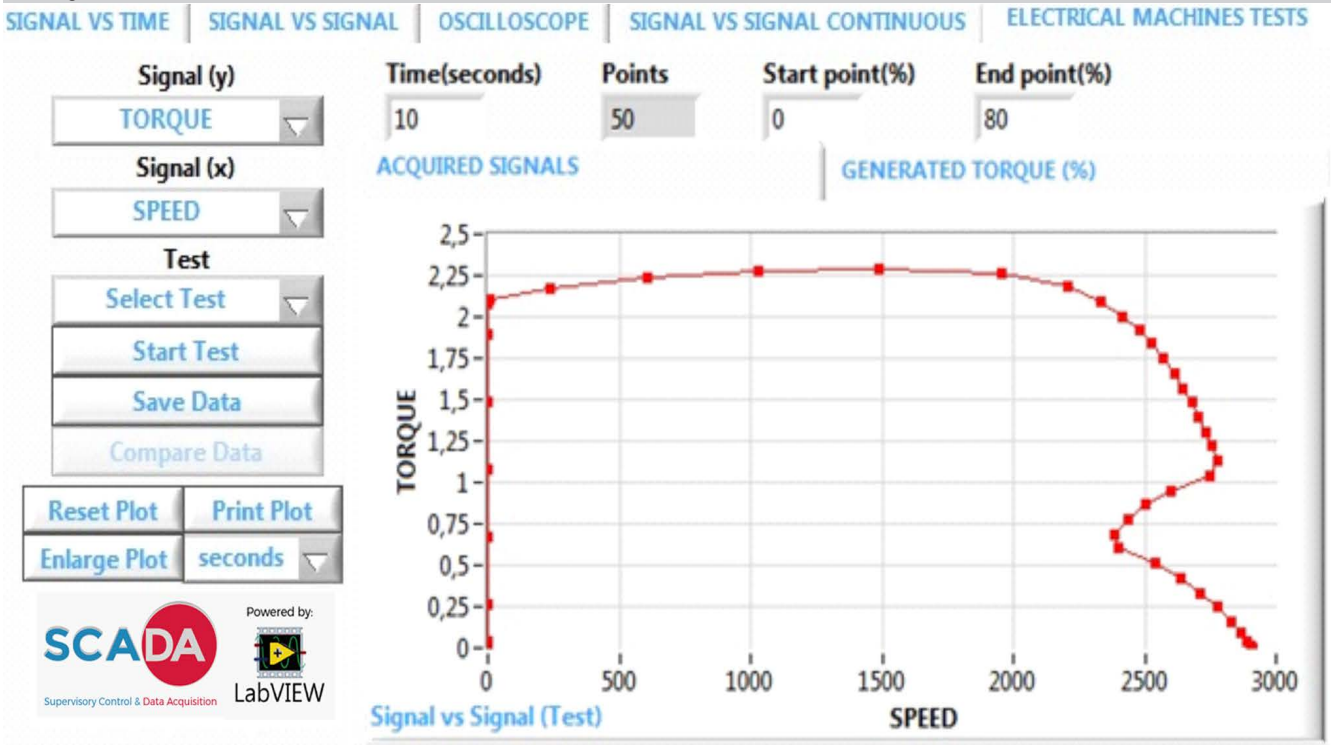
⑨ **End point.** It allows selecting (as a percentage) the end point of the test to be fulfilled.

Some **real** results obtained from this unit with the software **EM-SCADA** (recommended)

Obtained results for the automatic braking test with the three-phase asynchronous squirrel cage motor with delta connection, from 0 to 100 % and linear braking ramp. Notice that the motor nominal speed and the maximum torque can be seen, as well as the motor complete braking.

