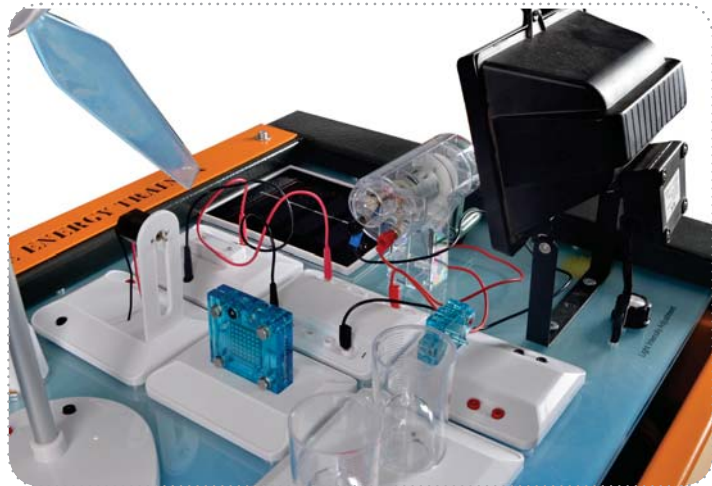


BS - 001

Renewable Energies Kits Lab.

Overview

The Renewable Energy Training System tends to allow the trainees to perform experiments in renewable energy, the Training System is consisting of wide range of renewable energy training kits which aim to focus on almost all types of renewable energies.



Specifications

- The training system covers most of the topics related to renewable energy by containing a set of educational training kits, each of which has an educational function in a field of renewable energy.
- The Training Kits included are: Solar PV Fundamental Training Kit, Solar Thermal Fundamental Training Kit, Energy Saving Training Kit, Emobility Training Kit, Fundamental of Wind Energy Training Kit, Smart Grid Training Kit, H2 Fuel Cell Training Kit, Biomass Fuel Training Kit, and Hydropower Training Kit.
- Each training kit includes all necessary equipment and tools for easily achieving of all experiments.
- The most aim from the Training system is to increase the opportunity to recognize opportunities for change and savings in energies.
- Considering the storage problems with renewable energies, the training system helps these topical issues should find their way into the curriculum.

- Experimental components for renewable energy, such as wind and photovoltaics, as well as energy stores such as lithium-iron phosphate batteries or fuel cells, provide a wide variety of fundamental experiments in addition to smart grid experiments.

- All training kits are considered as portable lightweight aluminum cases to ease working in any suitable environment.
- The training kits are in form of hard aluminum portable cases, easy to carry, move and store.

Training Kits

Solar PV Fundamental Training Kit

Code : BS-001.1



Overview

The Solar PV Fundamental Training Kit provides a big range of experiments from the physical fundamentals of photovoltaics, to the study of PV system components, and the design of complex PV systems on a laboratory scale. The Training Kit offers experiments for both electrical engineering and photovoltaics. The inverter displays the generation of alternating current from the solar panel current. And a number of different electrical consumers, such as a super bright LED or a light bulb, complete the kit, which can be used to compare their performance.

Component

- 3x Solar cell 0.5 V, 400 mA
- 3x Solar cell 1.5 V, 400 mA

- 1x Solar cell 5.5 V, 180mA
- 1x Solar Panel 12V/430mA
- 1x Diode module
- 1x Potentiometer module
- 1x Shunt regulator module
- 1x Motor module
- 1x Light bulb module
- 1x solar-base unit
- 2x LED module (high brightness)
- 1x Deep discharge protection module
- 1x Series regulator module
- 1x Capacitor module
- 1x Radio module
- 1x DC/ AC-Inverter
- 1x MPPT Solar Charge Controller 12V/24V, 20A
- Lead Acid Battery 12V
- 1x PWM regulator
- 1x Resistor plug element 33 Ohm
- 3x Resistor plug element 100 Ohm
- 2x Resistor plug element 10 Ohm
- 2x Resistor module
- 3x Lighting module (with safety sockets)
- 1x Base for solar panel
- 2x AV-Module

- 1x Power Module
- 1x Solar cell cover set (4 pieces)
- 1x Propeller
- 1x Aluminum case PV
- 6x safety banana cable, 25cm, red
- 6x safety banana cable, 25cm, black
- 6x safety banana cable, 25cm, yellow
- 3x safety banana cable, 50cm, red
- 3x safety banana cable, 50cm, black
- 3x Safety short-circuit module
- 1x Aluminum case
- 1x 80W lamp with Lamp housing
- 1x power supply
- 1x Layout diagram
- 1x multimeter
- Box for component with foam inserts
- 1x CD course software

Experiments:

- **Electrical engineering basic experiments:**

- Measurement of voltage current, and power Ohm's law
- Series connection of resistors (voltage divider)
- Parallel connection of resistors (current divider)

- **Photovoltaic basic experiments:**

- Series and parallel connection of solar cells
- Power dependence on the surface area of the solar cell
- Power dependence on the angle of incidence

- Power dependence on level of illumination
- Power dependence on level of illumination under load
- Internal resistance dependence on level of illumination
- Shading effect on solar cells
- Dark characteristic curve of solar cells
- I-V-characteristics, MPP and fill factor of solar cells
- Dependence of the I-V-characteristics of solar cells on level of illumination
- Dependence of the I-V-characteristics of solar cells on temperature
- Characteristic curve of solar modules
- I-V-characteristics of partly shaded solar modules
- Temperature coefficient of solar cells

- **Photovoltaic system experiments:**

- Components of an off-grid system
- Possible operating conditions of off-grid systems
- Working principle of shunt and series regulators
- Comparison of PWM- and series regulator
- Load characteristic of PWM regulators
- Working principle of a MPP tracker
- Characteristics of a MPP tracker
- Working principle of deep discharge protection
- Working principle of an inverter
- Determination of the output voltage progression at an inverter

2.Solar Thermal Fundamental Training Kit

Code : BS-001.2



Overview

The Solar Thermal Fundamental Training Kit facilitates the implementation of various technologies for the transformation of solar thermal energy in technical education. The Training kit contains various solar collector systems that can be operated with or without pumps, also CSP (Concentrated Solar Power) technology and a Peltier portion for direct conversion into electricity.

Another key function for the kit is the Experiments on the fundamentals of thermodynamics, such as heat radiation absorption and convective heat flow, which provide a detailed understanding of the physical effects applied.

Components:

- 1x Base unit
- 1x Motor module
- 1x Solar collector
- 1x Parabolic reflector
- 1x Absorber tube
- 1x Lens module
- 1x Absorber module for lens
- 1x Absorber B/W
- 1x Pump module
- 1x Heat exchanger water
- 1x Heat exchanger paraffin
- 2x Thermoelectric Cooler Peltier module
- 2x Hose-set
- 1x Power Module
- 2x Sorting rubber d=65, mark P
- 1x propeller
- 5x Safety banana cable, 25cm, yellow
- 5x Safety banana cable, 50cm, red
- 5x Safety banana cable, 50cm, black
- 1x Lamp housing
- 1x IR Lamp 230V
- 1x Safety plug, black
- 1x Safety plug, red
- 2x Digital multimeter
- 1x Laboratory thermometer
- 1x Beaker 250 ml
- 1x small tank
- 1x Temperature measuring sensor
- 1x Cooling pad
- 1x power supply
- 1x Aluminum case
- 1x Layout diagram
- Box for component with foam inserts
- 1x CD course software

Experiments:

- Absorptivity and reflectivity of different materials
- Focusing of light by a Fresnel lens
- Defocusing by lens
- Demonstration Thermal convection and layering
- Investigation of Thermal conduction
- Investigation of Thermal insulation
- Solar thermal collector with pump circulation
- Solar thermal collector with thermosiphon circulation
- Investigating the Variation of the flow speed
- Collector circuit with heat exchanger
- Collector circuit with paraffin heat reservoir
- Parabolic trough collector with pump cycle
- Qualitative demonstration of the functional principle
- Investigating the thermoelectric generator
- Quantitative determination of the electrical power

3. Energy Saving Training Kit

Code : BS-001.3

Overview

The Energy Saving Training Kit approach is holistic: students focus first on topics such as global energy use, climate change, or private household energy consumption. Students will make measurements based on the issue, such as room temperature or atmosphere, water and energy consumption, etc.

Components

- 1x base station
- 1x power supply
- 1x temperature + humidity sensor
- 1x temperature sensor indoor
- 1x temperature sensor outdoor
- 1x Luxmeter (UT383S)
- 1x LCD Non-contact IR Infrared Thermometer
- 2x Energy meter (UT230B-EU)
- 1x Flowmeter
- 1x power supply
- Box for component with foam inserts
- 1x CD course software

Experiments:

- **Understanding Energy**
 - Why saves energy?
 - Where do we need energy?
 - Primary- and secondary energy, resources and reserves
 - Units and conversions, key sizes
 - production of electricity, comparison of power plants
 - Worldwide energy consumption
 - Electrical energy in everyday life
 - Energy consumption
 - Hidden loss: stand-by-mode and the "off" position.
- **light**
 - Light in our live
 - Demonstration of different light sources

- Researching and controlling the light brightness
- **Heating**
 - Temperature in the world
 - Heat loss of buildings
 - Air quality
 - Heating and ventilating: correct behavior
 - Humidity
- **Water**
 - Where does drinking water come from?
 - Where does the used water go?
 - What are the annual consumption & costs?
 - Hot water preparation
 - Where is water consumed: correct behavior Electricity Consumption

4. Emobility Training Kit

Code : BS-001.4



Overview

The Emobility Training Kit shows students the physical and technological foundations and uses of various battery technology. The highly topical issue of electric mobility is being discussed in an autonomous concept vehicle. The dimensioning

and deployment of various types of batteries is as much a problem as life expectancy or charging methods. The properties of the different types of batteries are studied by means of qualitative and quantitative experiments. The commodity can be extended with a lithium-polymer and a lead battery module.

