edibon

Engineering and Technical Teaching Equipment

Computer Controlled **Heat Transfer Series,** with SCADA and PID Control

TSTCC

Teaching Technique used

EDIBON **SCADA** System and **PID Control** included

① TSTCC/CIB Control Interface for TSTCC (Common for all available modules type "TXC"

② Data Acquisition Board

(+) Computer Control Software for each Module

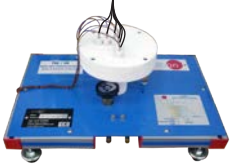
Computer (not included in the supply)

③ Cables and Accessories

④ Manuals

Required elements (at least one) (Not included):

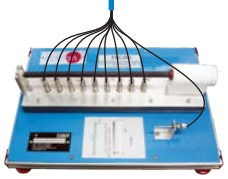
TXC/CL. Linear Heat Conduction Module for TSTCC (+)



TXC/CR. Radial Heat Conduction Module for TSTCC (+)

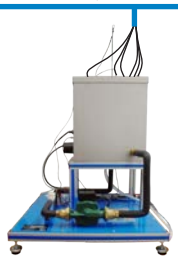
TXC/RC. Radiation Heat Transfer Module for TSTCC (+)

TXC/CC. Combined Free and Forced Convection and Radiation Module for TSTCC (+)

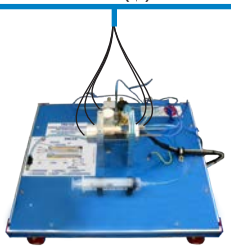


TXC/SE. Extended Surface Heat Transfer Module for TSTCC (+)

TXC/ER. Radiation Errors in Temperature Measurement Module for TSTCC (+)

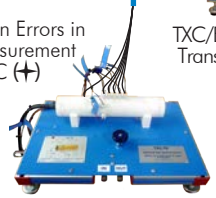


TXC/EI. Unsteady State Heat Transfer Module for TSTCC (+)



TXC/LG. Thermal Conductivity of Liquids and Gases Module for TSTCC (+)

TXC/FF. Free and Forced Convection Heat Transfer Module for TSTCC (+)



TXC/TE. Three Axes Heat Transfer Module for TSTCC (+)

TXC/MM. Metal to Metal Heat Transfer Module for TSTCC (+)

TXC/TC. Ceramic Heat Transfer Module for TSTCC (+)

TXC/TI. Insulating Material Heat Transfer Module for TSTCC (+)

Key features:

- **Advanced Real-Time SCADA and PID Control.**
- **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
9.- THERMODYNAMICS & THERMOTECHNICS

For more information about Key Features, click here

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

The physical phenomenon of transferring heat energy from one medium to another is called heat transfer, thermal transfer or heat transmission.If there is a difference of the temperature in any place, a heating transfer is produced. There are three different types of heating transfer process: conduction, convection and radiation:

- Conduction: Heat transfer by direct contact of particles of one material with those of another, without transferring matter between the bodies. The amount of heat transferred through conduction is determined by Fourier's Law, according to which the speed of heat transfer through a body is proportional to the temperature gradient that exists in it.

- Convection: Convection is the transport of heat through the movement of a fluid, whether gaseous or liquid. This transfer is determined by Newton's Law of Cooling, which states that a body loses its heat at a rate proportional to the difference in temperature between the body and its surroundings.

- Radiation: It is the heat emitted by a body due to its temperature, in this case there is no contact between the bodies, nor intermediate fluids that transport the heat. It is the only type of heat transfer that can occur in the absence of a physical medium, that is, in a vacuum. Its origin is in the thermal movement of charged particles of matter, which triggers the emission of thermal radiation, its intensity being dependent on its temperature and the wave length of the radiation considered.

GENERAL DESCRIPTION

The Computer Controlled Heat Transfer Series, "TSTCC," has been designed by EDIBON to study and compare different types of heat transfer on a small scale. It allows a wide range of heat transfer demonstrations and study the factors affecting and problems associated with different types of heat transfer.

The minimum supply consists of two main elements: Control Interface for TSTCC (Common for all "TXC" type modules), "TSTCC/CIB", and at least one of the required elements described below.

Each heat transfer module can be individually connected to the Control Interface for TSTCC (Common for all "TXC" type modules) "TSTCC/CIB", which provides the necessary electrical supply and instrumentation connections for the study of the different types of heat transfer.

Elements required (at least one) (Not included):

TXC/CL. Linear Heat Conduction Module for TSTCC: study of the principles of linear heat conduction and to allow the measurement of the conductivity of different solid conductors and insulators.

TXC/CR. Radial Heat Conduction Module for TSTCC: study of the principles of radial heat conduction and to allow the measurement of conductivity on a solid brass disc.

TXC/RC. Radiation Heat Transfer Module for TSTCC: study of the principles of heat transfer and exchange by radiation.

TXC/CC. Combined Free and Forced Convection and Radiation Module for TSTCC: study of the principles of convection (free and forced) combined with radiation from a heated horizontal cylinder. Studies the variation in the local heat transfer coefficient around a horizontal cylinder when it is subject to free and forced convection.

TXC/SE. Extended Surface Heat Transfer Module for TSTCC: study of temperature profiles and heat transfer characteristics on an extended surface. It studies the effects of adding fins to a body to extend its surface to achieve a change in the cooling rate. Fins of different materials and cross-sectional shapes are used to analyse the effects of cooling.

TXC/ER. Radiation Errors in Temperature Measurement Module for TSTCC: study of how temperature measurements can be influenced by sources of thermal radiation.

TXC/EI. Unsteady State Heat Transfer Module for TSTCC: study of heat transfer in the non-stationary state Study of transient conduction with convection.

TXC/LG. Thermal Conductivity of Liquids and Gases Module for TSTCC: study of the thermal conductivity of any gas or liquid compatible with building materials.

TXC/FF. Free and Forced Convection Heat Transfer Module for TSTCC: study of the performance of different exchangers, analysing the heat transmission coefficients of each of the exchangers exposed to different air flows.

TXC/TE. Three Axes Heat Transfer Module for TSTCC: study of heat transfer by studying the direction in the three axes.

TXC/MM. Metal to Metal Heat Transfer Module for TSTCC: study of the heat transfer of different metallic materials placed in series.

TXC/TC. Ceramic Heat Transfer Module for TSTCC: study of the heat transfer of different ceramic materials.

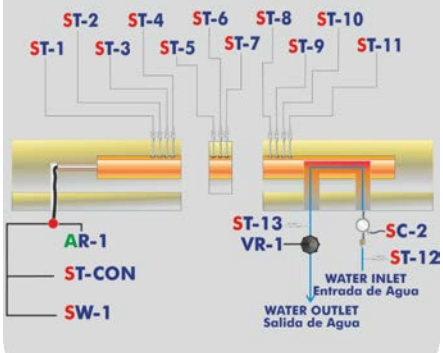
TXC/TI. Insulating Material Heat Transfer Module for TSTCC: study of the resistance to thermal conduction of different thermal insulation materials.

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

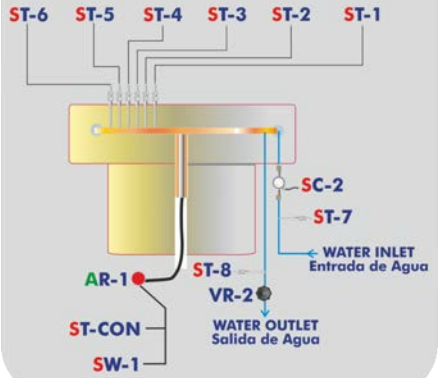
4 actuators and 19 sensors controlled from any computer, and working simultaneously

OPEN CONTROL + MULTICONTROL + REAL TIME CONTROL

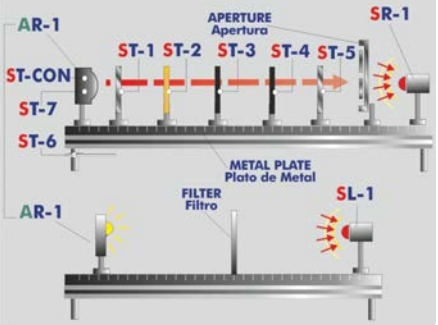
TXC/CL
LINEAR HEAT CONDUCTION MODULE
Módulo de Conducción de Calor Lineal



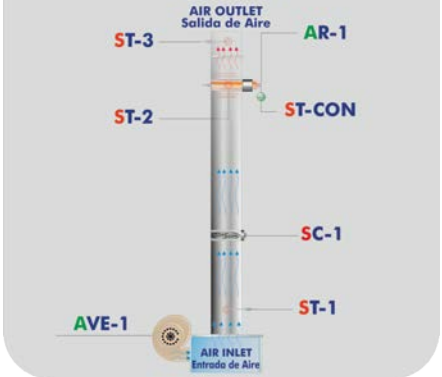
TXC/CR
RADIAL HEAT CONDUCTION MODULE
Módulo de Conducción de Calor Radial



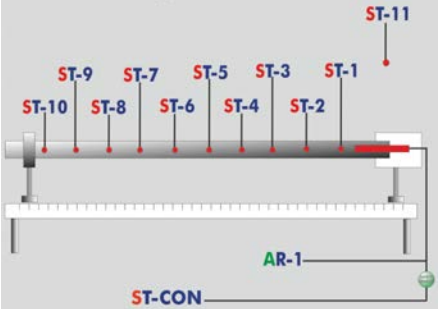
TXC/RC
RADIATION HEAT CONDUCTION MODULE
Módulo de Transferencia de Calor por Radiación



TXC/CC
COMBINED FREE AND FORCED CONVECTION AND RADIATION MODULE
Módulo Combinado de Convección Libre y Forzada y Radiación

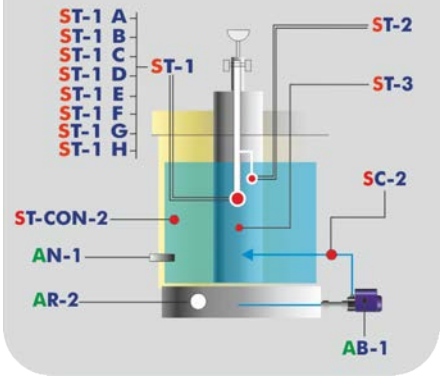


TXC/SE
EXTENDED SURFACE HEAT TRANSFER MODULE
Módulo de Transferencia de Calor en Superficie Extendida

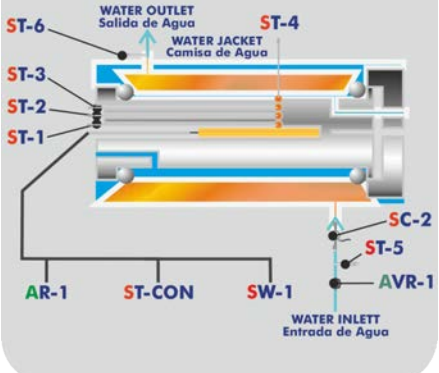


TXC/ER
RADIATION ERRORS IN TEMPERATURE MEASUREMENT MODULE
Módulo de Errores de Radiación en Medida de Temperatura

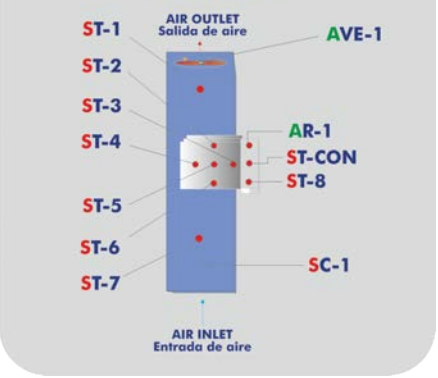
TXC/EI
UNSTEADY STATE HEAT TRANSFER MODULE
Módulo de Transferencia de Calor en Estado no Estacionario



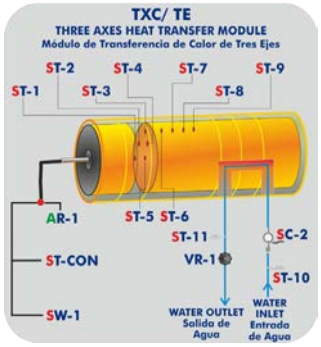
TXC/LG
THERMAL CONDUCTIVITY OF LIQUIDS AND GASES MODULE
Módulo de Conductividad Térmica de Líquidos y Gases



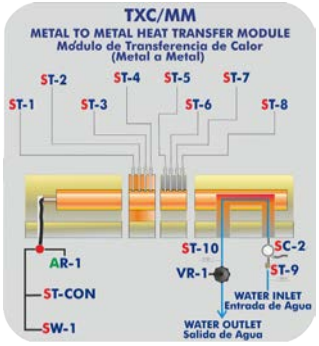
TXC/FF
FREE AND FORCED CONVECTION HEAT TRANSFER MODULE
Módulo de Transferencia de Calor por Convección Libre y Forzada



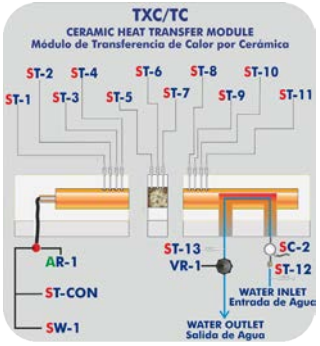
TXC/ TE
THREE AXES HEAT TRANSFER MODULE
Módulo de Transferencia de Calor de Tres Ejes



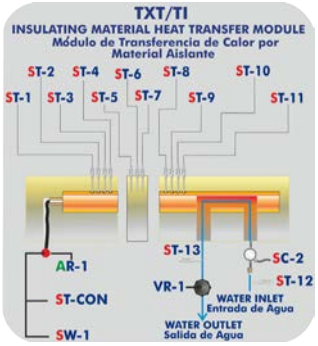
TXC/MM
METAL TO METAL HEAT TRANSFER MODULE
Módulo de Transferencia de Calor (Metal a Metal)



TXC/TC
CERAMIC HEAT TRANSFER MODULE
Módulo de Transferencia de Calor por Cerámica



TXT/TI
INSULATING MATERIAL HEAT TRANSFER MODULE
Módulo de Transferencia de Calor por Material Aislante



Note: ST=Temperature sensor. SC=Flow sensor. AR=Heating element. SR=Radiometer. SL= Luxmeter. AVE=Fan. AB=Pump. AN=Level switch.

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

Let us describe first the main items (1 to 4):

The complete unit includes:

Advanced Real-Time SCADA and PID Control.

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.

Required elements (at least one) (Not included):
- TXC/CL. Linear Heat Conduction Module for TSTCC.
- TXC/CR. Radial Heat Conduction Module for TSTCC.
- TXC/RC. Radiation Heat Transfer Module for TSTCC.
- TXC/CC. Combined Free and Forced Convection and Radiation Module for TSTCC.
- TXC/SE. Extended Surface Heat Transfer Module for TSTCC.
- TXC/ER. Radiation Errors in Temperature Measurement Module for TSTCC.
- TXC/EI. Unsteady State Heat Transfer Module for TSTCC.
- TXC/LG. Thermal Conductivity of Liquids and Gases Module for TSTCC.
- TXC/FF. Free and Forced Convection Heat Transfer Module for TSTCC.
- TXC/TE. Three Axes Heat Transfer Module for TSTCC.
- TXC/MM. Metal to Metal Heat Transfer Module for TSTCC.
- TXC/TC. Ceramic Heat Transfer Module for TSTCC.
- TXC/TI. Insulating Material Heat Transfer Module for TSTCC.

① TSTCC/CIB. Control Interface for TSTCC:

This control interface is common for the required elements (at least one) (Not included).

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.

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.

TSTCC/CIB

Shield and filtered signals to avoid external interferences.

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

Real time PID and on/off control for pumps, compressors, heating elements, control valves, etc.

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

Proportional control, integral control and derivative control, based on the real PID mathematical formula, by changing the values, at any time, of the three control constants (proportional, integral and derivative constants).

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

Possibility of automatization of the actuators involved in the process.

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

② DAB. Data Acquisition Board:

Common for the required elements (at least one) (Not included).

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

DAB

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)=±10 V. Data transfers=DMA, interrupts, programmed I/0. DMA channels=6.

Analog output:

Number of **channels=2**.

Resolution=16 bits, 1 in 65536.

Maximum output rate up to: 900 KS/s.

Output range (V)=±10 V. Data transfers=DMA, interrupts, programmed I/0.

Digital Input/Output:

Number of **channels=24 inputs/outputs**. D0 or DI Sample Clock frequency: 0 to 100 MHz.

Timing: Number of **Counter/timers=4**. Resolution: Counter/timers: 32 bits.

The Data Acquisition board model may change at any moment, providing the same or better features than those required for the unit.

③ Cables and Accessories, for normal operation.

④ Manuals:

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

Required elements (at least one) (Not included):

TXC/CL. Linear Heat Conduction Module for TSTCC

Bench-top unit to study the principles of linear heat conduction and to allow the conductivity of various solid conductors and insulators to be measured.

It is given with interchangeable samples of different materials, different diameters and different insulating materials that allow to demonstrate the area effects, the conductivity and the combinations in series in the heat transfer process.

Anodized aluminum frame and panels made of painted steel.

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

Input heat section.

Electric heater, computer controlled.

Refrigeration section with a surface cooled by water.

Interchangeable central sections:

- With brass of 25 mm of diameter.
- With brass of 10 mm of diameter.
- With stainless steel of 25 mm of diameter.

Flow sensor to measure the cooling water flow, range: 0.25 – 6.5 l/min.

Water flow regulation valve.

Thermal paste is supplied to demonstrate the difference between poor and good thermal contact between the sections.

Nineteen temperature sensors, "T" type (high precision):

- Seventeen temperature sensors distributed in the heating section (4 sensors), refrigeration section (4 sensors) and central sections (3 sensors in each central section).
- Temperature sensor at the water inlet of the unit.
- Temperature sensor at the water outlet of the unit.

Power measurement from the computer.

Cables and Accessories, for normal operation.

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

TXC/CL

(+) **TXC/CL/CCSOF. PID Computer Control+Data Acquisition+Data Management Software**:

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.

Analog and digital PID control.

Menu for PID and set point selection required in the whole work range.

Management, processing, comparison and storage of data.

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

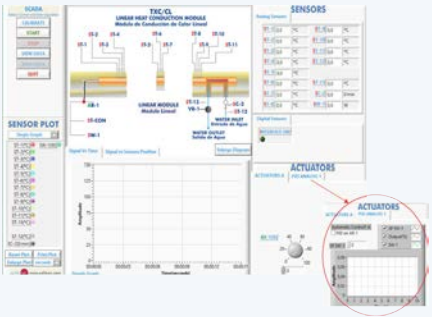
Calibration system for the sensors involved in the process.

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 to 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 results and manipulation of the unit, during the process, by using a projector or an electronic whiteboard.



-This module requires Control Interface Box (TSTCC/CIB) and Data Acquisition Board (DAB).

