edibon
Technical Teaching Equipment

Computer Controlled **Stirling Motor,** with SCADA

TMSC

① Unit: TMSC. Stirling Motor

EDIBON PATENT

Teaching Technique used

EDIBON **SCADA** System

② Control Interface Box

③ Data Acquisition Board

④ Software for:
- Computer Control
- Data Acquisition
- Data Management

Computer (not included in the supply)

⑤ Cables and Accessories
⑥ Manuals

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

OPEN CONTROL
+
MULTICONTROL
+
REAL TIME CONTROL

Key features:

- **Advanced Real Time SCADA.**
- **Open Control + Multicontrol + Real Time Control.**
- **Own Control Software based on Labview.**
- **National Instruments Data Acquisition board (250 KS/s (kilo samples per second)).**
- **Calibration exercises included.**
- **Students multipost (an entire class) by using a projector.**
- **Ready for doing applied research, real industrial simulation, training courses possibilities, etc.**
- **Unit is totally safe (Mechanical, Electronic/Electrical and Software safety devices included).**
- **Results calculation and analysis software (CAL).**
- **Several future expansions, as ESN. EDIBON Scada-Net System (many students working simultaneously), and more.**
- **Designed and manufactured under several quality standards.**

www.edibon.com
Products
Products range
Units
9.-Thermodynamics & Thermotechnics

ISO 9000: Quality Management
(for Design, Manufacturing, Commercialization and After-sales service)

European Union Certificate
(total safety)

Certificates ISO 14000 and **ECO-Management and Audit Scheme**
(environmental management)

Worlddidac Quality Charter Certificate
(Worlddidac Member)

INTRODUCTION

A Stirling motor is a heat engine that operates by cyclic compression and expansion of air or other gas, the working fluid, at different temperature levels such that there is a net conversion of heat energy to mechanical work.

The motor is an external combustion unit like a steam engine in that all heat transfer takes place through the engine wall and the heat source is outside the engine. But unlike the steam engine, the working fluid used by the Stirling motor is a fixed quantity of gas either air or other type.

Similarly to other heat engines, the general cycle consists of compressing cool gas, heating the gas, expanding the hot gas, and finally cooling the gas again before repeating the cycle.

The Stirling motor is noted for its high efficiency, quiet operation, and can be used with any type of heat source as the renewables ones.

GENERAL DESCRIPTION

The Stirling Motor is used to demonstrate the operation of a thermodynamic machine for the conversion of energy. It converts thermal energy into mechanical energy and operates as a motor (heat engine). Additionally it can operate an electrical generator and load.

An Stirling motor is usually composed of two cylinders, the hot one and the cold one. The gas moves between the two cylinders in a closed circuit.

The external heat source gives energy to the hot cylinder and the expansion of the gas moves its piston, attached to the other piston in the cold cylinder by a crankshaft with a delay of 90° between them.

The hot gas passed to the cold cylinder where it is cooled. During this time the cold cylinder piston compresses the cooled gas and forces it to move to the hot cylinder where it receives the heat from the heat source and the cycle starts again.

An ideal stirling cycle has four phases:

Phase 1- Constant volume heating of the gas in the hot cylinder.

Phase 2- Isothermal expansion at constant temperature in the hot cylinder.

Phase 3- Constant volume working in the cold cylinder.

Phase 4- Isothermal compression of the gas in the cold cylinder.

The Stirling motor designed by EDIBON is mainly formed by: a stirling engine with a heating element, a braking system, a fan, an electrical generator with pulley to convert the mechanical energy to electrical energy, equipped with an electrical load and current and voltage measurement system.

This unit is supplied with the suitable sensors and instrumentation for the control and measurement of the most representative parameters, as:

Flame control.

Fan control.

Temperatures measurement in the cylinders.

Pressures measurement in the cylinders.

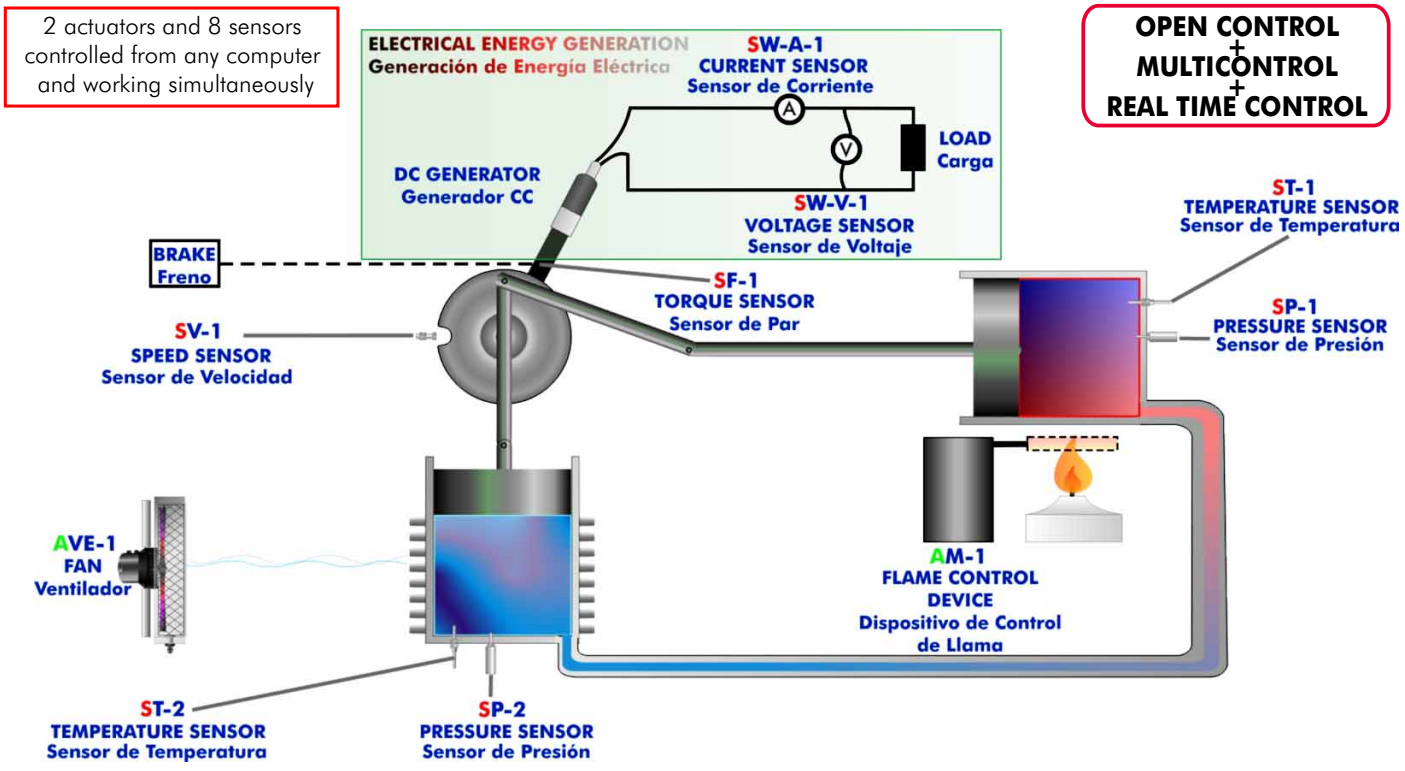
Speed measurement (rpm).

Torque measurement (force).

Power measurement, mechanical and electrical.

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

PROCESS DIAGRAM AND UNIT ELEMENTS ALLOCATION



COMPLETE TECHNICAL SPECIFICATIONS (for main items)

With this unit there are several options and possibilities:
- Main items: 1, 2, 3, 4, 5 and 6.
- Optional items: 7, 8, 9, 10, 11 and 12.