Components

- 1x Potentiometer module 110 Ohm
- 1x Battery module NiMH 3xAAA
- 1x Capacitor module
- 1x Base unit
- 1x Resistor module (triple)
- 1x Resistor plug element 1 Ohm
- 2x Resistor plug element 10 Ohm
- 1x Battery module holder 1xAAA
- 1xBattery module holder 3xAAA
- 1x Electric model car
- 1x lifepo battery AAA
- 1x Lithium-polymer
- 1x Box for component
- 1x Distilled water (100 ml)
- 1x Resistor plug element 100 Ohm
- 1x NiZn-battery AAA
- 1x Reversible Fuel cell
- 1x Lid for tray
- 1x NiMH battery AAA
- 1x Charger Module
- 1x Digital multimeter
- 1x AV-Module
- 2x Battery adapter cable

- 5x safety banana cable 25 cm
- 5x safety banana cable 25 cm
- 2x safety banana cable 50 cm
- 2x safety banana cable 50 cm
- Box for component with foam inserts
- 1x CD course software

Experiments:

- Ohm's law
- Series connection of ohmic resistances
- Parallel connection of ohmic resistances
- Nominal voltage and capacity of voltage sources
- Four-terminal sensing
- Internal resistance of voltage sources
- Series connection of voltage sources
- The capacitance of a battery module
- The energy density of battery modules
- The R_i efficiency of a battery modules
- The total efficiency of a battery module
- Temperature-dependent behavior of the lithium-polymer cell
- The charging process of a capacitor
- The discharge process of a capacitor
- I-V characteristics of the single NiMH battery module

- I-V characteristics of the NiZn battery module
- I-V characteristics of the battery module
- I-V characteristics of the lead battery module
- I-V characteristics of the lithium-polymer battery module
- I-V characteristics of the triple NiMH battery module
- I-V characteristics of the hydrogen fuel cell
- The charging process of the NiMH battery
- The charging process of the NiZn battery
- The charging process of the LiFePo battery
- The charging process of the lead battery
- The charging process of the lithium-polymer battery
- The charging behavior of battery module with resistance
- The charging behavior of battery module with an Mpp tracker
- The discharging process of a battery module
- Hydrogen production in the reversible hydrogen fuel cell
- The hydrogen of reversible hydrogen fuel cell
- Characteristic curve of the electrolyzer
- Hydrogen consumption of a fuel cell
- Characteristic curve of the fuel cell
- The efficiency of the hydrogen fuel

cell

- The Ri efficiency of a single NIMH, NIZN, LIFEPO, Lithium polymer, triple NIMH Battery modules
- Operation of the dc motor car with several battery modules
- Operation of the dc motor car with the reversible fuel cell

5. Fundamental of Wind Energy Training Kit

Code : BS-001.5



Overview

The Fundamental of Wind Energy Training Kit offers a realistic, focused experiments for technological training, while at the same time including fascinating simple experiments. Because of wind energy currently accounts for the largest proportion of clean electricity output and based on the very rapid build-up of modern wind power plants, the need for highly skilled workers is very strong.

Components:

- 1x base unit
- 1x wind machine module
- 1x wind generator module
- 1x Savonius rotor
- 1x 2 rotor blades

- 1x 3 rotor blades
- 1x 4 rotor blades
- 1x potentiometer module
- 2x motor module
- 2x Resistor module (triple)
- 1x Resistor plug element 33 Ohm
- 3x Resistor plug element 100 Ohm
- 2x Resistor plug element 10 Ohm
- 1x Power supply
- 1x Anemometer module (UT363S)
- 1x blade set
- 2x Digital multimeter
- 1x R.P.M. counter (UT373)
- 5x Safety banana cable, red, 25 cm
- 5x Safety banana cable, black, 25 cm
- 2x Safety banana cable, red, 50 cm
- 2x Safety banana cable, black, 50 cm
- 3x Safety short circuit plug
- Box for Wind component with foam inserts
- CD course software

Experiments:

- Basic electronic experiments
- Setup of a simple circuit
- Ohm's law
- Series connection of ohmic resistances
- Parallel connection of ohmic resistances
- Start-up and idling behavior of a motor

- Basic wind experiments
- Examine the wind speed behind the rotor
- Dependency of the distance on wind speed
- Energy balance sheet and efficiency of a wind turbine
- Rotational speed and speed ratio of a wind turbine.
- Change the turbine voltage by connecting a consumer
- Influence of a consumer
- Characteristic curves and rotational speed of a wind turbine
- Influence of the wind speed
- Voltage of a wind turbine dependent on the wind speed
- Rotational speed and output dependent on the wind speed
- Voltage dependent on the wind direction
- Influence of the wind direction
- Rotational speed and output dependent on the wind direction
- Influence of the generator model
- Voltage dependent on the rotor model
- Rotational speed and output dependent on the rotor model
- Influence of the rotor blade shape
- Voltage dependent on the rotor blade shape
- Rotational speed and output dependent on the rotor blade shape
- Influence of the number of rotor blades

- Comparison of the start-up speed of Savonius and three-bladed rotors
- Comparison of two-, three-, four-bladed rotors, savonius
- Voltage dependent on the number of blades
- Rotational speed and output dependent on the number of blades
- Voltage dependent on the rotor blade pitch
- Influence of the rotor blade pitch dependent on the rotor blade pitch
- Start-up speed of a wind turbine dependent on the rotor blade pitch
- Rotational speed and output dependent on the rotor blade pitch

6. *Smart Grid Training Kit*

Code : BS-0010.6



Overview

The Smart Grid Training Kit is designed to understand the interactions between green energy sources, energy stores and consumers in the smart grid. Through setting up smart grids on a laboratory scale and calculating and monitoring them, students can learn very demonstratively about the

electro-technical problems of mains operations. Pre-set allow students to increasingly build their skills in their own experiments. Students first observe the problem in the trial of designing methods to improve grid reliability on their own. At the end they would check them in realistic tests. Also complicated topics such as demand-side control or conductor rope tracking may be discussed in experiments. The Training kit allows the calculation and monitoring of energy fluxes in the experiments.

Components:

- 1x base unit
- 2x Smart Meter
- 1x Wind turbine module
- 1x Solar cell 5.5 V, 180mA
- 1xSolar Panel 12V/430mA
- 1x Wind machine
- 1x Motor module
- 1x Base for solar panel
- 2x Power Module
- 2x Wind rotor set
- 2x Light bulb module
- 1x Capacitor module
- 1x AV-Module
- 1x Battery module holder 1xAAA
- 1x LiFePo-battery AAA
- 1x Fuel cell holder
- 1x MPP-Tracker
- 2x Grid module
- 1x Diode module
- 1x Potentiometer module 110 Ohm
- 1x Illuminant 120W with housing

- 6x Safety short-circuit plug, with mid socket
- 5x Safety test lead, 25cm, red
- 4x Safety test lead, 25cm, black
- 4x Safety test lead, 50cm, red
- 4x Safety test lead, 50cm, black
- 1x propeller
- 1x Reversible Fuel cell
- 1x Azimuth angle scale
- 1x adapter
- DC converter 120V - 240V
- Box for component with foam inserts
- CD Course software

Experiments:

- **Smart Grid Experiments:**
 - Daily power fluctuations of a photovoltaic (PV) power plant
 - Daily power fluctuations of a wind power plant
 - Energy supply of a building by conventional power plants
 - Energy supply of a building by conventional and PV power plants
 - Energy supply of a building by conventional and PV power plants with storage
 - Voltage behavior and grid stability in a radial distribution system
 - Grid stability with PV power plants
 - Grid stability with PV power plants depending on consumer load
 - Grid stability with PV power plants depending on wire length
 - Grid stability with PV power plants

and smart transformer stations

- Grid stability with PV power plants and storages

- **Fundamental experiments**

- **Photovoltaics**

- IV-Characteristics of solar panels
 - IV-Characteristics depending on illumination
 - IV-Characteristics depending on temperature
 - MPP-Tracking

- **Wind energy**

- Turbine power dependent on blade shape and pitch angle
 - Turbine power dependent on number of blades
 - Turbine power dependent on wind direction

- **Fuel Cell and Electrolyzer**

- Functionality of an electrolyzer
 - IV-characteristics of an electrolyzer
 - Functionality of a fuel cell
 - IV-characteristics of a fuel cell

- **Storage technologies**

- Charge and discharge characteristics of a capacitor
 - Functionality and charge procedure of a LiFePo battery
 - Operation of fuel cells and electrolyzers.