Required elements (at least one) (Not included):

TXC/CR. Radial Heat Conduction Module for TSTCC

Bench-top unit to study the principles of radial heat conduction, and to allow the conductivity of solid brass disk to be measured.

Anodized aluminum frame and panels made of painted steel.

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

Brass disk of 110 mm of diameter and 3 mm of thickness.

Electric heater, computer controlled.

Peripherical cooling tube.

Flow sensor to measure the cooling water flow, range: 0.25 – 6.5 l/min.

Water flow regulation valve.

Eight temperature sensors, "T" type (high precision):

- Six temperature sensors distributed in the unit.
- Temperature sensor at the water inlet of the unit.
- Temperature sensor at the water outlet of the unit.

Power measurement from the computer.

Cables and Accessories, for normal operation.

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

TXC/CR

(+) **TXC/CR/CCSOF. PID Computer Control + Data Acquisition + Data Management Software**:

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Calibration system for the sensors involved in the process.

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

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Open software, allowing to 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.

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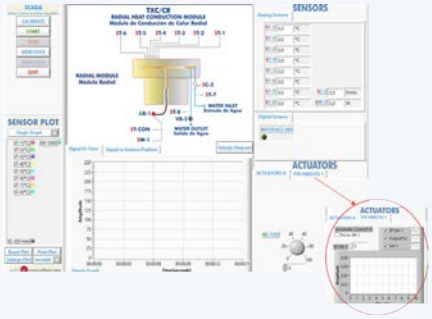


-This module requires Control Interface Box (TSTCC/CIB) and Data Acquisition Board (DAB).

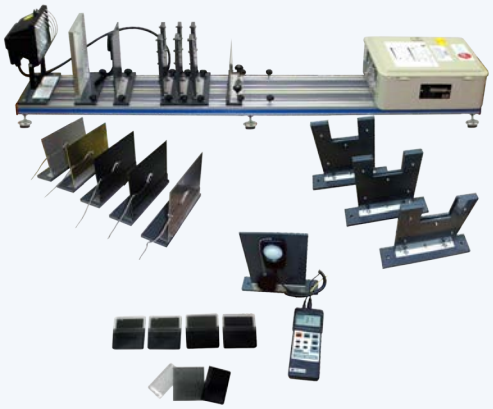
Required elements (at least one) (Not included):

TXC/RC. Radiation Heat Transfer Module for TSTCC

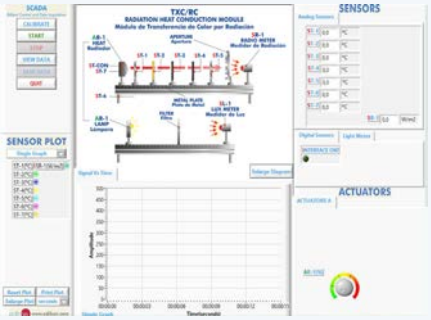
Bench-top unit designed to demonstrate the laws of radiant heat transfer and radiant heat exchange.
It basically consists of two independent parts. One of the parts is for the light radiation experiments and another part is for the thermal radiation experiments.
The elements provided with the unit allow making the measuring of the temperature, radiation, intensity light and the power in the heating element or bulb.
Anodized aluminum frame and panels made of painted steel.
Diagram in the front panel with distribution of the elements similar to the real one.
This unit consists of a metal plate with a heating element at one side and a lamp in the another side. Lengthwise of the metal plate you can place the elements supplied with the unit.
Heating element (ceramic), computer controlled.
Lamp 150 W, with diffuser.
The unit is provided with accessories for light experiments and radiation experiments.
Light accessories:
Luxmeter that allows to measure the intensity of the light:

Scale:	Resolution:	Accuracy:
0 to 1999 lux	1 lux	
2000 to 19990	10 lux	
20000 to 50000	100 lux	8%
Selection of light	Day, Tungsten, fluorescence or mercury	
Sensor	Photodiode with filter of adjustment of filter	
Sample frequency:	0.4 s	
Work temperature:	0 to 50 °C	

Filters:
They allow to filtrate the light in the experiments.
There are:
Three Grey Neutral Density A153 filters.
Grey Neutral Density A152 filter.
Grey Neutral Density A154 filter.
Three filter portholes.
Radiation accessories:
Radiometer (50 x 50 mm, 5μv (w/m^2)). It allows to measure the intensity of the radiation.
Planes surfaces. They are elements for studying the radiation and each one contains one.
Planes surfaces. They are elements for studying the radiation and each one contains one temperature sensor:
Polished aluminum.
Anodized aluminum.
Brass.
Two black bodies.
Variable slit or aperture. It allows to regulate the area of the radiation.
Seven temperature sensors, "T" type (high precision).
Power measurement from the computer.
Radiation measurement from the computer.
Lux measurement from the computer.
Cables and Accessories, for normal operation.
This unit is supplied with 8 manuals: Required Services, Assembly and Installation, Interface and Control Software, Starting-up, Safety, Maintenance, Calibration & Practices Manuals.
(+) **TXC/RC/CCSOF. PID Computer Control + Data Acquisition + Data Management Software**:
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.
Analog and digital PID control. Menu for PID and set point selection required in the whole work range. 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 to 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 results and manipulation of the unit, during the process, by using a projector or an electronic whiteboard.
-This module requires Control Interface Box (TSTCC/CIB) and Data Acquisition Board (DAB).



TXC/RC



Required elements (at least one) (Not included):

TXC/CC. Combined Free and Forced Convection and Radiation Module for TSTCC

Bench-top unit to study the principles of combined free and forced convection with radiation from a horizontal heater cylinder.

It studies the variation experimented by the local heat transfer coefficient around of a horizontal cylinder. It is subject to a forced and a free convection.

Anodized aluminum frame and panels made of painted steel.

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

Centrifugal fan (computer controlled) of 2650 rpm, which provides a maximum flow of 1200 l/min. and allows to the air to reach a maximum velocity around 5 m/s.

Stainless steel duct with interior cover, including:

- Temperature sensor, "T" type (high precision), in order to measure the temperature of inlet air.
- Flow sensor for measuring the air flow generated in the duct.
- Temperature sensor, "T" type (high precision), in order to measure the temperature of outlet air.

Heater:

- Copper cylinder with exterior cover: Interior heating element (computer controlled).

Temperature sensor, "T" type (high precision).

Power measurement from the computer.

Cables and Accessories, for normal operation.

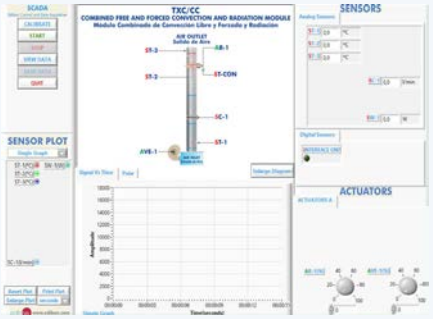
This unit is supplied with 8 manuals: Required Services, Assembly and Installation, Interface and Control Software, Starting-up, Safety, Maintenance, Calibration & Practices Manuals.

(+) **TXC/CC/CCSOF. PID Computer Control+Data Acquisition+Data Management Software**:

- 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.
- **Analog and digital PID control**.
- **Menu for PID and set point selection required in the whole work range.**
- **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 to 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 results and manipulation of the unit, during the process, by using a projector or an electronic whiteboard.**

-This module requires Control Interface Box (TSTCC/CIB) and Data Acquisition Board (DAB).

TXC/CC



Required elements (at least one) (Not included):

TXC/SE. Extended Surface Heat Transfer Module for TSTCC

Bench-top unit designed to demonstrate the temperature profiles and heat transfer characteristics for an extended surface. It studies the effect of adding fins to a body in order to extend its surface for a change in the cooling rate. Fins of different materials and cross section shapes are used to analyse the effect of cooling.

Anodized aluminum frame and panels made of painted steel.

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

Heating element (computer controlled), embedded in a copper capsule to permit a good contact with the interchangeable fins. The copper capsule is isolated by a coat of Teflon.

The fins are interchangeable, providing two different materials: brass and stainless steel and three different cross section shapes: square, circular and hexagonal.

The power to the heating element is controlled from the computer.

Eleven temperature sensors, "T" type (high precision).

Power measurement from the computer.

Cables and Accessories, for normal operation.

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

TXC/SE

(+) **TXC/SE/CCSOF. PID Computer Control+Data Acquisition+Data Management Software**:

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.

Analog and digital PID control.

Menu for PID and set point selection required in the whole work range.

Management, processing, comparison and storage of data.

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

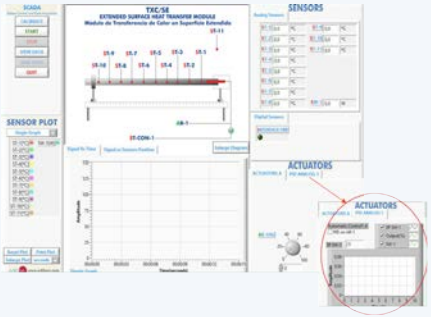
Calibration system for the sensors involved in the process.

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 to 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 results and manipulation of the unit, during the process, by using a projector or an electronic whiteboard.



-This module requires Control Interface Box (TSTCC/CIB) and Data Acquisition Board (DAB).

Required elements (at least one) (Not included):

TXC/ER. Radiation Errors in Temperature Measurement Module for TSTCC

Bench-top unit to demonstrate how temperature measurements can be influenced by sources of thermal radiation.

The objective of this module is to measure the error in a black thermocouple due the radiation with respect with another normal thermocouple where there are not radiative shielding in comparison when there are radiative shielding, error in function of material of the thermocouple's capsule, size of the thermocouple, etc.

Anodized aluminum frame and panels made of painted steel.

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

Centrifugal fan (computer controlled):

- 2650 rpm.
- Maximum flow of 1200 l/min.
- It allows to the air to reach a maximum velocity around 5 m/s.

Stainless steel duct with interior cover, including:

- Temperature sensor, "T" type (high precision), in order to measure the temperature of inlet air.
- Flow sensor for measuring the air flow generated in the duct.
- Temperature sensor, "T" type (high precision), in order to measure the temperature of outlet air.

Copper cylinder with exterior cover:

- Interior heating element (computer controlled).
- Temperature sensor, for measuring the temperature of the cylinder.

Five temperature sensors, "T" type (high precision), with different styles and sizes installed in the duct to demonstrate the differences in readings obtained:

- Temperature sensor of bare.
- Temperature sensor of inconel.
- Temperature sensor of s/steel.
- Temperature sensor of black s/steel.
- Temperature sensor of ceramic.

Power measurement from the computer.

Cables and Accessories, for normal operation.

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

(+) **TXC/ER/CCSOF. PID Computer Control+Data Acquisition+Data Management Software**:

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.

Analog and digital PID control.

Menu for PID and set point selection required in the whole work range.

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.

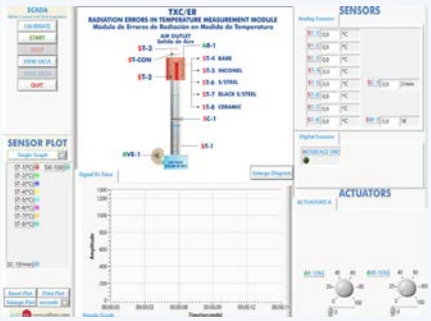
Comparative analysis of the obtained data, after the process and modification of the conditions during the process.

Open software, allowing to 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 results and manipulation of the unit, during the process, by using a projector or an electronic whiteboard.

-This module requires Control Interface Box (TSTCC/CIB) and Data Acquisition Board (DAB).

TXC/ER



Required elements (at least one) (Not included):

TXC/EI. Unsteady State Heat Transfer Module for TSTCC

Bench-top unit designed to allow practices and exercises to be performed in unsteady state heat transfer.

It studies the transient conduction with convection. Using different shapes (rectangular slabs, spheres and cylinders) of different materials, the temperature of other shapes and materials can be predicted.

Anodized aluminum frame and panels made of painted steel.

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

Dual concentric open top tanks filled with water, total tank capacity: 40 l, 300 x 350 x 400 mm concentric tank: 1.2 l, diameter: 70 mm.

Different shapes of different size and material are studied:

- Brass sphere (diameter: 40 mm).
- Brass sphere (diameter: 25 mm).
- Stainless steel sphere (diameter: 40 mm).
- Stainless steel sphere (diameter: 25 mm).
- Brass cylinder (diameter: 15 mm, length: 150 mm).
- Stainless steel cylinder (diameter: 15 mm, length: 150 mm).
- Aluminum rectangular slab (40 x 10 x 150 mm).
- Stainless steel rectangular slab (40 x 10 x 150 mm).

Each shape is fitted with a temperature sensor at the center of the object.

The shapes are installed in special holder at the center of the top cover of the large tank. The holder also has a temperature sensor that enters in the water bath at the same time as the shape.

Heating element (immersion heater). The high power allows reaching the steady state faster. It is computer controlled.

Water pump with variable speed (computer controlled). It allows to reach a maximum flow of 4 l/min.

Two temperature sensors, "T" type (high precision), allow to control the stability of the temperature of the water bath.

Flow sensor, range: 0.25 – 6.5 l/min.

Two temperature sensors, "T" type (high precision):

- The first one permits to record the evolution of the temperature of the shape at its center.
- The second one, works as a stopwatch, it will indicate the precise moment in which the shape is submerged.

Level switch.

Power measurement from the computer.

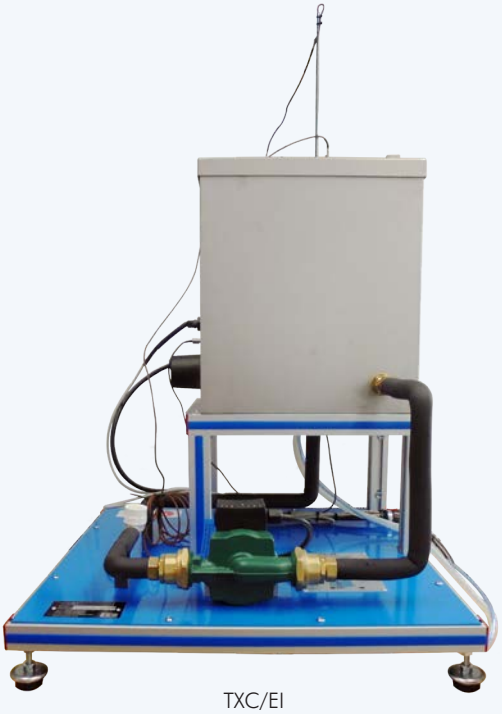
Cables and Accessories, for normal operation.

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

(+)**TXC/EI/CCSOF. PID Computer Control + Data Acquisition + Data Management Software**:

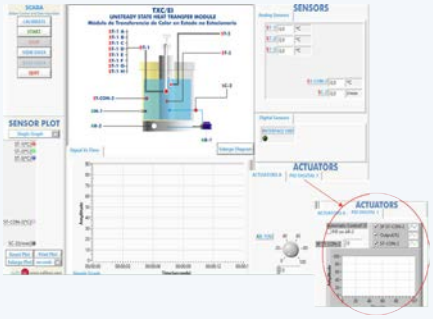
- Compatible with actual Windows operating systems. Graphic and intuitive simulation of the process in screen. **Compatible with the industry standards**.
- Registration and visualization of all process variables in an automatic and simultaneous way.
- **Flexible, open and multicontrol software**, developed with actual windows graphic systems, acting simultaneously on all process parameters.
- **Analog and digital PID control.**
- **Menu for PID and set point selection required in the whole work range.**
- **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 to 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 results and manipulation of the unit, during the process, by using a projector or an electronic whiteboard.**

-This module requires Control Interface Box (TSTCC/CIB) and Data Acquisition Board (DAB).



TXC/EI

Detail of the different shapes



Required elements (at least one) (Not included):

TXC/LG. Thermal Conductivity of Liquids and Gases Module for TSTCC

This unit has been designed to enable students to easily determine the thermal conductivity of liquids and gases.

By the realization of the practices the student can determine the thermal conductivity of any suitable gas or compatible liquid with materials on construction.

Anodized aluminum frame and panels made of painted steel.

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

Aluminum body (cylinder) with brass jacket that contains the test fluid and the refrigeration water.

Variable heating element (in the cylinder), computer controlled. Heating element power controlled from computer. The power is measured by a sensor.

Six temperature sensors, "T" type (high precision).

Flow sensor to measure the cooling water flow, range: 0.25 – 6.5 l/min.

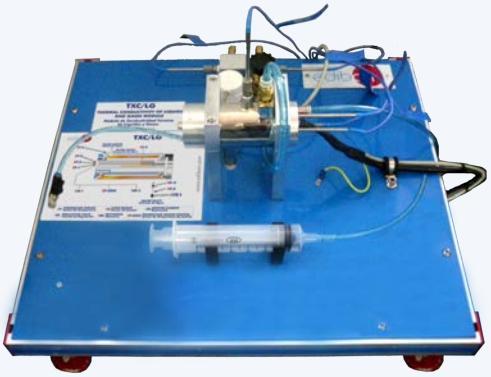
Water flow regulation valve.

Valves. Syringe.

Power measurement from the computer.

Cables and Accessories, for normal operation.

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



TXC/LG

(+) **TXC/LG/CCSOF. PID Computer Control+Data Acquisition+Data Management Software**:

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.

Analog and digital PID control.

Menu for PID and set point selection required in the whole work range.

Management, processing, comparison and storage of data.

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

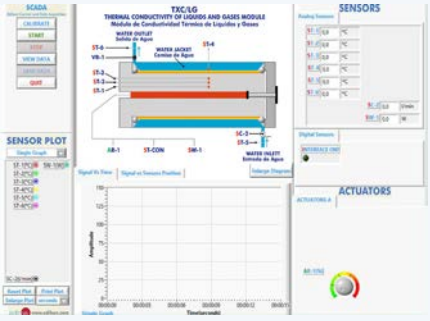
Calibration system for the sensors involved in the process.

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 to 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 results and manipulation of the unit, during the process, by using a projector or an electronic whiteboard.



-This module requires Control Interface Box (TSTCC/CIB) and Data Acquisition Board (DAB).

Required elements (at least one) (Not included):

TXC/FF. Free and Forced Convection Heat Transfer Module for TSTCC

This unit allows to study the efficiency of different exchangers, analyzing the heat transfer coefficients of each of the exchangers exposed to different airflows. A fan placed in the upper part of the tunnel allows controlling the airflow that goes through the tunnel.

Anodized aluminum frame and panels made of painted steel.

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

Stainless steel tunnel of rectangular section, 700 mm long, painted and resistant to corrosion. In the tunnel three type of different heat exchangers can be set.

Methacrylate viewer that allows a good visualization of the exchanger that is in use.

Stabilizers to guarantee an uniform air flux.

Eight temperature sensors, "T" type (high precision):

Two temperature sensors measure the air temperature at the inlet and outlet of the area of heat exchange.

Temperature measurements, at different distances of the base of the pins and fins exchangers, are made by other 5 temperature sensors that are introduced by one side of the tunnel.

Temperature sensor in the exchangers.

Maximum working temperature: 120 °C.

Flow sensor for measuring the air flow generated in the tunnel.

Three aluminum exchangers:

Flat heat exchanger (100 x 100 mm).

Pins heat exchanger. Seventeen pins, each one of 10 mm diameter and 125 mm longitude.

Fins heat exchanger. Nine fins, each one of 100 x 125 mm.

Heating element for each exchanger, computer controlled.

Variable speed fan, computer controlled, which generates air flux through the tunnel, range: 0 – 1200 l/min.

Cables and Accessories, for normal operation.

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

(+)**TXC/FF/CCSOF. PID Computer Control + Data Acquisition + Data Management Software**:

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.

Analog and digital PID control.

Menu for PID and set point selection required in the whole work range.

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.

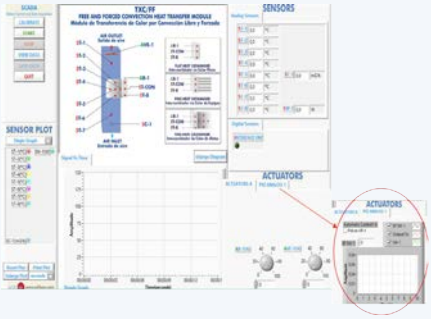
Open software, allowing to the teacher to modify texts, instructions. Teacher's and student's passwords to facilitate the teacher's control on the student, and allowing the access to different work levels.

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

-This module requires Control Interface Box (TSTCC/CIB) and Data Acquisition Board (DAB).

Sight of the different heat exchangers included

TXC/FF



Required elements (at least one) (Not included):

TXC/TE. Three Axes Heat Transfer Module for TSTCC

Bench-top unit designed to carry out heat transfer experiments and exercises studying the direction in three axes.

Anodized aluminum frame and panels made of painted steel.

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

Brass cylinder to study heat transfer.

Electric heater, computer controlled.

Refrigeration section with a surface cooled by water.

Flow sensor to measure the cooling water flow, range: 0.25 – 6.5 l/min.

Water flow regulation valve.

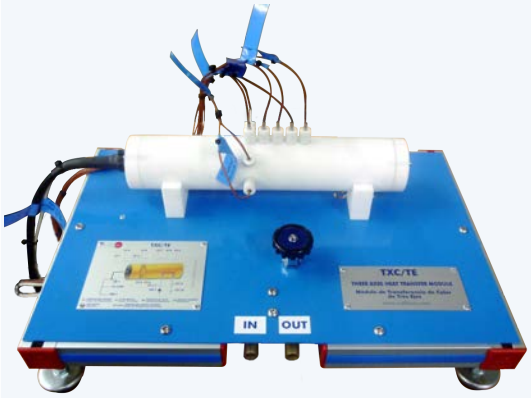
Eleven temperature sensors , "T" type (high precision):

- Temperature sensor at the water inlet of the unit.
- Temperature sensor at the water outlet of the unit.
- Five temperature sensors at different depth in a specific cross section.
- Four temperature sensors longitudinally distributed.

Power measurement from the computer.

Cables and Accessories, for normal operation.

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



TXC/TE

(+) **TXC/TE/CCSOF. PID Computer Control+Data Acquisition+Data Management Software**:

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.

Analog and digital PID control.

Menu for PID and set point selection required in the whole work range.

Management, processing, comparison and storage of data.

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

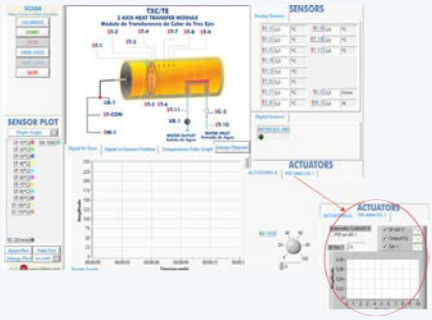
Calibration system for the sensors involved in the process.

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 to 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 results and manipulation of the unit, during the process, by using a projector or an electronic whiteboard.



-This module requires Control Interface Box (TSTCC/CIB) and Data Acquisition Board (DAB).

Required elements (at least one) (Not included):

TXC/MM. Metal to Metal Heat Transfer Module for TSTCC

Bench-top unit designed to study of the heat transfer of different metallic materials situated in series.

Anodized aluminum frame and panels made of painted steel.

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

Input heat section. It includes:

Electric heater, computer controlled.

Interchangeable central sections. They are formed by two different cylinders chosen from the four cylinders supplied:

Copper cylinder of 25 mm of diameter.

Brass cylinder of 25 mm of diameter.

Stainless steel cylinder of 25 mm of diameter.

Aluminum cylinder of 25 mm of diameter.

Four temperature sensors, "T" type (high precision) for each cylinder.

Refrigeration section with surface cooled by water. It includes four temperature sensors, type "T" (high precision).

Water flow regulation valve.

Two temperature sensors, "J" type, for the cooling water inlet and outlet.

Flow sensor to measure the cooling water flow, range: 0.25 – 6.5 l/min.

Thermal paste is supplied to demonstrate the difference between poor and good thermal contact between the sections.

Power measurement from the computer.

Cables and Accessories, for normal operation.

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

(+)**TXC/MM/CCSOF. PID Computer Control+Data Acquisition+Data Management Software**:

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.

Analog and digital PID control.

Menu for PID and set point selection required in the whole work range.

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.

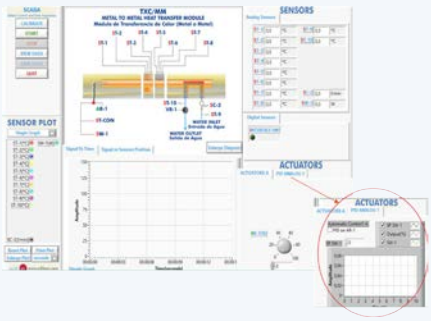
Comparative analysis of the obtained data, after the process and modification of the conditions during the process.

Open software, allowing to 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 results and manipulation of the unit, during the process, by using a projector or an electronic whiteboard.

-This module requires Control Interface Box (TSTCC/CIB) and Data Acquisition Board (DAB).

TXC/MM



Required elements (at least one) (Not included):

TXC/TC. Ceramic Heat Transfer Module for TSTCC

Bench-top unit designed to study of the heat transfer of different ceramic materials.

Anodized aluminum frame and panels made of painted steel.

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

Input heat section. It includes:

- Electric heater, computer controlled.
- Four temperature sensors, "T" type (high precision).

Interchangeable central sections. There are two types:

- Ceramic cylinder with a thermal conductivity of 1.46 W/m·°C.
- Ceramic cylinder with a thermal conductivity of 0.49 W/m·°C.
- Three temperature sensors, "T" type (high precision), for each cylinder.

Refrigeration section with surface cooled by water. It includes four temperature sensors, "T" type (high precision).

Water flow regulation valve.

Two temperature sensors, "J" type, for the cooling water inlet and outlet.

Flow sensor to measure the cooling water flow, range: 0.25 – 6.5 l/min.

Thermal paste is supplied to demonstrate the difference between poor and good thermal contact between the sections.

Power measurement from the computer.

Cables and Accessories, for normal operation.

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

TXC/TC

(+) **TXC/TC/CCSOF. PID Computer Control + Data Acquisition + Data Management Software**:

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.

Analog and digital PID control.

Menu for PID and set point selection required in the whole work range.

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 to 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 results and manipulation of the unit, during the process, by using a projector or an electronic whiteboard.

-This module requires Control Interface Box (TSTCC/CIB) and Data Acquisition Board (DAB).

Required elements (at least one) (Not included):

TXC/TI. Insulating Material Heat Transfer Module for TSTCC

Bench-top unit to study the thermal conduction resistance of different thermal insulating materials.

Anodized aluminum frame and panels made of painted steel.

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

Input heat section.

Electric heater, computer controlled.

Refrigeration section with a surface cooled by water.

Interchangeable central sections:

- With nylon of 50 mm of diameter.
- With Teflon of 50 mm of diameter.
- With Bakelite of 50 mm of diameter.

Flow sensor to measure the cooling water flow, range: 0.25 – 6.5 l/min.

Water flow regulation valve.

Thermal paste is supplied to demonstrate the difference between poor and good thermal contact between the sections.

Nineteen Temperature sensors, "T" type (high precision):

- Seventeen Temperature sensors distributed in the heating section (4 sensors), refrigeration section (4 sensors) and central sections (3 sensors in each central section).
- Temperature sensor at the water inlet of the unit.
- Temperature sensor at the water outlet of the unit.

Power measurement from the computer.

Cables and Accessories, for normal operation.

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

(+) **TXC/TI/CCSOF. PID Computer Control+Data Acquisition+Data Management Software**:

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.

Analog and digital PID control.

Menu for PID and set point selection required in the whole work range.

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.

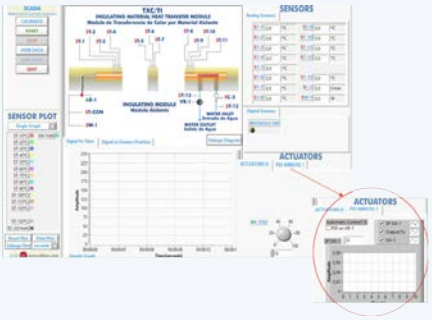
Comparative analysis of the obtained data, after the process and modification of the conditions during the process.

Open software, allowing to 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 results and manipulation of the unit, during the process, by using a projector or an electronic whiteboard.

-This module requires Control Interface Box (TSTCC/CIB) and Data Acquisition Board (DAB).

TXC/TI



Practices to be done with the Linear Heat Conduction Module for TSTCC (TXC/CL):

1.- Conduction through a simple bar.

2.- Conduction through a compound bar.

3.- Determination of the thermal conductivity "k" of different materials (conductors and insulators).

4.- The thermal conductivity properties of insulators may be found by inserting paper or other elements between the heating and cooling sections.

5.- Insulation effect.

6.- Determination of the thermal contact resistance R_{tc}.

7.- Effect of the crossing sectional area.

8.- Understanding the use of the Fourier equation in determining rate of heat flow through solid materials.

Additional practical possibilities:

9.- Sensors calibration.

Practices to be done with the Radial Heat Conduction Module for TSTCC (TXC/CR):

10.- Radial conduction.

11.- Determination of the thermal conductivity "k".

12.- Determination of the thermal contact resistance R_{tc}.

13.- Insulation effect.

14.- Understanding the use of the Fourier equation in determining rate of heat flow through solid materials.

Additional practical possibilities:

15.- Sensors calibration.

Practices to be done with the Radiation Heat Transfer Module for TSTCC (TXC/RC):

16.- Inverse of the distant square law for the radiation.

17.- Stefan Boltzmann Law.

18.- Emission power I.

19.- Emission power II.

20.- Kirchorff Law.

21.- Area factors.

22.- Inverse of the distant square law for the light.

23.- Lambert´s Cosine Law.

24.- Lambert Law of Absorption.

Additional practical possibilities:

25.- Sensors calibration.

Practices to be done with the Combined Free and Forced Convection and Radiation Module for TSTCC (TXC/CC):

26.- Demonstration of the combined heat transfer effect by radiation and convection on the surface of the cylinder. Determination of the combined heat transfer effect by forced convection and radiation.

27.- Demonstration of the influence of air flow in the heat transfer. Determination of the combined heat transfer effect by forced convection and radiation.

28.- Demonstration of the influence of input power in the heat transfer. Determination of the combined heat transfer effect by forced convection and radiation.

29.- Demonstration of the combined heat transfer effect of the radiation and convection on the surface of the cylinder. Determination of the combined heat transfer effect by free convection and radiation.

Additional practical possibilities:

30.- Sensors calibration.

31.- Determination of the airflow.

Practices to be done with the Extended Surface Heat Transfer Module for TSTCC (TXC/SE):

32.- Heat transfer from a Fin.

33.- Effect of cross section shape in heat transfer from a Fin.

34.- Heat transfer from Fins of two different materials.

35.- Measuring the temperature distribution along an extended surface.

Additional practical possibilities:

36.- Sensors calibration.

Practices to be done with the Radiation Errors in Temperature Measurement Module for TSTCC (TXC/ER):

37.- Radiation errors in temperature measurement.

38.- Measurement the errors in thermocouples in function of its painting, material of its capsules, size.

39.- Effect of air velocity on measurement error.

Additional practical possibilities:

40.- Sensors calibration.

Practices to be done with the Unsteady State Heat Transfer Module for TSTCC (TXC/EI):

41.- Predicting temperature at the center of a cylinder using transient conduction with convection.

42.- Predicting the conductivity of a similar shape constructed from a different material.

43.- Conductivity and temperature dependence on volume.

44.- Conductivity and temperature dependence on surrounding temperature $T\infty$.

Additional practical possibilities:

45.- Sensors calibration.

Practices to be done with the Thermal Conductivity of Liquids and Gases Module for TSTCC (TXC/LG):

46.- Obtaining of the curve of thermal conductivity of the air.

47.- Thermal conductivity in vacuum.

48.- Water thermal conductivity determination.

49.- Thermal conductivity determination of a mineral oil.

50.- Calibration of the Unit.

Additional practical possibilities:

51.- Sensors calibration.

52.- Dry air thermal conductivity under atmospheric pressure.

Practices to be done with the Free and Forced Convection Heat Transfer Module for TSTCC (TXC/FF):

53.- Demonstration of the basic principles of free and forced convection.

54.- Comparison between free and forced convection.

55.- Free convection in flat surfaces.

56.- Forced convection in flat surfaces.

57.- Dependence of the heat transfer with the temperature.

58.- Dependence of the heat transfer with the speed of the fluid.

59.- Dependence of the heat transfer with the exchanger geometry (finned or pinned surface).

60.- Temperature distribution in the additional surfaces.

61.- Study of the advantage of using pinned and finned surfaces in heat transfer in free convection.

62.- Study of the advantage of using pinned and finned surfaces in heat transfer in forced convection.

63.- Comparative study between the free convection of a horizontal surface and vertical surface.

Additional practical possibilities:

64.- Sensors calibration.

Practices to be done with the Three Axes Heat Transfer Module for TSTCC (TXC/TE):

65.- Determination of the thermal conductivity "k".

66.- Conduction through a simple bar.

67.- Conduction through three axes.

Additional practical possibilities:

68.- Sensors calibration.

Practices to be done with the Metal to Metal Heat Transfer Module for TSTCC (TXC/MM):

69.- Conduction in a simple bar.

70.- Determination of the thermal conductivity "k".

71.- Determination of the thermal contact resistance.

Additional practical possibilities:

72.- Sensors calibration.

Practices to be done with the Ceramic Heat Transfer Module for TSTCC (TXC/TC):

73.- Conduction in a simple bar.

74.- Determination of the thermal conductivity "k".

75.- Conduction through a compound bar.

76.- Determination of the thermal contact resistance.

Additional practical possibilities:

77.- Sensors calibration.

Practices to be done with the Insulating Material Heat Transfer Module for TSTCC (TXC/TI):

78.- Determination of the thermal conductivity "k".

79.- Calculation of the heat transfer properties of different specimens.

80.- Conduction through a compound bar.

81.- Insulation effect.

Additional practical possibilities:

82.- Sensors calibration.

Other possibilities to be done with this System:

83.-Many students view results simultaneously.

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

84.-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.

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

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

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

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

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

90.-Visualization of all the sensors values used in the 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 200 VAC – 240 VAC/50 Hz or 110 VAC – 127 VAC/60 Hz.
- Water supply and drainage.
- Computer.

REQUIRED ELEMENTS (Not included)

Required (at least one):

- TXC/CL. Linear Heat Conduction Module for TSTCC.
- TXC/CR. Radial Heat Conduction Module for TSTCC.
- TXC/RC. Radiation Heat Transfer Module for TSTCC.
- TXC/CC. Combined Free and Forced Convection and Radiation Module for TSTCC.
- TXC/SE. Extended Surface Heat Transfer Module for TSTCC.
- TXC/ER. Radiation Errors in Temperature Measurement Module for TSTCC.
- TXC/EI. Unsteady State Heat Transfer Module for TSTCC.
- TXC/LG. Thermal Conductivity of Liquids and Gases Module for TSTCC.
- TXC/FF. Free and Forced Convection Heat Transfer Module for TSTCC.
- TXC/TE. Three Axes Heat Transfer Module for TSTCC.
- TXC/MM. Metal to Metal Heat Transfer Module for TSTCC.
- TXC/TC. Ceramic Heat Transfer Module for TSTCC.
- TXC/TI. Insulating Material Heat Transfer Module for TSTCC.

DIMENSIONS AND WEIGHTS

TXC/CL Module:	-Dimensions:	400 x 300 x 300 mm approx. (15.74 x 11.81 x 11.81 inches approx).
	-Weight:	20 Kg approx. (44 pounds approx).
TXC/CR Module:	-Dimensions:	400 x 300 x 300 mm approx. (15.74 x 11.81 x 11.81 inches approx).
	-Weight :	20 Kg approx. (44 pounds approx).
TXC/RC Module :	-Dimensions:	1400 x 500 x 500 mm approx. (55.11 x 19.68 x 19.68 inches approx).
	-Weight:	40 Kg approx. (88 pounds approx).
TXC/CC Module:	-Dimensions:	430 x 350 x 1300 mm approx. (16.93 x 13.78 x 51.18 inches approx).
	-Weight:	50 Kg approx. (110 pounds approx).
TXC/SE Module:	-Dimensions:	600 x 300 x 175 mm approx. (23.62 x 11.81 x 6.89 inches approx).
	-Weight:	20 Kg approx. (44 pounds approx).
TXC/ER Module:	-Dimensions:	430 x 350 x 1300 mm approx. (16.93 x 13.78 x 51.18 inches approx).
	-Weight:	50 Kg approx. (110 pounds approx).
TXC/EI Module:	-Dimensions:	600 x 600 x 750 mm approx. (23.62 x 23.62 x 29.52 inches approx).
	-Weight:	60 Kg approx. (132 pounds approx).
TXC/LG Module:	-Dimensions:	500 x 400 x 300 mm approx. (19.68 x 15.74 x 11.81 inches approx).
	-Weight:	40 Kg approx. (88 pounds approx).
TXC/FF Module:	-Dimensions:	370 x 610 x 920 mm approx. (14.56 x 24.01 x 36.22 inches approx).
	-Weight:	25 Kg approx. (55 pounds approx).
TXC/TE Module:	-Dimensions:	400 x 300 x 300 mm approx. (15.74 x 11.81 x 11.81 inches approx).
	-Weight:	20 Kg approx. (44 pounds approx).
TXC/MM Module:	-Dimensions:	400 x 300 x 300 mm approx. (15.74 x 11.81 x 11.81 inches approx).
	-Weight:	20 Kg approx. (44 pounds approx.).
TXC/TC Module:	-Dimensions:	400 x 300 x 300 mm approx. (15.74 x 11.81 x 11.81 inches approx).
	-Weight:	20 Kg approx. (44 pounds approx).
TXC/TI Module:	-Dimensions:	400 x 300 x 300 mm approx. (15.74 x 11.81 x 11.81 inches approx).
	-Weight:	20 Kg approx. (44 pounds approx).
Control Interface Box:		
	-Dimensions:	490 x 330 x 310 mm approx. (19.29 x 12.99 x 12.20 inches approx).
	-Weight:	10 Kg approx. (22 pounds approx).

SIMILAR UNITS AVAILABLE

Offered in this catalog:

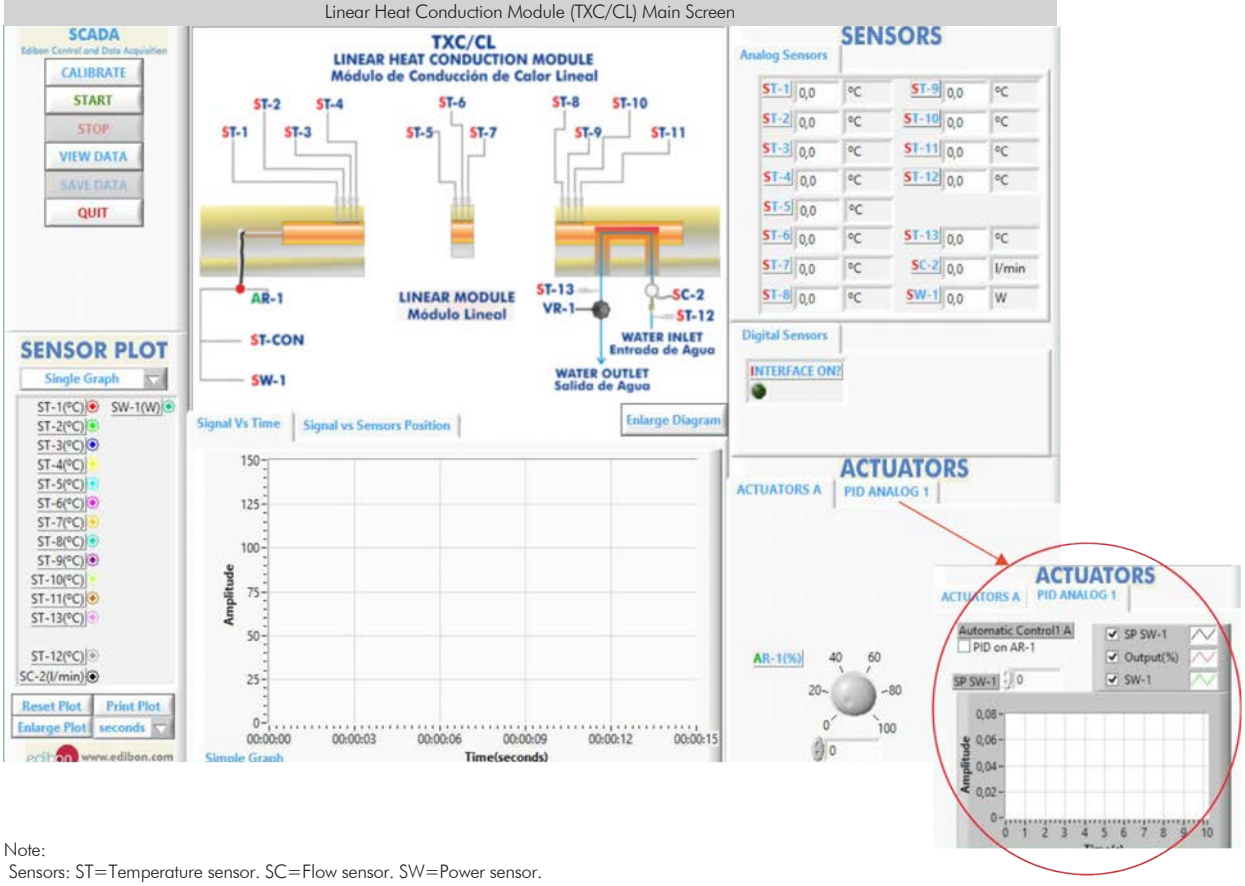
-TSTCC. Computer Controlled Heat Transfer Series.

Offered in other catalog:

-TSTCB. Heat Transfer Series.

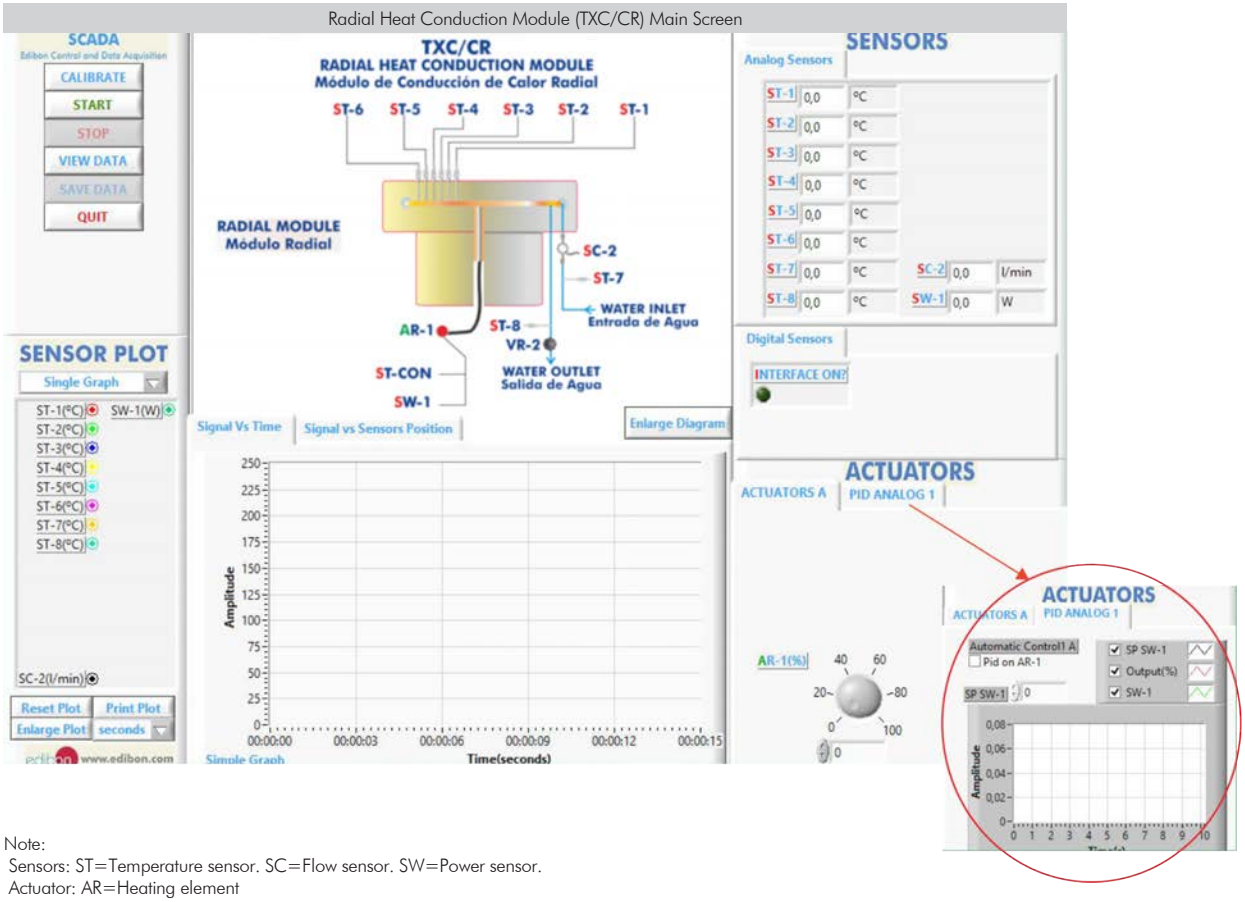
SCADA and PID Control
Main screen

Linear Heat Conduction Module (TXC/CL) Main Screen



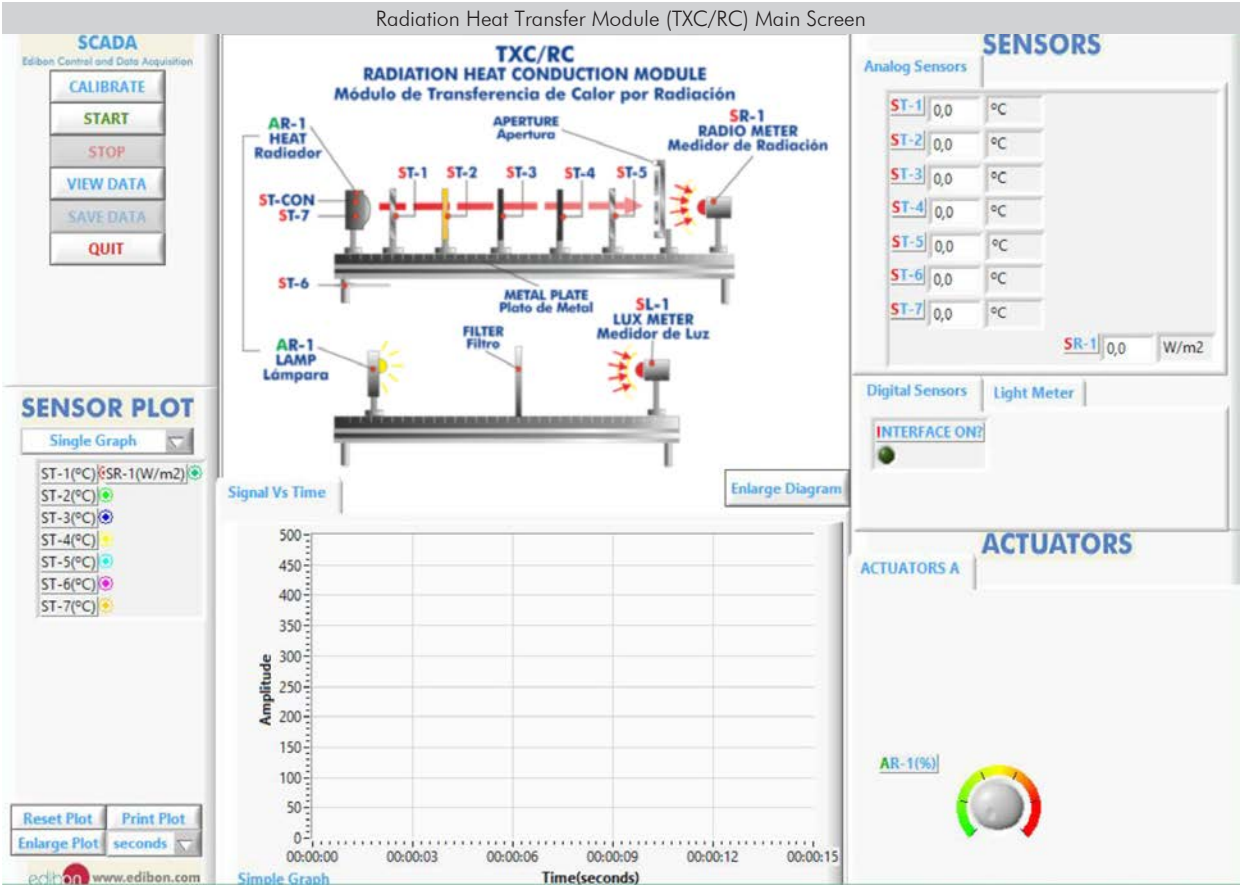
Note:
Sensors: ST=Temperature sensor. SC=Flow sensor. SW=Power sensor.
Actuator: AR=Heating element

Radial Heat Conduction Module (TXC/CR) Main Screen



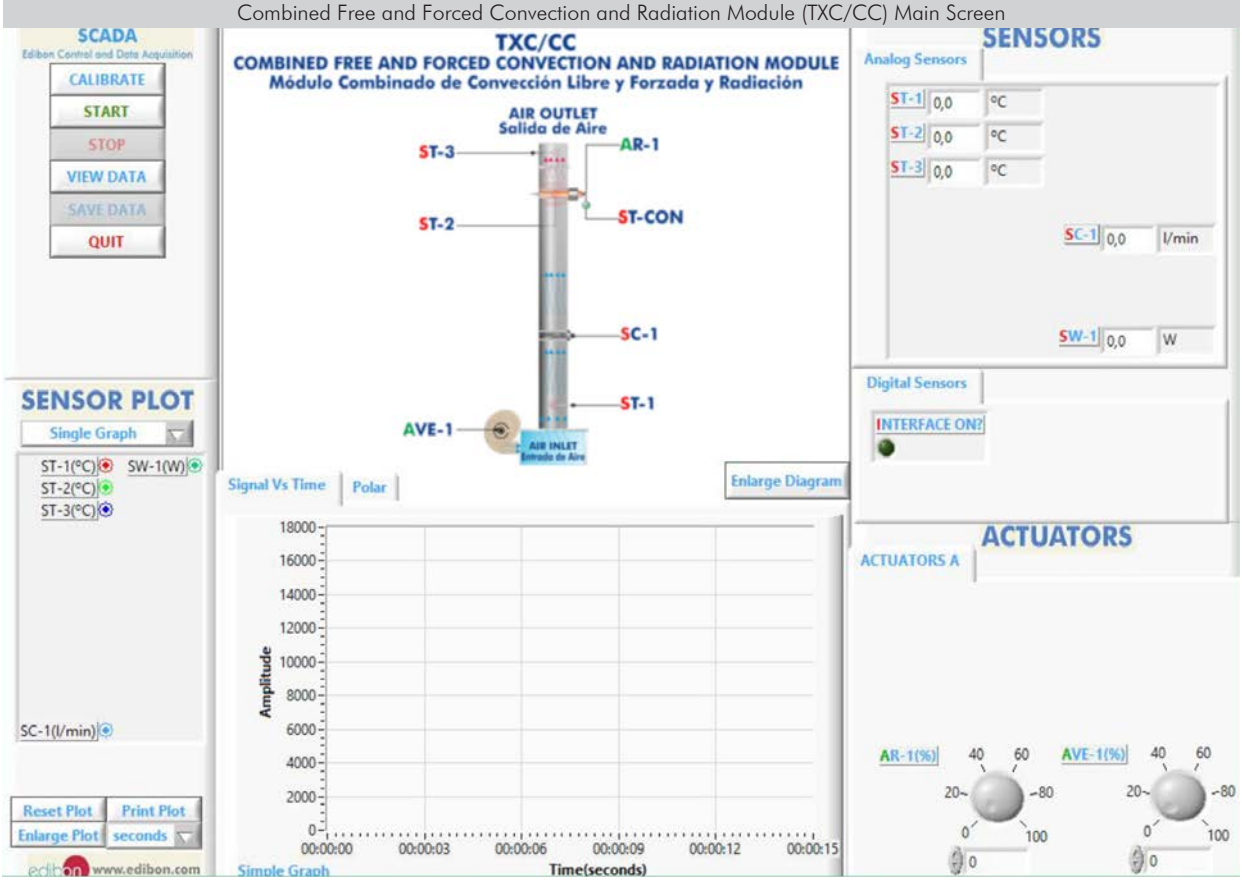
Note:
Sensors: ST=Temperature sensor. SC=Flow sensor. SW=Power sensor.
Actuator: AR=Heating element

Radiation Heat Transfer Module (TXC/RC) Main Screen



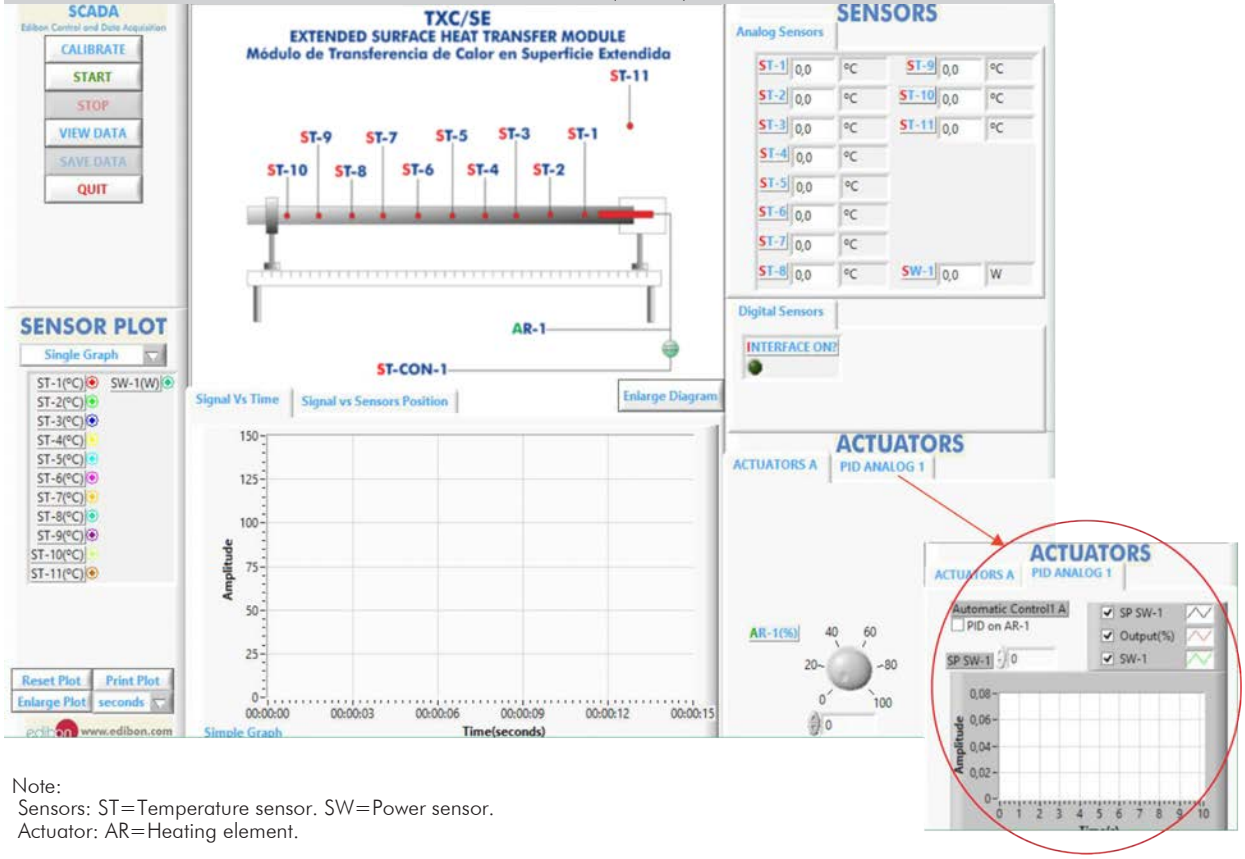
Note:
Sensors/Meters: ST=Temperature sensor. SW=Power sensor. SR=Radiometer. SL=Luxometer.
Actuator: AR=Heating element.