Let us describe first the main items (1 to 6):

① TMSC. Unit:

TMSC. Unit

Bench-top unit.
Anodized aluminium structure and panels in painted steel.
Diagram in the front panel with similar distribution to the elements in the real unit.
Stirling engine with a heating element controller (flame controller).
Device to control the flame of the heating element, to cover it and to release it.
Alcohol lamp as heating element.
Fan in the cold cylinder, computer controlled.
Braking system.
Electrical generator with a pulley for converting the generated mechanical energy into electrical energy. Equipped with an electrical load and current and voltage measurement system.
2 Tempeature sensors, one in the hot cylinder and the other in the cold cylinder.
2 Pressure sensors, one in the hot cylinder and the other in the cold cylinder.
Speed sensor (rpm).
Force sensor (torque).
Current sensor.
Voltage sensor.
Power measurement from the computer (PC).
Torque measurement by a brake and a force sensor.
Overtemperature protection with the activation of the device to control the flame.
The complete unit includes as well:

Advanced Real Time SCADA.
Open Control + Multicontrol + Real Time Control.
Own Control Software based on Labview.
National Instruments Data Acquisition board (250 KS/s (kilo samples per second)).
Calibration exercises included.
Students multipost (an entire class) by using a projector.
Ready for doing applied research, real industrial simulation, training courses possibilities, etc.
Unit is totally safe (Mechanical, Electronic/Electrical and Software safety devices included).
Results calculation and analysis software (CAL).
Several future expansions, as ESN. EDIBON Scada-Net System (many students working simultaneously), and more.
Designed and manufactured under several quality standards.

② TMSC/CIB. Control Interface Box:

The Control Interface Box is part of the SCADA system.
Control interface box with process diagram in the front panel and with the same distribution that the different elements located in the unit, for an easy understanding by the student.
All sensors, with their respective signals, are properly manipulated from -10V. to +10V. computer output. Sensors connectors in the interface have different pines numbers (from 2 to 16), to avoid connection errors.
Single cable between the control interface box and computer.


TMSC/CIB

The unit control elements are permanently computer controlled, without necessity of changes or connections during the whole process test procedure.
Simultaneous visualization in the computer of all parameters involved in the process.
Calibration of all sensors involved in the process.
Real time curves representation about system responses.
Storage of all the process data and results in a file.
Graphic representation, in real time, of all the process/system responses.
All the actuators' values can be changed at any time from the keyboard allowing the analysis about curves and responses of the whole process.
All the actuators and sensors values and their responses are displayed on only one screen in the computer.
Shield and filtered signals to avoid external interferences.
Real time computer control with flexibility of modifications from the computer keyboard of the parameters, at any moment during the process.
Real time computer control for pumps, compressors, resistances, control valves, etc.
Real time computer control for parameters involved in the process simultaneously.
Open control allowing modifications, at any moment and in real time, of parameters involved in the process simultaneously.
Three safety levels, one mechanical in the unit, another electronic in the control interface and the third one in the control software.

③ DAB. Data Acquisition Board:

The Data Acquisition board is part of the SCADA system.

PCI Data acquisition board (National Instruments) to be placed in a computer slot. Bus PCI.

Analog input:

Number of **channels= 16** single-ended or 8 differential.

Resolution=16 bits, 1 in 65536.

Sampling rate up to: 250 KS/s (Kilo samples per second).

Input range (V)=±10V.

Data transfers=DMA, interrupts, programmed I/O.

DMA channels=6.

DAB

Analog output:

Number of **channels=2**.

Resolution=16 bits, 1 in 65536.

Maximum output rate up to: 833 KS/s.

Output range(V)=±10V.

Data transfers=DMA, interrupts, programmed I/O.

Digital Input/Output:

Number of **Channels=24 inputs/outputs**.

D0 or DI Sample Clock frequency: 0 to 1 MHz.

Timing:

Number of **Counter/timers=2**.

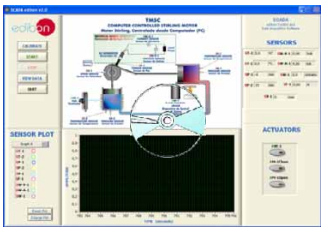
Resolution: Counter/timers: 32 bits.

④ TMSC/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.



TMSC/CCSOF

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

Management, processing, comparison and storage of data.

Sampling velocity up to 250 KS/s (kilo samples per second).

Calibration system for the sensors involved in the process.

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 blackboard.

⑤ Cables and Accessories, for normal operation.

⑥ Manuals: This unit is **supplied with 8 manuals:** Required Services, Assembly and Installation, Interface and Control Software, Starting-up, Safety, Maintenance, Calibration & Practices Manuals.

* References 1 to 6 are the main items: TMSC + TMSC/CIB + DAB + TMSC/CCSOF + Cables and Accessories + Manuals are included in the minimum supply for enabling normal and full operation.

EXERCISES AND PRACTICAL POSSIBILITIES TO BE DONE WITH MAIN ITEMS

1.- Study of the conversion of thermal-mechanical-electrical energy.

2.- Study of the relation between the temperatures difference of the thermal machine and the speed generated.

3.- Calculation of the "threshold" temperatures difference which generate motion.

4.- Study of the mechanical power in relation to speed.

5.- Study of the electrical power in relation to speed.

6.- Mechanical efficiency calculation.

7.- Electrical efficiency calculation.

8.- Study of the pV curve.

9.- Speed measurement (rpm).

10.- Torque measurement.

11.- Measurement of the generated electrical power.

12.- Temperature measurements.

13.- Pressure measurements.

Additional practical possibilities:

14.- Sensors calibration.

Other possibilities to be done with this Unit:

15.- Many students view results simultaneously.

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

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

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

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

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

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

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

21.- Control of the TMSC unit process through the control interface box without the computer.

22.- Visualization of all the sensors values used in the TMSC unit process.

- By using PLC-PI additional 19 more exercises can be done.

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

REQUIRED SERVICES

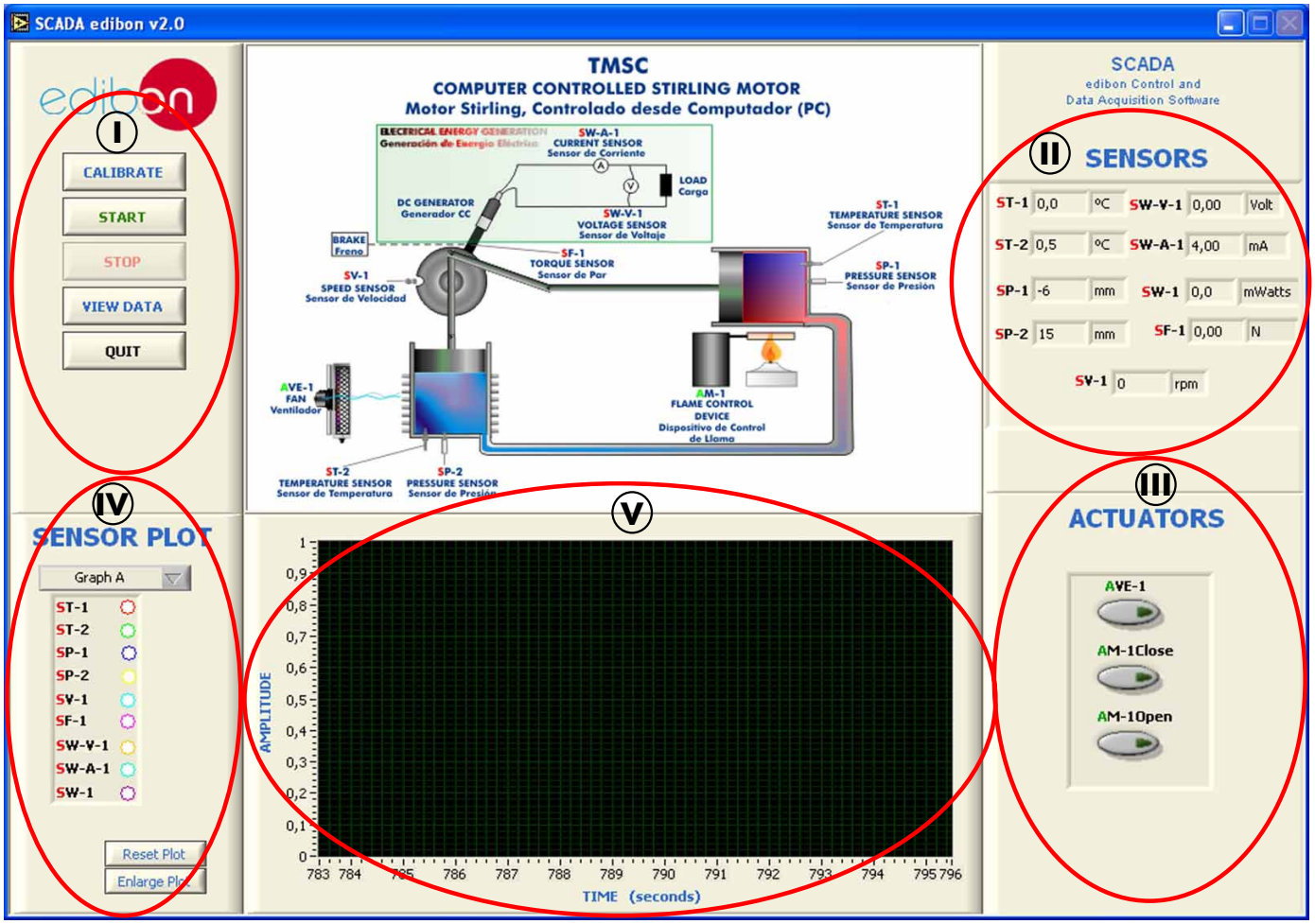
-Electrical supply: single-phase, 220 V/50 Hz. or 110 V/60 Hz.
- Alcohol or paraffin.
-Computer (PC).