7.H2 Fuel Cell Training Kit

Code : BS-001.7



Overview

The H2 Fuel Cell Training Kit delivers the broad range of new fuel cell technologies for technological education. The solar module, the electrolyzer and the fuel cell allow the solar-hydrogen cycle to be assembled and examined. Functional values, performance and characteristics of electrolyzer and fuel cell curves are some of the topics covered. In addition to the PEM-fuel cell, it also includes an ethanol-fuel cell in order to evaluate various technologies. H2 Charger and H2 Tank make it simple to produce and store hydrogen.

Components:

- 1x Base unit
- 1x Potentiometer module
- 1x Motor module without gear
- 5x Solar cell 0.5 V, 400 mA
- 1x Solar cell 5.5 V, 180mA
- 1x H2 Charger
- 1x H2 Storage
- 1x Gas storage module
- 1x Aluminum case
- 3x PEM-Fuel cell module

- 1x Electrolyzer module
- 1x ethanol fuel cell module
- 1x Propeller
- 15x Silicone tube 2 mm
- 1x Lamp with table clamp
- 2x Safety banana cable, 50cm, red
- 2x Safety banana cable, 50cm, black
- 4x Safety banana cable, 25cm, red
- 4x Safety banana cable, 25cm, black
- 2x Digital multimeter
- 1x Valve for H2 Storage
- Box for component with foam inserts
- CD Course of software

Experiments:

- What does an electrolyzes do?
- Characteristics of an electrolyzes
- Hydrogen production with the H2 Charger
- Hydrogen storage with the H2 Storage technology
- Characteristics of a PEM-Fuel cell
- Characteristics of an Ethanol-Fuel cell
- Faraday and energy efficiency of the electrolyzes
- Faraday and energy efficiency of the PEM-fuel cell
- Parallel- and series connection of PEM-fuel cells.

8. Biomass Fuel Training Kit

Code : *BD-001.8*

Overview

The Biomass Fuel Training Kit illustrates the entire biofuel development process in the form of student experiments. The case includes all the necessary parts and components and can be used at any place.

The first stage is the procurement of materials and fermentation. The resulting mash is then distilled with the custom-built condenser and the resulting ethanol is characterized. Lastly, biofuel generated must be turned into useful energy, for example, into electricity from the ethanol fuel cell supplied.

Components:

- 1x Potentiometer module
- 1x Motor module without gear
- 1x ethanol fuel cell module
- 1x Plug with hose
- 1x Yeast
- 1x Chain clamp
- 2x Digital multimeter
- 3x Test lead black 25 cm
- 2x Test lead red 25 cm
- 1x Propeller
- 1x Laboratory thermometer
- 1x Distilling head with Silicone ring
- 1x Condenser
- 1x Alcoholmeter
- 1x Erlenmeyer flask 1000 ml
- 1x Airlock
- 1x Rubber stopper

- 1x Areometer
- 1x Beaker 250 ml
- 3x Test tubes
- 1x Grip stopper
- 3x Pasteur pipette
- 1x Measuring cylinder 100ml
- 1x Syringe 2ml
- 1x Silicone ring
- 1x Universal stand clamp
- 1x Stand rod 60cm, M10
- 2x Double clamp
- 1x Stand base plate
- 1x Supplementary Biofuel
- 1x Bunsen burner
- Box for component with foam inserts
- CD course software

Experiments:

- **Biodiesel production**
 - Transesterification from fat to Biodiesel (FAME)
 - Determination of fat parameters
 - Extraction of fats from foods and oil plants
- **Alcohol fermentation**
 - Production of a mash/ alcoholic fermentation
 - Fermentation of different sugar types
 - (including catalytic splitting of starch)
 - Proof of fermentation gases

- **Distillation and production of Bioethanol**

- Distillation of mash
- Characteristics of the produced Ethanol

- **Ethanol fuels**

- Introduction Ethanol fuel cell
- I-V curve of Ethanol fuel cells
- Dependency of Ethanol fuel cells on concentration and temperature
- Energy balance of the whole process

9. Hydropower Training Kit

Code : BS-001.9

Overview

The Hydropower Training kit provides basic theoretical studies on the dynamics of water turbines in addition to qualitative studies on the issue of hydropower use. The Training Kit is fitted with a range of turbines-from a basic water wheel to a new, highly powerful Pelton turbine.

Components:

- 1x Water turbine
- 1x Turbines set
- 2x Manometer set 2/4 bar
- 1x Intake connector
- 1x Flow set 4 mm
- 1x Flow set 8 mm
- 1x Flow set 12 mm
- 1x Induction generator
- 1x AV-Module
- 1x Light bulb module

- 1x LED-module 2mA, red
- 1x Buzzer module
- 1x Motor module
- 1x Base unit
- 1x Resistor module
- 1x Flow box
- 1x Color discs
- 1x Connection set
- 1x Aluminum case
- 1x Water flow meter
- 4x Hose Clamp
- 2x safety banana cable 50 cm
- 2x safety banana cable 50 cm
- 4x safety banana cable 25 cm
- 4x safety banana cable 25 cm

- 1x Container box 6 Liter
- Box for component with foam inserts
- Cd course software

Experiments:

- Volume flow, flow velocity and power as a function of the height of fall
- Volume flow, flow velocity and power as a function of the pipe cross-section
- Comparison of the functionality of Pelton turbine, crossflow turbine and waterwheel
- Comparison of the performance of the Pelton turbine, crossflow turbine and waterwheel in dependence to the volume flow and pressure.

Photovoltaics Training System.

Overview

The training system is designed with the aim to demonstrate the principles of operation of the photovoltaic systems, Checking the correct alignment of solar modules and their characteristics, and Learning about different types of solar module wiring and connection configurations. The trainer is consisted of two units, the sun simulator PV unit that simulate the sun light and PV system output, and the control station that includes the components to process the output of the system to be grid connected.



Specifications

- The training system consists of two units, the control unit which includes display units, inverter and loads and the sun simulator PV unit.
- The sun simulator unit can work without the sun.
- The control and display unit shows all the measured values (Voltage, Current....)
- The characteristics curves can be easily drawn by means of interactive software at different operating points.
- The system can work on or off grid.
- The training system is able to deliver the following objectives:
 - Testing the optimum alignment of solar modules
 - Recording the characteristics of solar modules
 - Investigating the module's response to shadow formation
 - Investigating how bypass diodes operate
 - Learning about various types of wiring and connection configurations for solar modules
 - The training system is electrostatically painted and treated against rust.
 - The training system is fixed on four caster wheels with brakes

Experiments

- Testing the optimum alignment of solar modules
- Recording the characteristics of solar modules
- Investigating the module's response to shadow formation
- Investigating how bypass diodes operate
- Learning about various types of wiring and connection configurations for solar modules
- PV System Installation
- Design and Testing of Standalone and Grid-connected PV systems
- Measure of generated power of the system
- Determining the efficiency of the power grid inverter
- Investigating the response of a photovoltaic system when there is a power outage on the grid
- Economic benefits of photovoltaic systems

Technical Data

1-Solar module simulation model

Code : BS-002.1

- The Solar Module Simulation model is designed with the
- following features
- 3 SOLAR MODULES
- Power: 3 x 40 VA
- No-load voltage: 3 x 23V
- Maximum short-circuit current: 3 x 2 A
- Operating voltage: 230 VAC, 50 Hz
- Light intensity adjustable
- Bypass diode connectable
- Short-circuit proof
- Higher voltages and
- stronger currents can be realized by means of series and
- parallel circuit configurations
- connection option available for real solar module
- Displays: digital Voltmeter / ammeter

2- Solar module with solar altitude emulator

Code : BS-002.2

- » The solar module rack consists

- of a solar module and a
- » halogen spotlight as solar simulator.
- » The brightness of the
- » halogen spotlight can be adjusted using a dimmer.
- » rooftop angles can be emulated using the tilt adjustment of
- » the solar module allowing these effects on the solar module
- » to be investigated.
- » The halogen spotlight is swivel mounted
- » permitting it to simulate the progression of the sun over a
- » whole day.
- » To be able to emulate the various progressions of
- » the sun over the entire year, the tilt angle of the sun's
- » progression can be adjusted.
- » Technical data – halogen spotlight:
- » Power: 1000W
- » Power supply: 230 V
- » Technical data – solar module:

- » No-load voltage: 21 V
- » Short-circuit current: 650 mA

3- Load unit for solar module

Code : BS-002.3

- » The resistor can be used with the following:
 - » Solar module/simulation for recording characteristics
 - » and load resistance
 - » Solar charge regulator as load resistance
- » The solar load is equipped with the following features:
 - » Resistor: 0...1 k Ω / 500 W continuously adjustable,
 - » with stepped winding
 - » Current:
 - » 0 – 50 Ohm max. 6A
 - » 51 – 200 Ohm max 2A
 - » 201- 1k Ohm max 0.6A
 - » Connection terminals: 4 mm safety sockets

4-Solar charge controller 12/24V, 10A

Code : BS-002.4

- » The solar charge controller monitors the charge level of the accumulator and protects this against excessive and deep depletion
- » To charge up the lead accumulator, the charge controller uses the IU charging processes
- » LEDs provide information regarding the operating and charge status
- » Automatic 12/24 V switching
- » Charge/discharge current: 10 A
- » MPP-Tracker
- » Gassing regulation