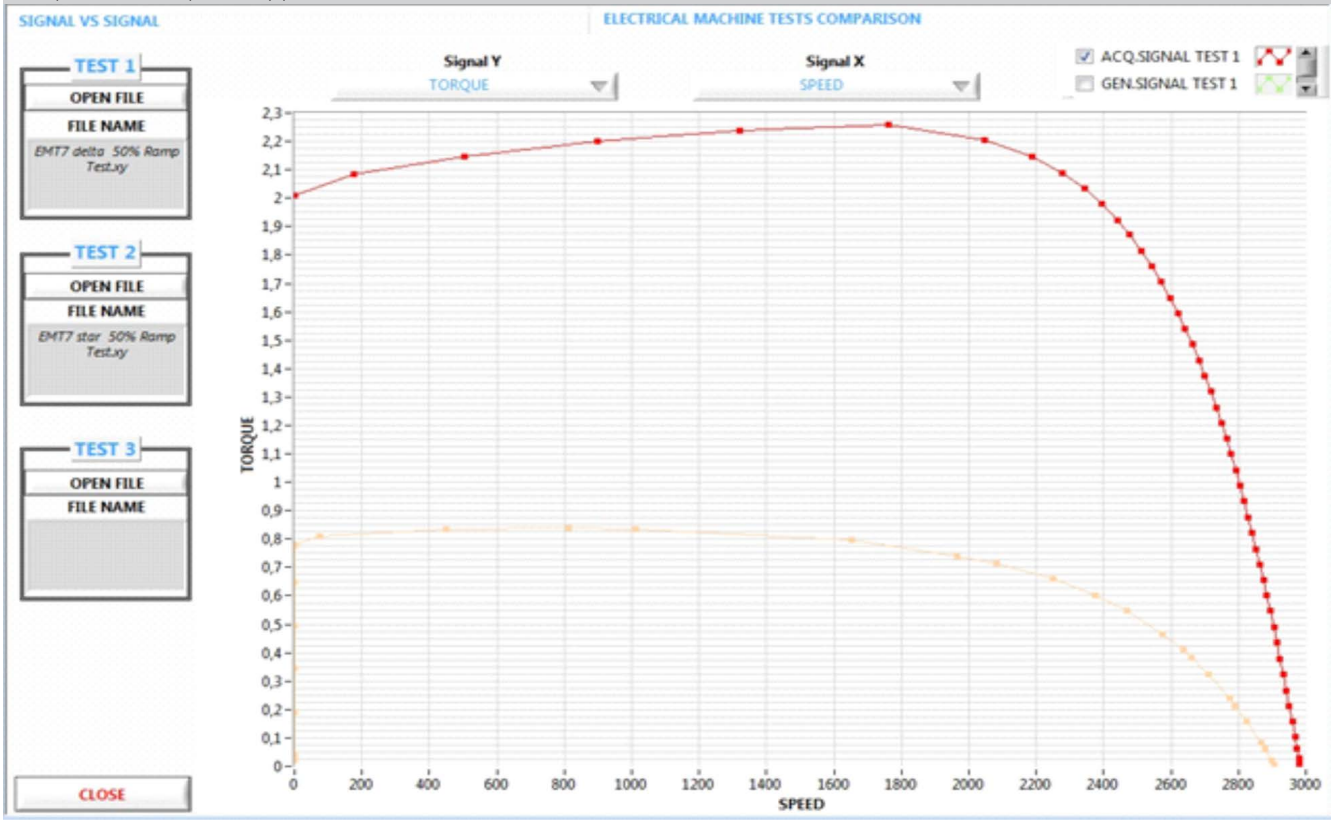


Obtained results for the automatic braking test with the three-phase asynchronous squirrel cage motor, with star-delta starting, from 0 to 80 % and linear braking ramp. Notice that the condenser operating point condenser can be appreciated, as well as the motor nominal speed and its complete braking.

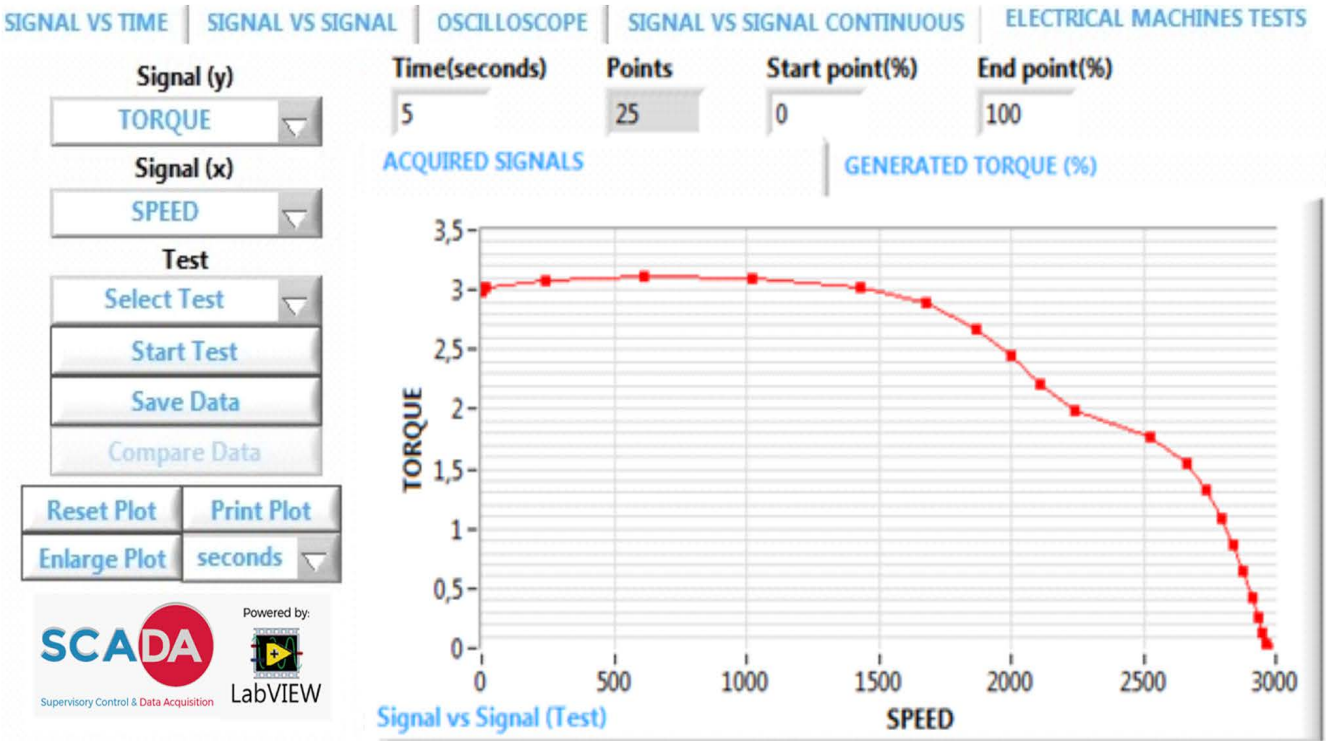


Some **real** results obtained from this unit with the software **EM-SCADA** (recommended)

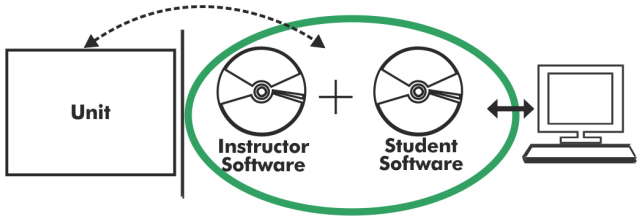
Comparison of two previously performed and stored tests.



Obtained results for the automatic braking test with the single-phase asynchronous motor with starting and running capacitor, from 0 to 100 % and linear braking ramp. Notice the capacitor operating point and the effects on the machine parameters can be appreciated, as well as the motor nominal speed and its complete braking.



AEL-AE9/ICAI. Interactive Computer Aided Instruction Software:



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

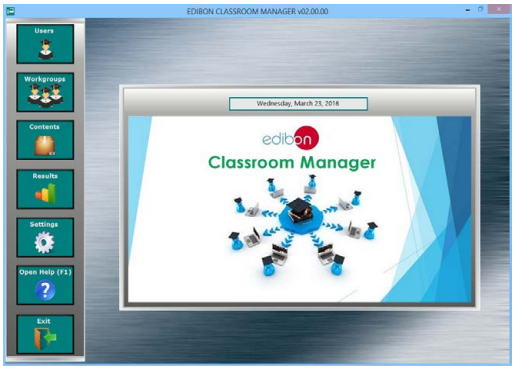
Instructor Software

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

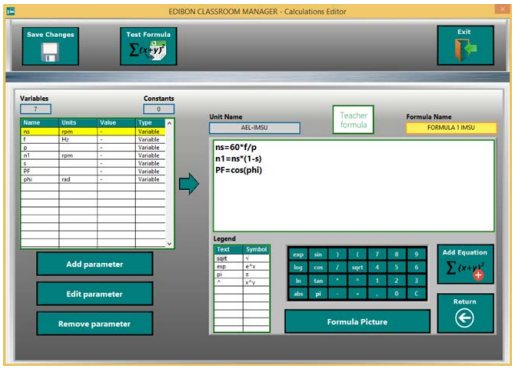
ECM-SOF is the application that allows the Instructor to register students, manage and assign tasks for workgroups, create own content to carry out Practical Exercises, choose one of the evaluation methods to check the Student knowledge and monitor the progression related to the planned tasks for individual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

Innovative features:

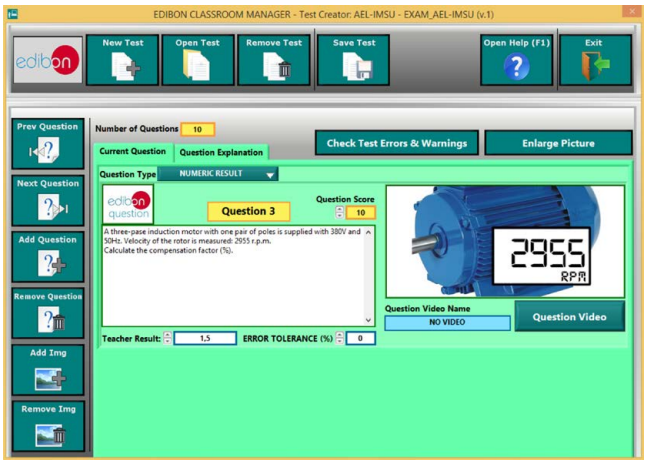
- **User Data Base Management.**
- **Administration and assignment of Workgroup, Task and Training sessions.**
- **Creation and Integration of Practical Exercises and Multimedia Resources.**
- **Custom Design of Evaluation Methods.**
- **Creation and assignment of Formulas & Equations.**
- **Equation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



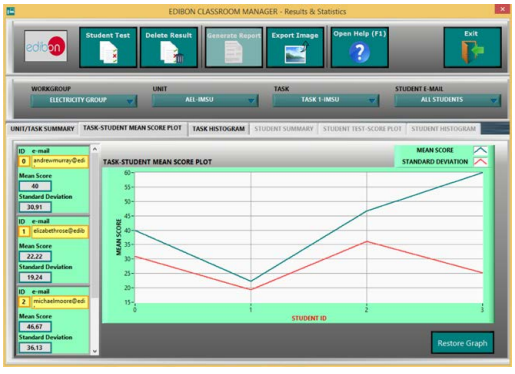
ECM-SOF. EDIBON Classroom Manager (Instructor Software) Application Main Screen



ECAL. EDIBON Calculations Program Package - Formula Editor Screen



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



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

Optional

Student Software

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

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

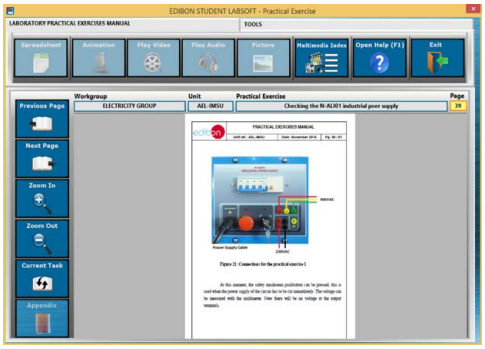
Innovative features:

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

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

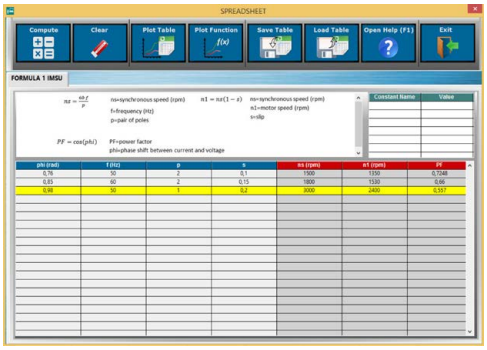
www.edibon.com/en/interactive-computer-aided-instruction-software

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

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

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REPRESENTATIVE: