EN106

Computerized photovoltaic installation demonstrator

Simulates a photovoltaic system with real and didactic components controlled by computer.

The EN106 equipment scales a complete photovoltaic solar system. It has been designed with special emphasis on the didactic aspect of the same, being able to observe at a glance all the components that a solar photovoltaic installation has and its arrangement. It allows the study, of both isolated photovoltaic solar energy installations and grid connection.

It has cables ready to connect and disconnect the various elements of the installation in different ways, being able to observe and analyze the operation of the panels connected independently, in series, in parallel, with batteries in series or in parallel, with direct output in Direct current or direct current to AC converter, working in isle or connected to the grid.

It is provided with elements of measurement of the variables necessary to analyze the characteristics of the panels and their behavior. Thus, it has a pyranometer that indicates the intensity of radiation that affects the panels, with voltmeters and ammeters that show us respectively the voltage and the intensity generated.

It also has ammeter and voltmeter in each of the batteries to indicate the state of these and the direction of flow of the current in them, that is to say if they are loading or providing load, and also has a measuring instrument that provides us all the characteristics of the alternating current obtained after the inverter.

Learning objectives

- Study of the operation of a solar photovoltaic installation.
  - Isolated panels.
  - Panels connected to batteries.
  - Operating with different types of continuous loads.
  - Conversion of direct current to alternating current.
  - Operating with different types of alternating loads.
  - Operation in isle and network connection.
  - Installation performance.
  - Efficiency of the investors.
  - Representation through energy balance.
- Determination of the characteristics of solar panels.
  - Intensity curve – voltage at different temperatures.
  - Intensity of short circuit.
  - Voltage in open circuit.
  - Power curve – Voltage at different temperatures.
  - Power curve – Load resistance.
  - Maximum power generated.
  - Form factor.
  - Efficiency.
- Influence of the angle of inclination and the intensity of radiation in the generated energy.
- Determination of the characteristics of the panels connected in series or in parallel.
- Determination of the characteristics of the panels connected in parallel.
- Study of the behavior of solar panels in various operating conditions.
  - Isolated panels.
  - In parallel with different loads.
  - In series with different loads.
  - Panels connected to batteries in series.
  - In parallel with different loads.
  - In series with different loads.
  - Panels connected to batteries in parallel.
  - In parallel with different loads.
  - In series with different loads.
- Study assisted in PC.

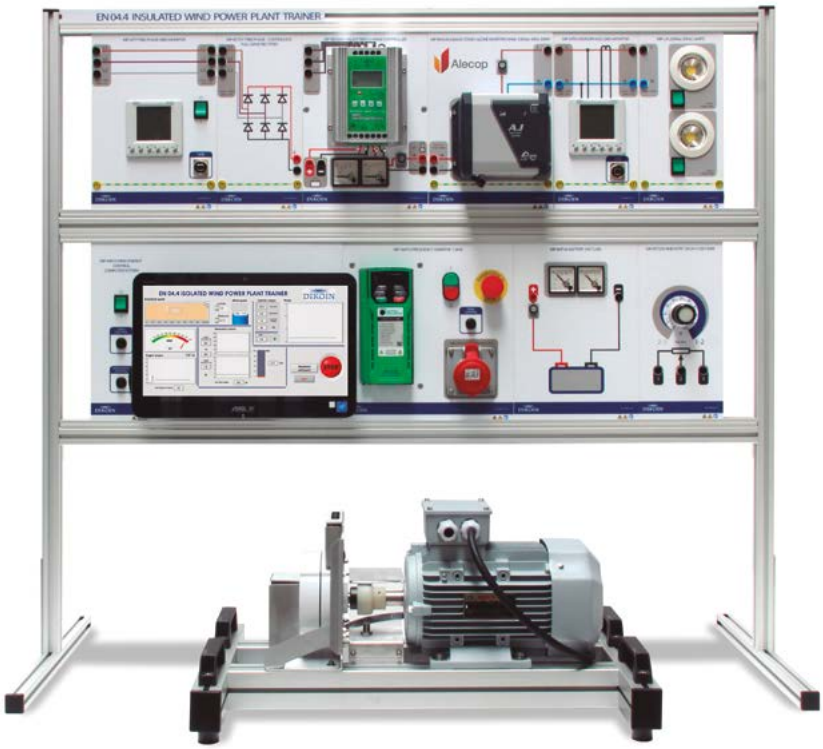
Technical characteristics

- Panels: 2 photovoltaic panels of 20Wp.
- Control of temperature in the solar panels, to control the efficiency as a function of temperature.
- Cooling system of photovoltaic panels using fans.
- Regulation of the intensity of the lights, which simulate the sun.
- Battery charge controller: Regulator with 12 or 24V CC operation, and maximum current =10A. Maximum input voltage= 45V.
- Batteries: 2 Batteries of 12V 10Ah.
- Investors:
  - Sinusoidal inverter operating on Island 200 VA power, with 230V/50Hz output.
  - Inverter for network connection 230V/50Hz.
- Solar panel emulator module for connection to inverter for network connection, with solar intensity regulation.
- Pyranometer for the measurement of solar intensity.
- Rheostat for analysis of voltage-current graph in solar panels and comparison with specifications. It allows in series or parallel connection.
- Data acquisition card.
- The equipment is supplied with a complete workbook with its resolute version.
- Computer integrated in the computer with teaching software.

EN044

Insulated wind power plant trainer

Simulates an isolated wind installation with real and didactic components controlled by computer.



With the EN044 equipment, the behavior of a wind turbine is emulated in a practical and didactic way. An electric motor acts as the blades and bush of a wind turbine, dragging a three-phase synchronous generator of permanent magnets, which transforms the mechanical energy transmitted to the shaft into electrical energy at the output.

The current generated is alternating three-phase, having to transform into direct current to be able to feed the regulator of charge of batteries and consumptions, and later to the inverter that in turn turns this into alternating current with the appropriate frequency. So that the generated electric energy can be stored in batteries or consumed directly, or also use the stored charge for consumption when is no wind.

The equipment is designed to understood in a very visual and intuitive way quickly the operation of the assembly, not only knowing the elements of which it consists, but having them also to connect by means of the security cables supplied for that purpose. This is achieved by arranging the equipment in schematic and connectable panels.

In addition it counts on a computer from which we control the operation of the equipment and we obtain the reading of all the necessary variables for the analysis of the system.

Learning objectives

- Study of the operation and disposal of an isolated wind power generation system.
- Drawing of the characteristic curves of the generator:
  - Three-phase voltage depending on the speed of rotation.
  - DC voltage depending on the speed of rotation.
  - Torque based on the generated current.
  - Three-phase active power depending on the speed of rotation.
  - DC Power as a function of the speed of rotation.
  - Three-phase reactive power as a function of the speed of rotation.
- Calculation of the constant of torque/current and voltage / speed of rotation of the generator.
- Performance of the rectifier.
- Tracing of yield calculation curves: Electric power to the net/mechanical drag power.
- Determination of optimum operating points against variable atmospheric conditions.
- Tracing of the power-wind speed characteristic curve.

Technical characteristics

- Structure of anodised aluminum.
- Single-phase network analyzer with indication of active, reactive and apparent power, current, voltage, frequency, power factor, etc.
- Three-phase network analyzer with indication of active, reactive and apparent power, current, voltage, frequency, power factor, etc.
- Analog DC voltage and current indicators for 12V batteries and loads.
- Three-phase synchronous generator of permanent magnets.
- Battery Charge Controller: Regulator with operation 12 or 24V DC, and maximum current = 10A. Maximum input voltage = 45V.
- Battery of 12V 12Ah.
- Three phase full wave rectifier.
- Variable consumption rheostat.
- 2 AC lamps.
- 1.5 kW asynchronous motor.
- 200VA 230V/50Hz inverter.
- Frequency variator 1,5 kW.
- Data acquisition module.
- Computer with control and data acquisition software.
- The equipment is supplied with a complete experiments manual.

EN042

Grid connected windmill energy plant trainer

Simulates a wind power installation with real and didactic components controlled by computer.

With the equipment EN042, the behaviour of a wind turbine is emulated in a practical and educational way. An electric motor operates as the turbine on a windmill moving a three-phase synchronous permanent magnet generator, which converts the transmitted mechanical energy to electric energy.

The generated electricity is alternating current three-phase, having to be transformed into direct current to feed the inverter, which transforms it into alternating current at an appropriate frequency, and other necessary features to connect to the network.

The equipment is designed for a very visual and intuitive operation, quickly understand the functioning of the whole system, not just knowing the elements that compose the unit, but also having to connect them through the supplied cables for this purpose. This is achieved by the provision of equipment in modular panels. It also has a computer from which to control the operation of the equipment and get all the necessary variables for system analysis.

Learning objectives

- Study of the operation and components of a wind generation system connected to the mains.
- Plotting of the characteristic curves of the generator:
  - Three phase voltage according to the rotation speed.
  - Continuous voltage according to the rotation speed.
  - Torque according to the generated current.
  - Three phase active power according to the rotation speed.
  - DC power according to the rotation speed.
  - Three phase reactive power according to the rotation speed.
- Calculation of the “constant torque/current” and “voltage/generator rotational speed”.
- Rectifier efficiency.
- Performance curves calculation: “Electrical power to the mains/mechanical power”.
- Determination of optimum operating points under changing wind conditions.
- Drawing the “power/wind speed” curve.
- Analysis of the energy fed into the mains.

Technical characteristics

- Anodized aluminium structure.
- Phase network analyzer indicating active, reactive and apparent current, voltage, frequency, power factor, etc.
- Three-phase permanent magnet synchronous generator.
- 1.5 kW asynchronous motor.
- Networks connected Inverter 500 W (for 230V/50Hz., this can change depending on the country).
- 1.5 kW inverter.
- Protection module for connection to the mains.
- Data acquisition module.
- Computer with touch screen attached to the main control panel.
- The system is controlled with the computer (not only data acquisition).
- The unit is supplied with a comprehensive workbook.

EN041

Windmill test-bench

Simulates a test bench for wind turbines.

The Windmill Test-bench (EN041), is a wind tunnel of 2 meters length designed to work with windmills of less or equal to 630mm diameter. The equipment has a 612 mm windmill included, which has a torque and rotation speed measurement system.

The wind tunnel has a transparent part, so a complete sight of the windmill working is allowed. That part, can also be opened, to facilitate the access and manipulation of the system.

The tunnel has a built-in system for the measurement of the speed of the air by means of electronic pressure transducers, to monitor in real time the speed of the air that the windmill is put under.

The new system also has an electronic control of the pitch, to be modified from the control panel or from the computer.

All the system, is monitored and controlled through a control module, which also can be connected to a computer with a USB port.

Learning objectives

- Measurement of the power taken by the windmill.
- Determination of the characteristic curves of the power recovered by the windmill based on the wind speed.
- Determination of the coefficient of power of the windmill.
- Determination of the coefficient of power based on the specific speed.
- Obtaining of the coefficient of power based on the angle of pitch of the profile.
- Interchange of the blades of the windmill, for analysis of the variations based on the aerofoil profile.
- Modification of the pitch to see differences.

Technical characteristics

- Wind tunnel
  - Approximate length of the tunnel: 2 meters.
  - Maximum diameter of the windmill: 630mm.
  - Wind speed in the tunnel, adjustable from 0 to 13m/s.
  - Structure made of light weight anodized aluminum.
  - Vertically adjustable Legs for a correct level of the equipment.
  - Wheels for easy displacement of the equipment, 2 of them with brake.
  - Transparent polycarbonate part in the tunnel, with opening for access to the windmill.
- Windmill
  - Diameter of the rotor: 612mm.
  - Electronic sensor for measurement of rotation speed.
  - Load sensor for measurement of mechanical torque.
  - The pitch of the blades can be changed.
  - Possibility of modification of the picth from the control module or software.
  - The blades can be replaced for different ones with 4 screws, without disassembling the windmill.
- Security
  - Security system that avoids the fan to start if the defense is open.
  - Protective grate in the suction bell, that avoids the frontal access (not shown).
  - Protective grate in the exit of air.
  - Emergency stop.
- Manual control panel
  - LCD display showing: brake power %, wind speed %, pitch %, turn speed of the windmill (rpm), wind speed (m/s) and mechanical torque in the windmill (Nm).
  - Potentiometer regulating the pitch of the wind turbine.
  - Potentiometer regulating the braking of the wind turbine.
  - Potentiometer regulating the air velocity in the tunnel.
  - Switch on or off the wind turbine braking system.
  - Control selector from control module, or from PC.
- ENS041 Control software (Optional)
  - Manual or automatic tests can be done, with only indicating the required variables and indicating how many points we want in the graph of results. This way we don't lose time writing the results and drawing the graphs by hand.
  - Automatic calibration system.
  - Wind speed control.
  - Windmill brake control with PID.
  - Atomatic experiments varying the required parameter by the user autonomously, and recording data at each point.
  - The resuslt can be shown in graphs and tables at the software, printed or exported to Excel.
  - It only needs a computer with a USB port and windows 7 or better.
  - Manual or automatic tests can be done, where the following values can be controlled and registered: Wind speed. turn speed of the turbine, torque of the turbine, etc.

EN051

Hydroelectric plant with Pelton turbine

Simulates a hydroelectric generation installation with real and didactic components.

Trainer EN051 has been designed as a small-scale hydropower plant and it is equipped with a Pelton-like turbine that provides full operation along with all the other accessories that complete a standard installation.

This training unit is composed of: a Pelton turbine, a water tank with a pump, a battery, a regulator, a current converter, a choice of charges both for DC and AC, a control panel, as well as voltage and current meters in key points in the installation circuit. Therefore, the unit enables students to observe and interpret accurately how a hydropower plants operates.

This training unit simulates the operation of a power generator, taking into account the hydraulic head of a reservoir, whereby potential water kinetic energy is transformed into electricity thanks to the operation of a turbine.

Additionally, the turbine is equipped with devices for measuring the motor torque and the rotational speed which enables calculations on mechanical energy retrieved and the mechanical and electric power efficiency rate.

Finally, there is a digital pressure transducer at the turbine inlet and a flowmeter which enable the calculation of hydropower output.

Learning objectives

- Turbine characteristic curves:
  - Torque – rotation speed (M-n).
  - Brake power – rotation speed (Pe- n).
  - Efficiency – rotation speed (h – n).
  - Torque – U (M-U).
  - Brake power – U (Pe- U).
  - Efficiency – U (h– U).
- Study of the operation of a hydraulic power installation.
  - Operation with different types of loads in continuous.
  - Conversion of direct current to alternating current.
  - Operation with different types of loads in alternation.
  - Installation efficiency.
- Determination of the electrical generation characteristics of the turbine, depending on the rotation speed.
  - Curve Intensity – Voltage.
  - Short circuit current.
  - Open circuit tension.
  - Power curve – Voltage.
  - Power curve – charge resistance.
  - Maximum power generated.
  - Form factor.
  - Efficiency.

Technical characteristics

- Pelton turbine with 16 blades, impeller diameter 124 mm and 1,900rpm.
- Pressure transducer.
- RPM detection sensor.
- Load cell for measuring torque.
- Electronic control module with two displays to show the system data.
- Battery charge regulator: Regulator with operation at 12 or 24V DC, and maximum current = 10A. Maximum input voltage = 45V.
- Battery: 12V 12Ah battery.
- Sinusoidal inverter operating on Island of 200 VA of power, with single-phase output.
- Analogue ammeter with positive and negative measurement (zero centered) and digital 4-digit with 12-bit resolution + sign.
- Panel of direct current lamps.
- Panel of alternating current lamps.
- Rheostat.
- Practice notebook.
- Possibility of connection to a computer via USB, to register all the data directly in tables.
- Power supply: 230V/Hz.

FL031

Series and Parallel Pumps

Simulates a hydraulic pump system and studies its behavior in series or parallel.

With this equipment you can practice much of the operations, start-up, operation and necessary regulations in a pump installation.

One of the pumps is controlled by a frequency variable, which allows varying the speed of rotation. Likewise, this pump has a measurement system of mechanical torque.

The flow rate is measured by an electronic flow meter.

In addition, you can make an study of the characteristics of a pump, working individually and in groups, in series or in parallel, performing a wide range of practices and experiences.

Learning objectives

- Start-up of a pump, analysis and study of different aspects to consider.
- Priming pump.
- Checking the sense of rotation.
- Over current produced in the engine.
- Study and obtain the characteristic curves of a pump.
  - Height – flow (H-Q).
  - Hydraulic power – flow (P-Q).
  - Torque – flow (M-Q).
  - Mechanical efficiency – flow (m-Q).
  - Mechanical power – flow (Pm – Q).
  - Efficiency of the engine – flow (e-Q).
  - Electric power – flow (Pe-Q).
  - Total efficiency – flow (-Q).
- Study of cavitation, and obtaining the N.P.S.H. Curve required-flow.
- Study of the different forms of regulating a pump. Checking similarity laws.
- Variation of the rotational speed. Obtaining the new characteristic curves.
- Changing the operating point by varying the pumping installation.
- Manoeuvred of the discharge valve.
- Analysis of the same and different pumps working in group.
- Characteristic curves operating in serie and parallel.
  - Height – flow (H-Q).
  - Power – flow (P-Q).
  - Efficiency – flow (-Q).

Technical characteristics

- Suction pipe diameters: internal 45.2 mm./external 50 mm.
- Drive pipe diameters: internal 45.2 mm./external 50 mm.
- Tank: 250 liters.
- Manometers:
  - Bourdon type with glycerin from –10 m.c.a. to 70 m.c.a.
  - Bourdon type with glycerin from –10 m.c.a. to 35 m.c.a. (x3)
- Pumps characteristics:
  - Manometric height 22 m.c.a.
  - Maximum flow 160 l/min. a 10 m.c.a.
  - Power consumed 750 W.
  - Rotational speed 2.900 r.p.m.
- Electronic flowmeter 1200-50000 l/h.
- Dynamometer 2 Kg x 10 gr.
- Wattmeters de 0 a 1200 W.
- Frequency variable 220V – 1,1 Kw.

AC031

Heat Pump Demonstration

Simulates a heat pump system and studies the utilization of ambient heat to heat water.

The AC031 equipment demonstrates clearly the operation of a heat pump air/water.

The system consists of: compressor, circulating pump, flow control valve, storage tank, condenser, filter/drier, expansion valve and evaporator fan, water flow meters, temperature sensors and pressure displays at strategic points circuit.

With this complete teaching unit, it can be studied with clarity the use of environmental energy to heat water.

The refrigerant absorbs ambient heat when passing through the evaporator with a fan, and subsequently transferred to the water in the condenser.

The hot water storage tank is equipped with an internal heat exchanger, which can be connected to the network, to exchange energy with the flow of water.

The heat absorbed by the water in the condenser, turn to hot water tank, where the heat energy can be exchanged with the flow of water.

The system is also ready to operate in open circuit, ie the mains water can enter directly to the condenser, which have instantaneous heating.

Technical characteristics

- R134a refrigerant.
- 533 W compresor/displacement: 6,1 cm^3.
- Finned evaporator fan. Power: 380 W.
- Evaporator fan nominal speed 1500 rpm/airflow: 250 m^3/h.
- Flowmeters scale: 35-350 l/h.
- Capacitor: exchanger concentric tubes.
- Hot water tank with internal heat exchanger, capacity: 5,5L.
- Circulation hot water circuit by circulator.
- Temperature sensors:
  - Input and output of the refrigerant to the condenser.
  - Input and output of the water to the condenser.
  - Input and output of the water to the coil.
- Pressure gauges: input and output of the refrigerant to the compressor.
- Flows: water flow through the condenser and through the coil of the accumulator.
- Working modes:
  - Heating with accumulation in the water tank.
  - Direct heating of water with the refrigerant-water exchanger.
- Requirements:
  - Input: 230V/50Hz.
  - Water supply.
  - Waste water connection.

Learning objectives

- Study of the operation of a heat pump.
- Study of the main components of the heat pump.
- Representation of reversible thermodynamic processes.
- Control of the temperatures and pressures in the process.
- Harnessing the accumulated heat.
- Energy balances:
  - Open circuit.
  - In closed circuit.