- » Connection terminals for:
 - » Solar generator
 - » Solar accumulator
 - » DC load
- » Displays: digital Voltmeter, ammeter
- » Connection terminals: 4 mm safety sockets

5-Solar Accumulator 12V, 7Ah

Code : BS-002.5

- » In modern standalone solar power systems, lead accumulators are used for energy storage
- » Voltage: 12 V
- » Capacity: 7 Ah
- » Re-chargeable
- » Overcurrent protection
- » Displays: digital Voltmeter, ammeter
- » Connection terminals: 4 mm safety sockets

6- Off-grid inverter 230V, 275VA

Code : BS-002.5

- » The board consists of a commercially available off-grid inverter which generates an output voltage of 230 V AC from an input voltage of 12 V DC
- » The off-grid inverter is equipped with a deep depletion protection facility with which it can be connected directly to a lead accumulator
- » On/off switch
- » LED display of operating status
- » Acoustic alarm to signal warnings
- » Output voltage: sinusoidal 230V +/- 5%
- » Power: 275VA
- » Efficiency: 93%
- » Safety functions:
 - » Cut out for excess battery voltage

- » Over temperature and overload protection
- » Short-circuit protection
- » Pole reversal protection
- » Connection terminals: 4 mm safety sockets

7- light module:

- » LAMP BOARD 12V
- » The lamp board allows for study and comparison of halogen and LED lights. The bulbs are of the same brightness and each can be activated individually. This allows for a variety of power-consumption scenarios to be investigated
- » Halogen lamps 25W
- » LEDs 5W
- » Operating voltage: 12V
- » LAMP BOARD 230V
- » The lamp board permits the investigation and the comparison of light bulb, energy saving lamp
- » All illuminant can be switched on individually.
- » Light bulb: 25W
- » Energy saving lamp: 4W
- » LED-bulb 4W
- » Operating Voltage: 230V/ 50/60Hz

8. *advanced Industrial on grid inverter*

- » Modern solar power systems using grid-connected inverters to feed electric power into the mains
- » monitoring unit. for the mains voltage, frequency and impedance and switches the system off in the event of deviations
- » Input voltage range: 40 - 80V
- » Output voltage: 230V / 50Hz

- » Max. input current: 9 A
- » Max. efficiency: 95%
- » Output power: 350 W
- » Connection terminals: 4 mm safety sockets

9. *energy monitor unit (smart meter)*

- » Controller
- » Operating voltage: 100....240 V AC
- » Frequency: 50 / 60 Hz
- » Displays: On LED, LAN LED, bus LED
- » LAN port: RJ45
- » Bus terminal: 2-mm safety sockets
- » Data transmission rate: 2400....9600 baud
- » Meter
- » Type: programmable digital multi-tariff duplex
- » meter
- » Measured values: U, I, f, P, Q, cos phi
- » Measurements: 3-phase, direct
- » Operating voltage: 100...240 V, 50 / 60 Hz
- » Inputs/outputs: 2 digital inputs/2 digital outputs

10. *SCADA software with remote distance learning facility*

- » Display of measured values and operating states in real time
- » Plotting of measured values over time in diagrams
- » Processing, analyzing and exporting of diagrams
- » Control and monitoring of power engineering systems.
- » Important parameters and signals can be controlled by the software
- » Alarm the User if a fault or error is presented.

11. Analogue/Digital test and measurement system with display and software

- » Simultaneous, measurement of voltage and current independent of the curve shape (max. 600 V, 20 A) (measurement of clocked voltages)
- » Calculation of active, apparent and reactive power as well as the power factor
- » Measurement of the total rms (RMS-AC+DC), AC rms (RMS-AC) and arithmetic mean (AV-AC+DC)
- » Impervious to electrical damage up to 20 A / 600 V
- » Large-scale, high-contrast background-illuminated graphic display (5.7")
- » Large-scale display or display of up to 4 measurement values
- » Digital or pseudo-analog display
- » USB interface
- » Internal resistance: current path 10 m Ω , voltage path 10 M Ω
- » Voltage ranges: 30, 300, 600 V

- » Current ranges: 1, 10, 20 A
- » Measurement accuracy: 2%
- » Automatic or manual measurement range selection
- » Demonstration test instrument for measuring properties of the electricity supply
- » Operating voltage: 230 V, 50 / 60 Hz
- » Software Capable of:
 - Oscilloscope display of voltage, current and power
 - Consumption meter to display power consumed and output
 - Data logger for 14 different variables
 - Data export for data logger
 - Characteristic recorder

12. Interactive Software For PhotoVolatic Power Planet

13. Set Of Safety Measurement Cables 4mm

14. PC (Dell ,Corei7,8GB RAM,1TB HDD, 19 inch LED)

Advanced Three-Phase on Grid Photovoltaic System

Overview

The Advanced Three-phase Photovoltaic System is a Grid connected PV System which can simulate the output of a real PV system and illustrate the methods of storing and installing the system to the grid. The training system helps in configuration and testing of a photovoltaic device with feed to the power grid. Measurement of photovoltaic systems' energy generated, Tracking Maximal Power Point (MPP), Investigate the reaction of the photovoltaic system when there is a power outage on the grid, and response to Inverter Power Grid Control are also functions for the training system.



Specifications

- The trainer consists of Solar output Simulator to simulate the PV output and grid connection components such as inverters, batteries and charge controller
- The unit contain a power quality meter which can measure all electrical units such as Power, Energy, Power Factor, Voltage, Current and more
- The unit comes with test and measurements panel which contains Voltage and current meters and large display to simulate faults.
- The unit comes with a SCADA System to Monitor, Control and Alert users.
- The training system is electrolytically painted and treated against rust.
- The training system is fixed on four caster wheels with brakes.

Experiments

- Installation of photovoltaic systems
- Set-up and testing of a photovoltaic system with feed to the power grid
- Measurement of energy generated by photovoltaic systems
- Maximum Power Point (MPP) Tracking
- Limiting the power of the photovoltaic inverter (derating)
- Provision of reactive power
- Determining the efficiency of the power grid inverter
- Response to control of the power grid inverter
- Recording output data using sun passage emulator
- Investigating the response of a photovoltaic system when there is a power outage on the grid
- Lightning protecting for photovoltaic systems
- Economic benefits of photovoltaic systems

Technical Data

1. *Solar output Simulator:*

- Can be configured through software:
- Simulate I-V Curve under varying environmental conditions such as:
 - » Light intensity from 0% ... 100%
 - » Partial Shading
- Measure and display the operating point of the Emulator
- Graphically Represent I-V Curves and the point of operation and MMP
- Measurement and display of all Electrical Values (Current, Voltage, Power...)
- Technical data:
- Short Circuit Protection
- Operating Voltage: 100 – 230 V AC, 50-60 Hz
- Output Voltage: Up to 500 V
- Output Current: Up to 10 A
- Power output: 1500 W

2. *PV Inverter:*

- Photovoltaic inverter consisting of an actual inverter, a monitoring unit and a DC circuit breaker
- Feed management conforming to EEG2012 via separate communications interface
- Power reduction adjustable from 0 to 100% in 1% steps
- Adjustable power factor from 0.8 capacitive to 0.8 inductive
- Integrated web server user interface
- USB port for remote operation via SCADA Power Lab
- Integrated DC circuit breaker
- Overload voltage protection for photovoltaic and bus terminals
- DC input voltage range: 250-1000V
- Maximum input current: 11.0 A
- Output voltage: 3x400 V, 50Hz
- Maximum output current: 7.0 A
- Power output: 3300 W
- Terminals take the form of 4-mm safety sockets
- Max. efficiency: 98.0 %
- Power factor $\cos \phi$: 0.8 capacitive ... 0.8 inductive
- Overvoltage Protection

3. *Three-Phase Transformer*

- Input voltages: 3 x 400V
- Output voltage 1: 3 x 400V, 2 A
- Output voltage 2: 3 x 30V, 1.25A
- Power rating: 1000 VA, for a short time: 2000VA
- Vector group: Dyn5
- Protection: 1 automatic circuit breaker 1.8-2.5A, adjustable
- Inputs/Outputs: 4mm safety sockets

4. *Three-Phase Variable Transformer*

- Primary: 3x up to 400 V windings
- Secondary: 3x 0 ... 450 V, 2 A windings
- Nominal power: 1000 VA
- Frequency: 50/60 HZ
- Vector group: Yan0
- 24 V input/"Increase voltage" button
- 24 V input/"Decrease voltage" button
- Protection: 1 automatic circuit breaker, (adjustable)
- Inputs/outputs: 4-mm safety sockets

5. *Variable Ohmic load*

- Three-Phase Variable Resistive load
- x3 x750 Ω ,
- Current 3A,
- Input/output 4 mm Banana socket.

6. *SCADA*

- Display of measured values and operating states in real time
- Plotting of measured values over time in diagrams
- Processing, analyzing and exporting of diagrams
- Control and monitoring of power engineering systems.
- Important parameters and signals can be controlled by the software

- Alarm the User if a fault or error is presented.

7. *Universal Power Supply*

- Outputs:
- Three phase: L1, L2, L3, N from 4-mm safety sockets
- DC: 0...240 V DC variable, controlled and electronically protected against overload and short circuits.
- Output current: 3...10 A (adjustable current limiting)
- Second DC supply ca. 210 V DC, 6 A fixed
- Three phase: L1, L2, L3, N from 4-mm safety sockets

8. *Three-Phase Power Meter*

- Measurement types: 1 ph, 2 ph or 3 ph
- Measured voltage: 690 V / 400 V (CAT III) for IEC
- Current inputs: 1A or 5A nominal
- Power supply: 95...240V AC ($\pm 10\%$) / 110...340V DC ($\pm 10\%$)
- Display: Background-illuminated, graphic LCD, 128 x 96
- Integrated digital inputs: 24 Vdc / 4 mA
- Integrated digital outputs: 30 Vdc max. / 10-27 mA; 100 mA max.
- **Communication:**
 - » Ethernet (up to 32 Modbus serial devices) in gateway mode, 10/100 Base-T (100 Mbit/ sec)
 - » Modbus TCP (Integrated RJ45 port), 10/100 Base-T (100 Mbit/ sec)
 - » Set point monitoring
 - » V, I, power, VAR, VA, Freq. THD, PF (Up to 12 values)
- Measurement accuracy
 - » Sampling rate: 170 samples/ cycle at 60Hz

- » Voltages: ± 0.2
- » Currents: ± 0.2
- » Power factor and power: $\pm 0.5\%$
- » Active power 0.2%
- » Reactive power 1%

- **Instantaneous values:**

- » Voltage: Phase-phase / phase-neutral
- » Currents: Per phase and neutral (calculated)
- » Apparent, active and reactive power (kW, kVAR, kVA): Per phase and total
- » (PF) and displacement power factor (cos phi): Per phase and total
- » Frequency: 45...64 Hz
- » THD for voltage and current: Per phase
- » Individual harmonics: Through the 31st for volts and amps
- » Min. / max. values:
- » Voltage - phase-phase, phase-neutral
- » Current / Power / Power factor / THD/ per phase
- » Frequency, phase angle
- » Three phase average voltage and current
- » Odd harmonics for voltage and current per phase up the 31st
- » Demand values for active, apparent and reactive power
- » Average values:
- » Voltage - phase-phase, phase-neutral
- » Voltage min. / max. for phase-phase-phase-neutral
- » Current

- » Current min. / max

- Detection of harmonic oscillations and neutral conductor current in the electricity supply
- Pulse measurement
- Event logging
- Real-time clock
- Display in tables, diagrams and vector diagrams

9. *Test and Measurement Module*

- Simultaneous, measurement of voltage and current independent of the curve shape (max. 600 V, 20 A) (measurement of clocked voltages)
- Calculation of active, apparent and reactive power as well as the power factor
- Measurement of the total rms (RMS-AC+DC), AC rms (RMS-AC) and arithmetic mean (AV-AC+DC)
- Impervious to electrical damage up to 20 A / 600 V
- Large-scale, high-contrast background-illuminated graphic display (5.7")
- Large-scale display or display of up to 4 measurement values
- Digital or pseudo-analog display
- USB interface
- Internal resistance: current path 10 m Ω , voltage path 10 M Ω
- Voltage ranges: 30, 300, 600 V
- Current ranges: 1, 10, 20 A
- Measurement accuracy: 2%
- Automatic or manual measurement range selection
- Demonstration test instrument for measuring properties of the electricity supply
- Operating voltage: 230 V, 50 / 60 Hz

- **Software Capable of:**

- » Oscilloscope display of voltage, current and power
- » Consumption meter to display power consumed and output
- » Data logger for 14 different variables
- » Data export for data logger
- » Characteristic recorder

10. Interactive Software

- Interactive experiment set-up
- Measurements and graphics can be saved in the experiment instruction pages themselves by means of drag and drop.
- Virtual instruments can be started directly from the experiment instruction page
- Questions with feedback and evaluating logic to test knowledge
- Printed document for easy print-out of the experiment instructions complete with results
- The software is provided with a class management program that allows for profiles creation for both students and teachers via different dashboards.
- The interactive multimedia is able to submit a detailed report about the student attendance, performance, progress and final grade.

- The software provides a complete monitoring controlling and data storing for the whole system.
- Can be Connected to the WAN for remote distance Learning Capability

11. Set of safety measurement cables 4mm

- measurement cables with 4mm safety plugs, colored, PVC insulation, highly flexible Each set includes the following:
 - » 6 x 25cm long, black
 - » 4 x 50cm long, black
 - » 2 x 100cm long, blue
 - » 2 x 100cm long, red
 - » 1 x 100cm long, green/yellow
 - » 1 x 150cm long, blue
 - » 1 x 150cm long, green/yellow
 - » 2 x 150cm long, green
 - » 4 x 150cm long, brown
 - » 4 x 150cm long, black
 - » 4 x 150cm long, grey

12. PC

- Dell
- Core i7
- 8GB Ram
- 1 TB HDD
- 19" LED Monitor
- Keyboard and mouse

Small Wind Power Plant Station

Overview

The Small Wind Power Plant Station is an educational trainer that consists of a small wind generation system which can be simulated using a synchronous generator, servo machine and components to supply loads (Lamps) with required power through the system, the educational trainer helps to understand the production and operating of existing small wind power stations, develop and initial operation of a small wind power generator. The trainer also offers Exploring hybrid off-grid power supply systems using wind power and photovoltaic (wind / solar) systems.



Specifications

- The unit consists of synchronous generator and servo test stand to simulate a wind generation system
- The wind generation system can be used to supply loads such as lamps via a charge controller and off-grid inverter
- The unit comes with test and measurements panel which contains Voltage and current meters and large display to simulate faults.
- The unit comes with a SCADA System to Monitor, Control and Alert users
- The interactive software is capable of displaying and recording of all data and draw efficient curves.

Experiments

- Understand the design and operation of modern small wind power stations
- Explore the physical fundamentals “from wind to wave”
- Become familiar with different wind power station concepts
- Design and initial operation of a small wind power generator
- Operation with fluctuation wind force in off-line operation
- Energy storage, optimization of the system
- Design of an off-grid system for the generation of AC voltage
- Explore hybrid systems for off-grid power supply using wind power and photovoltaic systems (wind/solar trainer)

Technical Data

1. Charge controller

- The charge controller is specially designed for the operation of small-scale wind turbines. It ensures optimum charging of the associated battery. If the battery is unable to charge up any further, the excess energy is converted into heat by means of load resistors. This ensures that there is always a load on the wind generator and prevents it rotating at unacceptably high speeds. In addition to the charge controller itself, both the battery and load resistors are integrated into the package
- Battery voltage 12V
- Charging/discharging current: 20A
- Load resistor 0.34ohms/300W
- Battery capacity 7Ah
- Terminals: 4mm safety sockets

2. SYNCHRONOUS GENERATOR 12V FOR SMALL WIND POWER PLANT WITH PERMANENT MAGNETS

- Voltage with no load: 19 V
- Nominal current: 10 A
- Nominal speed: 1000 rpm
- Nominal power: 0.3 kW
- Provision of motor data by electronic nameplate EDD (Electronic Drive Data)

3. Halogen and Led Lamp Module

- The lamp board allows for study and comparison of halogen and LED lights. The bulbs are of the same brightness and each can be activated individually. This allows for a variety of power-consumption scenarios to be investigated.
- The lamp board has the following features:
- Halogen lamps 25W
- LEDs 2W
- Operating voltage: 12V

4. LOAD UNIT 1KOHM, 500W

- Load resistor for solar module and solar power units.
- **The resistor can be used with the following:**
- Solar module/simulation for recording characteristics and load resistance
- Solar charge regulator as load resistance
- Inverter as load resistor
- The solar load is equipped with the following features:
 - » Resistor: 0...1 kOhm / 500 W continuously adjustable, with stepped winding

- » Current:
- » 0 – 50 Ohm max. 6A
- » 51 – 200 Ohm max 2A
- » 201- 1k Ohm max 0.6A
- Connection terminals: 4 mm safety socket

5. **OFF-GRID INVERTER 230V, 275VA**

- To operate standard commercially available electrical devices used in standalone solar power systems, the generated DC voltage must be converted into AC voltage. The board consists of a commercially available off-grid inverter which generates an output voltage of 230 V AC from an input voltage of 12 V DC. The off-grid inverter is equipped with a deep depletion protection facility with which it can be connected directly to a lead accumulator.
- **The off-grid inverter is equipped with the following features:**
 - » On/off switch
 - » LED display of operating status
 - » Acoustic alarm to signal warnings
 - » Output voltage: sinusoidal 230V +/- 5%
 - » Power: 275VA
 - » Efficiency: 93%
- **Safety functions:**
 - » Cut out for excess battery voltage
 - » Over temperature and overload protection
 - » Short-circuit protection
 - » Pole reversal protection
- Connection terminals: 4 mm safety sockets

6. **Light Bulb, Energy Saving Lamps and Led Bulb Module**

- The lamb board permits the investigation and the comparison of light bulb, energy saving lamp and LED bulb. All

illuminant have the same brightness and can be switched on individually.