Combined Free and Forced Convection and Radiation Module (TXC/CC) Main Screen



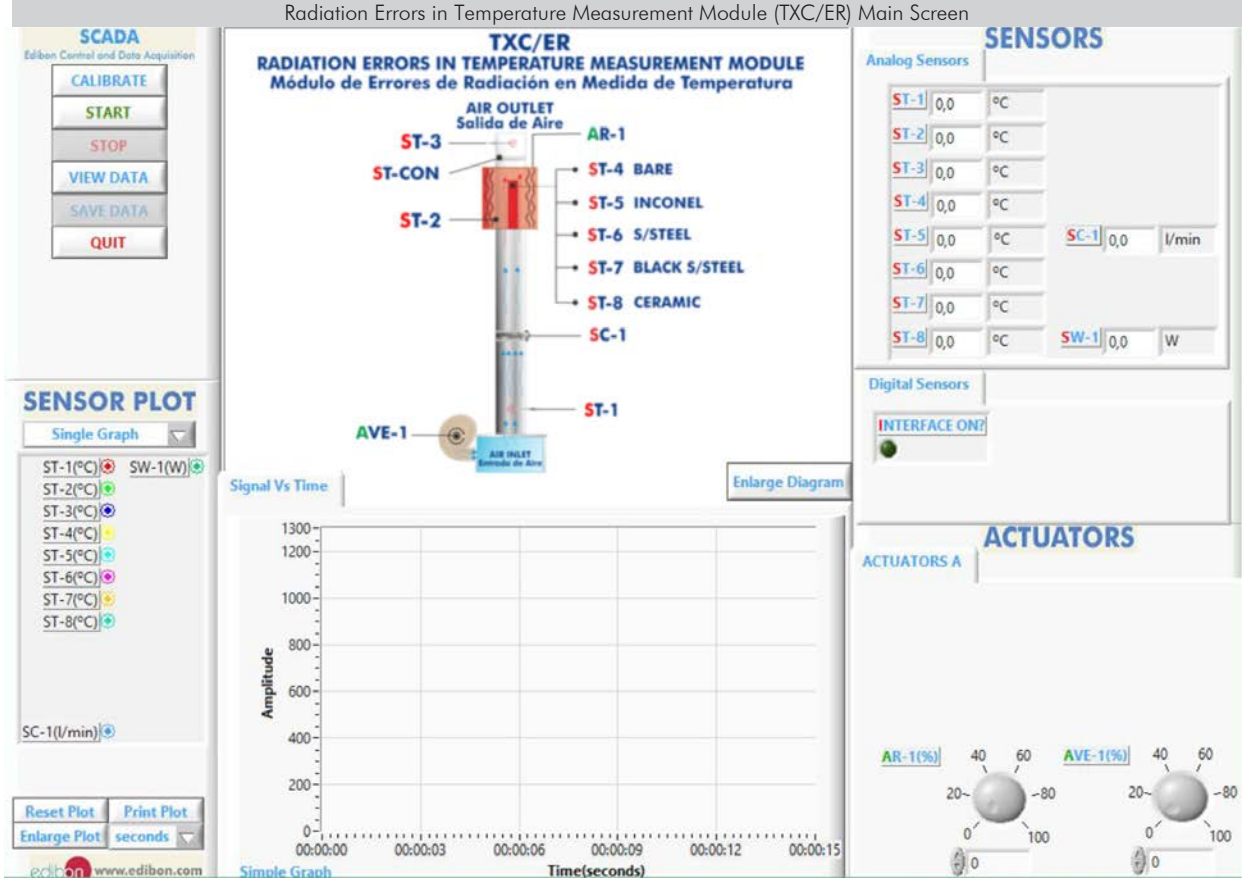
Note:
Sensors: ST=Temperature sensor. SC=Flow sensor. SW=Power sensor.
Actuators: AR=Heating element. AVE=Fan.

Extended Surface Heat Transfer Module (TXC/SE) Main Screen



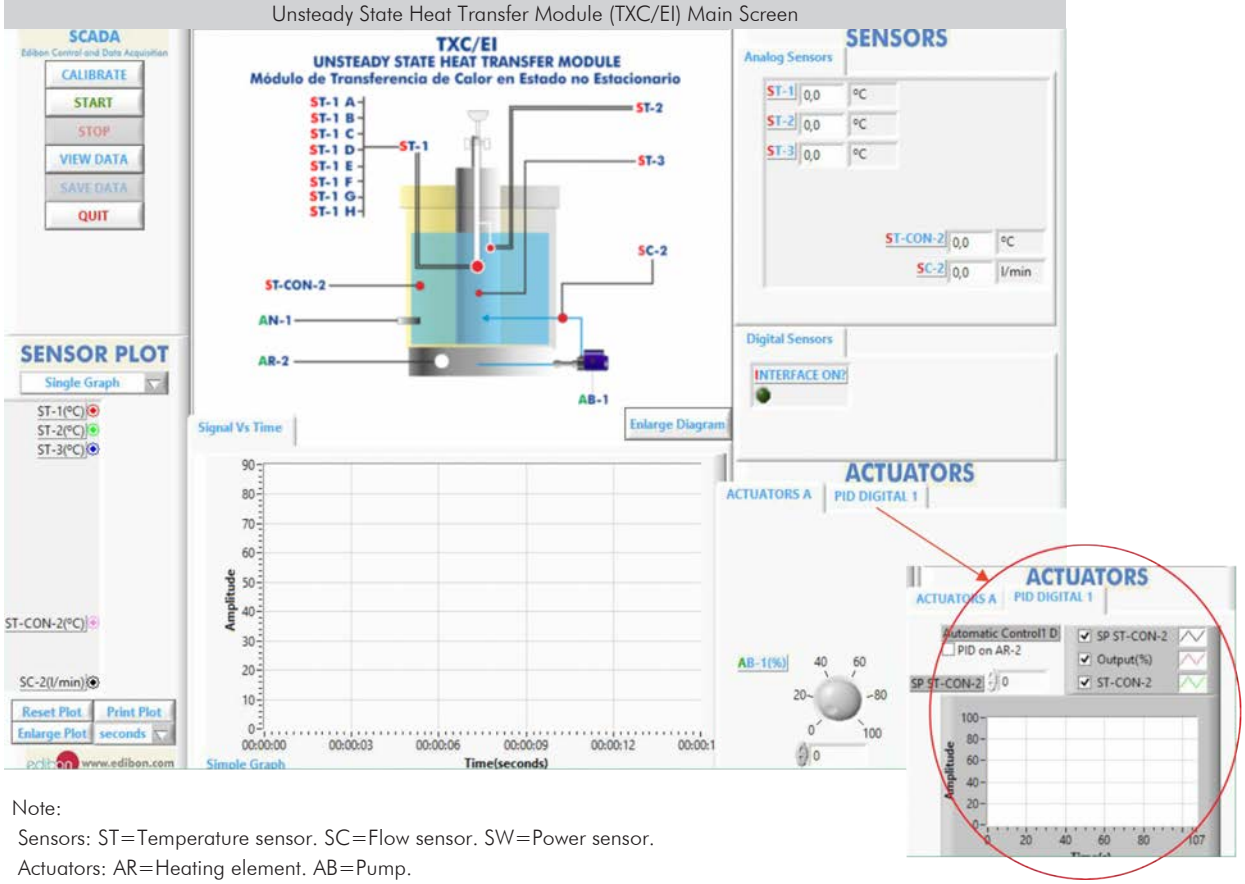
Note:
Sensors: ST=Temperature sensor. SW=Power sensor.
Actuator: AR=Heating element.

Radiation Errors in Temperature Measurement Module (TXC/ER) Main Screen



Note:
Sensors: ST=Temperature sensor. SC=Flow sensor. SW=Power sensor.
Actuators: AR=Heating element. AVE=Fan

Unsteady State Heat Transfer Module (TXC/EI) Main Screen

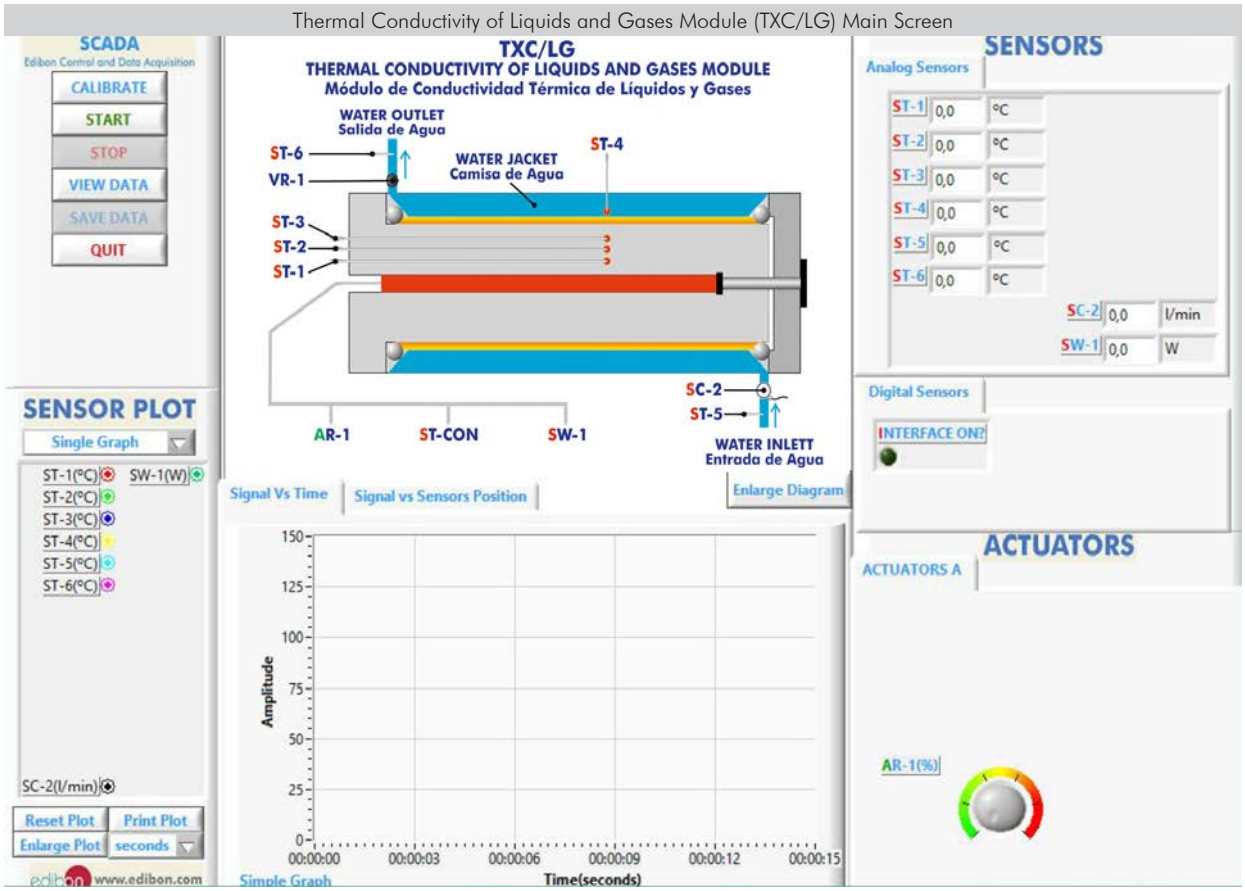


Note:

Sensors: ST=Temperature sensor. SC=Flow sensor. SW=Power sensor.

Actuators: AR=Heating element. AB=Pump.

Thermal Conductivity of Liquids and Gases Module (TXC/LG) Main Screen

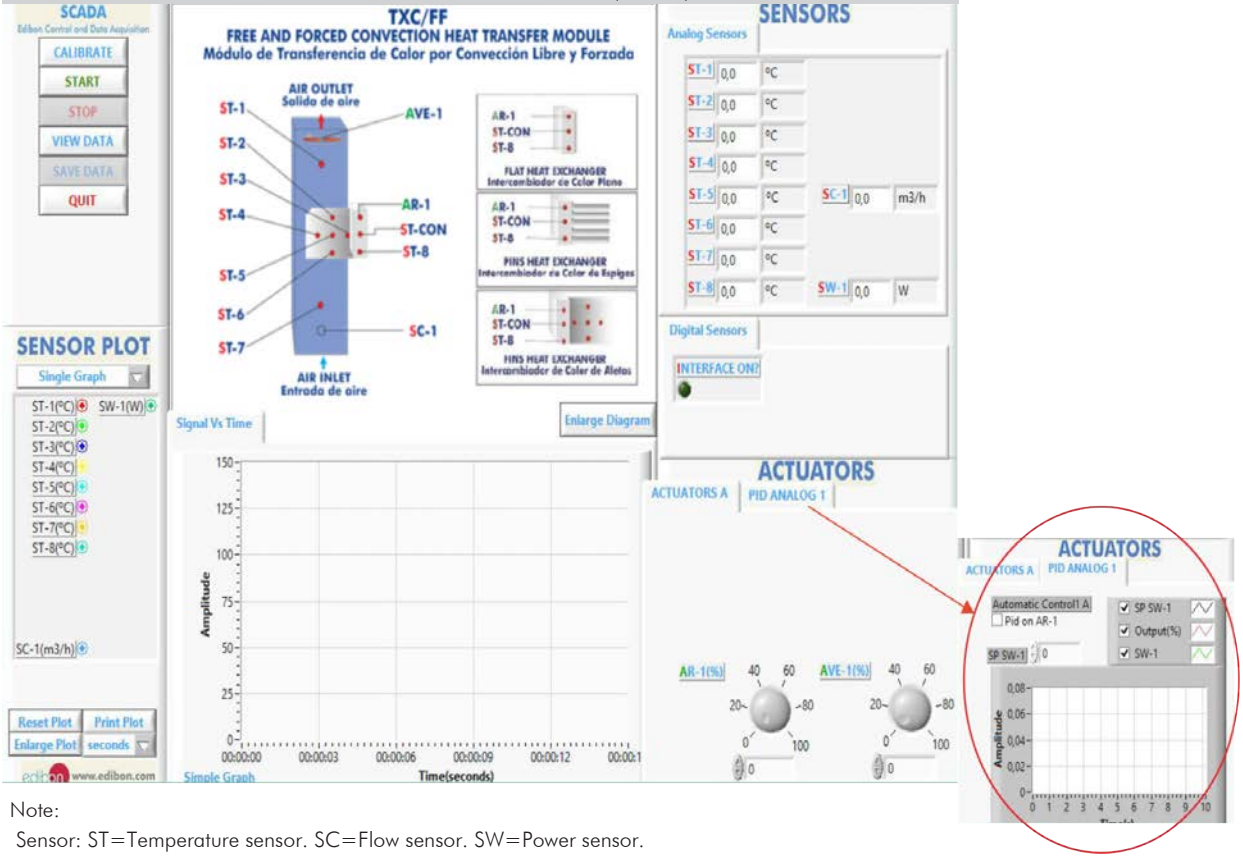


Note:

Sensors: ST=Temperature sensor. SC=Flow sensor. SW=Power sensor.

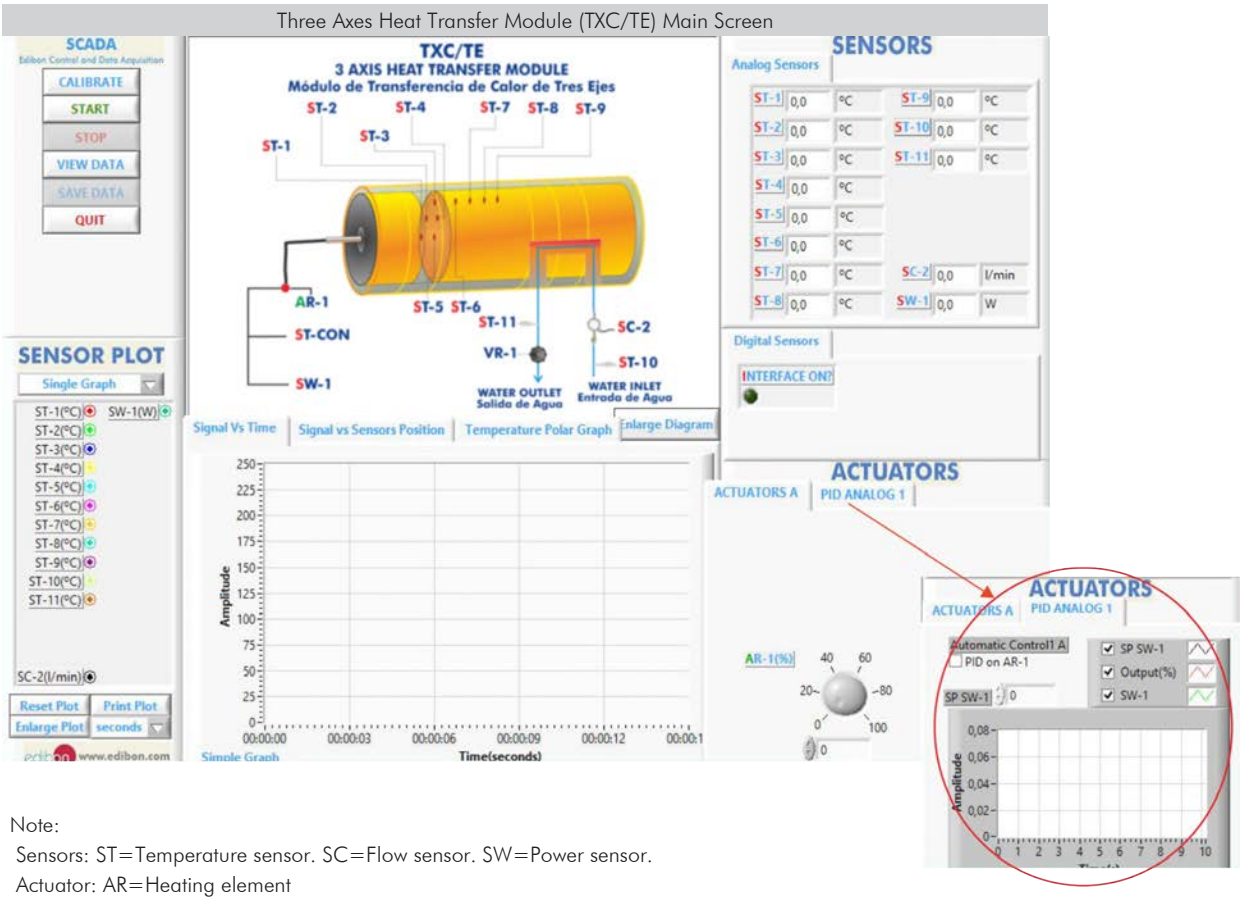
Actuator: AR=Heating element.

Free and Forced Convection Heat Transfer Module (TXC/FF) Main Screen



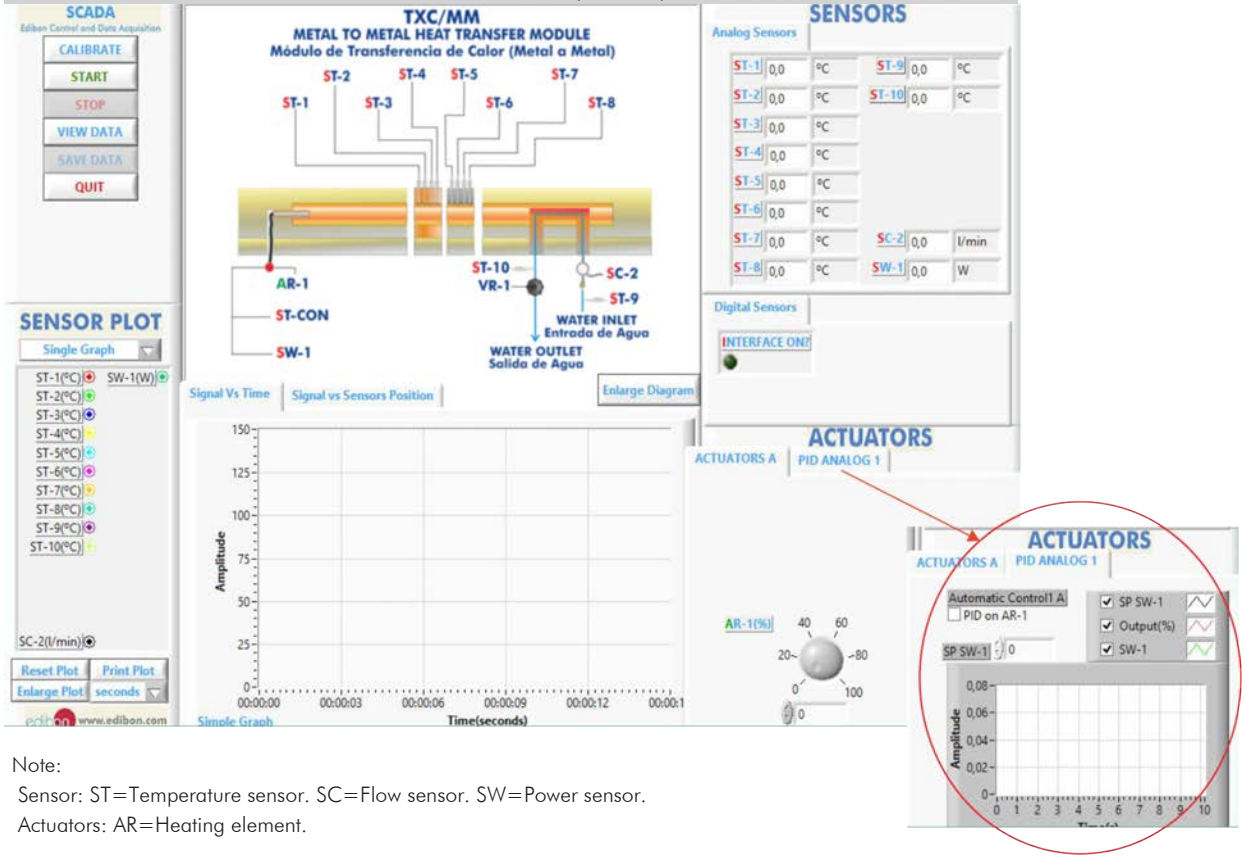
Note:
Sensor: ST=Temperature sensor. SC=Flow sensor. SW=Power sensor.
Actuators: AR=Heating element. AVE=Fan.

Three Axes Heat Transfer Module (TXC/TE) Main Screen



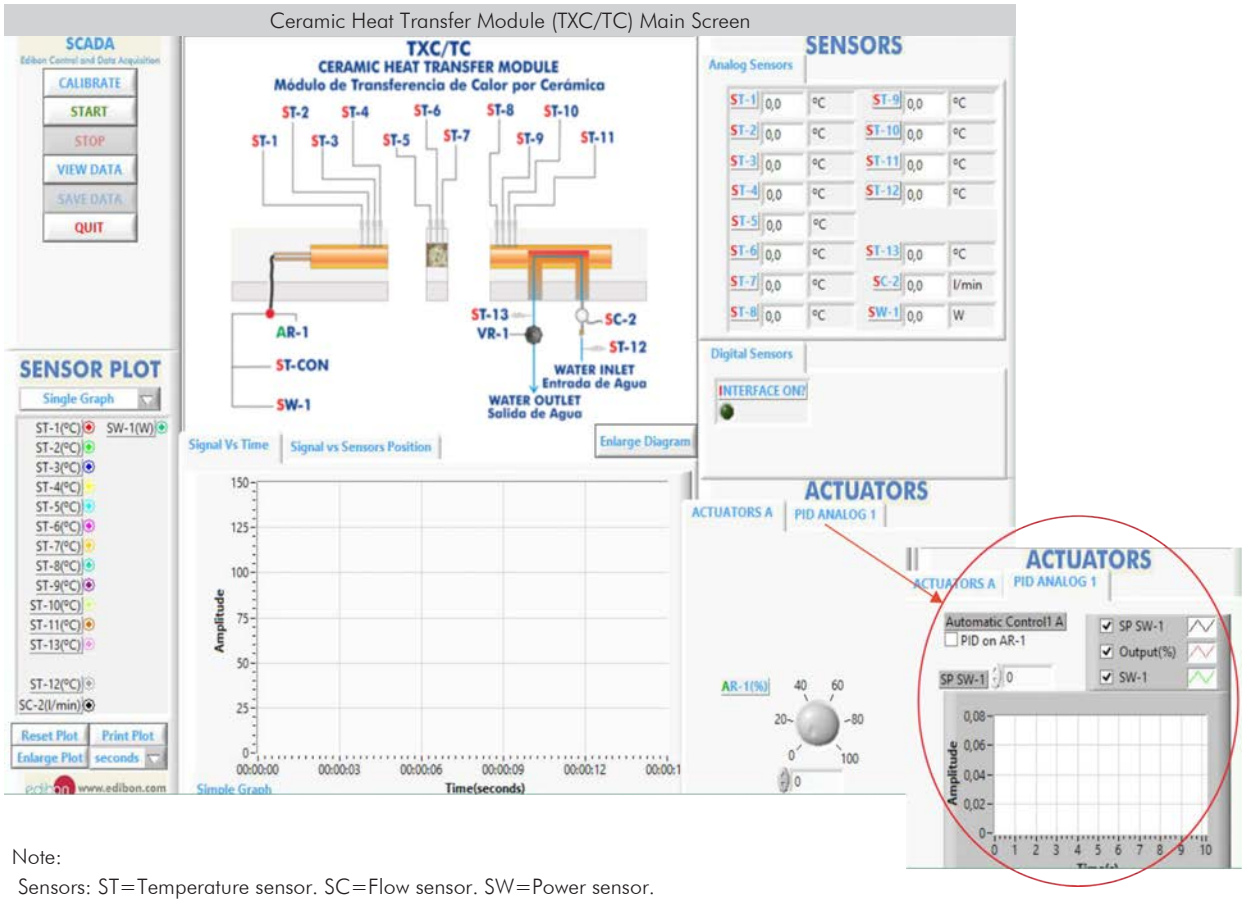
Note:
Sensors: ST=Temperature sensor. SC=Flow sensor. SW=Power sensor.
Actuator: AR=Heating element

Metal to Metal Heat Transfer Module (TXC/MM) Main Screen



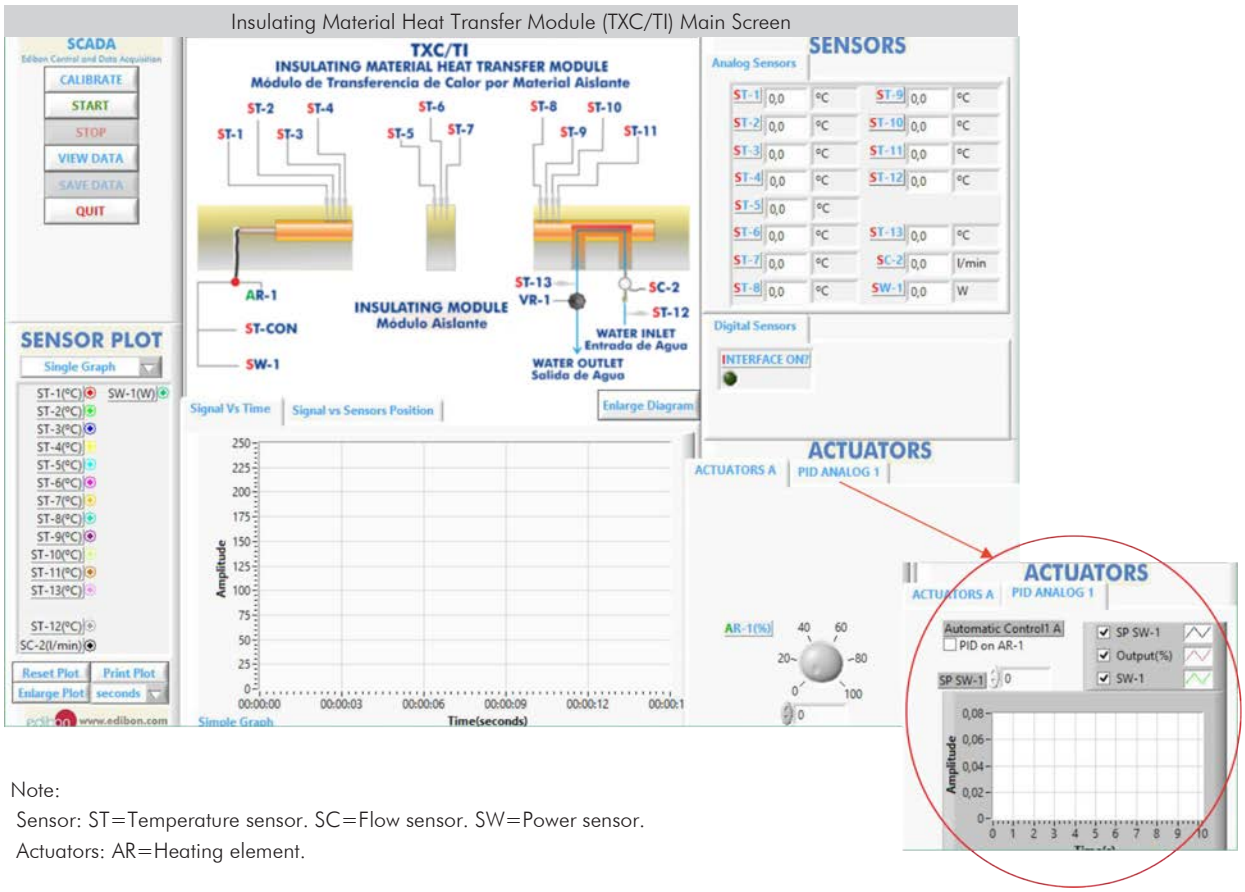
Note:
Sensor: ST=Temperature sensor. SC=Flow sensor. SW=Power sensor.
Actuators: AR=Heating element.

Ceramic Heat Transfer Module (TXC/TC) Main Screen



Note:
Sensors: ST=Temperature sensor. SC=Flow sensor. SW=Power sensor.
Actuator: AR=Heating element.

Insulating Material Heat Transfer Module (TXC/TI) Main Screen



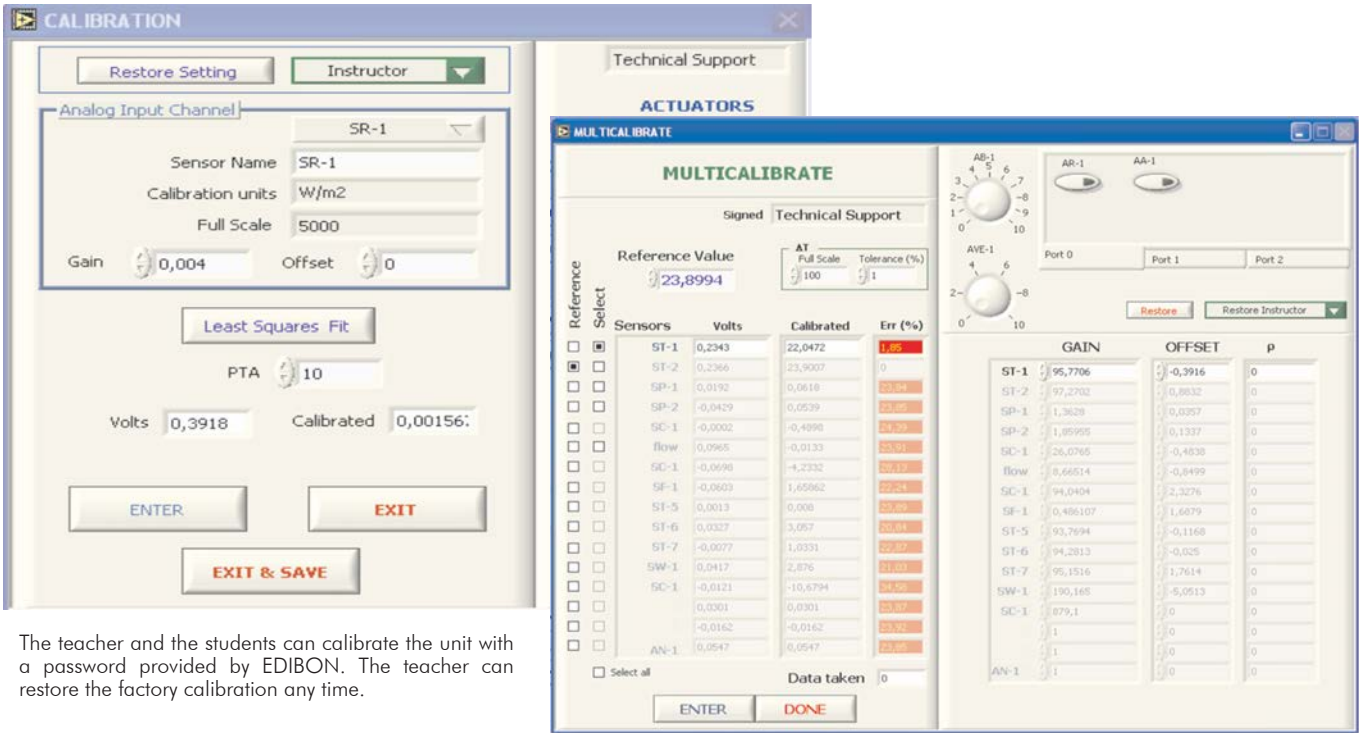
Note:

Sensor: ST=Temperature sensor. SC=Flow sensor. SW=Power sensor.

Actuators: AR=Heating element.

Software for Sensors Calibration

Example of screen



The teacher and the students can calibrate the unit with a password provided by EDIBON. The teacher can restore the factory calibration any time.

Additionally to the main items (1 to 4) described, we can offer, as optional, other items from 5 to 9.
All these items try to give more possibilities for:

a) Industrial configuration. (PLC)
b) Technical and Vocational Education configuration. (ICAI and FSS)
c) Multipost Expansions options. (MINI ESN and ESN)

a) Industrial configuration

⑤ **PLC. Industrial Control using PLC** (it includes PLC-PI Module plus PLC-SOF Control Software):

-PLC-PI. PLC Module:

This unit is common for the modules type "TXC" and can work with one or several modules.

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 (-10 V. to + 10 V.) (through SCSI connector).

Analog outputs block:

4 Analog outputs (-10 V. to + 10 V.) (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.

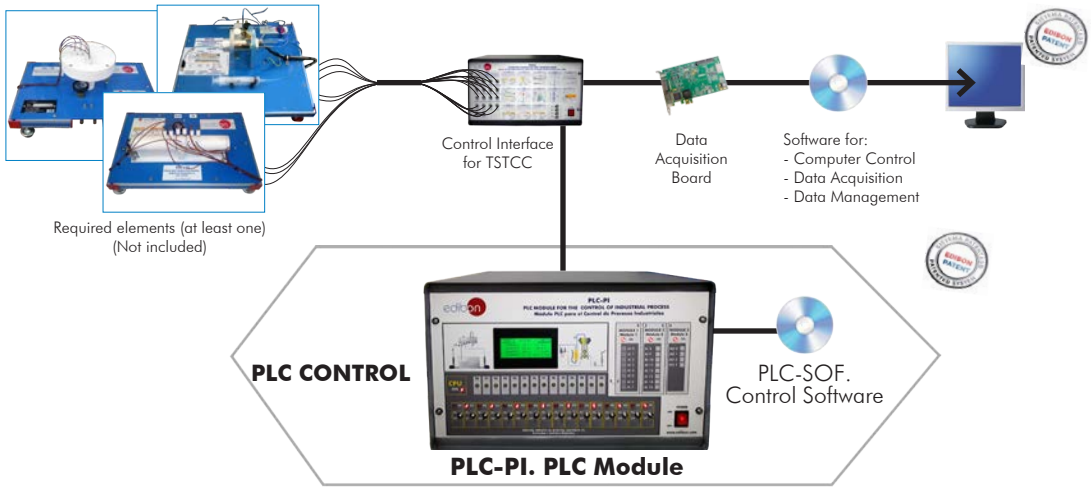
Communication RS232 wire to computer (PC).

Dimensions: 490 x 330 x 310 mm. approx. (19.29 x 12.99 x 12.20 inches approx.). Weight: 30 Kg. approx. (66 pounds approx.).

-TSTCC/PLC-SOF. PLC Control Software:

Always included with PLC supply.

Each module has its own Software.



Practices to be done with PLC-PI:

1.- Control of the particular unit process through the control interface box without the computer.
2.- Visualization of all the sensors values used in the particular unit process.
3.- Calibration of all sensors included in the particular unit process.
4.- Hand on of all the actuators involved in the particular unit process.
5.- Realization of different experiments, in automatic way, without having in front the particular unit. (These experiments can be decided previously).
6.- Simulation of outside actions, in the cases do not exist hardware elements. (Example: test of complementary tanks, complementary industrialenvironment to the process to be studied, etc).
7.- PLC hardware general use.
8.- PLC process application for the particular unit.
9.- PLC structure.
10.- PLC inputs and outputs configuration.
11.- PLC configuration possibilities.
12.- PLC program languages.
13.- PLC different programming standard languages (ladder diagram (LD), structured text (ST), instructions list (IL), sequential function chart (SFC), function block diagram (FBD)).
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 particular unit process.
17.- Possibility of creating new process in relation with the particular unit.
18.- PLC Programming Exercises.
19.- Own PLC applications in accordance with teacher and student requirements.

b) Technical and Vocational Education configuration

⑥ TSTCC/ICAI. Interactive Computer Aided Instruction Software.

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 6).

- 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).

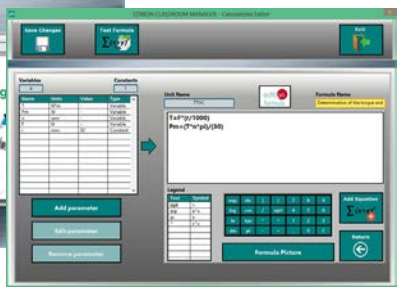
ESL-SOF is the application addressed to the Students that helps them to understand theoretical concepts by means of practical exercises and to prove their knowledge and progression by performing tests and calculations in addition to Multimedia Resources. Default planned tasks and an Open workgroup are 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:

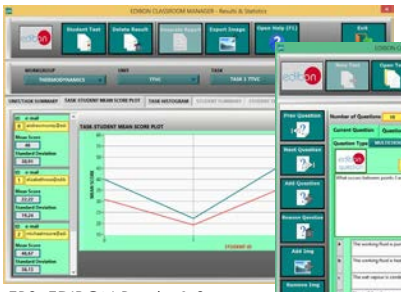
- **Student Log-In & Self-Registration.**
- **Existing Tasks checking & Monitoring.**
- **Default contents & scheduled tasks available to be used from the first session.**
- **Practical Exercises accomplishment by following the Manual provided by EDIBON.**
- **Evaluation Methods to prove your knowledge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

Instructor Software

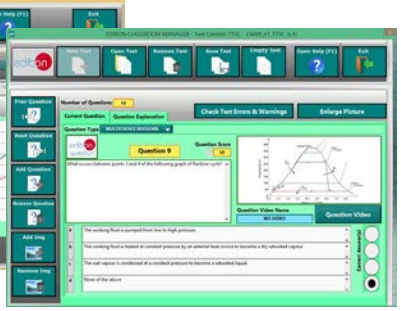
ECM-SOF. EDIBON Classroom Manager (Instructor Software) Application Main Screen



ECAL. EDIBON Calculations Program Package - Formula Editor Screen



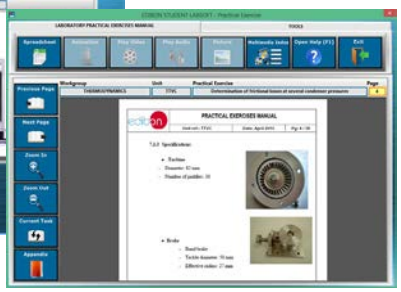
ERS. EDIBON Results & Statistics Program Package - Student Scores Histogram



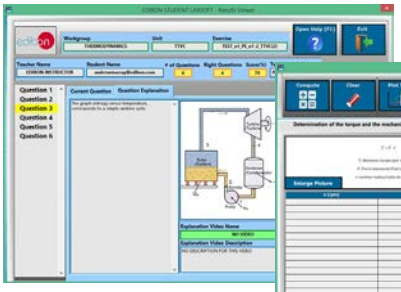
ETTE. EDIBON Training Test & Exam Program Package - Main Screen with Numeric Result Question

Student Software

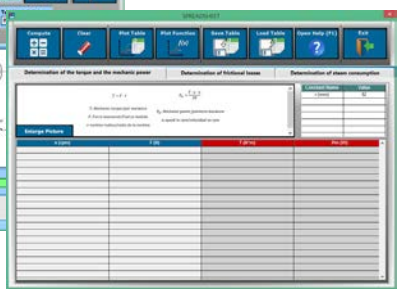
ESL-SOF. EDIBON Student LabSoft (Student Software) Application Main Screen



EPE. EDIBON Practical Exercise Program Package Main Screen



ERS. EDIBON Results & Statistics Program Package - Question Explanation



ECAL. EDIBON Calculations Program Package Main Screen

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

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

⑦ TSTCC/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 in 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 channels 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.

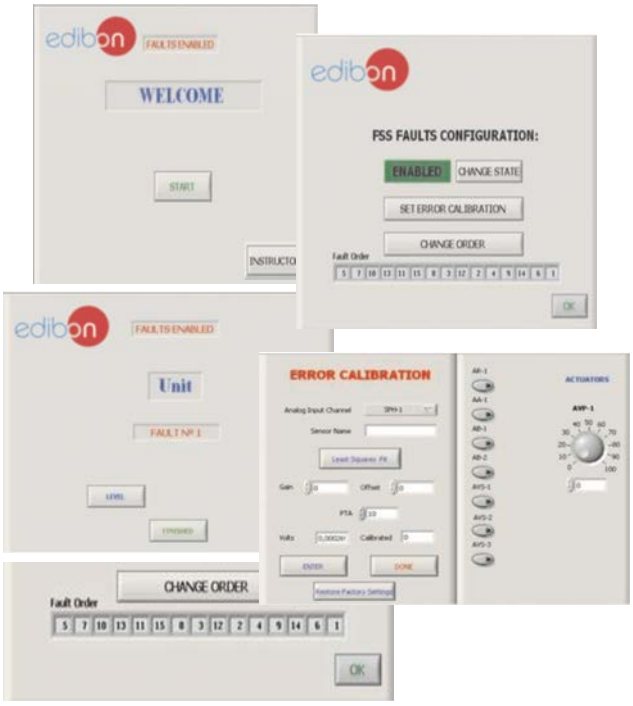
- Reduction or increase of the calculated total response.

- 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/en/fault-simulation-system

c) Multipost Expansions options

⑧ 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 and PID Control 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 up to 30 students to work simultaneously with the EDIBON Computer Controlled Unit with SCADA and PID Control, 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.

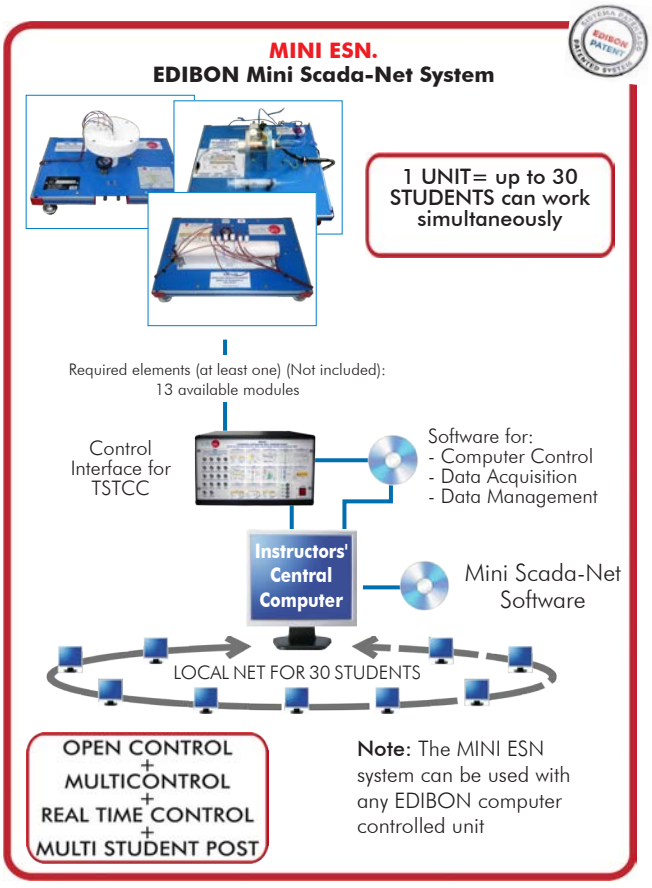
- Continuous communication between the instructor and all the users/students connected.

Main advantages:

- 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/edibon-scada-net

⑨ 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/edibon-scada-net

Main items (always included in the supply)

① **TSTCC/CIB. Control Interface for TSTCC.** (Can work with the Required elements (at least one) (Not included)).

② **DAB. Data Acquisition Board.** (Can work with the Required elements (at least one) (Not included)).

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

④ **Manuals.**

Required elements (at least one) to be used with the Control Interface for TSTCC "TSTCC/CIB":

TXC/CL. Linear Heat Conduction Module for TSTCC. (+)

TXC/CR. Radial Heat Conduction Module for TSTCC. (+)

TXC/RC. Radiation Heat Transfer Module for TSTCC. (+)

TXC/CC. Combined Free and Forced Convection and Radiation Module for TSTCC. (+)

TXC/SE. Extended Surface Heat Transfer Module for TSTCC. (+)

TXC/ER. Radiation Errors in Temperature Measurement Module for TSTCC. (+)

TXC/EI. Unsteady State Heat Transfer Module for TSTCC. (+)

TXC/LG. Thermal Conductivity of Liquids and Gases Module for TSTCC. (+)

TXC/FF. Free and Forced Convection Heat Transfer Module for TSTCC. (+)

TXC/TE. Three Axes Heat Transfer Module for TSTCC. (+)

TXC/MM. Metal to Metal Heat Transfer Module for TSTCC. (+)

TXC/TC. Ceramic Heat Transfer Module for TSTCC. (+)

TXC/TI. Insulating Material Heat Transfer Module for TSTCC. (+)

*IMPORTANT: Under TSTCC/CIB we always supply all the elements for immediate running as 1, 2, 3 and 4.

Optional items (supplied under specific order)

a) Industrial configuration

⑤ PLC. Industrial Control using PLC (it includes PLC-PI Module plus PLC-SOF Control Software):

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

b) Technical and Vocational Education configuration

⑥ TSTCC/ICAI. Interactive Computer Aided Instruction Software.

⑦ TSTCC/FSS. Faults Simulation System.

c) Multipost Expansions options

⑧ MINI ESN. EDIBON Mini Scada-Net System for being used with EDIBON Teaching Units.

⑨ ESN. EDIBON Scada-Net Systems.

The complete unit includes:

Advanced Real-Time SCADA and PID Control.
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.

Required elements (at least one) (Not included):

TXC/CL. Linear Heat Conduction Module for TSTCC:

Bench-top unit to study the principles of linear heat conduction and to allow the conductivity of various solid conductors and insulators to be measured.
It is given with interchangeable samples of different materials, different diameters and different insulating materials that allow to demonstrate the area effects, the conductivity and the combinations in series in the heat transfer process.
Anodized aluminum frame and panels made of painted steel.
Diagram in the front panel with distribution of the elements similar to the real one.
Input heat section.
Electric heater, computer controlled.
Refrigeration section with a surface cooled by water.
Interchangeable central sections:
With brass of 25 mm of diameter.
With brass of 10 mm of diameter.
With stainless steel of 25 mm of diameter.
Flow sensor to measure the cooling water flow, range: 0.25 – 6.5 l/min.
Water flow regulation valve.
Thermal paste is supplied to demonstrate the difference between poor and good thermal contact between the sections.
Nineteen temperature sensors, "T" type (high precision):
Seventeen temperature sensors distributed in the heating section (four sensors), refrigeration section (4 sensors) and central sections (three sensors in each central section).
Temperature sensor at the water inlet of the unit.
Temperature sensor at the water outlet of the unit.
Power measurement from the computer.
Cables and Accessories, for normal operation.
This unit is supplied with 8 manuals: Required Services, Assembly and Installation, Interface and Control Software, Starting-up, Safety, Maintenance, Calibration & Practices Manuals.

(+) TXC/CL/CCSOF. PID 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.
Analog and digital PID control.
PID menu and set point selection required in the whole work range.
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 whiteboard.

TXC/CR. Radial Heat Conduction Module for TSTCC:

Bench-top unit to study the principles of radial heat conduction, and to allow the conductivity of solid brass disk to be measured.
Anodized aluminum frame and panels made of painted steel.
Diagram in the front panel with distribution of the elements similar to the real one.
Brass disk of 110 mm of diameter and 3 mm of thickness.
Electric heater, computer controlled.
Peripherical cooling tube.
Flow sensor to measure the cooling water flow, range: 0.25 – 6.5 l/min.
Water flow regulation valve.
Eight temperature sensors, "T" type (high precision):
Six temperature sensors distributed in the unit.
Temperature sensor at the water inlet of the unit.
Temperature sensor at the water outlet of the unit.
Power measurement from the computer.
Cables and Accessories, for normal operation.
This unit is supplied with 8 manuals: Required Services, Assembly and Installation, Interface and Control Software, Starting-up, Safety, Maintenance, Calibration & Practices Manuals.

(+) TXC/CR/CCSOF. PID 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.
Analog and digital PID control.
PID menu and set point selection required in the whole work range.
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 whiteboard.

TXC/RC. Radiation Heat Transfer Module for TSTCC:
Bench-top unit designed to demonstrate the laws of radiant heat transfer and radiant heat exchange.
It basically consists of two independent parts. One of the parts is for the light radiation experiments and another part is for the thermal radiation experiments.
The elements provided with the unit allow making the measuring of the temperature, radiation, intensity light and the power in the heating element or bulb.
Anodized aluminum frame and panels made of painted steel.
Diagram in the front panel with distribution of the elements similar to the real one.
This unit consists of a metal plate with a heating element at one side and a lamp in the another side. Lengthwise of the metal plate you can place the elements supplied with the unit.
Heating element (ceramic), computer controlled.
Lamp 150 W, with diffuser.
The unit is provided with accessories for light experiments and radiation experiments.
Light accessories:
Luxmeter that allows to measure the intensity of the light:

Scale:	Resolution:	Accuracy:
0 to 1999 lux	1 lux	
2000 to 19990	10 lux	
20000 to 50000	100 lux	8%
Selection of light	Day, Tungsten, fluorescence or mercury	
Sensor	Photodiode with filter of adjustment of filter	
Sample frequency:	0.4 s	
Work temperature:	0 to 50 °C	

Filters:
They allow to filtrate the light in the experiments.
There are:
Three Grey Neutral Density A153 filters.
Grey Neutral Density A152 filter.
Grey Neutral Density A154 filter.
Three filter portholes.
Radiation accessories:
Radiometer (50 x 50 mm, 5μv (w/m^2)). It allows to measure the intensity of the radiation.
Planes surfaces. They are elements for studying the radiation and each one contains one.
Planes surfaces. They are elements for studying the radiation and each one contains one temperature sensor:
Polished aluminum.
Anodized aluminum.
Brass.
Two black bodies.
Variable slit or aperture. It allows to regulate the area of the radiation.
Seven temperature sensors, "T" type (high precision).
Power measurement from the computer.
Radiation measurement from the computer.
Lux measurement from the computer.
Cables and Accessories, for normal operation.
This unit is supplied with 8 manuals: Required Services, Assembly and Installation, Interface and Control Software, Starting-up, Safety, Maintenance, Calibration & Practices Manuals.
(+)TXC/RC/CCSOF. PID 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.
Analog and digital PID control.
PID menu and set point selection required in the whole work range.
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 whiteboard.

TXC/CC. Combined Free and Forced Convection and Radiation Module for TSTCC:
Bench-top unit to study the principles of combined free and forced convection with radiation from a horizontal heater cylinder.
It studies the variation experimented by the local heat transfer coefficient around of a horizontal cylinder. It is subject to a forced and a free convection.
Anodized aluminum frame and panels made of painted steel.
Diagram in the front panel with distribution of the elements similar to the real one.
Centrifugal fan (computer controlled) of 2650 rpm, which provides a maximum flow of 1200 l/min. and allows to the air to reach a maximum velocity around 5 m/s.
Stainless steel duct with interior cover, including:
Temperature sensor, "T" type (high precision), in order to measure the temperature of inlet air.
Flow sensor for measuring the air flow generated in the duct.
Temperature sensor, "T" type (high precision), in order to measure the temperature of outlet air.
Heater:
Copper cylinder with exterior cover: Interior heating element (computer controlled).
Temperature sensor, "T" type (high precision).
Power measurement from the computer.
Cables and Accessories, for normal operation.
This unit is supplied with 8 manuals: Required Services, Assembly and Installation, Interface and Control Software, Starting-up, Safety, Maintenance, Calibration & Practices Manuals.
(+)TXC/CC/CCSOF. PID 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.
Analog and digital PID control.
PID menu and set point selection required in the whole work range.
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 whiteboard.

TXC/SE. Extended Surface Heat Transfer Module for TSTCC:
Bench-top unit designed to demonstrate the temperature profiles and heat transfer characteristics for an extended surface. It studies the effect of adding fins to a body in order to extend its surface for a change in the cooling rate.
Fins of different materials and cross section shapes are used to analyse the effect of cooling.
Anodized aluminum frame and panels made of painted steel.
Diagram in the front panel with distribution of the elements similar to the real one.
Heating element (computer controlled), embedded in a copper capsule to permit a good contact with the interchangeable fins. The copper capsule is isolated by a coat of Teflon.
The fins are interchangeable, providing two different materials: brass and stainless steel and three different cross section shapes: square, circular and hexagonal.
The power to the heating element is controlled from the computer.
Eleven temperature sensors, "T" type (high precision).
Power measurement from the computer.
Cables and Accessories, for normal operation.
This unit is supplied with 8 manuals: Required Services, Assembly and Installation, Interface and Control Software, Starting-up, Safety, Maintenance, Calibration & Practices Manuals.
(+)TXC/SE/CCSOF. PID 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.
Analog and digital PID control.
PID menu and set point selection required in the whole work range.
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 whiteboard.

TXC/ER. Radiation Errors in Temperature Measurement Module for TSTCC:
Bench-top unit to demonstrate how temperature measurements can be influenced by sources of thermal radiation.
The objective of this module is to measure the error in a black thermocouple due the radiation with respect with another normal thermocouple where there are not radiative shielding in comparison when there are radiative shielding, error in function of material of the thermocouple's capsule, size of the thermocouple, etc.
Anodized aluminum frame and panels made of painted steel.
Diagram in the front panel with distribution of the elements similar to the real one.
Centrifugal fan (computer controlled):
2650 rpm.
Maximum flow of 1200 l/min.
It allows to the air to reach a maximum velocity around 5 m/s.
Stainless steel duct with interior cover, including:
Temperature sensor, "T" type (high precision), in order to measure the temperature of inlet air.
Flow sensor for measuring the air flow generated in the duct.
Temperature sensor, "T" type (high precision), in order to measure the temperature of outlet air.
Copper cylinder with exterior cover:
Interior heating element (computer controlled).
Temperature sensor, for measuring the temperature of the cylinder.
Five temperature sensors, "T" type (high precision), with different styles and sizes installed in the duct to demonstrate the differences in readings obtained:
Temperature sensor of bare.
Temperature sensor of inconel.
Temperature sensor of s/steel.
Temperature sensor of black s/steel.
Temperature sensor of ceramic.
Power measurement from the computer.
Cables and Accessories, for normal operation.
This unit is supplied with 8 manuals: Required Services, Assembly and Installation, Interface and Control Software, Starting-up, Safety, Maintenance, Calibration & Practices Manuals.
(+)TXC/ER/CCSOF. PID 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.
Analog and digital PID control.
PID menu and set point selection required in the whole work range.
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 whiteboard.

TXC/EI. Unsteady State Heat Transfer Module for TSTCC:
Bench-top unit designed to allow practices and exercises to be performed in unsteady state heat transfer.
It studies the transient conduction with convection. Using different shapes (rectangular slabs, spheres and cylinders) of different materials, the temperature of other shapes and materials can be predicted.
Anodized aluminum frame and panels made of painted steel.
Diagram in the front panel with distribution of the elements similar to the real one.
Dual concentric open top tanks filled with water, total tank capacity: 40 l, 300 x 350 x 400 mm concentric tank: 1.2 l, diameter: 70 mm.
Different shapes of different size and material are studied:
Brass sphere (diameter: 40 mm).
Brass sphere (diameter: 25 mm).
Stainless steel sphere (diameter: 40 mm).
Stainless steel sphere (diameter: 25 mm).
Brass cylinder (diameter: 15 mm, length: 150 mm).
Stainless steel cylinder (diameter: 15 mm, length: 150 mm).
Aluminum rectangular slab (40 x 10 x 150 mm).
Stainless steel rectangular slab (40 x 10 x 150 mm).

Each shape is fitted with a temperature sensor at the center of the object.
The shapes are installed in special holder at the center of the top cover of the large tank. The holder also has a temperature sensor that enters in the water bath at the same time as the shape.
Heating element (immersion heater). The high power allows reaching the steady state faster. It is computer controlled.
Water pump with variable speed (computer controlled). It allows to reach a maximum flow of 4 l/min.
Two temperature sensors, "T" type (high precision), allow to control the stability of the temperature of the water bath.
Flow sensor, range: 0.25 – 6.5 l/min.
Two temperature sensors, "T" type (high precision):
The first one permits to record the evolution of the temperature of the shape at its center.
The second one, works as a stopwatch, it will indicate the precise moment in which the shape is submerged.
Level switch.
Power measurement from the computer.
Cables and Accessories, for normal operation.
This unit is supplied with 8 manuals: Required Services, Assembly and Installation, Interface and Control Software, Starting-up, Safety, Maintenance, Calibration & Practices Manuals.

(+)TXC/EI/CCSOF. PID 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.
Analog and digital PID control.
PID menu and set point selection required in the whole work range.
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 whiteboard.

TXC/LG. Thermal Conductivity of Liquids and Gases Module for TSTCC:
This unit has been designed to enable students to easily determine the thermal conductivity of liquids and gases.
By the realization of the practices the student can determine the thermal conductivity of any suitable gas or compatible liquid with materials on construction.
Anodized aluminum frame and panels made of painted steel.
Diagram in the front panel with distribution of the elements similar to the real one.
Aluminum body (cylinder) with brass jacket that contains the test fluid and the refrigeration water.
Variable heating element (in the cylinder), computer controlled. Heating element power controlled from computer. The power is measured by a sensor.
Six temperature sensors, "T" type (high precision).
Flow sensor to measure the cooling water flow, range: 0.25 – 6.5 l/min.
Water flow regulation valve.
Valves. Syringe.
Power measurement from the computer.
Cables and Accessories, for normal operation.
This unit is supplied with 8 manuals: Required Services, Assembly and Installation, Interface and Control Software, Starting-up, Safety, Maintenance, Calibration & Practices Manuals.

(+)TXC/LG/CCSOF. PID 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.
Analog and digital PID control.
PID menu and set point selection required in the whole work range.
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 whiteboard.

TXC/FF. Free and Forced Convection Heat Transfer Module for TSTCC:
This unit allows to study the efficiency of different exchangers, analyzing the heat transfer coefficients of each of the exchangers exposed to different airflows. A fan placed in the upper part of the tunnel allows controlling the airflow that goes through the tunnel.
Anodized aluminum frame and panels made of painted steel.
Diagram in the front panel with distribution of the elements similar to the real one.
Stainless steel tunnel of rectangular section, 700 mm long, painted and resistant to corrosion. In the tunnel three type of different heat exchangers can be set.
Methacrylate viewer that allows a good visualization of the exchanger that is in use.
Stabilizers to guarantee an uniform air flux.
Eight temperature sensors, "T" type (high precision):
Two temperature sensors measure the air temperature at the inlet and outlet of the area of heat exchange.
Temperature measurements, at different distances of the base of the pins and fins exchangers, are made by other 5 temperature sensors that are introduced by one side of the tunnel.
Temperature sensor in the exchangers.
Maximum working temperature: 120 °C.
Flow sensor for measuring the air flow generated in the tunnel.
Three aluminum exchangers:
Flat heat exchanger (100 x 100 mm).
Pins heat exchanger. 17 pins, each one of 10 mm diameter and 125 mm longitude.
Fins heat exchanger. 9 fins, each one of 100 x 125 mm.
Heating element for each exchanger, computer controlled.
Variable speed fan, computer controlled, which generates air flux through the tunnel, range: 0 – 1200 l/min.
Cables and Accessories, for normal operation.
This unit is supplied with 8 manuals: Required Services, Assembly and Installation, Interface and Control Software, Starting-up, Safety, Maintenance, Calibration & Practices Manuals.

(+)TXC/FF/CCSOF. PID 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.
Analog and digital PID control.

PID menu and set point selection required in the whole work range.
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 whiteboard.

TXC/TE. Three Axes Heat Transfer Module for TSTCC:
Bench-top unit designed to carry out heat transfer experiments and exercises studying the direction in three axes.
Anodized aluminum frame and panels made of painted steel.
Diagram in the front panel with distribution of the elements similar to the real one.
Brass cylinder to study heat transfer.
Electric heater, computer controlled.
Refrigeration section with a surface cooled by water.
Flow sensor to measure the cooling water flow, range: 0.25 – 6.5 l/min.
Water flow regulation valve.
Eleven temperature sensors , "T" type (high precision):
Temperature sensor at the water inlet of the unit.
Temperature sensor at the water outlet of the unit.
Five temperature sensors at different depth in a specific cross section.
Four temperature sensors longitudinally distributed.
Power measurement from the computer.
Cables and Accessories, for normal operation.
This unit is supplied with 8 manuals: Required Services, Assembly and Installation, Interface and Control Software, Starting-up, Safety, Maintenance, Calibration & Practices Manuals.
(+)TXC/FF/CCSOF. PID 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.
Analog and digital PID control.
PID menu and set point selection required in the whole work range.
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 whiteboard.

TXC/MM. Metal to Metal Heat Transfer Module for TSTCC:
Bench-top unit designed to study of the heat transfer of different metallic materials situated in series.
Anodized aluminum frame and panels made of painted steel.
Diagram in the front panel with distribution of the elements similar to the real one.
Input heat section. It includes:
Electric heater, computer controlled.
Interchangeable central sections. They are formed by two different cylinders chosen from the four cylinders supplied:
Copper cylinder of 25 mm of diameter.
Brass cylinder of 25 mm of diameter.
Stainless steel cylinder of 25 mm of diameter.
Aluminum cylinder of 25 mm of diameter.
Four temperature sensors, "T" type (high precision) for each cylinder.
Refrigeration section with surface cooled by water. It includes four temperature sensors, type "T" (high precision).
Water flow regulation valve.
Two temperature sensors, "J" type, for the cooling water inlet and outlet.
Flow sensor to measure the cooling water flow, range: 0.25 – 6.5 l/min.
Thermal paste is supplied to demonstrate the difference between poor and good thermal contact between the sections.
Power measurement from the computer.
Cables and Accessories, for normal operation.
This unit is supplied with 8 manuals: Required Services, Assembly and Installation, Interface and Control Software, Starting-up, Safety, Maintenance, Calibration & Practices Manuals.
(+)TXC/MM/CCSOF. PID 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.
Analog and digital PID control.
PID menu and set point selection required in the whole work range.
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 whiteboard.

TXC/TC. Ceramic Heat Transfer Module for TSTCC:
Bench-top unit designed to study of the heat transfer of different ceramic materials.
Anodized aluminum frame and panels made of painted steel.
Diagram in the front panel with distribution of the elements similar to the real one.
Input heat section. It includes:
Electric heater, computer controlled.
Four temperature sensors, "T" type (high precision).
Interchangeable central sections. There are two types:
Ceramic cylinder with a thermal conductivity of 1.46 W/m·ºC.
Ceramic cylinder with a thermal conductivity of 0.49 W/m·ºC.

Three temperature sensors, "T" type (high precision), for each cylinder.
Refrigeration section with surface cooled by water. It includes four temperature sensors, "T" type (high precision).
Water flow regulation valve.
Two temperature sensors, "J" type, for the cooling water inlet and outlet.
Flow sensor to measure the cooling water flow, range: 0.25 – 6.5 l/min.
Thermal paste is supplied to demonstrate the difference between poor and good thermal contact between the sections.
Power measurement from the computer.
Cables and Accessories, for normal operation.
This unit is supplied with 8 manuals: Required Services, Assembly and Installation, Interface and Control Software, Starting-up, Safety, Maintenance, Calibration & Practices Manuals.

(+) TXC/TC/CCSOF. PID 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.
Analog and digital PID control.
PID menu and set point selection required in the whole work range.
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 whiteboard.

TXC/TI. Insulating Material Heat Transfer Module for TSTCC:
Bench-top unit to study the thermal conduction resistance of different thermal insulating materials.
Anodized aluminum frame and panels made of painted steel.
Diagram in the front panel with distribution of the elements similar to the real one.
Input heat section.
Electric heater, computer controlled.
Refrigeration section with a surface cooled by water.
Interchangeable central sections:
With nylon of 50 mm of diameter.
With Teflon of 50 mm of diameter.
With Bakelite of 50 mm of diameter.
Flow sensor to measure the cooling water flow, range: 0.25 – 6.5 l/min.
Water flow regulation valve.
Thermal paste is supplied to demonstrate the difference between poor and good thermal contact between the sections.
Nineteen Temperature sensors, "T" type (high precision):
Seventeen Temperature sensors distributed in the heating section (4 sensors), refrigeration section (4 sensors) and central sections (3 sensors in each central section).
Temperature sensor at the water inlet of the unit.
Temperature sensor at the water outlet of the unit.
Power measurement from the computer.
Cables and Accessories, for normal operation.
This unit is supplied with 8 manuals: Required Services, Assembly and Installation, Interface and Control Software, Starting-up, Safety, Maintenance, Calibration & Practices Manuals.

(+) TXC/TI/CCSOF. PID 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.
Analog and digital PID control.
PID menu and set point selection required in the whole work range.
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 whiteboard.

① **TSTCC/CIB. Control Interface for TSTCC:**
This control interface is common for the required elements (at least one) (Not included).
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 PID control with flexibility of modifications from the computer keyboard of the PID parameters, at any moment during the process.
Real time PID control for parameters involved in the process simultaneously.
Proportional control, integral control and derivative control, based on the real PID mathematical formula, by changing the values, at any time, of the three control constants (proportional, integral and derivative constants).
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.

② **DAB. Data Acquisition Board:**
Common for the required elements (at least one) (Not included).
PCI Express 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.
The Data Acquisition board model may change at any moment, providing the same or better features than those required for the unit.

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

④ **Manuals:**
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 the Main Items

Practices to be done with the Linear Heat Conduction Module for TSTCC (TXC/CL):

1.- Conduction through a simple bar.
2.- Conduction through a compound bar.
3.- Determination of the thermal conductivity "k" of different materials (conductors and insulators).
4.- The thermal conductivity properties of insulators may be found by inserting paper or other elements between the heating and cooling sections.
5.- Insulation effect.
6.- Determination of the thermal contact resistance Rtc.
7.- Effect of the crossing sectional area.
8.- Understanding the use of the Fourier equation in determining rate of heat flow through solid materials.

Additional practical possibilities:

9.- Sensors calibration.

Practices to be done with the Radial Heat Conduction Module for TSTCC (TXC/CR):

10.- Radial conduction.
11.- Determination of the thermal conductivity "k".
12.- Determination of the thermal contact resistance Rtc.
13.- Insulation effect.
14.- Understanding the use of the Fourier equation in determining rate of heat flow through solid materials.

Additional practical possibilities:

15.- Sensors calibration.

Practices to be done with the Radiation Heat Transfer Module for TSTCC (TXC/RC):

16.- Inverse of the distant square law for the radiation.
17.- Stefan Boltzmann Law.
18.- Emission power I.
19.- Emission power II.
20.- Kirchorff Law.
21.- Area factors.
22.- Inverse of the distant square law for the light.
23.- Lambert´s Cosine Law.
24.- Lambert Law of Absorption.

Additional practical possibilities:

25.- Sensors calibration.

Practices to be done with the Combined Free and Forced Convection and Radiation Module for TSTCC (TXC/CC):

26.- Demonstration of the combined heat transfer effect by radiation and convection on the surface of the cylinder. Determination of the combined heat transfer effect by forced convection and radiation.
27.- Demonstration of the influence of air flow in the heat transfer. Determination of the combined heat transfer effect by forced convection and radiation.
28.- Demonstration of the influence of input power in the heat transfer. Determination of the combined heat transfer effect by forced convection and radiation.
29.- Demonstration of the combined heat transfer effect of the radiation and convection on the surface of the cylinder. Determination of the combined heat transfer effect by free convection and radiation.

Additional practical possibilities:

30.- Sensors calibration.
31.- Determination of the airflow.

Practices to be done with the Extended Surface Heat Transfer Module for TSTCC (TXC/SE):

32.- Heat transfer from a Fin.
33.- Effect of cross section shape in heat transfer from a Fin.
34.- Heat transfer from Fins of two different materials.
35.- Measuring the temperature distribution along an extended surface.

Additional practical possibilities:

36.- Sensors calibration.

Practices to be done with the Radiation Errors in Temperature Measurement Module for TSTCC (TXC/ER):

37.- Radiation errors in temperature measurement.
38.- Measurement the errors in thermocouples in function of its painting, material of its capsules, size.
39.- Effect of air velocity on measurement error.

Additional practical possibilities:

40.- Sensors calibration.

Practices to be done with the Unsteady State Heat Transfer Module for TSTCC (TXC/EI):

41.- Predicting temperature at the center of a cylinder using transient conduction with convection.
42.- Predicting the conductivity of a similar shape constructed from a different material.
43.- Conductivity and temperature dependence on volume.
44.- Conductivity and temperature dependence on surrounding temperature T_∞.

Additional practical possibilities:
45.- Sensors calibration.

Practices to be done with the Thermal Conductivity of Liquids and Gases Module for TSTCC (TXC/LG):

46.- Obtaining of the curve of thermal conductivity of the air.
47.- Thermal conductivity in vacuum.
48.- Water thermal conductivity determination.
49.- Thermal conductivity determination of a mineral oil.
50.- Calibration of the Unit.
Additional practical possibilities:
51.- Sensors calibration.
52.- Dry air thermal conductivity under atmospheric pressure.

Practices to be done with the Free and Forced Convection Heat Transfer Module for TSTCC (TXC/FF):

53.- Demonstration of the basic principles of free and forced convection.
54.- Comparison between free and forced convection.
55.- Free convection in flat surfaces.
56.- Forced convection in flat surfaces.
57.- Dependence of the heat transfer with the temperature.
58.- Dependence of the heat transfer with the speed of the fluid.
59.- Dependence of the heat transfer with the exchanger geometry (finned or pinned surface).
60.- Temperature distribution in the additional surfaces.
61.- Study of the advantage of using pinned and finned surfaces in heat transfer in free convection.
62.- Study of the advantage of using pinned and finned surfaces in heat transfer in forced convection.
63.- Comparative study between the free convection of a horizontal surface and vertical surface.
Additional practical possibilities:
64.- Sensors calibration.

Practices to be done with the Three Axes Heat Transfer Module for TSTCC (TXC/TE):

65.- Determination of the thermal conductivity “k”.
66.- Conduction through a simple bar.
67.- Conduction through three axes.
Additional practical possibilities:
68.- Sensors calibration.

Practices to be done with the Metal to Metal Heat Transfer Module for TSTCC (TXC/MM):

69.- Conduction in a simple bar.
70.- Determination of the thermal conductivity “k”.
71.- Determination of the thermal contact resistance.
Additional practical possibilities:
72.- Sensors calibration.

Practices to be done with the Ceramic Heat Transfer Module for TSTCC (TXC/TC):

73.- Conduction in a simple bar.
74.- Determination of the thermal conductivity “k”.
75.- Conduction through a compound bar.
76.- Determination of the thermal contact resistance.
Additional practical possibilities:
77.- Sensors calibration.

Practices to be done with the Insulating Material Heat Transfer Module for TSTCC (TXC/TI):

78.- Determination of the thermal conductivity “k”.
79.- Calculation of the heat transfer properties of different specimens.
80.- Conduction through a compound bar.
81.- Insulation effect.
Additional practical possibilities:
82.- Sensors calibration.
Other possibilities to be done with this System:
83.- Many students view results simultaneously. To view all results in real time in the classroom by means of a projector or an electronic whiteboard.
84.- 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.
85.- The Computer Control System with SCADA and PID Control allow a real industrial simulation.
86.- This unit is totally safe as uses mechanical, electrical and electronic, and software safety devices.
87.- This unit can be used for doing applied research.
88.- This unit can be used for giving training courses to Industries even to other Technical Education Institutions.
89.- Control of the unit process through the control interface box without the computer.
90.- Visualization of all the sensors values used in the 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

⑤ 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.

-TSTCC/PLC-SOF. PLC Control Software:

Always included with PLC supply. Each Heat Exchanger has its own Software.

Practices to be done with PLC-PI:

1.- Control of the particular unit process through the control interface box without the computer.
2.- Visualization of all the sensors values used in the particular unit process.
3.- Calibration of all sensors included in the particular unit process.
4.- Hand on of all the actuators involved in the particular unit process.
5.- Realization of different experiments, in automatic way, without having in front the particular unit. (These experiments can be decided previously).
6.- Simulation of outside actions, in the cases do not exist hardware elements. (Example: test of complementary tanks, complementary industrialenvironment to the process to be studied, etc).
7.- PLC hardware general use.
8.- PLC process application for the particular unit.
9.- PLC structure.
10.-PLC inputs and outputs configuration.
11.-PLC configuration possibilities.
12.-PLC program languages.
13.-PLC different programming standard languages (ladder diagram (LD), structured text (ST), instructions list (IL), sequential function chart (SFC), function block diagram (FBD)).
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 particular unit process.
17.-Possibility of creating new process in relation with the particular unit.
18.-PLC Programming Exercises.
19.-Own PLC applications in accordance with teacher and student requirements.

b) Technical and Vocational Education configuration

⑥ TSTCC/ICAI. Interactive Computer Aided Instruction Software.

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.

⑦ TSTCC/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 in 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 channels 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) Multipost Expansions options

⑧ 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.

The MINI ESN system consists of the adaptation of any EDIBON Computer Controlled Unit with SCADA and PID Control 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 up to 30 students to work simultaneously with the EDIBON Computer Controlled Unit with SCADA and PID Control, 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.

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.

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REPRESENTATIVE: