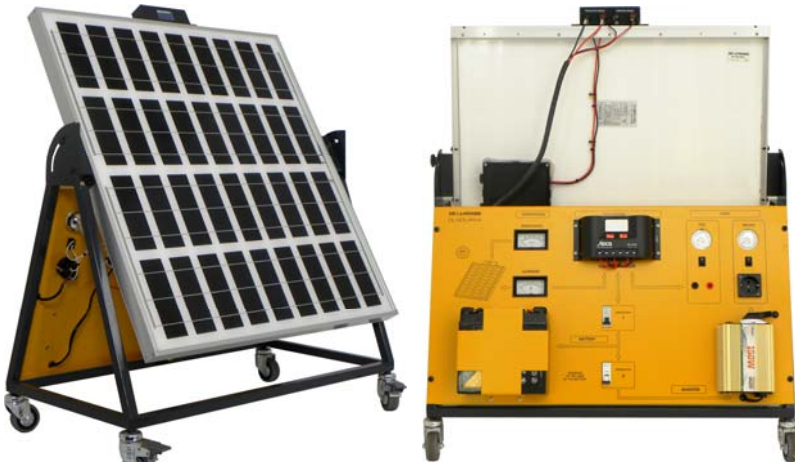




## PHOTOVOLTAIC SOLAR ENERGY TRAINER



**DL SOLAR-A**

Didactic system for the theoretical and practical study of photovoltaic solar energy facilities.

It is mounted on a mobile structure that allows it to be moved to the venue for practical sessions and allowing the photovoltaic panel to receive solar radiation.

Complete with connecting cables and experiment manual.

### TRAINING OBJECTIVES

- Identification of all components of the trainer and how they are associated with its operation
- Measurement of solar irradiation
- Measurement of the voltage and power parameters of the photovoltaic panel
- Programming the load regulator
- Analysis of the installation of the trainer
- Direct current supply
- Alternating current supply

BASE DIMENSIONS: 400 x 610 mm.  
HEIGHT WITH THE PANEL AT 45°: 900 mm.  
Net weight: 50 kg.

The photovoltaic panel, which can be inclined through a range of 0° to 90°, and the calibrated cell used to measure solar irradiation, are on one side, and all of the components of a basic photovoltaic facility used to provide 12 V of direct current and 230 V of alternating current are on the other side.

### TECHNICAL SPECIFICATIONS

- 50 W, 12 V photovoltaic panel.
- Cell for measuring solar irradiation.
- Programmable electronic load regulator, with a large LCD screen.
- 150 Wp semi sinusoidal inverter to obtain 230 V of alternating current.
- 17 A/h battery.
- Lamps used with loads of 12 V and 230 V
- Instrument used to measure solar irradiation in W/m<sup>2</sup>.
- Instrument used to measure the charging current.
- Two protective magneto-thermal switches.

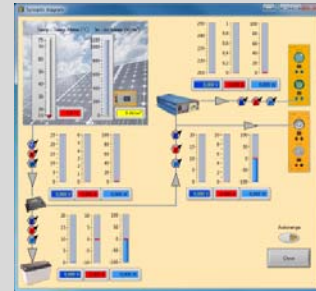


## SOLAR ENERGY MODULAR TRAINER



**DL SOLAR-B**

Modular trainer for the theoretical-practical study of the electrical installations with photovoltaic solar energy.



Complete with connecting cables, experiment manual and **software for data acquisition and processing**.

### TRAINING OBJECTIVES

- Measurement of solar irradiation
- Measurement of the voltage of the photovoltaic panel at no-load
- Graph of current – voltage of the photovoltaic panel
- Measurement of the voltage of the panel in overload
- Regulation and charge of the battery
- Direct current solar plant
- Alternate current solar plant
- Dimensioning criteria

Approx. packing dimensions: 0.62 x 1.21 x 0.82 m.  
Net weight: 51 kg.

### OPTION: DL SIMSUN

Composed of 4 halogen lamps, 300 W each, for lighting the solar tracking system. Possibility to adjust the light intensity.

### ALTERNATIVE: DL SOLAR-BT

Trainer with solar tracking panel instead of the standard solar panel.

### TECHNICAL SPECIFICATIONS

- A photovoltaic inclinable module, 90W, 12V, complete with a cell for measuring the solar irradiation and with a temperature sensor.
- A supporting frame for the modules.
- A battery.
- A battery control module, 12V, 32A.
- A load module. It includes two 12V lamps, dichroic 20W and LED 3W, with independent switches.
- A load module. It includes two mains voltage lamps, dichroic 35W and LED 3W, with independent switches.
- An electronic regulation module, with LCD screen.
- A rheostat.
- A module for the measurement of: solar irradiation ( $\text{W/m}^2$ ), solar panel temperature ( $^{\circ}\text{C}$ ), current up to 30V,  $\pm 15\text{A}$  (two dc ammeters), voltage up to 40V and power up to 300W.
- A dc to ac converter module, with sinusoidal output at mains voltage. Average power: 300 W.



## PHOTOVOLTAIC SOLAR ENERGY TRAINER



**DL SOLAR-C**

Trainer for the theoretical and practical study of the applications of the photovoltaic solar energy in a house.

Complete with connecting cables and experiment manual.

### TRAINING OBJECTIVES

- Identification of all the operational components and controls, and association with their functions. Placing the equipment into operation and testing the lighting bridge.
- Measurement of solar irradiation
- Connection of the photovoltaic modules and measurement of their voltage and short-circuit current, with the light in the classroom and from the lighting bridge.
- Lighting for homes. Interconnect the six photovoltaic modules and apply the obtained voltage to the house in which a charge regulator and its corresponding battery are assumed to be installed.
- Measurement of battery voltage.
- Irrigation system. Experiment with the operation of the motor used to extract water from a well.
- Calculation of electrical consumption.

### TECHNICAL SPECIFICATIONS

Composed of:

- A simulation panel with the graphical representation of a house, complete with lamps, switches, motor for the extraction of water, etc.
- Six photovoltaic modules with 2 mm. terminals for experiencing series, parallel and mixed configurations and for measuring voltage and current as a function of the solar irradiation.
- A battery for experimenting energy accumulation.
- A digital multimeter for performing the measurements.
- A lighting bridge over the photovoltaic modules with two 50 W dichroic lamps and an electronic light regulator. It is possible to change the inclination of the bridge from 0 to 90° as well as the intensity of the light in order to simulate in the classroom the effect of the solar irradiation in the different hours of the day.

Dimensions of the trainer: 486 x 289 x 70 mm.  
Dimensions of the case: 520 x 370 x 120 mm.  
Net weight: 10 kg.

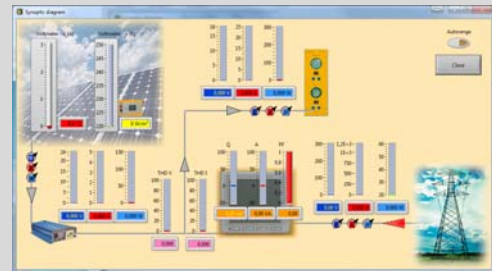


## SOLAR ENERGY MODULAR TRAINER WITH CONNECTION TO MAINS



**DL SOLAR-D1**

Didactic system for the study of the generation of electric energy from photovoltaic panels and its inlet in the mains network.



Complete with connecting cables, experiment manual and **software for data acquisition and processing**.

### TRAINING OBJECTIVES

- Measuring the mains voltage
- Measuring the load current, voltage, power and energy
- Setting the solar panel to the most irradiated position
- Changing the inclination of the solar panel
- Changing the azimuth of the solar panel
- Covering the solar panel with different materials
- Obtaining the solar irradiation data
- Obtaining the solar panel voltage-irradiation curve
- Calculating the inner resistance of the solar panel
- Obtaining the solar panel current-voltage curve
- Measuring the electricity delivered to the mains grid
- Measuring the electricity produced by the solar panel and delivered/taken from the mains grid
- Measuring the electricity produced by the solar panel, delivered/ taken from the mains grid, and the loading of lamps

Approx. packing dimensions: 0.62 x 1.21 x 0.82 m.

Net weight: 51 kg.

### OPTION: DL SIMSUN

Composed of 4 halogen lamps, 300 W each, for lighting the solar tracking system. Possibility to adjust the light intensity.

### ALTERNATIVE: DL SOLAR-D1T

Trainer with solar tracking panel instead of the standard solar panel.

### TECHNICAL SPECIFICATIONS

- A photovoltaic inclinable module, 90W, 12V, complete with a cell for measuring the solar irradiation and with a temperature sensor.
- A supporting frame for the modules.
- A load module. It includes two mains voltage lamps, dichroic 35W and LED 3W, with independent switches.
- A power rheostat, 6 A, 80 W.
- A differential magneto-thermal switch module.
- A module for the measurement of: solar irradiation ( $\text{W/m}^2$ ), solar panel temperature ( $^{\circ}\text{C}$ ), solar panel current, load current, solar panel voltage and active power at mains voltage.
- A grid type inverter, with output at mains voltage, 12 V, 300 W.
- An electric energy measurement module in kW/h.
- A network distributor.

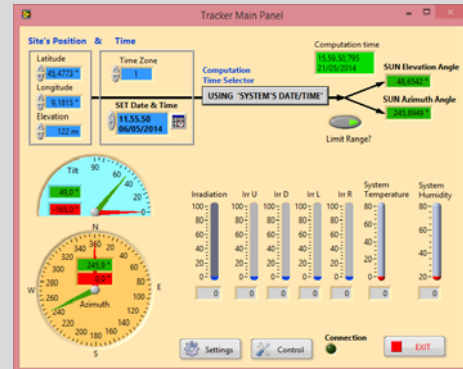


## SOLAR POSITION TRACKING SYSTEM



**DL SUNTRACKER** (bench not included)

For the study of the operation of a solar panel that follows the sun light direction thanks to a motor system.



Complete with connecting cables, experiment manual and **software for control and data acquisition**.

### TRAINING OBJECTIVES

With the trainer, it is possible to monitor the most meaningful parameters of the sun tracker and to compare them with the expected optimal setting according to the actual sun position.

### TECHNICAL SPECIFICATIONS

The trainer is composed of the following:

- A two-axis solar tracking system, 2 x 20W, 12V, to allow the tracking of the sun light direction.
- A supporting frame for the modules.
- A battery.
- A battery charge regulator, 12V, 30A.
- A circuit breaker.

Approx. packing dimensions: 0.62 x 1.21 x 0.82 m.  
Net weight: 51 kg.

### OPTION

#### DL SIMSUN-T

Composed of halogen lamps for lighting the solar tracking system.



### OTHER FEATURES:

- Automatic or manual tracking.
- Temperature sensor.
- Humidity sensor
- Compass sensor.
- Protection against gust.
- RS485 Modbus RTU communication.





## LAMPS FOR PHOTOVOLTAIC SOLAR TRAINERS



front view

back view

### DL SIMSUN

This product is used to provide suitable lighting to the photovoltaic solar module that is used in the DL SOLAR-B, DL SOLAR-D1 and DL SUN-WIND De Lorenzo trainers.

The light intensity can be manually adjusted through a potentiometer or automatically controlled through a 0-10 V input, to allow performing experiments with different light intensities, therefore simulating the light conditions from dawn to twilight.

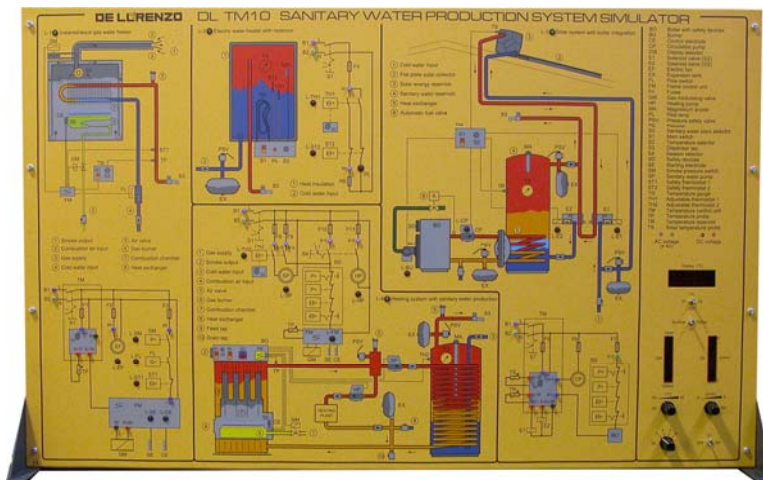
The DL SIMSUN includes the following main components:

- 4 off halogen lamps, 300 W each
- Dimmer for controlling the light intensity
- Magneto-thermal switch, differential 10 A
- Potentiometer, 10k

Approx. packing dimensions: 1.36 x 0.75 x 0.72 m.  
Net weight: 20 kg.



## SANITARY WATER PRODUCTION SYSTEMS



**DL TM10**

The simulator allows the study, the performing of experiments and the troubleshooting for the following systems:

- Instantaneous geyser;
- Store electric water heater;
- Solar system for sanitary water production with boiler integration;
- Central system for heating and sanitary water production

These systems are reproduced on the panel, through a colour representation which allows a complete analysis of the fluid circuit, of its components and of the electrical/electronic circuit for control and regulation.

### TRAINING OBJECTIVES

It is possible to simulate the behaviour of components and systems, on the basis of the operating conditions which can be monitored directly on the panel or through Personal Computer by teacher and students.

The Personal Computer constantly keeps under control the simulation in progress and displays its behaviour through analog and digital signals and meters; in this way the student, through measurements and tests, can go on with the troubleshooting.

Dimensions: 0.66 x 1.04 x 0.35 m.

Net weight: 16 kg.

Average training hours: 10 h.

The system is supplied with a Student Navigator software that allows students to perform their learning activities through a Personal Computer, without the need for any other documentation.

Moreover, the Student Navigator is provided with an interface to the Laboratory Management software.

The instantaneous geyser is composed of the following main elements:

- Forced draught gas-fired wall boiler
- Flame control device
- Sanitary water regulation thermostat and safety thermostat
- Sanitary water flow meter
- Smoke pressure switch
- Modulating valve for gas capacity

The store electric water heater is composed of the following main elements:

- Steel boiler with insulation
- Electric resistance
- Sanitary water regulation thermostat and safety thermostat
- Safety valves
- Magnesium anode
- Sanitary water thermometer
- Pilot light for electric resistance insertion

### TECHNICAL DESCRIPTION

The solar system for sanitary water production with boiler integration is composed of the following main elements:

- Solar panel with natural circulation, with tank for sanitary water storage
- Boiler and relevant gas burner
- Safety and regulation devices for the boiler
- Boiler for sanitary water storage
- Boiler pump
- Sanitary water regulation thermostat
- Probe for boiler temperature and boiler sanitary water thermometer
- Probe for stored sanitary water temperature through solar panels
- Safety valve
- Electrovalve for control of the heating through solar panel or through solar panel with boiler integration
- Sanitary water with heating through boiler

The central system for heating and sanitary water production is composed of the following main elements:

- Gas boiler
- Safety and regulation devices for the boiler
- Flame control device
- Modulating valve for gas capacity
- Heating circulation pump
- Expansion tank
- Air exhaust valve
- Boiler for sanitary water storage
- Boiler pump
- Sanitary water regulation thermostat
- Probe for boiler temperature and boiler sanitary water thermometer
- Safety valves
- Magnesium anode



## PHOTOVOLTAIC AND THERMAL PANELS



**DL TM11**

The simulator allows the study, the performing of experiments and the troubleshooting for the following system:

- Photovoltaic silicon single crystal cell, squared, side 135 mm
- Two photovoltaic cells with series connection
- Two photovoltaic cells with parallel connection
- Panel composed of 36 photovoltaic cells with series connection
- Thermal panel with liquid circulation

These systems are reproduced on the panel, through a colour representation which allows a complete analysis of the fluid circuit, of its components and of the electrical/electronic circuit for control and regulation.

### TRAINING OBJECTIVES

It is possible to simulate the behaviour of components and systems, on the basis of the operating conditions which can be monitored directly on the panel or through Personal Computer by teacher and students.

The Personal Computer constantly keeps under control the simulation in progress and displays its behaviour through analog and digital signals and meters; in this way the student, through measurements and tests, can go on with the troubleshooting.

Dimensions: 0.66 x 1.04 x 0.35 m.

Net weight: 16 kg.

Average training hours: 10 h.

The system is supplied with a Student Navigator software that allows students to perform their learning activities through a Personal Computer, without the need for any other documentation.

Moreover, the Student Navigator is provided with an interface to the Laboratory Management software.

### TECHNICAL DESCRIPTION

The experimentation on the photovoltaic systems (described here under) is organized as follows:

- Possibility to simulate several values of the solar radiation intensity ( $W/m^2$ )
- Possibility to simulate several values of the photovoltaic cells temperature
- Possibility to change the electrical load of the above-mentioned photovoltaic systems
- Detection of the characteristic voltage-current (V-I), supplied by the photovoltaic systems, as a function of solar radiation intensity and cells temperature
- Detection of the characteristic voltage-power (V-P), supplied by the photovoltaic systems, as a function of solar radiation intensity and cells temperature
- Evaluation of the conversion efficiency (radiating energy-electric power) of the photovoltaic systems

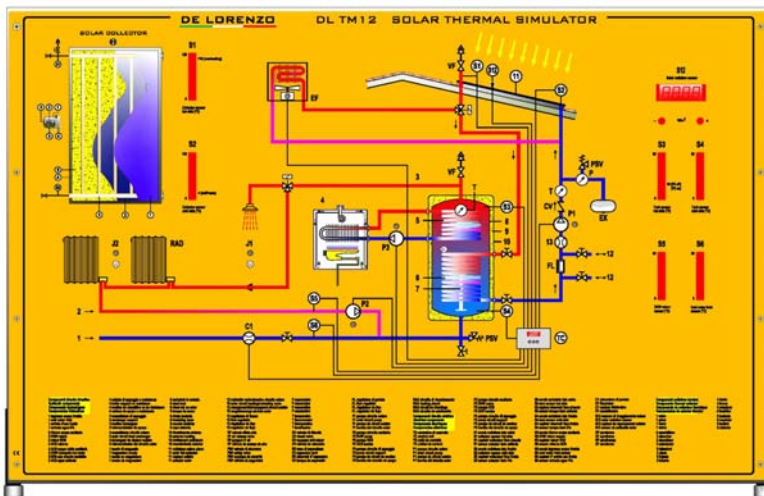
The experimentation on the thermal panel with liquid circulation is organized as follows:

- Possibility to simulate several values of the solar radiation intensity ( $W/m^2$ )
- Possibility to simulate several values of the temperature of the thermal-carrier liquid at the panel's entrance
- Possibility to change the thermal-carrier liquid capacity through the thermal panel
- Evaluation of the thermal-carrier liquid temperature at the panel's exit, as a function of the solar radiation intensity and of the entrance temperature
- Evaluation of the conversion efficiency (radiating energy-electric power) of the thermal panel





## SOLAR THERMAL HOME PLANT SIMULATOR



**DL TM12**

Didactic system for the theoretical study of solar plants that are used to get hot water for sanitary and air conditioning purposes or other civil applications.

The simulator allows a wide range of didactic applications. It is provided with six temperature probes available in different points of the circuit and with a solar irradiation sensor that is used to calculate the absorbed energy.

### TRAINING OBJECTIVES

It allows performing the following teaching activities:

- Identification and study of all the components of solar thermal circuits and of their connections.
- Interpretation of the technical parameters of all the components.
- Dimensioning criteria for of sanitary hot water installations, etc.
- Criteria for assembly and maintenance of the plants.
- Interpretation of the data provided by the control system.

Dimensions: 0.66 x 1.04 x 0.35 m.

Net weight: 16 kg.

Average training hours: 10 h.

The system is supplied with a manual containing exercises the theory about solar thermal systems and that addresses the following topics:

- The solar energy
- Systems for exploiting the solar energy
- Types of solar thermal systems
- Main components of a solar thermal system
- Sizing of collectors, pipes and tanks
- Examples of how to dimensioning a plant

### TECHNICAL DESCRIPTION

The trainer simulates the following three operating sections:

#### PRIMARY SYSTEM

Represented on the panel by the diagram of the circulation of the liquid, coming from the collector, that heats the water contained in the storage tank.

#### SOLAR THERMAL COLLECTOR

Provided with two temperature probes for the hot (inlet) and cold (return) liquid. A light sensor detects the solar radiation and allows the plant to be operational or not operational (night). This part of the circuit is complete with an automatic lowering of the temperature where it is too high in the primary circuit.

#### SECONDARY CIRCUIT (use of the hot water)

As an application of the production of hot water, the circuit of the use of the hot water that has been obtained is here represented. In this part of the circuit we have: a tank sensor on the hot side, one on the cold side, one at the cold water inlet and one at the used hot water outlet.

Displays and led bars allow the visualization of the temperature values in order to control the operation of the plant.



## SOLAR THERMAL ENERGY TRAINER



### DL THERMO-A1

Didactic system for the theoretical and practical study of solar power facilities used to obtain hot water for sanitation, air conditioning and similar services.

It is a forced circulation system with a wide range of didactic applications. It incorporates six temperature probes available at four different points, and a solar irradiation sensor that is used to calculate energy.

Complete with connecting cables, experiment manual and software for data acquisition from the solar controller and processing.

#### TRAINING OBJECTIVES

- Identification of all components and how they are associated with its operation.
- Interpretation of the technical parameters of all components.
- Local control of the processor
- Heating and check of the convector heater
- Forcing the reserve energy
- Forcing the recirculation pump
- Sizing criteria for ACS facilities, air conditioning, etc.
- Assembly and maintenance criteria for facilities.
- Interpretation of situational data supplied by the control.

Approx. packing dimensions: 1.77 x 1.22 x 1.91 m.

Gross weight: 283 kg.

Net weight: 124 kg.

#### ALTERNATIVE: DL THERMO-A2

Trainer with a real solar panel placed in a metal structure and connected to the main module through flexible pipes, provided with discharge, safety and filling valves.

#### TECHNICAL SPECIFICATIONS

The trainer is composed of three operating units, as follows:

##### MAIN MODULE

Dimensions 1000 x 650 x 1650 mm., front panel with the block diagram of the system. It contains the components for the circulation, storage and control of the liquid in the primary and secondary circuits. These components are placed vertically on a base, facilitating comfortable access to all parts for assembly and disassembly operations carried out during the practical sessions described in your handbook. The front control panel is placed in the top part of the main module and it is composed of: block diagram of the system, electronic control centre with an LCD screen for the visualization of the data, situation lights. The hydraulic sockets for cold water inlet, hot sanitary water outlet, connection to the solar panel, etc., are located at the back of the module.

##### SOLAR PANEL

Simulator of a solar panel supplied by the mains to allow performing the practical exercises in a classroom.

##### CONVECTOR HEATER

As a means of applying the hot water produced, a convector heater is available for use. It is connected through flexible pipes. This component allows us to experiment with the effects of hot water obtained with this system. However, the system is sufficiently open to permit easy use with other applications, such as hot sanitary water supply, under-floor heating, etc.



## SOLAR THERMAL ENERGY TRAINER



### DL THERMO-A2

Didactic system for the theoretical and practical study of solar power facilities used to obtain hot water for sanitation, air conditioning and similar services.

It is a forced circulation system with a wide range of didactic applications. It incorporates six temperature probes available at four different points, and a solar irradiation sensor that is used to calculate energy.

Complete with connecting cables, experiment manual and software for data acquisition from the solar controller and processing.

#### TRAINING OBJECTIVES

- Identification of all components and how they are associated with its operation.
- Interpretation of the technical parameters of all components.
- Local control of the processor
- Heating and check of the convector heater
- Forcing the reserve energy
- Forcing the recirculation pump
- Sizing criteria for ACS facilities, air conditioning, etc.
- Assembly and maintenance criteria for facilities.
- Interpretation of situational data supplied by the control.

#### TECHNICAL SPECIFICATIONS

The trainer is composed of three operating units, as follows:

##### MAIN MODULE

Dimensions 1000 x 650 x 1650 mm., front panel with the block diagram of the system. It contains the components for the circulation, storage and control of the liquid in the primary and secondary circuits. These components are placed vertically on a base, facilitating comfortable access to all parts for assembly and disassembly operations carried out during the practical sessions described in your handbook. The front control panel is placed in the top part of the main module and it is composed of: block diagram of the system, electronic control centre with an LCD screen for the visualization of the data, situation lights. The hydraulic sockets for cold water inlet, hot sanitary water outlet, connection to the solar panel, etc., are located at the back of the module.

##### SOLAR PANEL

Trainer with a real solar panel placed in a metal structure and connected to the main module through flexible pipes, provided with discharge, safety and filling valves.

##### CONVECTOR HEATER

As a means of applying the hot water produced, a convector heater is available for use. It is connected through flexible pipes. This component allows us to experiment with the effects of hot water obtained with this system. However, the system is sufficiently open to permit easy use with other applications, such as hot sanitary water supply, under-floor heating, etc.

Approx. packing dimensions: 1.37 x 1.47 x 2.12 m.

Gross weight: 375 kg.

Net weight: 216 kg.

#### ALTERNATIVE: DL THERMO-A1

Trainer with a simulator of a solar panel supplied by the mains, instead of a real solar panel, to allow performing the practical exercises in a classroom.

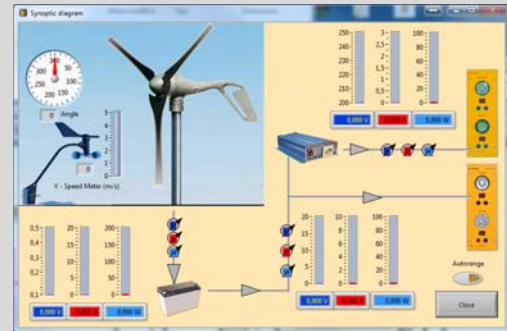


## WIND ENERGY MODULAR TRAINER



**DL WIND-A**

Didactic system for the theoretical and practical study of wind power facilities.



Complete with connecting cables, experiment manual and **software for data acquisition and processing**.

### TRAINING OBJECTIVES

- Identification of the components
- Installation and testing of the wind turbine
- Installation and testing of the anemometer
- Connecting the wind turbine and the anemometer to the trainer
- Battery regulating and charging
- Direct current wind energy installation
- Alternating current wind energy installation
- Complete system for wind energy

Approx. packing dimensions: 1.11 x 1.11 x 1.12 m.  
Weight: 200 kg.

### ALTERNATIVES:

#### DL WIND-A1S

Trainer with motor drive for indoor use.

#### DL WIND-A1G

Trainer with connection to mains.

#### DL WIND-B

Wind power trainer with wind tunnel.

### TECHNICAL SPECIFICATIONS

- A wind turbine, 160W, 12V.
- Anemometer and wind direction sensor mounted on a stand.
- A supporting frame for the modules.
- A battery.
- A battery control module, 12V, 32A.
- A load module. It includes two 12V lamps, dichroic 20W and LED 3W, with independent switches.
- A load module. It includes two mains voltage lamps, dichroic 35W and LED 3W, with independent switches.
- A module for the measurement of: wind speed (m/s), wind direction (degrees), current up to 30V,  $\pm 15A$  (two dc ammeters), voltage up to 30V and power up to 1000W.
- A dc to ac converter module, with sinusoidal output at mains voltage. Average power: 300 W.



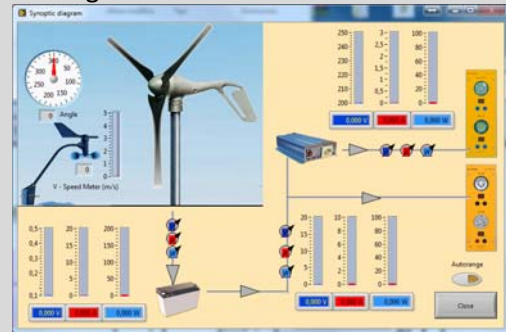
## WIND ENERGY MODULAR TRAINER WITH MOTOR DRIVE FOR INDOOR USE



**DL WIND-A1S**

Didactic system for the theoretical and practical study of wind power facilities.

The device includes a stepper motor kit to drive the wind generator in absence of wind.



Complete with connecting cables, experiment manual and **software for data acquisition and processing**.

### TRAINING OBJECTIVES

- Identification of the components
- Installation and testing of the wind turbine
- Installation and testing of the anemometer
- Operating the wind turbine and the anemometer
- Braking in the no load operation/open circuit/free spinning mode
- Braking in the braking mode
- Battery regulating and charging
- Direct current wind energy installation
- Supplying AC load with wind power stored in a battery
- Supplying AC load with wind power and a battery
- Complete system for wind energy

Approx. packing dimensions: 1.11 x 1.11 x 1.12 m.  
Weight: 200 kg.

### ALTERNATIVES:

#### DL WIND-A

Trainer with real wind turbine.

#### DL WIND-A1G

Trainer with connection to mains.

#### DL WIND-A1

Same as DL WIND-A1S, but with a DC drive motor kit instead of the stepper drive motor kit.

#### DL WIND-B

Wind power trainer with wind tunnel.

### TECHNICAL SPECIFICATIONS

- A wind turbine, 160W, 12V.
- Anemometer and wind direction sensor mounted on a stand.
- A supporting frame for the modules.
- A battery.
- A battery control module, 12V, 32A.
- A load module. It includes two 12V lamps, dichroic 20W and LED 3W, with independent switches.
- A load module. It includes two mains voltage lamps, dichroic 35W and LED 3W, with independent switches.
- A module for the measurement of: wind speed (m/s), wind direction (degrees), current up to 30V,  $\pm 15A$  (two dc ammeters), voltage up to 30V and power up to 1000W.
- A dc to ac converter module, with sinusoidal output at mains voltage. Average power: 300 W.
- A step motor driving kit.





## WIND ENERGY MODULAR TRAINER WITH CONNECTION TO MAINS



**DL WIND-A1G**

### TRAINING OBJECTIVES

- Identification of the components and association with their function
- Interpretation of diagrams and association with their objective
- Measurement of wind speed
- Analysis of the behavior of the wind turbine
- Assembly of the proposed installations
- Analysis of the operation of the installations once assembled

Approx. packing dimensions: 1.11 x 1.11 x 1.12 m.  
Weight: 200 kg.

### MORE AVAILABLE TRAINERS:

#### DL WIND-A

Trainer with real wind turbine isolated from mains.

#### DL WIND-A1S

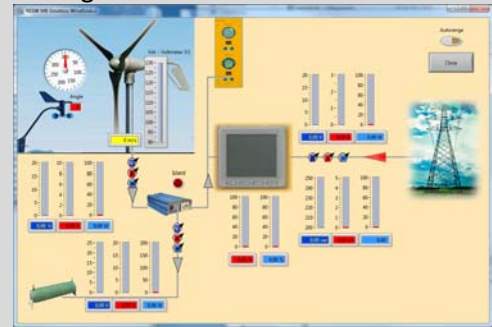
Trainer with motor drive for indoor use isolated from mains.

#### DL WIND-B

Wind power trainer with wind tunnel.

Didactic system for the study of the generation of electric energy from a wind turbine and its inlet in the mains network.

The device includes a stepper motor kit to drive the wind generator in absence of wind.



Complete with connecting cables, experiment manual and **software for data acquisition and processing**.

### TECHNICAL SPECIFICATIONS

- A wind turbine, 400W, 12Vac.
- Anemometer and wind direction sensor mounted on a stand.
- A supporting frame for the modules.
- A braking resistance, 250 W, 3 Ohm.
- A load module. It includes two mains voltage lamps, dichroic 35W and LED 3W, with independent switches.
- A module for the measurement of: wind speed (m/s), wind direction (degrees), current up to 30V,  $\pm 15A$  (two dc ammeters), voltage up to 30V and power up to 1000W.
- A dc to ac converter module.
- An energy measurement module.
- A differential magneto-thermal switch.
- A network distributor.
- A motor kit for driving the wind turbine, composed of a stepper motor and a 300 W power supply.



## WIND POWER TRAINER WITH WIND TUNNEL



**DL WIND-B**

### TRAINING OBJECTIVES

- Identification of the construction parts
- Starting the training device
- Wind speed with external anemometer
- Wind speed with internal anemometer
- Wind tunnel voltage and current
- Relationship of the wind tunnel with the wind front
- Practical tests in open environment

Dimensions: 1780 x 610 x 1360 mm.

Net weight: 51 kg.

### MORE AVAILABLE TRAINERS:

#### DL WIND-A

Trainer with real wind turbine isolated from mains.

#### DL WIND-A1S

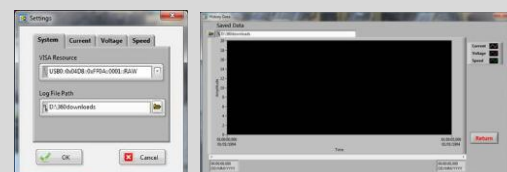
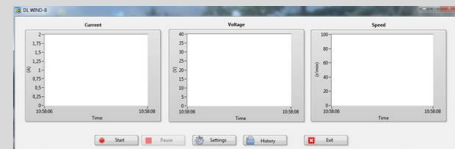
Trainer with motor drive for indoor use isolated from mains.

#### DL WIND-A1G

Trainer with real wind turbine with connection to mains.

Trainer for the theoretical and practical study of the generation of electricity by means of wind power.

With this trainer it is possible to change the flow of the air that reaches the wind turbine and to experiment its operation at no load and load conditions.



Complete with connecting cables, experiment manual and **software for data acquisition and processing**.

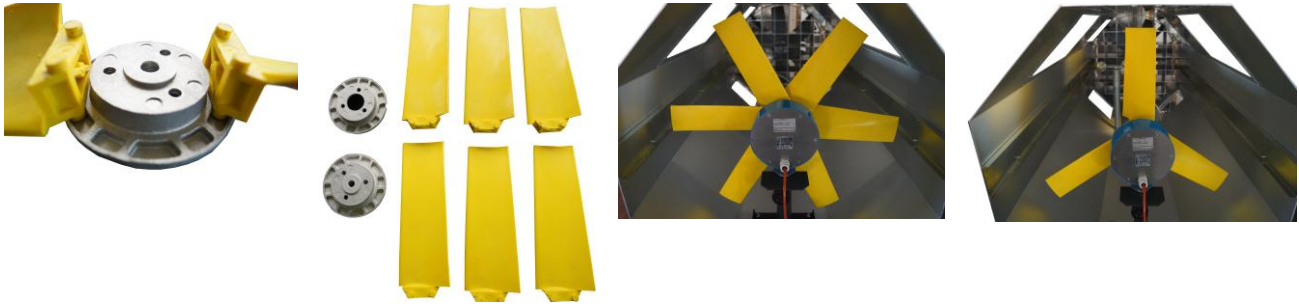
### TECHNICAL SPECIFICATIONS

- A wind tunnel in which the following components are installed:
  - A single-phase industrial fan with electronic speed regulator.
  - A 12 V, 40 W wind turbine, with a mechanism for changing its orientation with respect to the source of the wind.
- An anemometer mounted on a stand.
- A voltmeter.
- An ammeter.
- A power supply, 0÷230 V, 4 A, with instruments for reading wind speed, voltage and current, a potentiometer for controlling the fan simulating the wind and a lamp representing a resistive load. Analogue output from each instrument: 0-10 V.
- A variable resistive load.



## NOTE

The blades of the wind turbine can be removed for efficiency tests with variable number of blades or to allow their replacement with blades designed by the student and made with a 3D printer.

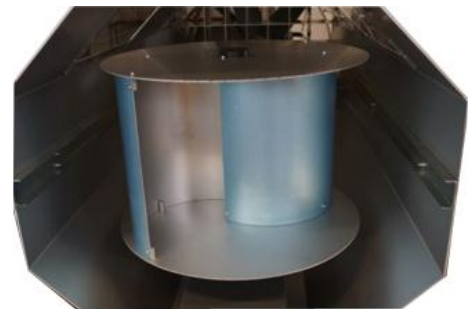
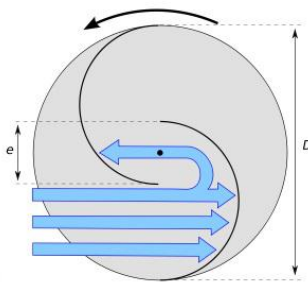


## OPTIONS: VERTICAL AXIS TURBINES

### SAVONIUS TURBINE

This turbine belongs to the category of resistance turbines, where the resistance to the force of the wind causes the rotation of the axis.

The greatest handicap of vertical axis turbines, which limits their performance, consists in the fact that a part of them will rotate in the opposite direction to the wind and a part in favor. The Savonius turbine, to avoid this problem, is made of two half-shells (in the simplest version) which are not joined to the rotor of the turbine, but arranged so that a part of the half-shells lets the thrust air flow also through the upwind part.



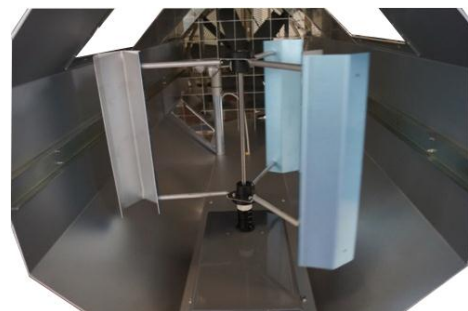
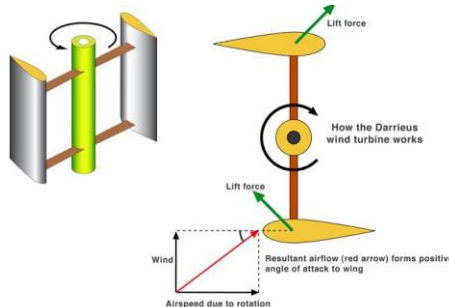
DL VAWT

### GIROMILL TURBINE (Savonius – Darrieus)

This turbine belongs to the category of lift turbines. The lift is the force that acts on a wing profile because of a pressure difference, given by the different speeds which takes the fluid when "lapping" the surfaces of the profile.

With the increase of the speed of rotation, the upwind blade acts as a brake and limits and stabilizes the speed of rotation.

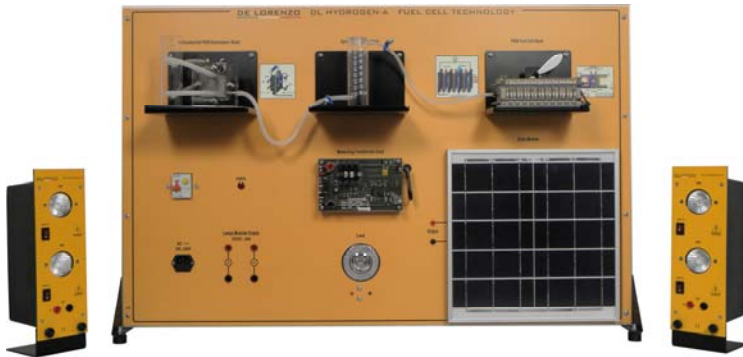
Another important aspect to be monitored is related to the resistances that oppose the start of the movement. It may happen, in fact, that these are greater than the forces of rotation impressed by the wind to the machine. This is why some wind turbines of this type can be started only with strong winds or through auxiliary starting motors.



DL GMLL

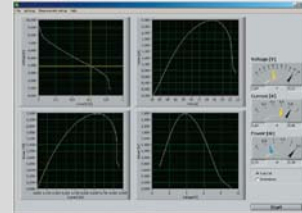


## TRAINER FOR EXPERIENCES ON HYDROGEN FUEL CELLS



**DL HYDROGEN-A**

Trainer for the theoretical-practical study of the hydrogen based fuel cells energy.



Complete with connecting cables, experiment manual and **software for data acquisition and display**.

### TRAINING OBJECTIVES

- Study of a fuel cell stack up to ten cells
- Producing and storing hydrogen
- Determining characteristic curve of solar panel
- Voltage controlled automatic measurements
- Determining characteristic curve of electrolyser
- Learning about Faraday's laws
- Determining characteristic curves of fuel cell
- Determining fuel cell efficiency
- Determining decomposition voltage of water
- Long-term measurements at your own PC
- Fixing the output at different operating points of the fuel cell stack
- Monitoring single cell stack voltages at your PC
- Power-controlled automatic measurements

### TECHNICAL SPECIFICATIONS

The trainer includes: PEM fuel cell stack 10 (ten cells), electrolyser, power supply, fuel cell monitor software, hydrogen storage tank, electric load (lamp), fan, solar module and 2 modules with lamps for the solar panel.

#### Specifications:

- Electrolyser: 15 W
- Fuel cell
- Power per cell: 200 mW
- Power (10 cells): 2 W
- Solar module: 4 V / 3,3 A
- Gas storage: 80 cm<sup>3</sup>
- Lamp: 4.4 W
- Power supply: 6 Vdc / 3 A
- Monitoring software

Approx. packing dimensions: 1.03 x 0.50 x 0.97 m.  
Net weight: 35 kg.

The following accessories are also included: water bottle (with distilled water), protective goggles, silicone tubing, textbook.



## FUEL CELLS SYSTEMS TRAINER



**DL HYDROGEN-B**

This trainer has been designed for the study of fuel cell systems. It teaches their engineering principles and it allows performing a set of experiments for educational purposes.

It is safe and easy to be operated.



Complete with connecting cables, experiment manual and **software for data acquisition and processing**.

### TRAINING OBJECTIVES

The trainer is very flexible, modular and suitable for the understanding of basic principles as well as more complex technology concepts.

It allows performing the following experiments:

- Familiarize yourself with the trainer
- Performance of the PEM Fuel Cell with fixed loads, without DC/DC converter
- Performance of the PEM Fuel Cell with fixed loads, with DC/DC Converter
- Recording of the current/voltage characteristic curve of the PEM Fuel Cell with variable load
- Calculation of the energy efficiency of the PEM Fuel Cell

Approx. packing dimensions: 1.21 x 0.62 x 0.82 m.

Net weight: 35 kg.

### Option:

DL HYGEN: Hydrogen generator, for filling the hydride storage canister

### TECHNICAL SPECIFICATIONS

The trainer includes the following modules:

- 100 W PEM fuel cell. Performance: 14 V at 7.2 A. Consumption of  $H_2$ : 1.4 l/min. it includes the electronic controller.
- 225 NI aluminum storage canister
- DC/DC converter, output 12 V, 8 A
- Load, with one halogen lamp, 12 V, 50 W, and one LED lamp, 12 V, 3 x 1 W
- Variable logarithmic rheostat, 1.5 Ohm ÷ 17 Ohm, 100 W,  $I_{max} = 8$  A
- Battery
- Instruments module, containing 4 multifunction meters and 4 LCD displays





## HYDROELECTRIC POWER TRAINER



**DL HYDRO-EL**

The system is designed for the study and display of both the behavior and the characteristics of a Pelton turbine.

The turbine housing is transparent so as to show how the turbine uses the inertia produced by a water jet.

Through the different indicators of the system, it is possible to visualize all the variables related to the transformation of energy. The braking device by means of an electric brake allows working at different speeds in a simple and effective way.

### TRAINING OBJECTIVES

- characteristic curves of the turbine (torque-speed, brake power-speed, performance-speed, torque-voltage, brake power-voltage, efficiency-voltage)
- curves of iso-efficiency
- efficiency of the turbine-electric generator system

### TECHNICAL DATA

#### *Diameters:*

- Impulse piping  $\varnothing_{\text{external}} = 32 \text{ mm}$ .
- Inlet piping  $\varnothing_{\text{internal}} = 10 \text{ mm}$ .

#### *Manometers:*

- Bourdon type with glycerine 0 to 25 m.w.c.

#### *Characteristics of the electric brake:*

- DC generator
- Rated speed: 3000 rpm
- Rated power: 1000 W

#### *Characteristics of the turbine:*

- Number of blades: 16.
- Diameter of the rotor: 124 mm.
- Depth of the buckets: 14 mm.
- Diameter of the jet flow: 10 mm.
- Diameter of the axis: 16 mm.
- Rated speed: 1000 rpm

#### *More data:*

- Speed sensor
- Load cell
- Electronic displays

### Necessary accessory:

#### **DL DKL-014 – Hydraulic bench**

The basic hydraulic bench is a simple, mobile, self-contained module that allows a supply of "hydraulic energy", i.e. an accurately controlled and measurable flow of water.

It includes two collecting tanks, a centrifugal pump, a flowmeter, a mobile frame work on wheels, a set of valves and piping.





## PLANT FOR THE PRODUCTION OF BIODIESEL



**DL BIO-30**

Biodiesel is produced by the chemical reaction of a vegetable oil or animal fat with methanol or ethanol (waterless sugar cane alcohol) in the presence of a catalyst.

This process is known as **transesterification**, and the catalyst can be alkaline, acid or enzymatic. This process also produces glycerin, used for the production of soaps and other products.

The Transesterification Process Plant for Biodiesel Production was developed by experienced professionals, using conventional equipment components available on the common market and automated with the technical features used in industrial processes, allowing didactic application and investigations.

### Options:

DL BIO-10 – Biodiesel production plant with a capacity of 10 litres/batch

DL BIO-70 – Biodiesel production plant with a capacity of 70 litres/batch

Biodiesel can be used in automotive diesel engines (trucks, tractors, vans, automobiles, etc.) or stationary engines (generators of electricity, heat, etc.), in its natural form or mixed with petroleum diesel, in different proportions.

The biodiesel does not require any modification in the standard engines. Our Biodiesel Plant allows producing fuel that can be used in the above diesel applications.

With this plant it is possible to control the heating temperatures of the vegetable oil, of the reaction and of the washing. It is also possible to re-circulate the mixture during the reaction time.

According to the requirements of the end users, our Technical Department is able to design BIODIESEL PLANTS with specific technical features. For instance, the capacity of the plant can be different from case to case. The plant may or may not include the alcohol recovery system or the ultrasound technology to improve the efficiency of the mixing phase.

Therefore, the plant that is described hereunder must be considered as a sample pilot plant with specific features that can be further discussed with the end user.

**In this particular case, the plant has a capacity of 30 litres/batch, it includes the alcohol recovery system and does not include the ultrasound device.**



## TECHNICAL FEATURES OF THE BIODIESEL PLANT DL BIO-30

**Capacity of the plant:** 30 litres/batch

**Main Components:**

- Vegetable oils treatment system:
  - Tank for the reception of the raw material.  
Capacity: 30 litres, complete with sieve to filter solid bodies in the upper side. In stainless steel
  - Electrical heating system
  - Thermometer
  - 10 µm filter
- Transesterification reaction system:
  - Conical tank in stainless steel AISI 316L. Capacity: 30 litres
  - Stirring system
  - Electrical heating system
  - Alcohol recovery system
  - Pump
- Digital control panel
- Catalyst dispenser
- Tank in stainless steel AISI 304L for mixing the methyl.  
Mixing capacity: 4 litres
- Decantation tank in stainless steel.  
Capacity: 30 litres with recovery of the alcohol and condenser with an area of 0.5 m<sup>2</sup>
- Washing system with filtering:
  - Washing tank. Capacity: 30 litres
  - Stirring system
  - Electrical heating system
  - 10 µm and 1 µm filters
- Installation kit in stainless steel for interconnecting the equipment
- Accessories
  - Digital scale
  - Thermometer
  - pH meter
  - Flat bottom 500 ml flask
  - 1000 ml beaker
  - Burette with support
  - Funnel
  - Graduated pipette
  - Volumetric pipette
  - Test tube
  - Sampling tubes with support
  - Bunsen beak
  - Tripod
  - Asbestos sheet
- Metal structure in carbon steel and high resistance epoxy paint.

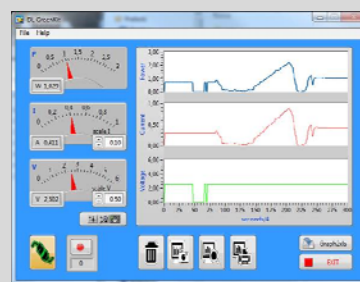
Dimensions: 2 x 0.9 x 1.8 metres

## SOLAR-WIND-FUEL CELLS ENERGY TRAINER



**DL GREENKIT**

This trainer has been designed for the study of renewable energies: solar energy, wind energy and hydrogen fuel cell systems.



Complete with connecting cables, experiment manual, interface to PC and software for data acquisition and display.

### TRAINING OBJECTIVES

- Assembling a fuel cell
- Producing and storing hydrogen
- Determining characteristic curve of solar panel
- Hydrogen/oxygen or hydrogen/air operation
- Determining characteristic curve of electrolyser
- Determining electrolyser efficiency
- Learning about Faraday's laws
- Determining characteristic curves of fuel cell
- Determining fuel cell efficiency
- Determining decomposition voltage of water
- Building a model hydrogen car
- Using methanol to generate electricity
- Determining characteristic curves of DMFC
- Influence of the surface of a solar module on voltage and current intensity of a solar module
- Voltage and current in a series connection of solar panels
- Voltage and current in a parallel connection of solar panels
- Voltage and current in a solar panel as a function of light intensity
- The characteristic current-voltage curve of a solar panel
- Electrical Energy from wind energy
- Effects of the wind speed
- Wind from different directions
- Influence of the number of rotor blades
- Influence of different positions of the blades
- Observation of a wind wheel under load
- Current voltage characteristic of the wind generator
- Storage of electrical energy from wind by using hydrogen technology
- Concept of an autarkic system with renewable energy

Approx. packing dimensions: 0.81 x 0.61 x 0.61 m.

Net weight: 29 kg.



## Technical specifications

**Electrolyser cell:**

5 cm<sup>3</sup>/min H<sub>2</sub>; 2,5 cm<sup>3</sup>/min O<sub>2</sub>;  
1.16 W

**RFC H<sub>2</sub>/O<sub>2</sub>/Air:**

Electrolyser mode: 5 cm<sup>3</sup>/min H<sub>2</sub>; 2.5 cm<sup>3</sup>/min O<sub>2</sub>;  
1.16 W  
Fuel cell mode:  
H<sub>2</sub>/O<sub>2</sub> mode: 300 mW  
H<sub>2</sub>/air mode: 100 mW

**PEMFC Kit:**

H<sub>2</sub>/O<sub>2</sub> mode: 600 mW  
H<sub>2</sub>/air mode: 200 mW

**Methanol Fuel Cell:**

Power: 10 mW

**Gas storage:** 30 cm<sup>3</sup> H<sub>2</sub>; 30 cm<sup>3</sup> O<sub>2</sub>

**Solar module:** 2.0 V / 600 mA

**Battery Box:** 4.5 VDC / 0.8 A

**Power supply:** 1.2 A

**Load (fan):** 10 mW

**Load (car):** 150 mW

**Cable length:** 250 mm

**Wind generator**

(Average performance with table fan)

U<sub>max</sub> = 6.0 V

I<sub>max</sub> = 0.3 A

**Solar module:** 2.0 V / 600 mA

**Decade Resistor:**

Max. capacity: 1.2 W

Ports: 2 mm

Weight: 190 g

H x W x D: 40 x 160 x 130 mm

**Multimeters:**

Ports: 2 mm

Weight: 140 g

H x W x D: 125 x 70 x 30 mm

**2 carrying cases:** 140 x 450 x 380 mm. each

**Weight:** 4 kg. each

**Option:**

Double spotlight with 2 halogen lamps.





## SOLAR/WIND ENERGY MODULAR TRAINER



**DL SUN-WIND-S**

Modular trainer for the theoretical-practical study of the electrical installations with photovoltaic solar energy and wind energy.



Complete with connecting cables, experiment manual and **software for data acquisition and processing**.

### TRAINING OBJECTIVES

- Measuring the load current, voltage and power
- Setting the solar panel to the most irradiated position
- Changing the inclination of the solar panel
- Changing the azimuth of the solar panel
- Covering the solar panel with different materials
- Obtaining the solar irradiation data
- Obtaining the solar panel voltage-irradiation curve
- Calculating the inner resistance of the solar panel
- Obtaining the solar panel current-voltage curve
- Obtaining the solar panel current-power curve
- Overloaded solar panel measurements
- Battery charging
- Supplying DC load
- Supplying AC load
- Identification of wind turbine components
- Wind turbine installation and testing
- Anemometer installation and testing
- Operating the wind turbine and the anemometer
- Braking in the no load operation /open circuit/ free spinning mode
- Braking in the braking mode
- Using the wind turbine to charge the battery
- Supplying AC load with wind power stored in a battery
- Supplying AC load with wind power and a battery
- Supplying AC load with a hybrid system

### TECHNICAL SPECIFICATIONS

- A photovoltaic inclinable module, 90W, 12V, complete with a cell for measuring the solar irradiation and with a temperature sensor.
- A wind turbine
  - Wind turbine 12 Vdc, 160 W.
  - Supporting frame 1.5 m.
  - Anemometer and wind direction sensor.
- A set of modules with a supporting frame:
  - A battery control module, 12V, 32A, with battery.
  - A load module with two 12V lamps, dichroic 20W and LED 3W, with independent switches.
  - A load module with two mains voltage lamps, dichroic 35W and LED 3W, with independent switches.
  - An electronic regulation module, with LCD screen.
  - A rheostat.
  - A module for the measurement of: solar irradiation ( $\text{W/m}^2$ ), solar panel temperature ( $^{\circ}\text{C}$ ), current, voltage and power.
  - A stepper motor kit for indoor use of the wind turbine.
  - A dc to ac converter module, with sinusoidal output at mains voltage. Average power: 300 W.

Approx. packing dimensions: 2.12 x 1.12 x 1.13 m.

Net weight: 104 kg.

### OPTION:

**DL SIMSUN** - module with lamps to provide suitable lighting for the solar panel when used indoor.

### ALTERNATIVES:

**DL SUN-WIND** – DC motor kit instead of stepper motor.

**DL SUN-WIND-ST** – Stepper motor kit and solar tracking panel instead of the standard solar panel.

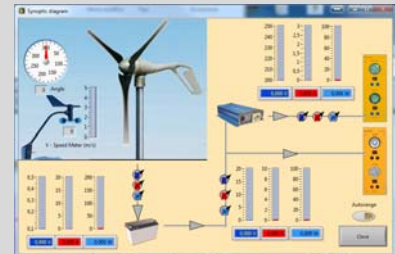


## SOLAR/WIND ENERGY TRAINER WITH CONNECTION TO MAINS



**DL SUN-WIND-G**

Modular trainer for the theoretical-practical study of the electrical installations with photovoltaic solar energy and wind energy with connection to mains.



Complete with connecting cables, experiment manual and **software for data acquisition and processing**.

### TRAINING OBJECTIVES

- To generate power into the grid with both systems
- To measure the power generated by the two systems
- To connect a load and see how the generated power is distributed in the system
- To find the power balance
- To analyse the power flows
- To simulate the behaviour of the system in day and night
- To simulate a failure, a alarm status, a brake mode or overload of one system and see how the other behaves
- To calculate the efficiency of the whole system at min. power and max. power

#### Wind grid system:

- Power generation
- Simulation of the island mode
- Load and power balance
- Power flows
- Grid fault

#### Solar grid system:

- Power generation
- Simulation of the island mode
- Load and power balance
- Power flows

#### Solar-wind grid system:

- Operation of the complete system

### TECHNICAL SPECIFICATIONS

- A photovoltaic inclinable module, 90W, 12V, complete with a cell for measuring the solar irradiation and with a temperature sensor.
- A wind turbine
  - Wind turbine 12 Vdc, 160 W.
  - Supporting frame 1.5 m.
  - Anemometer and wind direction sensor.
- A set of modules with a supporting frame:
  - A load module with two mains voltage lamps, dichroic 35W and LED 3W, with independent switches.
  - DC to AC converter for the solar section.
  - Braking resistance for the wind turbine.
  - A rheostat.
  - A module for the measurement of: solar irradiation ( $\text{W/m}^2$ ), solar panel temperature ( $^{\circ}\text{C}$ ), current, voltage and power.
  - A module for measuring wind speed and direction.
  - Module for energy measurement.
  - Differential magneto-thermal switch.
  - Network distributor.
  - A motor kit for indoor use of the wind turbine.
  - A dc to ac converter module, with sinusoidal output at mains voltage. Average power: 300 W.

Approx. packing dimensions: 2.12 x 1.12 x 1.13 m.

Net weight: 104 kg.

### OPTION:

**DL SIMSUN** – Module with lamps to provide suitable lighting for the solar panel when used indoor.

### ALTERNATIVE:

**DL SUN-WIND-GT** – With solar tracking panel instead of the standard solar panel.

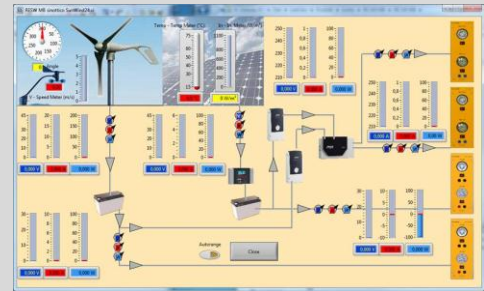


## HYBRID SOLAR / WIND ENERGY TRAINER



### DL SUN-WIND24V and DL SUN-WIND12V

The main target of a hybrid power system is to combine multiple sources to deliver non-intermittent electric power, trying to take advantage of multiple available renewable energies.



Complete with connecting cables, experiment manual and **software for data acquisition and processing**.

#### TRAINING OBJECTIVES

##### Solar energy:

- Measurement of solar irradiation
- Measurement of the voltage of the photovoltaic panel at no-load
- Measurement of the short circuit current of the photovoltaic module
- Graph of current – voltage of the photovoltaic panel
- Measurement of voltage and current of the panel in overload
- Regulation and charge of the battery
- DC solar plant
- AC installation

##### Wind energy:

- Activating the braking action
- Regulating and charging the battery
- DC wind installation
- AC installation: standby function investigation

##### Hybrid system:

- Low voltage parallel connected, AC separated
- Low voltage separated, AC parallel connected
- Low voltage and AC parallel connected

#### GENERAL FEATURES

The Trainer is composed of two sub-systems, one for the generation of electric energy from solar photovoltaic energy through a solar panel and the other for the generation of electric energy from wind energy through a wind turbine.

In this trainer, one of the two inverters, acting as master, synchronizes the frequency of the second inverter, acting as slave, to allow creating a connection between the two outputs that operate as a single line with double available power.

Approx. packing dimensions:

1.77 x 1.02 x 0.96 m.

Net weight: 93 kg.

Gross weight: 189 kg.



The trainers are composed of:

		<b>24V version</b>	<b>12V version</b>
<b>PFS</b>	Photovoltaic module mounted on a support with wheels and complete with graduated scale on one side for adjustment of the inclination and calibrated cell in the upper part for measuring the solar irradiation.	185W, 24V	90W, 12V
<b>AEROGEN</b>	160W wind turbine, with anemometer and wind direction sensor mounted on a stand. The wind turbine is provided with a motor kit in order to use the trainer inside the classroom or in case of absence of wind.		
<b>DL 9012</b>	Electronic regulator module for battery charging, with LCD display for information on the status of the subsystem. It is able to display both solar voltage and battery voltage as well as charging current, Amp-Hour charge accumulation and temperature.		
<b>DL 9013MS</b>	DC/AC converter module, with sinusoidal output to generate an electrical network (mains). With a circuit breaker to switch on and off the inverter. It operates as master or slave. Complete with control panel.	Two of 900W each with four 12V batteries	Two of 450W each with two 12V batteries
<b>DL 9015</b>	Module for the parallel of the inverters. It allows up to one master and 4 slaves.		
<b>DL 9044</b>	Load module with a 20 W, 12Vdc halogen lamps and a 3W, 12Vdc LED lamp. Each lamp incorporates an On/Off control independent switch.	4 supplied	2 supplied
<b>DL 9017</b>	Load module with a 35W, mains halogen lamp and a 3W, mains LED lamp. Each lamp incorporates an On/Off control independent switch.		
<b>DL 9018</b>	Variable logarithmic rheostat module, 80Ω, 6A max., to load the photovoltaic panel in order to detect the voltage-current characteristic curves.		
<b>DL 9021</b>	Instruments module for measuring solar parameters. It displays: voltages and currents, solar irradiance, temperature of the solar panel, electric power.		
<b>DL 9022</b>	Instruments module for measuring wind parameters. It displays: voltages and currents, wind speed, wind direction, electric power.		
<b>DL SIMSUN</b>	Set of lamps to light the photovoltaic solar panel in order to use the trainer inside the classroom or in case of a cloudy sky. The intensity of the light can be controlled by the operator locally through a potentiometer or remotely through a DC signal.	2 supplied	1 supplied
<b>DL 2100-3M</b>	Frame for the modules.		



## ENERGY EFFICIENCY IN ELECTRIC MOTORS



### DL EFFICIENCY-A

#### TRAINING OBJECTIVES

- Learning and setting a Multifunction Network Analyzer (MNA)
- Learning and programming an industrial Variable Speed Drive (VSD)
- Introduction to electric motors
- Learning and programming an advanced PLC with operator interface
- Introduction to the different sensors/actuators used in this trainer and their main features (float switch, flow sensor, pressure sensors and solenoid valves)
- Learning the energy savings with electric motors and drives
- Possibility to import data (saved on microSD card) in Microsoft Excel environment for processing.

Trainer for the study of the energy efficiency in the control of electric motors.

The trainer allows studying the energy efficiency in a hydraulic circuit with motor driven pump controlled by an inverter.

The trainer is composed of:

- A didactic panel on which the components of a hydraulic circuit are assembled. The circuit simulates, in a schematic way, an aqueduct. From a reservoir tank the water is flown, by means of a pump, through an instrumented hydraulic circuit that ends with a set of 3 water intakes of different diameters and controlled by electro-valves.
- A control module containing: a PLC, an inverter, a network analyzer with its interface module

#### TECHNICAL SPECIFICATIONS

- 3-phase motor driven pump, 0.37 kW, with cast iron body and brass impeller, max. flow rate 40 l/min.
- Three 2-way NC electro-valves, direct control, brass body
- Flow-rate transducer, 1 to 40 l/min.
- Pressure transducer, 0 to 10 bar, output signal range 0-10 V
- Pressure switch, 1 to 12 bar
- PLC, 12 digital inputs, 4 analogue inputs, 6 relay outputs
- Inverter, 0.4 kW, PID control mode as standard, 7 user-configurable preset speeds
- Multifunction network analyzer, line voltages and currents, total active and reactive power, power factors, active and reactive energies, etc.

Approx. packing dimensions: 1.04 x 0.63 x 0.72 m.  
Net weight: 46 kg.





## SOLAR PHOTOVOLTAIC ENERGY INSTALLATION KIT



**DL SOLAR-KIT**

Photovoltaic solar energy kit for the generation of electrical energy.

### TRAINING OBJECTIVES

- To investigate how the solar irradiation influences the solar panel output voltage
- To calculate the inner resistance of the solar panels
- To obtain a daily irradiation curve
- To cover the solar panel with different materials
- To charge the battery using solar energy
- To use both solar power and energy stored in the battery to power the DC load
- To test the complete system

### TECHNICAL SPECIFICATIONS

- Two photovoltaic inclinable **panels**, 90W, 12V.
- A supporting **frame** for the panel.
- An electronic **current regulation** module, with LCD screen, output 12 V, 30 A.
- An **inverter**, with output at mains voltage, 12 V, 30 A, 300 W.
- A **battery control** switch, 0-600 V, 32A with **battery**, 100 Ah.
- Two **mains voltage lamps**, dichroic 35W and LED 3W, with independent switches.
- Two **12V lamps**, dichroic 20 W and LED 3W, with independent switches.
- **Cables, connectors** and **accessories**.
- A frame for supporting the electrical components of the system: lamps, switches, protections, etc.

The trainer is complete with installation manual.



## SOLAR AND WIND ENERGY INSTALLATION KIT



Photovoltaic solar energy and wind energy kit for the generation of electrical energy.

### DL SOLAR-WIND KIT

#### TRAINING OBJECTIVES

- To investigate how the solar irradiation influences the solar panel output voltage
- To calculate the inner resistance of the solar panels
- To obtain a daily irradiation curve
- To cover the solar panel with different materials
- To investigate how the wind speed influences the wind turbine output voltage
- To test the braking mode of the wind turbine
- To charge the battery using solar energy
- To charge the battery using wind energy
- To use both solar power and energy stored in the battery to power the DC load
- To test the complete system

#### TECHNICAL SPECIFICATIONS

- Two photovoltaic inclinable **panels**, 90W, 12V.
- A supporting **frame** for the panel.
- An electronic **current regulation** module, with LCD screen, output 12 V, 30 A.
- A **wind turbine**, 160W, 12V
- An **inverter**, with output at mains voltage, 12 V, 30 A, 300 W.
- A **battery control** switch, 0-600 V, 32A with **battery**, 100 Ah.
- Two **mains voltage lamps**, dichroic 35W and LED 3W, with independent switches.
- Two **12V lamps**, dichroic 20 W and LED 3W, with independent switches.
- **Cables, connectors** and **accessories**.
- A frame for supporting the electrical components of the system: lamps, switches, protections, etc.

The trainer is complete with installation manual.



## CATHODIC PROTECTION TRAINING BENCH



**DL MK1**

The bench provides facilities to study the case of isolated systems, as well as the case of systems where different metals are coupled together. Particular attention is given to the presence or not of several kinds of insulating materials over the surfaces of the samples, in order to demonstrate the different behavior of the same material when coated or bare.

The bench provides suitable devices to highlight the concept of the free corrosion potential, measured with easy to use reference electrodes and means suitable to build with a certain accuracy the polarization curves.

Protective techniques are represented as per sacrificial anodes systems of several type of metals as per impressed current Cathodic Protection systems with the possibility to see which is the explanation of the use of constant voltage, constant current and constant potential feeders.

### TRAINING OBJECTIVES

- The use of the voltmeter
- The measurement of the difference of potential of a sample into an electrolyte
- The reference cell
- The Daniel cell
- The first and second species conductors
- Introduction to the cathodic protection criteria
- Introduction to the sacrificial anodes in Zn, Mg, and Al
- Introduction to the cathodic protection impressed current system
- The consumable impressed current anode (Fe)
- The inert impressed anode (Fe-Si)
- Resistance concept, circuit for the first and second species conductors
- Introduction to the specific resistance concept over three different first species conductors (Fe; Cu; Fe-Ni)
- Introduction to the concept of interference due to the presence of external electric fields on buried or submerged structures (stray currents)
- Air presence influence on resistivity (insufflate air effect)
- Current density introduction and Tafel curves construction
- Temperature effect over the current density (thermostatic cell)
- Air presence influence over the current density (insufflate air effect)
- Coating and current density

### TECHNICAL FEATURES

The Cathodic protection is a technique to control the corrosion of a metal surface by making it work as a cathode of an electrochemical cell. This is achieved by placing in contact with the metal to be protected another more easily corroded metal to act as the anode of the electrochemical cell. Cathodic protection systems are most commonly used to protect steel, water or fuel pipelines and storage tanks, steel pier piles, ships, offshore oil platforms and onshore oil well casings.

The bench is provided with measuring facilities characterized by suitable sensitivity and accuracy, in order to introduce which must be the basis of the laboratory tests to be executed, to recognize which is the correct way in order to determine the behavior of a metal in contact with the electrolyte in different conditions of temperature (thermostatic bath) and in high oxygen concentration (air insufflations pump).

A suitable multi-channel interface can connect the bench to a PC in order to record the experiment results and give the trace for further studies.



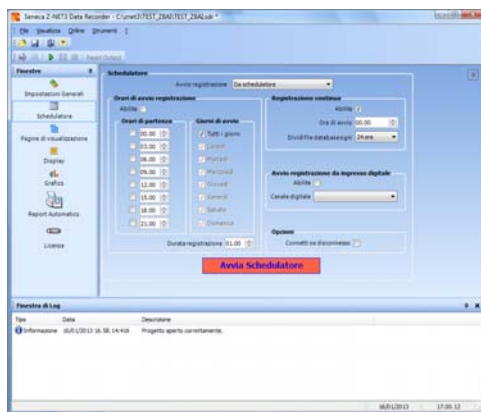
Approx. packing dimensions: 0.62 x 1.21 x 0.82 m.

Net weight: 51 kg.

Average training hours: 15 h.

### Complete with:

- User and experiments manuals.
- PC interface and software for data acquisition.



### ALTERNATIVE:

#### DL MK2

Single station cathodic protection training bench.



### LIST OF MATERIALS

- Bench with wheels with electrical console to connect to the mains Vac supply and lockable shelves. Provided with waterproof top surface.
- 4 DC feeders (each provided with constant voltage, constant current, constant potential facilities). The relevant instruments are on the front console of the bench.
- Digital voltmeter on console.
- 2 digital ammeters on console.
- PC interface for the measurement and record of 5 different channels.
- 3 sets of safety glasses and gloves.
- Digital voltmeter.
- 2 Cu/CuSO<sub>4</sub> reference cells.
- 2 Ag/AgCl reference cells.
- 2 Zn reference cells.
- 10 copper electrodes, 30 x 140 mm., thickness 2 mm.
- 10 carbon steel electrodes (bare).
- 4 transparent basins to build the electrolytic test bath.
- Simple circuit with sliding resistor and lamp for the insertion into the electrical circuit of the electrolytic cell.
- 20 Zinc electrodes 8 mm., length 140 mm.
- 20 Magnesium electrodes 25 mm., length 140 mm.,
- 20 Aluminum electrodes 25 mm., length 140 mm.,
- 4 Fe-Si anodes (net anode 50 mm. x 140 mm.)
- Cu bar 1mm., length 0.5 m.
- Fe bar 1mm., length 0.5 m.
- Fe-Ni bar 1mm., length 0.5 m.
- Resistivity fluid cell.
- Waterproof resistor with thermostatic device.
- Air pump with relevant sprayer.
- 10 carbon steel electrodes (completely coated with epoxy compound)
- 10 carbon steel electrodes (partially coated with epoxy compound)
- Various reagents in plastic cans (0.25 kg/each) with technical sheet as per the requirement of CE.
- Set of spare fuses.
- Set of ancillaries and connecting leads (20 pieces).



## SINGLE STATION CATHODIC PROTECTION TRAINING BENCH



**DL MK2**

The bench provides facilities to study the case of isolated systems, as well as the case of systems where different metals are coupled together. Particular attention is given to the presence or not of several kinds of insulating materials over the surfaces of the samples, in order to demonstrate the different behavior of the same material when coated or bare.

The bench provides suitable devices to highlight the concept of the free corrosion potential, measured with easy to use reference electrodes and means suitable to build with a certain accuracy the polarization curves.

Protective techniques are represented as per sacrificial anodes systems of several type of metals as per impressed current Cathodic Protection systems with the possibility to see which is the explanation of the use of constant voltage, constant current and constant potential feeders.

### TRAINING OBJECTIVES

- The use of the voltmeter
- The measurement of the difference of potential of a sample into an electrolyte
- The reference cell
- The Daniel cell
- The first and second species conductors
- Introduction to the cathodic protection criteria
- Introduction to the sacrificial anodes in Zn, Mg, and Al
- Introduction to the cathodic protection impressed current system
- The consumable impressed current anode (Fe)
- The inert impressed anode (Fe-Si)
- Resistance concept, circuit for the first and second species conductors
- Introduction to the specific resistance concept over three different first species conductors (Fe; Cu; Fe-Ni)
- Introduction to the concept of interference due to the presence of external electric fields on buried or submerged structures (stray currents)
- Air presence influence on resistivity (insufflate air effect)
- Current density introduction and Tafel curves construction
- Temperature effect over the current density (thermostatic cell)
- Air presence influence over the current density (insufflate air effect)
- Coating and current density

### TECHNICAL FEATURES

The Cathodic protection is a technique to control the corrosion of a metal surface by making it work as a cathode of an electrochemical cell. This is achieved by placing in contact with the metal to be protected another more easily corroded metal to act as the anode of the electrochemical cell. Cathodic protection systems are most commonly used to protect steel, water or fuel pipelines and storage tanks, steel pier piles, ships, offshore oil platforms and onshore oil well casings.

The bench is provided with measuring facilities characterized by suitable sensitivity and accuracy, in order to introduce which must be the basis of the laboratory tests to be executed, to recognize which is the correct way in order to determine the behavior of a metal in contact with the electrolyte in different conditions of temperature (thermostatic bath) and in high oxygen concentration (air insufflations pump).

A suitable multi-channel interface can connect the bench to a PC in order to record the experiment results and give the trace for further studies.





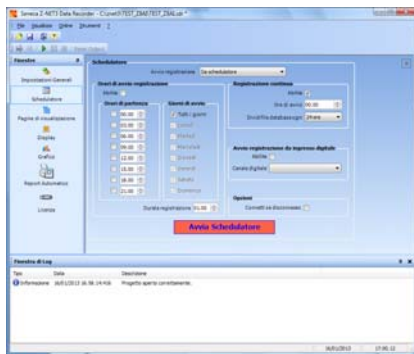
Approx. packing dimensions: 0.62 x 1.21 x 0.82 m.

Net weight: 51 kg.

Average training hours: 15 h.

## Complete with:

- User and experiments manuals.
- PC interface and software for data acquisition.



## ALTERNATIVE:

### DL MK1

Cathodic protection training bench.



## NOTE:

The DL MK2 version of the Cathodic Protection trainer differs from the DL MK1 version on the possibility of performing simultaneously the same experiment with different values of the parameters. In the DL MK2 version, the experiments can be performed in sequential mode, that is, if you want to change the value of a specific parameter, you can do it after performing the same experiment with the previous value. You must then record the results on your notebook and then compare the different results. With the DL MK1 version you can perform the same experiment with two different parameter configurations at the same time.

## LIST OF MATERIALS

- Bench with wheels with electrical console to connect to the mains Vac supply and lockable shelves. Provided with waterproof top surface.
- DC feeders (each provided with constant voltage, constant current, constant potential facilities). The relevant instruments are on the front console of the bench.
- Digital voltmeter on console.
- Digital ammeter on console.
- PC interface for the measurement and record of 5 different channels.
- Safety glasses and gloves.
- Digital voltmeter.
- Cu/CuSO<sub>4</sub> reference cell.
- Ag/AgCl reference cell.
- Zn reference cell.
- Copper electrodes.
- Carbon steel electrodes (bare).
- Transparent basins to build the electrolytic test bath.
- Simple circuit with sliding resistor and lamp for the insertion into the electrical circuit of the electrolytic cell.
- Zinc electrodes 8 mm., length 140 mm.
- Magnesium electrodes 25 mm., length 140 mm.
- Aluminum electrodes 25 mm., length 140 mm.
- Fe-Si anodes (net anode 50 mm. x 140 mm.)
- Cu bar 1mm., length 0.5 m.
- Fe bar 1mm., length 0.5 m.
- Fe-Ni bar 1mm., length 0.5 m.
- Resistivity fluid cell.
- Waterproof resistor with thermostatic device.
- Air pump with relevant sprayer.
- Carbon steel electrodes (completely coated with epoxy compound)
- Carbon steel electrodes (partially coated with epoxy compound)
- Various reagents in plastic cans with technical sheet as per the requirement of CE.
- Set of spare fuses.
- Set of ancillaries and connecting leads.





## WIND POWER PLANTS



### DL WPP

This trainer allows the students to study the functions and operations of a modern wind power plant simulating the effects of the wind force and their effects on the plant.

This system operates through a brushless machine and the simulation software and the double-feed asynchronous machine allows a practical and effective approach to this trainer.

The trainer has a modular structure that will grant teachers and students extreme flexibility during the study of the related topics and the performance of the experiments.

An interactive multimedia software is also available to allow performing the experiments set-up as well as the visualization and management of the collected data through PC.

The control unit of this trainer allows controlling and operating a speed-variable double-feed asynchronous generator. Thanks to this control unit it is possible to simulate and investigate the operating principles of this topic.

This control unit allows approaching and theoretically in depth analyzing the following topics:

- Operation of the double-feed asynchronous generator;
- Integrated power switch for switching the generator on line;
- Reactive and active power, frequency and voltage control;
- Mains synchronization.



This trainer is complete with the relevant software that can control and set the several operations of the system; with this software it is possible to adjust the wind speed and profile and to examine the effects on the operating functions of a real wind power plant. Another important feature of this software is related to the possibility to control, parameterize and visualize the obtained data.

In particular, with this software it is possible to perform the following activities:

- Measurement, calculation and graphic representation of many mechanical and electrical operating parameters.
- Selection of the set-point values for reactive and active power.
- Definition and simulation of wind power and profiles.
- Interactive experiments set-up.
- Values and graphs can be stored.
- Experiments instructions can be viewed directly from the software.
- Possibility to print documents for easy hardcopy printing of experiments instructions with solutions.

With this wind power plant trainer it is possible to perform the following experiments:

- Study of functions and operations of a modern wind power plant.
- Relationships between a pitch control system and the wind.
- Analysis of the mechanical parameters within an induction generator.
- Analysis of the electrical parameters within an induction generator.
- Starting method of a wind system
- DFIG – doubly fed induction generator.

With the optional modules it is possible to perform also:

- Experiments on the Fault Ride Through



## BRUSHLESS CONTROLLER with MOTOR

### DL 2108T26

Study of the automatic control for a brushless motor.

Control and operation of a brushless motor in voltage.

The system allows the study of the operation of a brushless motor of a typical industrial process automation.

The student has the opportunity to learn to control and parameterize an automatic operation.

The control and monitoring system is done through a software that can:

- Set system parameters
- Draw graphic curves
- Monitor real-time system (torque, speed, etc.)



#### Specifications

- 1kW power brushless motor with electronic encoder
- Control of the system in frequency and voltage
- Mechanical braking system for the analysis of the torque
- Encoder outputs for the analysis of speed
- Display system for controlling and monitoring events
- Button start and stop action and automatic stop intervention in case of alarm
- Complete software for PC interfaced to the system via RS485

## BRAKING RESISTANCE

### DL 2108T26BR

With cooling fan.



## SLIP RING THREE-PHASE ASYNCHRONOUS MOTOR

### DL 1022P4

Induction motor with both stator and rotor three-phase windings.

#### Technical features:

- Power: 1.1 kW
- Voltage: 220/380 V  $\Delta/Y$
- Speed: 1680 rpm, 50 Hz





## THREE PHASE SUPPLY UNIT



### DL 2108TAL-CP

Power supply unit for three-phase connection with 4-pole cam mains switch.

25 A current operated earth leakage circuit breaker, sensitivity 30 mA.

Three-phase indicator lamps.

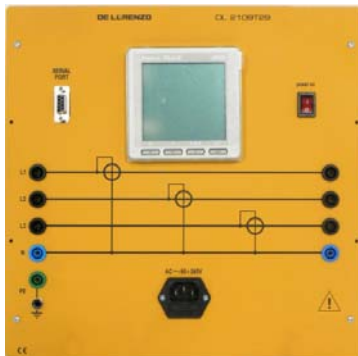
Output through 5 safety terminals:

L1, L2, L3, N and PE.

Switch for simulation of wind or photovoltaic energy power source.

Modbus RS485 Protocol Communication

## THREE-PHASE POWER METER



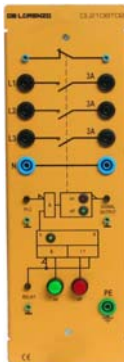
### DL 2109T29

Microprocessor controlled three-phase power analyzer.

Measurement of voltages, currents, frequencies, active power, reactive power, apparent power.

- Input voltage: 450 V (max 800 Vrms)
- Input current: 5 A (max 20 Arms)
- Operating frequency: 47 ÷ 63 Hz
- Auxiliary supply: single-phase from mains

## POWER CIRCUIT BREAKER

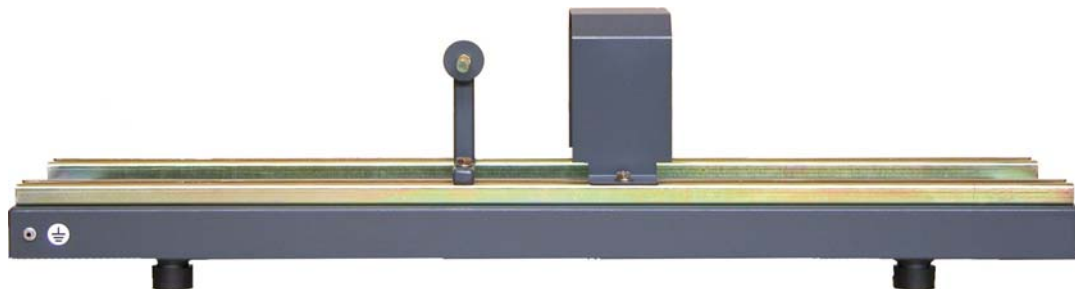


### DL 2108T02

Three-phase power circuit breaker with normally closed auxiliary contact.

- Contact load capability: 400 Vac, 3 A
- Supply voltage: single-phase from mains.

## BASE



### DL 1013A

Duralumin alloy varnished structure mounted on anti-vibration rubber feet, provided with slide guides to fix one or two machines and with coupling guard.





## BACK TO BACK INVERTER



### DL 2108T29

The architecture of a back-to-back converter, needed to feed the rotor windings of a 3-phase doubly-fed induction machine and such that power can flow both ways.

A back-to-back converter is needed for a control of a doubly-fed induction machine (an induction machine fed from both the rotor and the stator) because in some operation ranges the rotor energy may come back to the converter.

Inverter: 1.5 kW, 400 V with DC BUS

AFE (Active front End) Regenerative Interface

DC Bus Monitor Display

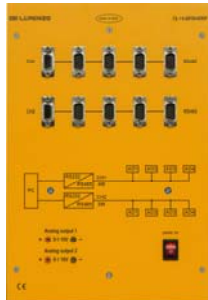
Three Phase instrument Monitor Grid Side

Fuse Protection

Modbus RS485 Protocol Communication

---

### COMMUNICATION MODBUS + SOFTWARE SCADA



### DL HUBRS485F – DL SCADA3

---

### WIND SIMULATOR



### DL WINDSIM

System composed of: wind speed and direction sensor, power supply, fan, potentiometer, measurement circuit, RJ45 and RS485 port.

It allows simulating the wind force and direction.



**KIT OF CONNECTING LEADS**

**DL 1155WPP**



**FRAME**

**DL 2100-3M-AS**



**THREE-PHASE TRANSFORMER**

**DL 2100TT**

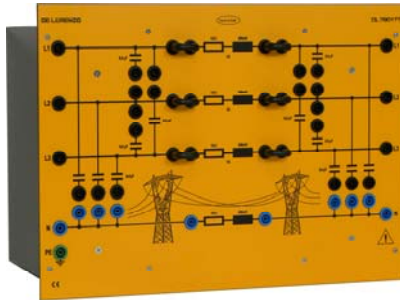


The system includes an All-In-One Personal Computer.



## OPTIONS

### LINE MODEL



#### DL 7901TT

Three-phase model of an overhead power transmission line 360 km long, voltage 380 kV and current 1000 A.

Scale factor: 1:1000

Line resistance: 13  $\Omega$

Line inductance: 290 mH

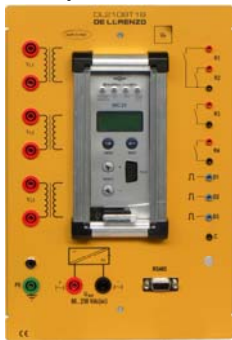
Mutual capacitance: 1  $\mu\text{F}$

Earth capacitance: 2  $\mu\text{F}$

Earth resistance: 11  $\Omega$

Earth inductance: 250 mH

### MULTIFUNCTION THREE-PHASE OVERVOLTAGE/UNDERVOLTAGE RELAY



#### DL 2108T18

Three-phase voltage relay, suitable for protection of HV, MV, LV power transmission and distribution systems. The relay measures the true RMS value of the 3 phase to neutral voltages fed to three transformers isolated high-impedance inputs.

Two Under Voltage elements. Two Over Voltage elements. One Under Frequency element. One Over Frequency element.

One omopolar sequence Over Voltage element. One negative sequence Over Voltage element. One positive sequence Under Voltage element.

Time tagged multiple event recording. Oscillographic wave form capture.

Modbus RTU / IEC870-5-103. Display LCD 16 (2x8) characters.

### RESISTIVE LOAD



#### DL 1017R

- Single or three-phase resistive step-variable load.

- Max power: 3 x 400 W

- Max voltage: 220/380 V  $\Delta/Y$



## CONFIGURATIONS

### DL WPP

DL 2108T26	BRUSHLESS CONTROLLER WITH MOTOR	1
DL 2108T26BR	BRAKING RESISTANCE	1
DL 1022P4	SLIP RING THREE-PHASE ASYNCHRONOUS MOTOR	1
DL 1013A	BASE	1
DL 2108TAL-CP	THREE PHASE SUPPLY UNIT	1
DL 2109T29	THREE-PHASE POWER METER	1
DL 2108T29	BACK TO BACK INVERTER	1
DL 2108T02	POWER CIRCUIT BREAKER	3
DL HUBRS485F	MODBUS COMMUNICATION HUB	1
DL WINDSIM	WIND SIMULATOR	1
DL SCADA3	SOFTWARE SCADA	1
DL 1155WPP	KIT OF CONNECTING LEADS	1
DL 2100-3M-AS	FRAME	1
DL PCGRID	ALL-IN-ONE PERSONAL COMPUTER	1
SOCKET-MAINS	THREE-PHASE SOCKETS HOLDER	1
DL 1001-1-AS	WORKBENCH	1
DL 2600TT	THREE-PHASE TRANSFORMER	1

### OPTIONS FOR THE FAULT RIDE THROUGH

DL 7901TT	LINE MODEL	1
DL 2108T18	MULTIFUNCTION THREE-PHASE OVERVOLTAGE/UNDERVOLTAGE RELAY	1
DL 1017R	RESISTIVE LOAD	1
DL 2108T02	POWER CIRCUIT BREAKER	1
DL 2100-3M-AS	FRAME	1