- Technical Data
- Light bulb: 25W
- Energy saving lamp: 4W
- LED-bulb 4W
- Operating Voltage: 230V/ 50/60Hz
- 3 sockets E27

7. **DYNAMIC SERVO MACHINE TEST SYSTEM WITH CONTROL SOFTWARE**

- The servo-machine test bench is a complete testing system for examining electrical machines and drives. It consists of a digital controller and brake. The system combines state-of-the-art technology with ease of operation.
- The system also allows manual and automated synchronization to be carried out.
- The controller has the following features:
 - Dynamic and static four-quadrant operation
 - 13 selectable operating modes/machine models (torque control, speed control, flywheel, lifting drive, roller/calander, fan, pump, compressor, winding gear, arbitrarily defined time-dependent load, manual and automated network synchronization)
 - Testing for the presence of a shaft cover.
 - Disconnection of the supply voltage of the motor under test in the absence of shaft cover
 - Interface for reading electronic nameplates EDD of the machines under test
 - Integrated galvanically isolated amplifier for voltage and current measurement
 - Four-quadrant monitor
 - Isolated USB interface
 - Thermal monitoring of the machine under test

- Connection voltage: 400V, 45...65Hz
- Maximum power output: 4kVA
- The brake is self-cooled asynchronous servo-brake with resolver.
- The motor and sensor leads are connected via polarity-safe plugs. The machine has thermal monitoring and, in conjunction with the controller, it constitutes a driving and braking system that is free of drift and requires no calibration.
- Maximum speed: 4000rpm
- Maximum torque 10Nm
- Temperature monitoring: continuous temperature sensor (PT1000)
- Resolver resolution: 65536 pulses/revolution
- a program for recording characteristics of machines and for determining dynamic and static operating points. It emulates eight different loads (flywheel, pump, fan, calander, lifting drive, compressor, winding gear, arbitrarily configurable time-dependent load) for which the parameters can be individually configured.
- Features:
- Measurement, calculation and display of mechanical and electrical variables
- (Speed, torque, mechanical power output, current, voltage, active, apparent and reactive power, efficiency, power factor)
- Simultaneous display of measured and calculated values (e.g. instant display of efficiency)
- Measurement of voltage and current (including RMS values even for non-sinusoidal waveforms)
- Configuration of settings via electronic nameplates EDD of the DUTs
- Speed or torque-controlled operation
- Recording of variables over time

- Programming of limiting values of speed or torque to prevent inappropriate loading of the machine under test.
- Operation in all four quadrants (display of generated torque)
- Arbitrarily defined ramp functions for PC-controlled load experiments
- Display of characteristics from several experiments to better illustrate the effect of parameter changes
- Export of graphics and measurements

8. *analog/digital test measurement system*

- Simultaneous, measurement of voltage and current independent of the curve shape (max. 600 V, 20 A)
- Calculation of active, apparent and reactive power as well as the power factor
- Measurement of the total rms (RMS-AC+DC), AC rms (RMS-AC) and arithmetic mean (AV-AC+DC)
- Independent inputs for current and voltage
- Isolated USB interface
- Voltage ranges: 30, 300, 600 V
- Current ranges: 1, 10, 20 A
- Measurement accuracy: 2%
- Automatic or manual measurement range selection
- Demonstration test instrument for measuring properties of the electricity supply
- Operating voltage: 230 V, 50/60 Hz
- Internal resistance: current path 10 mΩ, voltage path 10 MΩ
-
- A software allows all the measurements to be displayed on the PC. Up to 17 different displays can be opened.
- Oscilloscope display of voltage, current and power

- Consumption meter to display power consumed and output
- Data logger for 14 different variables
- Data export for data logger
- Characteristic recorder
- LabVIEW driver and supplied example

9. INTERACTIVE LAB ASSISTANT For SMALL WIND POWER PLANTS with remote distance learning facility

- The experiment instructions are provided by an interactive lab wizard course. This multimedia course guides students step by step through the topics of design and operation of small-scale wind turbines. Physical principles are explained by means of easily understood animations. The interactive lab wizard combined with virtual instruments creates a comfortable environment for experiments.
- **Features:**
- Interactive experiment set-up
- Measurements and graphics can be saved in the experiment instruction pages themselves by means of drag and drop.
- Virtual instruments can be started directly from the experiment instruction pages
- Questions with feedback and

evaluating logic to test knowledge

- Printed document for easy print-out of the experiment instructions complete with results

10. Set of safety measurement cables 4mm

- measurement cables with 4mm safety plugs, colored, PVC insulation, highly flexible Each set includes the following:
 - » 6 x 25cm long, black
 - » 4 x 50cm long, black
 - » 2 x 100cm long, blue
 - » 2 x 100cm long, red
 - » 1 x 100cm long, green/yellow
 - » 1 x 150cm long, blue
 - » 1 x 150cm long, green/yellow
 - » 2 x 150cm long, green
 - » 4 x 150cm long, brown
 - » 4 x 150cm long, black
 - » 4 x 150cm long, grey

11. PC

- Dell
- Core i7
- 8GB Ram
- 1 TB HDD
- 19" LED Monitor
- Keyboard and mouse

Energy Conversion of wind power plant

Overview

Energy Conversion of Wind Power Plant is an educational trainer that designed to study the transformation of kinetic wind energy into electrical energy. The educational trainer consists of a wind tunnel and a control unit to display and control the speed of the wind, to simulate a real-life scenario of wind generation and to determine the performance of a wind power plant.



Specifications

- The educational unit Consists of two units the wind tunnel and the control unit
- The control unit capable of adjusting the speed of the wind and displaying the measured wind and rotor speed and voltage and current values
- The wind blades yaw angle can be easily adjusted as well as the rotor blade angel
- Characteristic curves can be drawn by means of interactive software
- * A PC with software also included for data accusation. * The unit is fixed on four caster wheels to eases its motion inside the laboratory, these caster wheels are equipped with breaks to prevent the trainer from sliding during the operation, and a drawer cabinet is added for storing purposes.
- * The unit is treated against rust and electrolytically painted.

Experiments

- conversion of kinetic wind energy into electrical energy
 - function and design of a stand-alone system with a wind power plant
 - determining the power coefficient as a function of tip speed ratio
 - and rotor blade adjustment angle
 - and yaw angle
 - energy balance in a wind power plant
- determining the efficiency of a wind power plant
 - Power Adjustment by means of
 - Speed adjustment
 - Rotor blade adjustment
 - Behavior in case of oblique flow
 - Comparison of different rotor blades
 - Characteristics curves

Technical Data

1. Wind Tunnel

▶ Axial fan

- max. volumetric flow rate: 5 m³/s
- max. power: 1,5 kW
- Wind velocity: 10 m/s

▶ Two Guide Blades

▶ Generator

- * max. output: 60W
- * voltage: 12VDC
- * max. charging current: 5A

▶ Rotor

- Rotor blade adjustment: -5..35°
- Speed: 3000 RPM

▶ Length: 1700 mm

- Diameter: 550 mm

2. Control Unit

• 2x Accumulator

• voltage: 12VDC

• capacity: 8Ah

▶ Electrical load (bulbs)

- voltage: 12VDC
- power: 55W each

▶ Charge controller

- nominal voltage: 12V

- max. current: 40A

▶ Inverter

- » Rated power 300W

- » Input voltage 12V

- » Output voltage 230V

- » Output frequency 50Hz±3

▶ 3x Digital Display:

- » Wind Velocity: 0,3...50m/s,

- » Rotor Speed: 0...3000min-1

- » Current: 0...35A

- » Voltage: 0...20VDC

- » Yaw Angle 0.....90°

▶ Axial Fan Control

- » On/Off Switch

- » Speed Control

- » Emergency Stop Push Button

▶ Wind Tunnel Connection Switch

▶ Load Resistance

• Software:

- » Capable of displaying and recording of all measured units

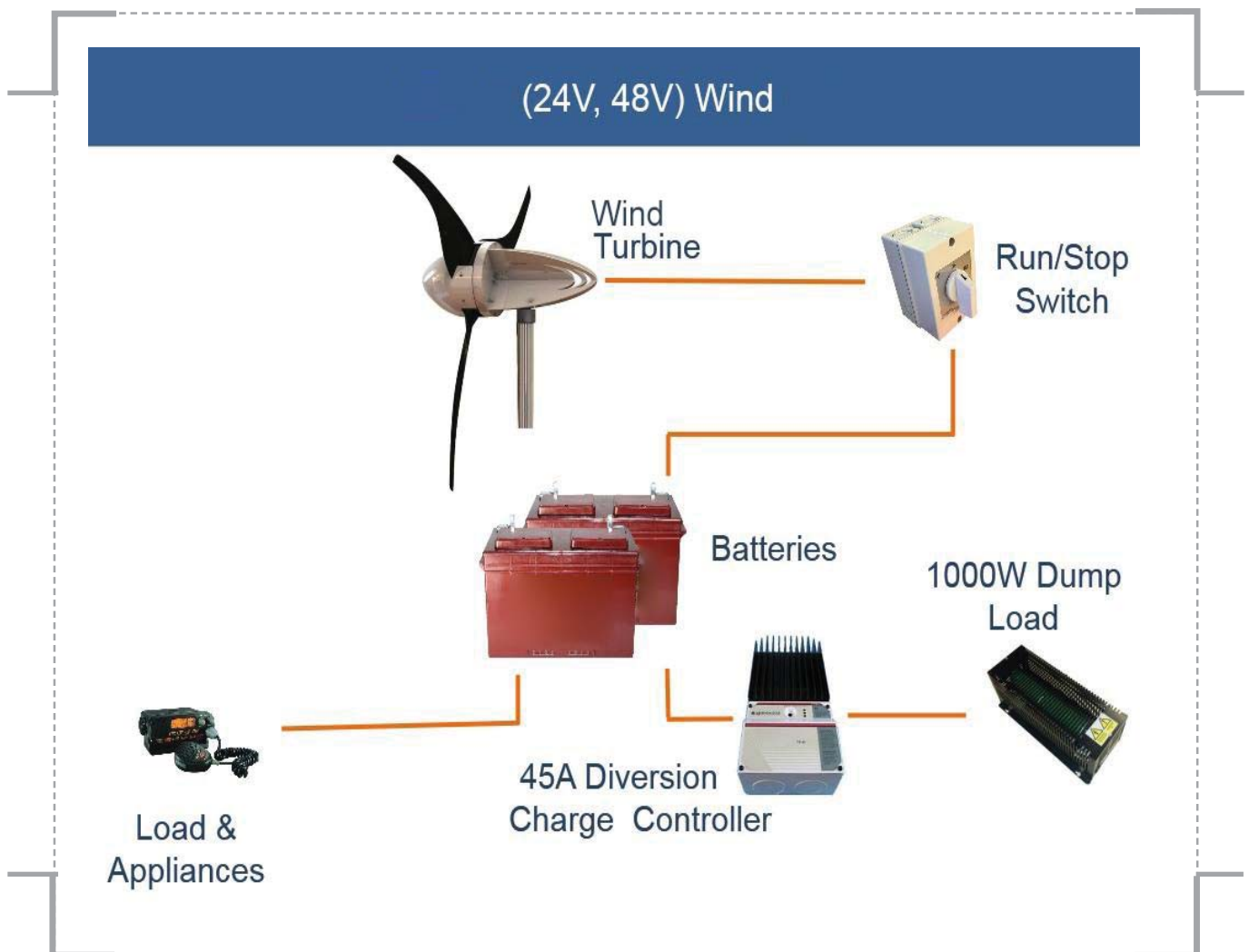
- » Control of the wind speed

- » Draw characteristics curves

Wind turbine installation training system

Overview

The wind turbine installation system consists of turbine parts and all necessary components to connect the output voltage to load applications.



Experiments

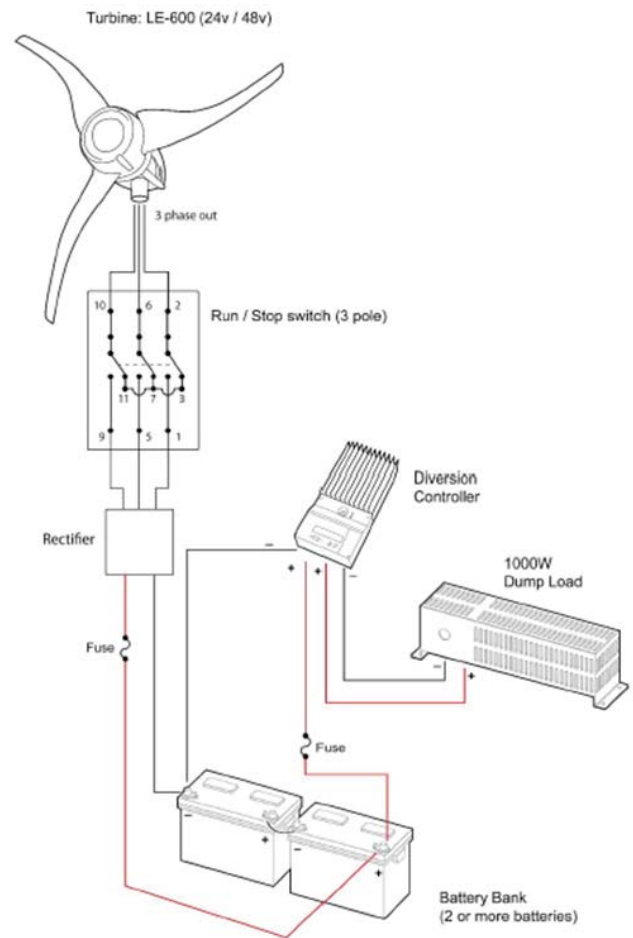
- Assembly and disassembly of a wind turbine.
- Familiarization of the wind system components

- Connecting the system to load application
- System Troubleshooting and repairing
- Installation of the system in real-life seniors

Technical Data

- 1. Run/Stop Switch**
 - Three-Pole
- 2. Dump Load**
 - 24V
 - 1000 W
- 3. Batteries**
 - Two batteries
 - 12 V
 - 100 Ah
- 4. Turbine**
 - » Rotor diameter: 1.54 metres
 - » Rotor type: 3-Blade downwind
 - » Blade material: Glass reinforced nylon
 - » Rated output: 160 watts @ 8m/s (17.8mph)
 - » Peak output: 750 watts @ 18m/s (40mph)
 - » Cut-in speed: 3m/s (6.7mph)
 - » Generator type: 3-Phase brushless NIB magnet rotor out-runner PMA
- 5. Diversion charge controller**
 - » 45A
 - » 24V
 - » **Spare Parts:**
 - » 3x Rotor Blade
 - » 1x Magnet Rotor
 - » 1x Stator (12V, 24V, 48V)
 - » 1x Nose Cone
 - » 1x Yaw pivot & slip ring module
 - » 2x Rotor Bearings & Housing

System Connection



Hybrid Photovoltaic and wind turbines System

Overview

The Hybrid Photovoltaic and wind turbines System is PV and wind System which can simulate the output of a real PV system using PV Emulator and Wind Generation using Synchronous Generator and illustrate the methods of storing and installing of the system. The training system illustrate the configuration and testing of Hybrid Systems. Measurement of Wind and Photovoltaic Generated power and Energy Management, Calculation of the system efficacy and Compare between Wind and photovoltaic Generation Methods.



Specifications

- The trainer can simulate a PV system via Emulator and Wind System via Synchronous generator
- The trainer illustrates the operation of hybrid PV and Wind System
- The trainer is supplied with all the components to connect the system to the grid via inverter, charge controller and batteries for storage
- The SCADA software display, control and alert the user in case of faults or errors.
- The interactive software is capable of displaying and recording of all data and draw efficient curves.
- A PC with software also included for data accusation. * The unit is fixed on four caster wheels to ease its motion inside the laboratory, these caster wheels are equipped with breaks to prevent the trainer from sliding during the operation, and a drawer cabinet is added for storing purposes.
- The unit is treated against rust and electrolytically painted.

Experiments

- Installation of photovoltaic hybrid systems with small wind turbine system
- Parameters for charging controller
- Energy flow study with simulation of the course of the sun and wind profile emulation
- Familiarization with operating and monitoring in off-grid operation
- Familiarization with operating and monitoring in on-grid operation
- Parameterization and operating of an UPS
- Parameterization and operating of a system to increase the autarky
- Investigation of installing photostatic hybrid system with small wind turbines
- Parameterization of charge controllers
- Familiarization with operating and monitoring of a microgrid consisting of pv hybrid system and small wind turbine
- Energy analysis with solar and wind profile emulation.

Technical Data

1. Inverter Module

- **First: Inverter**
 - » System voltage: 12 V
 - » System power: 1200 VA, 2400 VA for 5 sec.
 - » Input voltage: 90 V to 280 V AC
 - » Transfer time: 10 ms (UPS mode)
 - » Output voltage: 230 V AC +/-5 %
 - » Output frequency: 50 / 60 Hz
 - » Battery voltage: 10 V to 15 V
 - » Max. charging current PV: 40 A
 - » Max. charging current AC: 20 A (Programmable)
 - » MPPT charge controller:
 - » Min. MPP voltage: 15 V
 - » Max. MPP voltage: 80 V
 - » Nominal charging power: 550 W
 - » Min. Open circuit voltage of PV module: 18 V
 - » Max. Open circuit voltage of PV module: 100 V
- **Second: Panel Protection**
 - » Overvoltage protection grid connection: 255 V
 - » Circuit breaker: 12 A
 - » Battery fuse: 30A
 - » Connections: 4 mm safety sockets

2. PV Output Emulator (Programmable):

- » 1kW, 80 V
- » Irradiance: 0% to 100%
- » **Can be configured through software:**
 - Simulate I-V Curve under varying environmental conditions such as:
 - Light intensity
 - Partial Shading
 - Measure and display the operating point of the Emulator
 - Graphically Represent I-V Curves and the point of operation and MMP
 - Measurement and display of all Electrical Values (Current, Voltage, Power....)
- » **Technical data:**
 - Short Circuit Protection
 - Operating Voltage: 100 – 230 V AC, 50-60 Hz
 - Output Voltage: Up to 80 V
 - Output Current: Up to 40 A

3. Solar Battery Module

- » **Battery:**
 - Voltage: 12 V
 - Capacity: 138 Ah
 - Re-chargeable

» **Panel:**

- Overcurrent Protected
- Displays:
- Voltmeter 0 ... 20 V (analog),
- Ammeter -6 ... 6 A (analog)

4. Variable Ohmic load

- » Three-Phase Variable Resistive load
- » x3 x750 Ω ,
- » Current 3A,
- » Input/output 4 mm Banana socket.