DIMENSIONS & WEIGHTS

TMSC Unit:	-Dimensions: 400 x 350 x 450 mm. approx.
	-Weight: 20 Kg. approx.
Control Interface Box:	-Dimensions: 490 x 330 x 310 mm. approx.
	-Weight: 10 Kg. approx.

SCADA

Main screen



Ⓘ Main Controls.

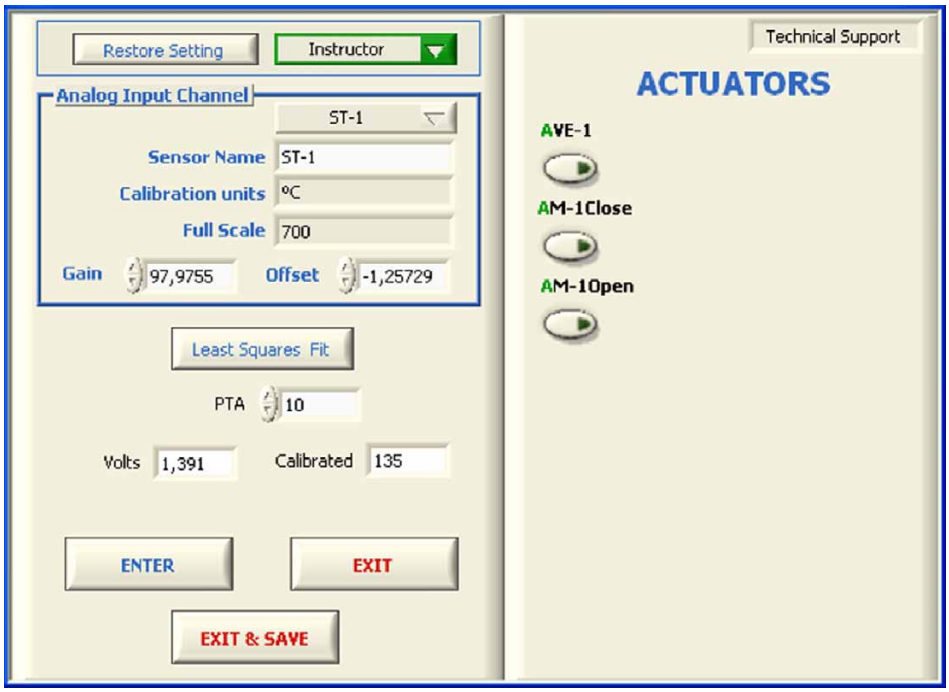
Ⓘ Ⓘ **Sensors displays and extra output parameters. Sensors:** ST= Temperature sensor. SP= Pressure sensor. SW-V= Voltage sensor. SW-A= Current sensor. SW= Power sensor. SF= Force sensor. SV= Speed sensor.

Ⓘ Ⓘ Ⓘ **Actuators controls. Actuators:** AVE= Fan. AM= Flame control device.

Ⓘ Ⓥ Channel selection and other plot parameters.

Ⓥ Graphical Display.

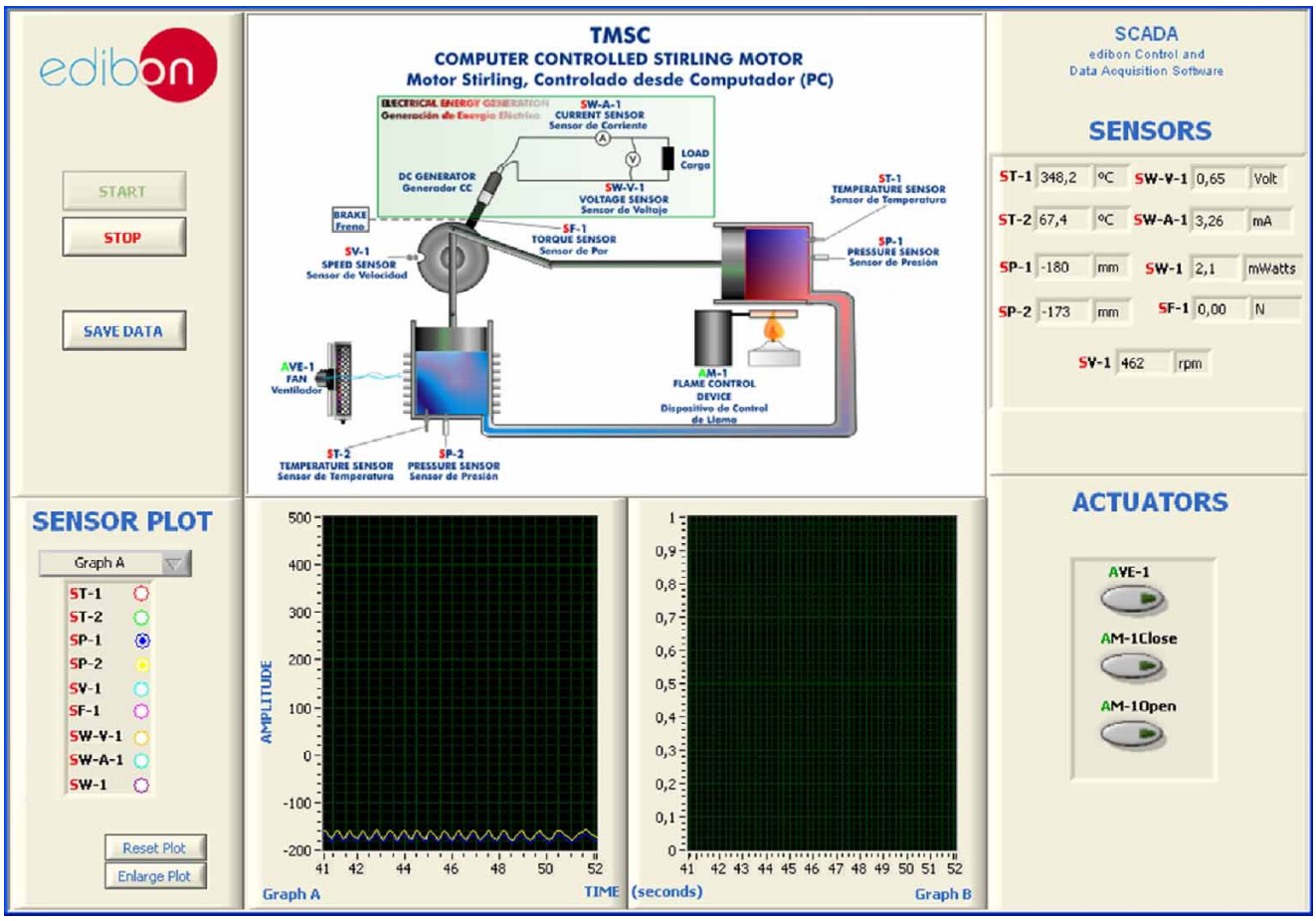
Software for Sensors Calibration



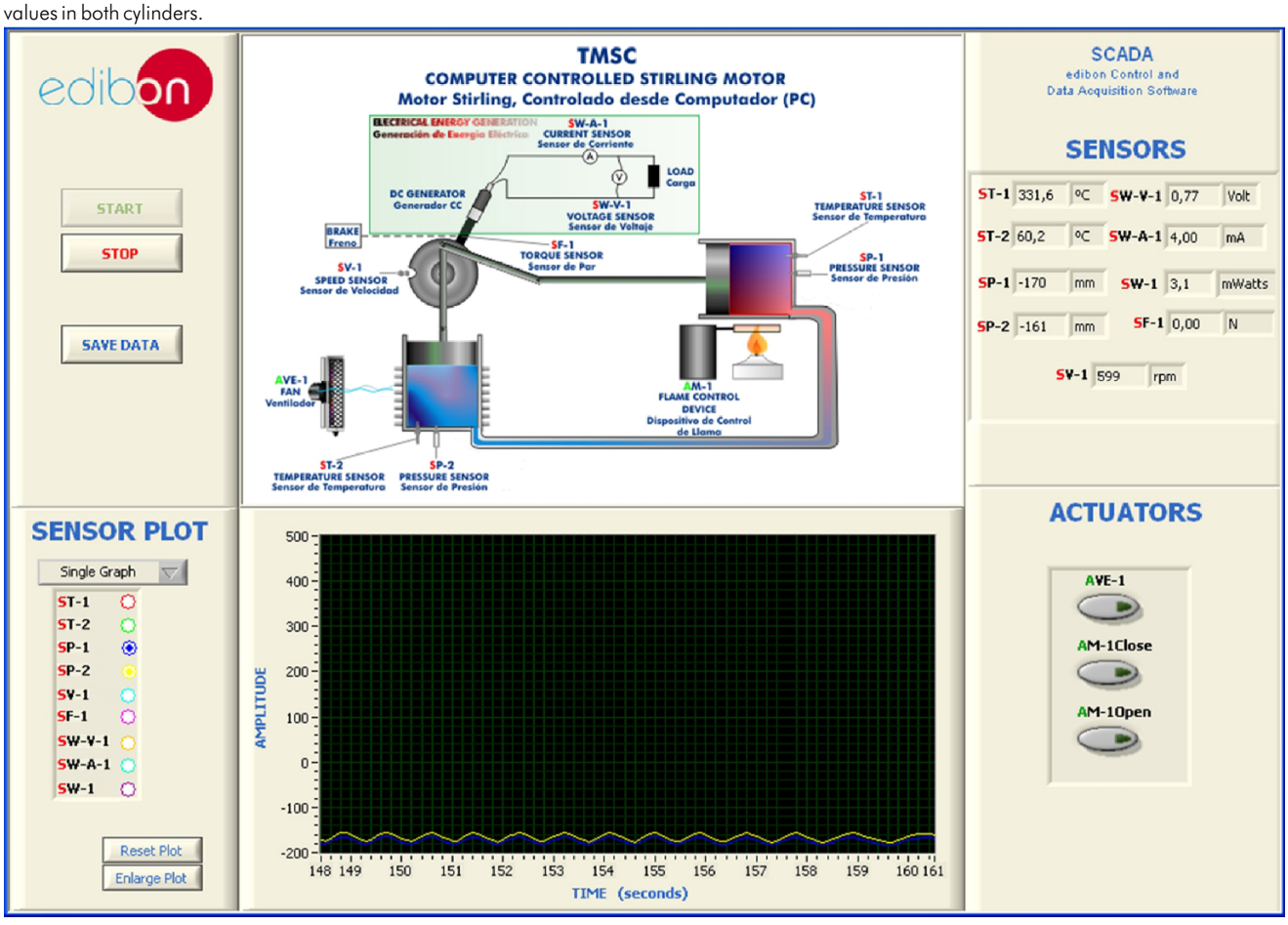
By using a free of charge code, the teacher and the students can calibrate the unit.

The teacher can recover his/her own calibration by using the EDIBON code that we give free of charge.

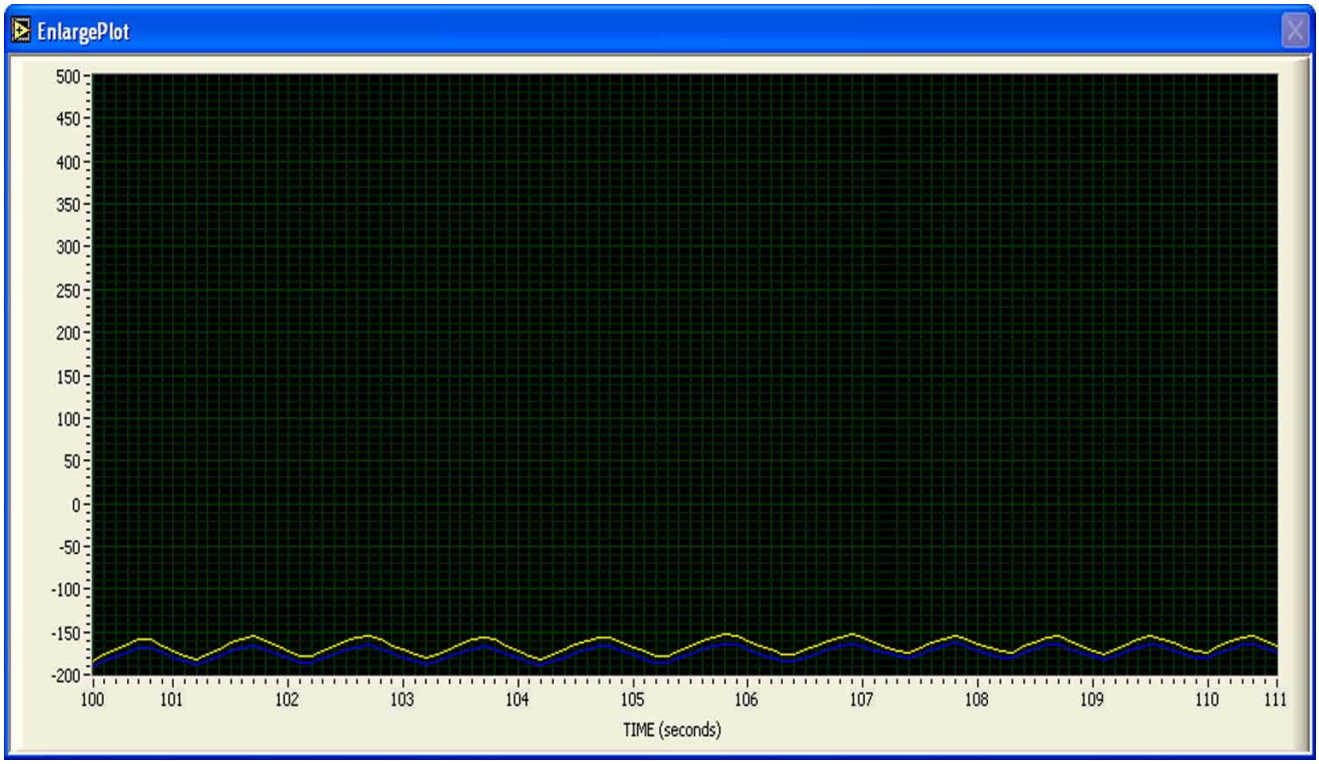
It can be observed how the temperature difference between the hot cylinder (ST-1sensor) and the cold cylinder (ST-2 sensor) generates electric power, which is measured through the computer. Current and tension can also be observed. Two graphs are represented at the bottom.



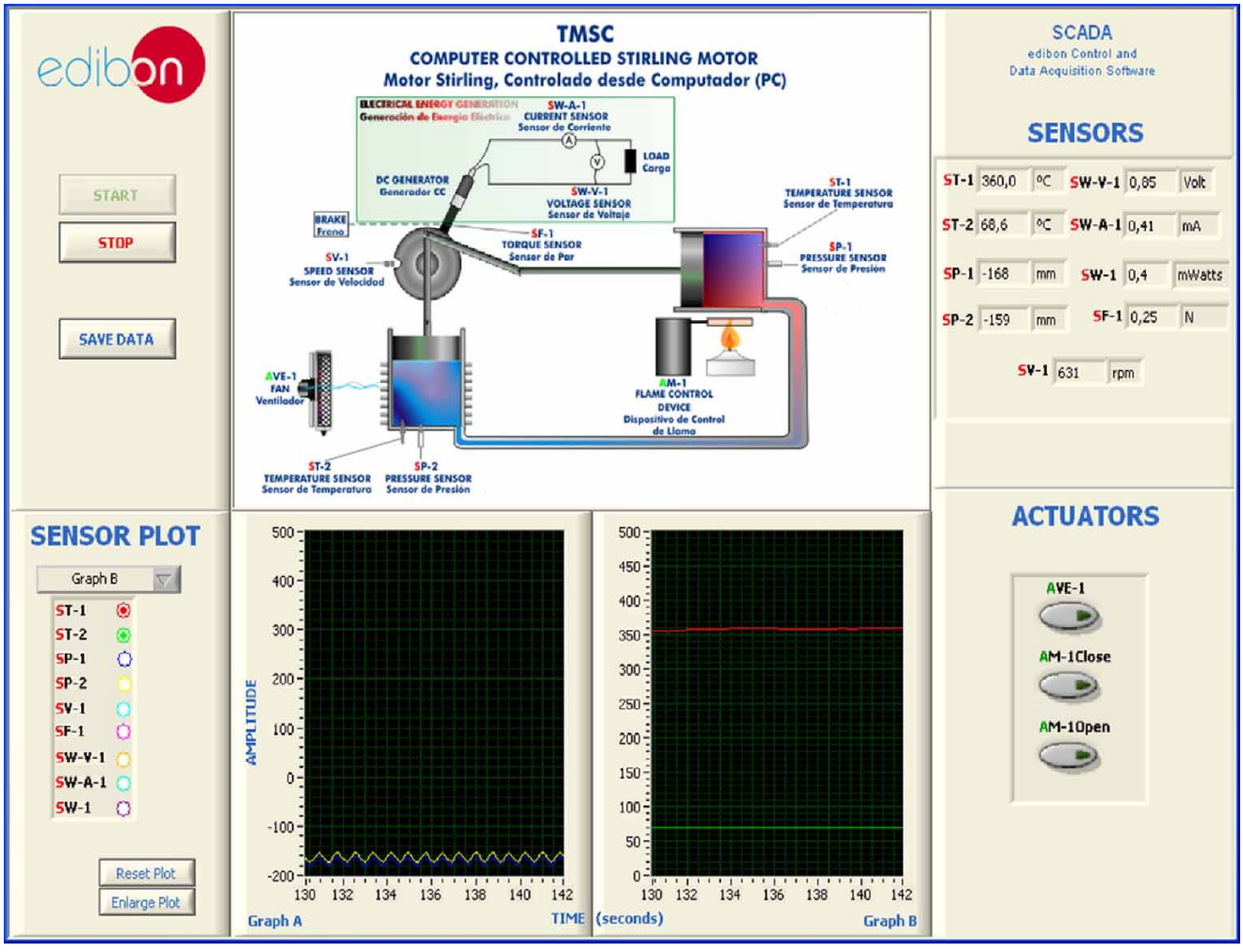
It can be observed how the temperature difference between the hot cylinder (ST-1 sensor) and the cold cylinder (ST-2 sensor) generates electric power, which is measured through the computer. Current and tension can also be observed. A graph is represented at the bottom, it shows pressure sensors values in both cylinders.



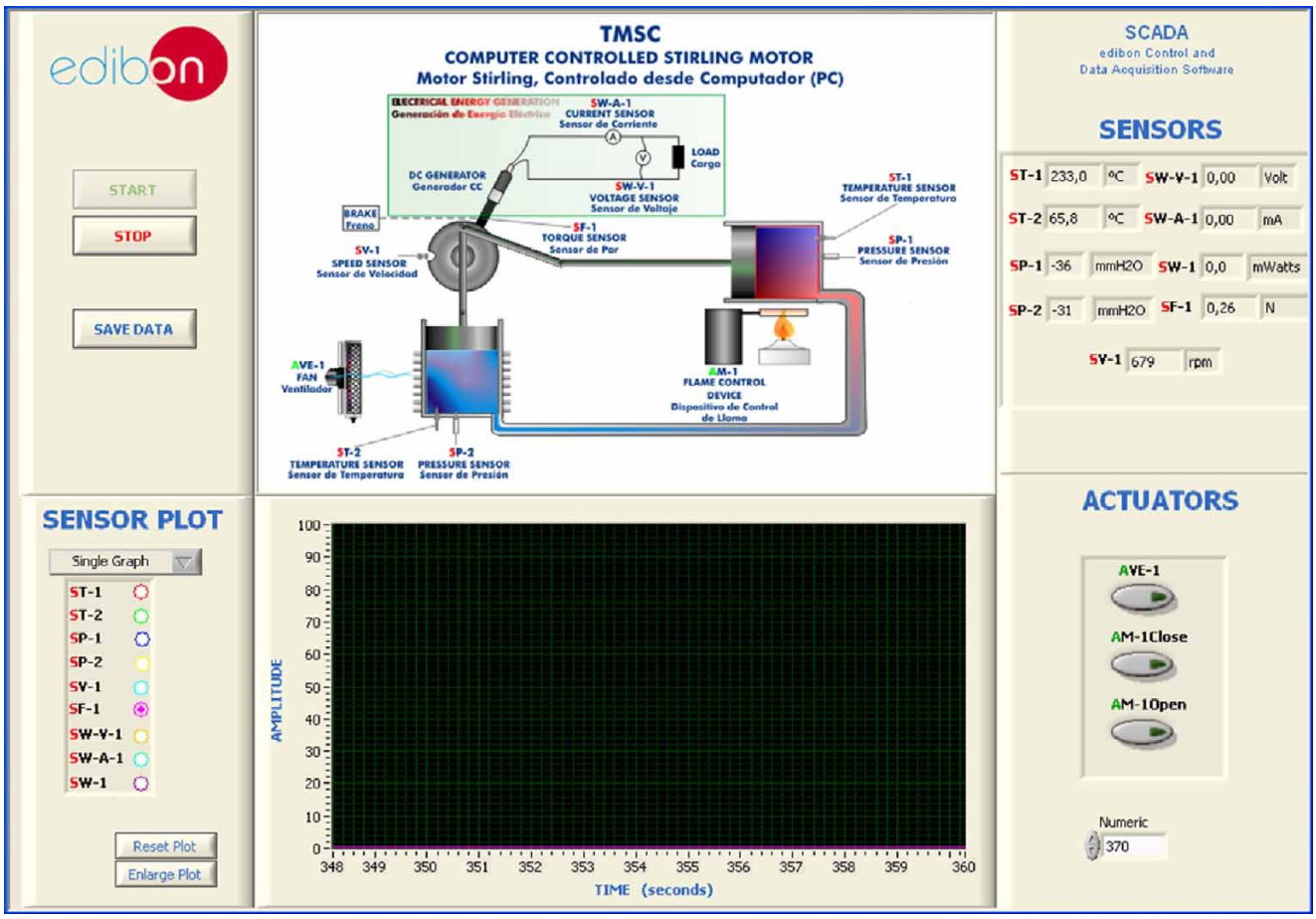
Graph where the pressure measurements in both cylinders are represented (SP-1 measures the pressure of the hot cylinder and SP-2 the pressure of the cold cylinder). It can be observed how they vary periodically and how pressure goes up and down representing the gas expansion and compression.



Besides measuring the current intensity and the tension generated, mechanical energy is measured by means of a speed sensor (SV-1) that indicates the rpm and the torque transmitted by a force sensor (SF-1). Two graphs are represented at the bottom. The one at the left side represents the pressure in both cylinders and the one at the right side represents the temperature.



To determine the mechanical power, the torque transmitted and the speed obtained are measured through the sensors SF-1 (force sensor) and SV-1 (speed sensor. The force transmitted as the engine is working is represented in the graph at the bottom.



COMPLETE TECHNICAL SPECIFICATIONS (for optional items)

Additionally to the main items (1 to 6) described, we can offer, as optional, other items from 7 to 12.
All these items try to give more possibilities for:

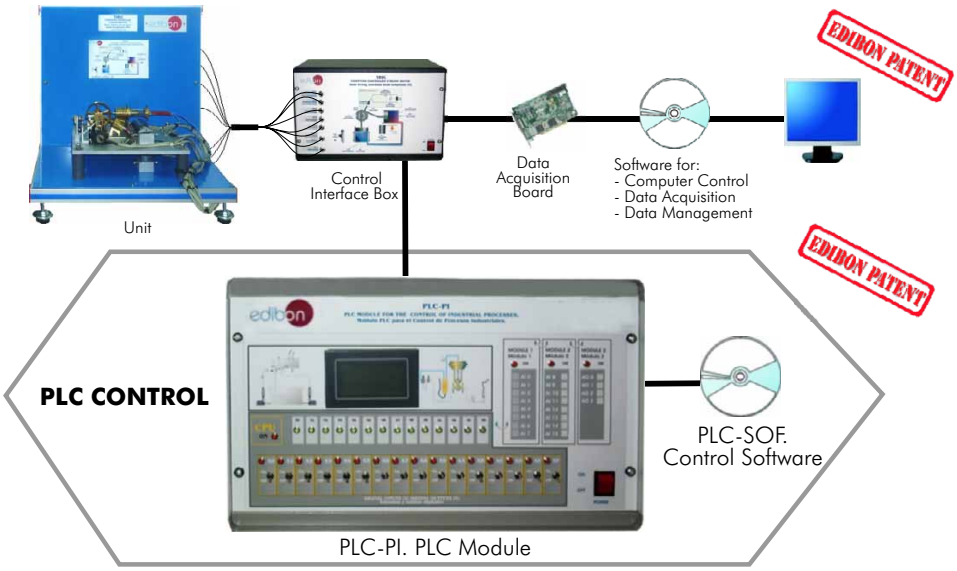
a) Industrial configuration. (PLC)
b) Technical and Vocational Education configuration. (CAI and FSS)
c) Higher Education and/or Technical and Vocational Education configuration. (CAL)
d) Multipost Expansions options. (Mini ESN and ESN)

a) Industrial configuration

⑦ PLC. Industrial Control using PLC (it includes PLC-PI Module plus PLC-SOF Control Software):

-**PLC-PI. PLC Module:**
Metallic box.
Circuit diagram in the module front panel.
Front panel:
Digital inputs(X) and Digital outputs (Y) block:
16 Digital inputs, activated by switches and 16 LEDs for confirmation (red).
14 Digital outputs (through SCSI connector) with 14 LEDs for message (green).
Analog inputs block:
16 Analog inputs (-10V. to + 10V.) (through SCSI connector).
Analog outputs block:
4 Analog outputs (-10V. to + 10V.) (through SCSI connector).
Touch screen:
High visibility and multiple functions. Display of a highly visible status. Recipe function. Bar graph function. Flow display function. Alarm list. Multi language function. True type fonts.
Back panel:
Power supply connector. Fuse 2A. RS-232 connector to PC. USB 2.0 connector to PC.
Inside:
Power supply outputs: 24 Vdc, 12 Vdc, -12 Vdc, 12 Vdc variable.
Panasonic PLC:
High-speed scan of 0.32 µsec. for a basic instruction.
Program capacity of 32 Ksteps, with a sufficient comment area.
Power supply input (100 to 240 V AC).
DC input: 16 (24 V DC).
Relay output: 14.
High-speed counter.
Multi-point PID control.
Digital inputs/outputs and analog inputs/outputs Panasonic modules.
Communication RS232 wire to computer (PC).
Dimensions: 490 x 330 x 310 mm. approx. Weight: 30 Kg. approx.

-**TMSC/PLC-SOF. PLC Control Software:**
For this particular unit, always included with PLC supply.
The software has been designed using Labview and it follows the unit operation procedure and linked with the Control Interface Box used in the Computer Controlled Stirling Motor (TMSC).



Practices to be done with PLC-PI:

1.- Control of the TMSC unit process through the control interface box without the computer.
2.- Visualization of all the sensors values used in the TMSC unit process.
3.- Calibration of all sensors included in the TMSC unit process.
4.- Hand on of all the actuators involved in the TMSC unit process.
5.- Realization of different experiments, in automatic way, without having in front the unit. (This experiment can be decided previously).
6.- Simulation of outside actions, in the cases hardware elements do not exist. (Example: test of complementary tanks, complementary industrial environment to the process to be studied, etc).
7.- PLC hardware general use and manipulation.
8.- PLC process application for TMSC unit.
9.- PLC structure.
10.- PLC inputs and outputs configuration.
11.- PLC configuration possibilities.
12.- PLC programming languages.
13.- PLC different programming standard languages.
14.- New configuration and development of new process.
15.- Hand on an established process.
16.- To visualize and see the results and to make comparisons with the TMSC unit process.
17.- Possibility of creating new process in relation with the TMSC unit.
18.- PLC Programming exercises.
19.- Own PLC applications in accordance with teacher and student requirements.

⑧TMSC/CAI. Computer Aided Instruction Software System.

This complete package included two Softwares: the INS/SOF. Classroom Management Software (Instructor Software) and the TMSC/SOF. Computer Aided Instruction Software (Student Software).

This software is optional and can be used additionally to items (1 to 6).

This complete package consists on an Instructor Software (INS/SOF) totally integrated with the Student Software (TMSC/SOF). Both are interconnected so that the teacher knows at any moment what is the theoretical and practical knowledge of the students. These, on the other hand, get a virtual instructor who helps them to deal with all the information on the subject of study.

- INS/SOF. Classroom Management Software (Instructor Software):

The Instructor can:

Organize Students by Classes and Groups.

Create easily new entries or delete them.

Create data bases with student information.

Analyze results and make statistical comparisons.

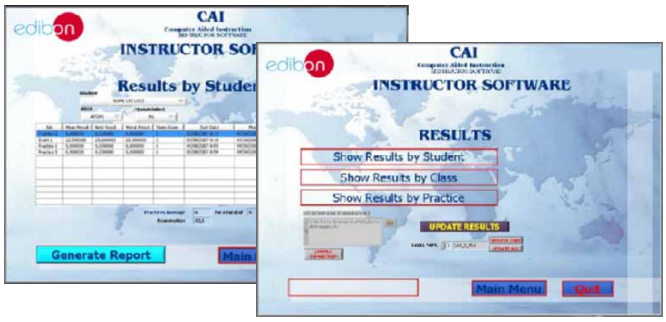
Print reports.

Develop own examinations.

Detect student's progress and difficulties.

...and many other facilities.

Instructor Software



- TMSC/SOF. Computer Aided Instruction Software (Student Software):

It explains how to use the unit, run the experiments and what to do at any moment.

This Software contains:

Theory.

Exercises.

Guided Practices.

Exams.

Student Software

For more information see **CAI** catalogue. Click on the following link:
www.edibon.com/products/catalogues/en/CAI.pdf

⑨TMSC/FSS. Faults Simulation System.

Faults Simulation System (FSS) is a Software package that simulates several faults in any EDIBON Computer Controlled Unit. It is useful for Technical and Vocational level.

The "FAULTS" mode consists on causing several faults in the unit normal operation. The student must find them and solve them.

There are several kinds of faults that can be grouped in the following sections:

Faults affecting the sensors measurement:

- An incorrect calibration is applied to them.
- Non-linearity.

Faults affecting the actuators:

- Actuators canals interchange at any time during the program execution.
- Response reduction of an actuator.

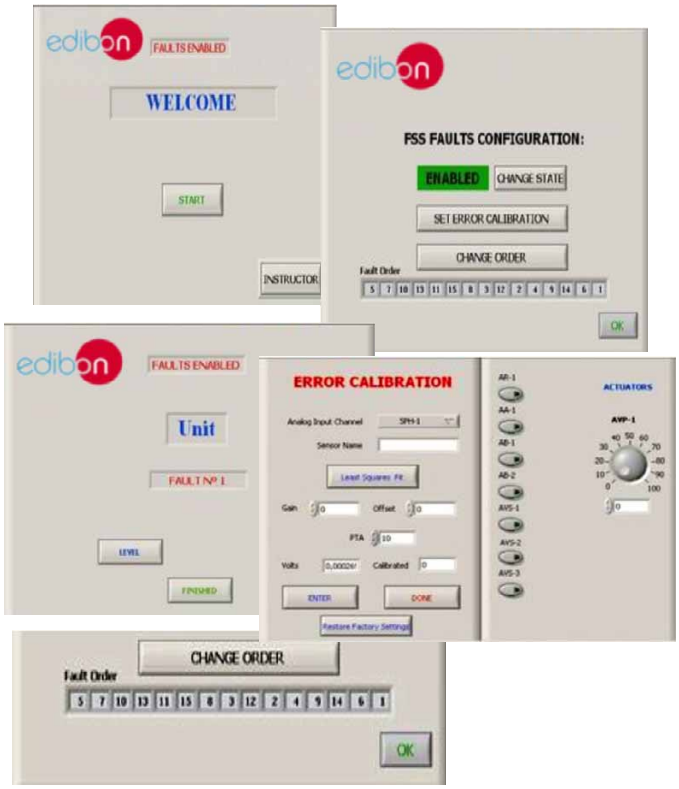
Faults in the controls execution:

- Inversion of the performance in ON/OFF controls.
- Reduction or increase of the calculated total response.
- The action of some controls is annulled.

On/off faults:

- Several on/off faults can be included.

Example of some screens



For more information see **FSS** catalogue. Click on the following link:
www.edibon.com/products/catalogues/en/FSS.pdf

c) Higher Education and/or Technical and Vocational Education configuration

⑩TMSC/CAL. Computer Aided Learning Software (Results Calculation and Analysis).

This Computer Aided Learning Software (CAL) is a Windows based software, simple and very easy to use, specifically developed by EDIBON. It is very useful for Higher Education level.

CAL is a class assistant that helps in making the necessary calculations to extract the right conclusions from data obtained during the experimental practices.

CAL will perform the calculations.

CAL computes the value of all the variables involved.

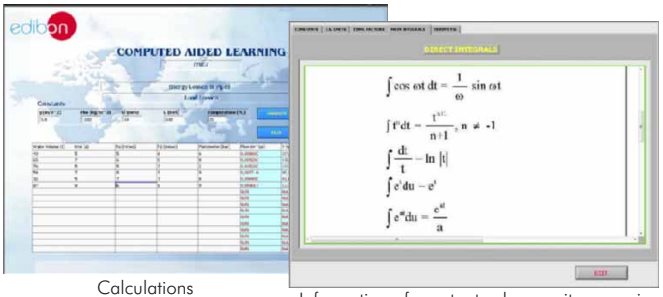
It allows to plot and print the results. Between the plotting options, any variable can be represented against any other.

Different plotting displays.

It has a wide range of information, such as constant values, unit conversion factors and integral and derivative tables.

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

www.edibon.com/products/catalogues/en/CAL.pdf



Calculations

Information of constant values, unit conversion factors and integral and derivative tables

Plotting options

d) Multipost Expansions options

⑪ Mini ESN. EDIBON Mini Scada-Net System.

Mini ESN. EDIBON Mini Scada-Net System allows 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 on the adaptation of any EDIBON Computer Controlled Unit with SCADA integrated in a local network.

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

Main characteristics:

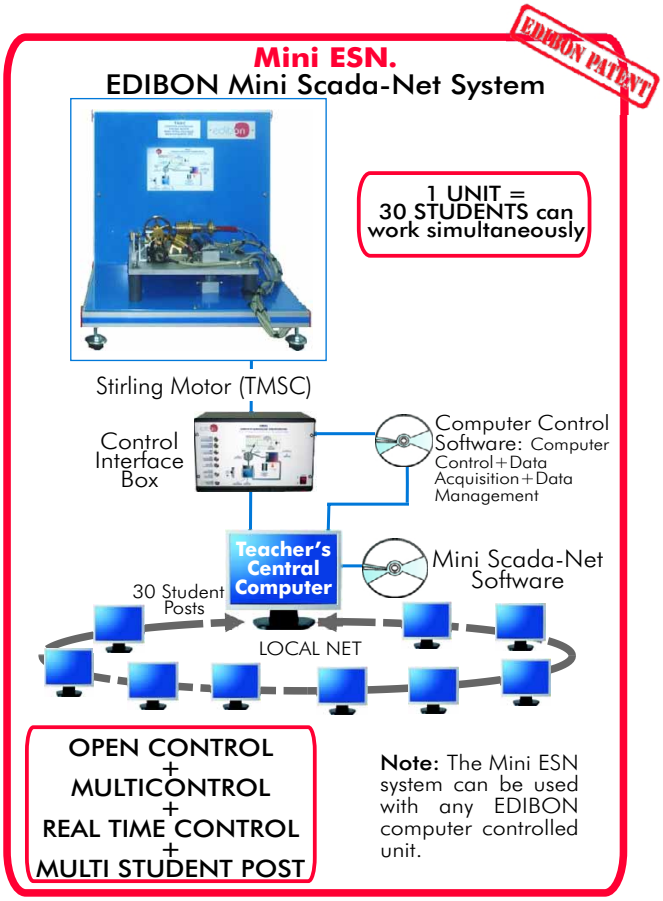
- **It allows 30 students to work simultaneously with the EDIBON Computer Controlled Unit with SCADA, connected in a local net.**
- **Open Control + Multicontrol + Real Time Control + Multi Student Post.**
- **Teacher controls and explains to all students at the same time.**
- **Any user/student can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

Main advantages:

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

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

www.edibon.com/products/catalogues/en/Mini-ESN.pdf



⑫ESN. EDIBON Scada-Net System.

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

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

www.edibon.com/products/catalogues/en/units/thermodynamicsthermotechnics/esn-thermodynamics/ESN-THERMODYNAMICS.pdf

ORDER INFORMATION

Main items (always included in the supply)

Minimum supply always includes:

① **Unit: TMSC. Stirling Motor.**

② **TMSC/CIB. Control Interface Box.**

③ **DAB. Data Acquisition Board.**

④ **TMSC/CCSOF. Computer Control + Data Acquisition + Data Management Software.**

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

⑥ **Manuals.**

* IMPORTANT: Under TMSC we always supply all the elements for immediate running as 1, 2, 3, 4, 5 and 6.

Optional items (supplied under specific order)

a) Industrial configuration

⑦ PLC. Industrial Control using PLC (it includes PLC-PI Module plus PLC-SOF Control Software):

- PCL-PI. PLC Module.
- TMSC/PLC-SOF. PLC Control Software.

b) Technical and Vocational configuration

⑧ TMSC/CAI. Computer Aided Instruction Software System.

⑨ TMSC/FSS. Faults Simulation System.

c) Higher Education and/or Technical and Vocational Education configuration

⑩ TMSC/CAL. Computer Aided Learning Software (Results Calculation and Analysis).

d) Multipost Expansions options

⑪ Mini ESN. EDIBON Mini Scada-Net System.

⑫ ESN. EDIBON Scada-Net System.

①TMSC. Unit:

Bench-top unit.

Anodized aluminium structure and panels in painted steel.

Diagram in the front panel with similar distribution to the elements in the real unit.

Stirling engine with a heating element controller (flame controller).

Device to control the flame of the heating element, to cover it and to release it.

Alcohol lamp as heating element.

Fan in the cold cylinder, computer controlled.

Braking system.

Electrical generator with a pulley for converting the generated mechanical energy into electrical energy. Equipped with an electrical load and current and voltage measurement system.

2 Tempeature sensors, one in the hot cylinder and the other in the cold cylinder.

2 Pressure sensors, one in the hot cylinder and the other in the cold cylinder.

Speed sensor (rpm).

Force sensor (torque).

Current sensor.

Voltage sensor.

Power measurement from the computer (PC).

Torque measurement by a brake and a force sensor.

Overtemperature protection with the activation of the device to control the flame.

The complete unit includes as well:

- Advanced Real Time SCADA.
- Open Control + Multicontrol + Real Time Control.
- Own Control Software based on Labview.
- National Instruments Data Acquisition board (250 KS/s (kilo samples per second)).
- Calibration exercises included.
- Students multipost (an entire class) by using a projector.
- Ready for doing applied research, real industrial simulation, training courses possibilities, etc.
- Unit is totally safe (Mechanical, Electronic/Electrical and Software safety devices included).
- Results calculation and analysis software (CAL).
- Several future expansions, as ESN. EDIBON Scada-Net System (many students working simultaneously), and more.
- Designed and manufactured under several quality standards.