5. Power Circuit Breaker

- » Nominal voltage: 200-400V, 50/60Hz
- » Control voltage: 24V
- » Nominal operating current: 16A, ohmic
- » Functions: 2 pushbutton switches and remote control for switch-off relay
- » Indicators: signal lamps for "on" and "off" and alarm Lamp in case of fault
- » Contacts: 3 N.O & 2 Auxiliary
- » Inputs/outputs: 4mm safety sockets
- » Can be Manually or automatically controlled.

6. Synchronous Generator (Permanent Magnet) (Wind Simulator)

- » Voltage with no load: 19 V
- » Nominal current: 10 A
- » Nominal speed: 1000 rpm
- » Nominal power: 0.3 kW
- » Thermally Protected

7. Charge Controller

- » Battery voltage 12V
- » Charging/discharging current: 20A
- » Load resistor 0.34ohms/300W
- » Battery capacity 7Ah
- » Terminals: 4mm safety sockets

8. Lamps Module to act as a Load

- » Consists of 4 Lamps
- » Halogen lamp 25W and 35W
- » LED 2W and 4W
- » Operating voltage: 12V

On/Off Switch for each Lamp

9. Three-Phase AC Power Supply

» **Outputs:**

- Three phase: L1, L2, L3, N from 4-mm safety sockets

» **Protective systems:**

- Motor protection switch adjustable from 6.3...16A
- Under voltage trip
- Safety cut-out

Power connection: 3x 230/400V, 50/60Hz via CEE plug with 1.8m power lead

Emergency Push button

10. Servo Machine with Software

- » Dynamic and static four-quadrant operation
- » 13 selectable operating modes/machine models (torque control, speed control, flywheel, lifting drive, roller/calander, fan, pump, compressor, winding gear, arbitrarily defined time-dependent load, manual and automated network synchronization)
- » Testing for the presence of a shaft cover.
- » Disconnection of the supply voltage of the motor under test in the absence of shaft cover
- » Interface for reading electronic nameplates EDD of the machines under test
- » Integrated galvanically isolated amplifier for voltage and current measurement
- » 5.7" colour touch display
- » Four-quadrant monitor
- » Isolated USB interface
- » Thermal monitoring of the machine under test
- » Connection voltage: 400V, 45...65Hz
- » Maximum power output: 4kVA
- » Maximum speed: 4000rpm
- » Maximum torque 10Nm
- » Temperature monitoring: continuous temperature sensor (PT1000)
- » Resolver resolution: 65536 pulses/revolution

- » Software:
 - Measurement, calculation and display of mechanical and electrical variables (Speed, torque, mechanical power output, current, voltage, active, apparent and reactive power, efficiency, power factor)
 - Simultaneous display of measured and calculated values (e.g. instant display of efficiency)
 - Measurement of voltage and current (including RMS values even for non-sinusoidal waveforms)
 - Configuration of settings via electronic nameplates EDD of the DUTs
 - Speed or torque-controlled operation
 - Recording of variables over time
 - Programming of limiting values of speed or torque to prevent inappropriate loading of the machine under test.
 - Operation in all four quadrants (display of generated torque)
 - Arbitrarily defined ramp functions for PC-controlled load experiments
 - Display of characteristics from several experiments to better illustrate the effect of parameter changes
 - Export of graphics and measurements

11. Power Quality Meter

- » Measurement types: 1 ph, 2 ph or 3 ph
- » Measured voltage: 690 V / 400 V (CAT III) for IEC
- » Current inputs: 1A or 5A nominal
- » Power supply: 95...240V AC ($\pm 10\%$) / 110...340V DC ($\pm 10\%$)
- » Display: Background-illuminated, graphic LCD, 128 x 96
- » Integrated digital inputs: 24 Vdc / 4 mA
- » Integrated digital outputs: 30 Vdc max. / 10-27 mA; 100 mA max.
- » **Communication:**
 - Ethernet (up to 32 Modbus serial devices) in gateway mode, 10/100 Base-T (100 Mbit/ sec)
 - Modbus TCP (Integrated RJ45 port), 10/100 Base-T (100 Mbit/ sec)

- » **Set point monitoring**
 - V, I, power, VAR, VA, Freq. THD, PF (Up to 12 values)
- » **Measurement accuracy**
 - Sampling rate: 170 samples/cycle at 60Hz
 - Voltages: ± 0.2
 - Currents: ± 0.2
 - Power factor and power: $\pm 0.5\%$
 - Active power 0.2%
 - Reactive power 1%
- » **Instantaneous values:**
 - Voltage: Phase-phase / phase-neutral
 - Currents: Per phase and neutral (calculated)
 - Apparent, active and reactive power (kW, kVAR, kVA): Per phase and total
 - (PF) and displacement power factor (cos phi): Per phase and total
 - Frequency: 45...64 Hz
 - THD for voltage and current: Per phase
 - Individual harmonics: Through the 31st for volts and amps
 - Min. / max. values:
 - Voltage - phase-phase, phase-neutral
 - Current / Power / Power factor / THD/ per phase
 - Frequency, phase angle
 - Three phase average voltage and current
 - Odd harmonics for voltage and current per phase up the 31st
 - Demand values for active, apparent and reactive power
 - **Average values:**
 - Voltage - phase-phase, phase-neutral
 - Voltage min. / max. for phase-phase-phase-neutral
 - Current
 - Current min. / max
- » Detection of harmonic oscillations

and neutral conductor current in the electricity supply

- » Pulse measurement
- » Event logging
- » Real-time clock
- » Display in tables, diagrams and vector diagrams

12. Test and Measurement System

- » Consists of a Display to show electrical values up to 3 values at the same time and interactive software via USB
- » Simultaneous, measurement of voltage and current independent of the curve shape (max. 600 V, 20 A) (measurement of clocked voltages)
- » Calculation of active, apparent and reactive power as well as the power factor
- » Measurement of the total rms (RMS-AC+DC), AC rms (RMS-AC) and arithmetic mean (AV-AC+DC)
- » Impervious to electrical damage up to 20 A / 600 V
- » Large-scale, high-contrast background-illuminated graphic display (5.7")
- » Large-scale display or display of up to 4 measurement values
- » Digital or pseudo-analog display
- » USB interface
- » Internal resistance: current path 10 mΩ, voltage path 10 MΩ
- » Voltage ranges: 30, 300, 600 V
- » Current ranges: 1, 10, 20 A
- » Measurement accuracy: 2%
- » Automatic or manual measurement range selection
- » Demonstration test instrument for measuring properties of the electricity supply
- » Operating voltage: 230 V, 50 / 60 Hz
- » **The Software is capable of:**
 - Oscilloscope display of voltage, current and power
 - Consumption meter to display power consumed and output
 - Data logger for 14 different variables

- Data export for data logger
- Characteristic recorder

13. SCADA Software

Display of measured values and operating states in real time

Plotting of measured values over time in diagrams

Processing, analyzing and exporting of diagrams

Control and monitoring of power engineering systems.

Important parameters and signals can be controlled by the software

Alarm the User if a fault or error is presented.

14. Interactive Software

Interactive experiment set-up

Measurements and graphics can be saved in the experiment instruction pages themselves by means of drag and drop.

Virtual instruments can be started directly from the experiment instruction page

Questions with feedback and evaluating logic to test knowledge

Printed document for easy print-out of the experiment instructions complete with results

The software is provided with a class management program that allows for profiles creation for both students and teachers via different dashboards.

The interactive multimedia is able to submit a detailed report about the student attendance, performance, progress and final grade.

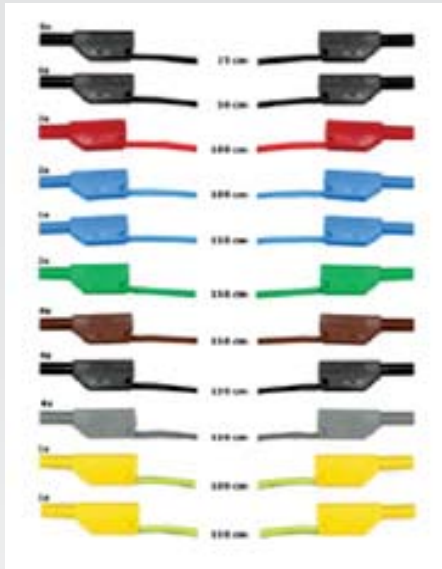
The software provides a complete monitoring controlling and data storing for the whole system.

Can be Connected to the WAN for remote distance Learning Capability

15. Set of safety measurement cables 4mm

- » measurement cables with 4mm safety plugs, colored, PVC insulation, highly flexible Each set includes the following:
 - 6 x 25cm long, black
 - 4 x 50cm long, black
 - 2 x 100cm long, blue
 - 2 x 100cm long, red

- 1 x 100cm long, green/yellow
- 1 x 150cm long, blue
- 1 x 150cm long, green/yellow
- 2 x 150cm long, green
- 4 x 150cm long, brown
- 4 x 150cm long, black
- 4 x 150cm long, grey



16. PC

- » Dell
- » Core i7
- » 8GB Ram
- » 1 TB HDD
- » 19" LED Monitor
- » Keyboard and mouse