②TMSC/CIB. Control Interface Box:

The Control Interface Box is part of the SCADA system. Control interface box with process diagram in the front panel.

The unit control elements are permanently computer controlled.

Simultaneous visualization in the computer of all parameters involved in the process.

Calibration of all sensors involved in the process.

Real time curves representation about system responses.

All the actuators' values can be changed at any time from the keyboard allowing the analysis about curves and responses of the whole process.

Shield and filtered signals to avoid external interferences.

Real time computer control with flexibility of modifications from the computer keyboard of the parameters, at any moment during the process.

Real time computer control for parameters involved in the process simultaneously.

Open control allowing modifications, at any moment and in real time, of parameters involved in the process simultaneously.

Three safety levels, one mechanical in the unit, another electronic in the control interface and the third one in the control software.

③DAB. Data Acquisition Board:

The Data Acquisition board is part of the SCADA system.

PCI Data acquisition board (National Instruments) to be placed in a computer slot.

Analog input: Channels= 16 single-ended or 8 differential. Resolution=16 bits, 1 in 65536. Sampling rate up to: 250 KS/s (kilo samples per second).

Analog output: Channels=2. Resolution=16 bits, 1 in 65536.

Digital Input/Output: Channels=24 inputs/outputs.

④TMSC/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.

Sampling velocity up to 250 KS/s (kilo samples per second).

Calibration system for the sensors involved in the process.

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 blackboard.

⑤Cables and Accessories, for normal operation.

⑥Manuals: This unit is supplied with 8 manuals: Required Services, Assembly and Installation, Interface and Control Software, Starting-up, Safety, Maintenance, Calibration & Practices Manuals.

Exercises and Practical Possibilities to be done with Main Items

1.- Study of the conversion of thermal-mechanical-electrical energy.
2.- Study of the relation between the temperatures difference of the thermal machine and the speed generated.
3.- Calculation of the "threshold" temperatures difference which generate motion.
4.- Study of the mechanical power in relation to speed.
5.- Study of the electrical power in relation to speed.
6.- Mechanical efficiency calculation.
7.- Electrical efficiency calculation.
8.- Study of the pV curve.
9.- Speed measurement (rpm).
10.- Torque measurement.
11.- Measurement of the generated electrical power.
12.- Temperature measurements.
13.- Pressure measurements.

Additional practical possibilities:

14.- Sensors calibration.

Other possibilities to be done with this Unit:

15.- Many students view results simultaneously.
To view all results in real time in the classroom by means of a projector or an electronic blackboard.
16.- Open Control, Multicontrol and Real Time Control.
This unit allows intrinsically and/or extrinsically to change the span, gains; proportional, integral, derivate parameters; etc in real time.
17.- The Computer Control System with SCADA allows a real industrial simulation.
18.- This unit is totally safe as uses mechanical, electrical and electronic, and software safety devices.
19.- This unit can be used for doing applied research.
20.- This unit can be used for giving training courses to Industries even to other Technical Education Institutions.
21.- Control of the TMSC unit process through the control interface box without the computer.
22.- Visualization of all the sensors values used in the TMSC unit process.

- By using PLC-PI additional 19 more exercises can be done.
- Several other exercises can be done and designed by the user.

a) Industrial configuration

⑦ PLC. Industrial Control using PLC (it includes PLC-PI Module plus PLC-SOF Control Software):

-**PLC-PI. PLC Module:**

Metallic box.
Circuit diagram in the module front panel.
Digital inputs(X) and Digital outputs (Y) block: 16 Digital inputs. 14 Digital outputs.
Analog inputs block: 16 Analog inputs.
Analog outputs block: 4 Analog outputs.
Touch screen.
Panasonic PLC:
High-speed scan of 0.32 µsec. Program capacity of 32 Ksteps. High-speed counter. Multi-point PID control.
Digital inputs/outputs and analog inputs/outputs Panasonic modules.

-**TMSC/PLC-SOF. PLC Control Software:**

For this particular unit, always included with PLC supply.

Practices to be done with PLC-PI:

1.- Control of the TMSC unit process through the control interface box without the computer.
2.- Visualization of all the sensors values used in the TMSC unit process.
3.- Calibration of all sensors included in the TMSC unit process.
4.- Hand on of all the actuators involved in the TMSC unit process.
5.- Realization of different experiments, in automatic way, without having in front the unit. (This experiment can be decided previously).
6.- Simulation of outside actions, in the cases hardware elements do not exist. (Example: test of complementary tanks, complementary industrial environment to the process to be studied, etc).
7.- PLC hardware general use and manipulation.
8.- PLC process application for TMSC unit.
9.- PLC structure.
10.- PLC inputs and outputs configuration.
11.- PLC configuration possibilities.
12.- PLC programming languages.
13.- PLC different programming standard languages.
14.- New configuration and development of new process.
15.- Hand on an established process.
16.- To visualize and see the results and to make comparisons with the TMSC unit process.
17.- Possibility of creating new process in relation with the TMSC unit.
18.- PLC Programming exercises.
19.- Own PLC applications in accordance with teacher and student requirements.

b) Technical and Vocational Education configuration

⑧ TMSC/CAI. Computer Aided Instruction Software System.

This complete package consists on an Instructor Software (INS/SOF) totally integrated with the Student Software (TMSC/SOF).
-INS/SOF. Classroom Management Software (Instructor Software):
The Instructor can:
Organize Students by Classes and Groups.
Create easily new entries or delete them.
Create data bases with student information.
Analyze results and make statistical comparisons.
Print reports.
Develop own examinations.
Detect student's progress and difficulties.
-TMSC/SOF. Computer Aided Instruction Software (Student Software):
It explains how to use the unit, run the experiments and what to do at any moment.
This Software contains:
Theory.
Exercises.
Guided Practices.
Exams.

⑨ TMSC/FSS. Faults Simulation System.

Faults Simulation System (FSS) is a Software package that simulates several faults in any EDIBON Computer Controlled Unit.
The "FAULTS" mode consists on causing several faults in the unit normal operation. The student must find them and solve them.
There are several kinds of faults that can be grouped in the following sections:
Faults affecting the sensors measurement:
- An incorrect calibration is applied to them.
- Non-linearity.

Faults affecting the actuators:
- Actuators canals interchange at any time during the program execution.
- Response reduction of an actuator.

Faults in the controls execution:
- Inversion of the performance in ON/OFF controls.
- Reduction or increase of the calculated total response.
- The action of some controls is annulled.

On/off faults:
- Several on/off faults can be included.

c) Higher Education and/or Technical and Vocational Education configuration

⑩TMSC/CAL. Computer Aided Learning Software (Results Calculation and Analysis).

This Computer Aided Learning Software (CAL) is a Windows based software, simple and very easy to use.
CAL is a class assistant that helps in making the necessary calculations to extract the right conclusions from data obtained during the experimental practices.
CAL will perform the calculations.
CAL computes the value of all the variables involved.
It allows to plot and print the results. Between the plotting options, any variable can be represented against any other.
Different plotting displays.
It has a wide range of information, such as constant values, unit conversion factors and integral and derivative tables.

d) Multipost Expansions options

⑪Mini ESN. EDIBON Mini Scada-Net System.

EDIBON Mini Scada-Net System allows 30 students to work with a Teaching Unit in any laboratory, simultaneously.
The Mini ESN system consists on the adaptation of any EDIBON Computer Controlled Unit with SCADA integrated in a local network.
This system allows to view/control the unit remotely, from any computer integrated in the local net (in the classroom), through the main computer connected to the unit.
Main characteristics:

-It allows 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.
-Teacher controls and explains to all students at the same time.
-Any user/student can work doing "real time" control/multicontrol and visualisation.
-The manager/teacher can see in his/her computer what any user/student is doing in the unit.
-Continuous communication between the manager and all the users/students connected.

Main advantages:

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

The system basically will consist of:

This system can be used with Computer Controlled Unit.
-Manager/Teacher computer.
-Computers in a local net.
-Mini SCADA-NET system (Manager/Instructor Software + User/Student Software + Unit Software adaptation + Unit-Control Interface adaptation + Webcam + cables and accessories required for a normal operation).

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

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