LUCAS-NÜLLE

RENEWABLE ENERGIES

eCO2Train

1st Edition

HYBRID SYSTEM WITH RENEWABLE ENERGIES

An uninterrupted power supply is guaranteed in a hybrid power system that taps into different energy sources. This concept primarily uses photovoltaic hybrid systems. An energy storage unit secures the demand-based supply of the consumers and compensates for any fluctuations. These predominantly involve daytime- and weather-dependent fluctuations in solar energy which have an impact on power generation.

A photovoltaic hybrid system can be supplemented with other energy sources like wind power turbines, hydroelectric plants and/or diesel generators. This can make sense particularly in regions with less powerful sunlight so that any fluctuations over the day or in the course of the year caused by wrongly dimensioned photovoltaic systems can be compensated for. In regions with lots of sunlight, a hybrid system can serve to boost power supply reliability and independence.

A hybrid system can be implemented in different ways:

- **Grid-connected**
  - Local consumption optimised to boost self-sufficiency
  - Uninterruptable power supply (USPs) to guarantee power supply security in the event of a power failure
- **Off-grid (stand-alone)**
  - Photovoltaic system with energy storage unit for load power supply
  - MicroGrid comprised of battery, PV and wind turbine system

THE EXPANDABLE HYBRID PHOTOVOLTAIC SYSTEM

The training system uses industrial components to permit a hybrid photovoltaic system to be set up in a realistic fashion. The use of fault-protected connections and safety leads makes it possible to convey the operating principles of the system in a secure environment. Complex energy flows within the hybrid system are graphically visualized and evaluated with the help of SCADA. The off-grid, grid-connected and uninterruptible power supply (UPS) modes of operation are replicated with the compact training system. The experiments in the laboratory are performed with the aid of a solar panel emulator. This guarantees reproducible results even when there is no sun.

This training system can be combined with the training systems for wind turbines and solar pump systems to create a microgrid. There is also the option of expanding the system to include real PV systems and wind turbines, thus allowing the training system to be used outside the laboratory.

Training contents

- Configuration of the charging characteristic for the accumulator
- Efficiencies of the system components
- Operating principles of an inverter
- Dimensioning the system components
- Set-up and configuration of the components
- Consideration of different operating modes: Off-grid, grid-connected and UPS operation
- Analysis of complex energy flows with SCADA
- Expandable with the small wind turbine to create a microgrid
- Expandable with the solar pump system

THE HYBRID INVERTER

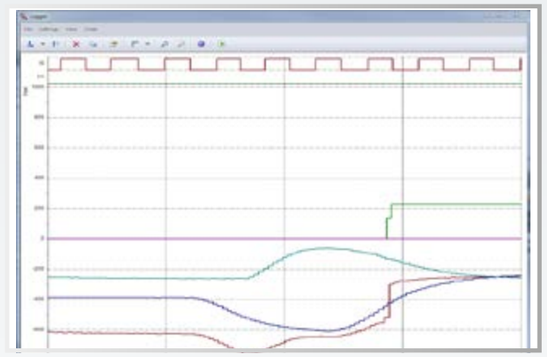
The hybrid inverter supplies the connected load from the accumulator, the PV system or the power grid. The accumulator can be charged with the IUoU charging characteristic by means of an integrated AC charge controller and/or an MPPT solar charge controller. The hybrid inverter protects the accumulator from overload, overcharging and deep discharge. A display and LEDs provide information about the operating status and state of charge.

Order no. CO3208-1U

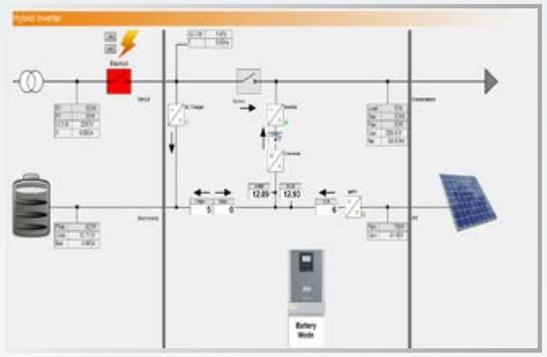
Benefits and technical data

- Fault-protected industrial hybrid inverter
  - Reverse polarity and overvoltage protection of the battery connection terminals: 30 A ATO
  - Line connection overvoltage protection: 255 V
  - Line circuit breaker: 6 A
- Compact system consisting of:
  - Inverter
  - MPP tracker
  - Charge controller
  - Bypass for direct power supply to loads from the power grid
- System voltage: 12 V
- System power: 1200 VA, 2400 VA for 5 sec.
- MPPT charge controller, 15 V to 80 V, max. 100 V
- Connectors: 4-mm safety sockets

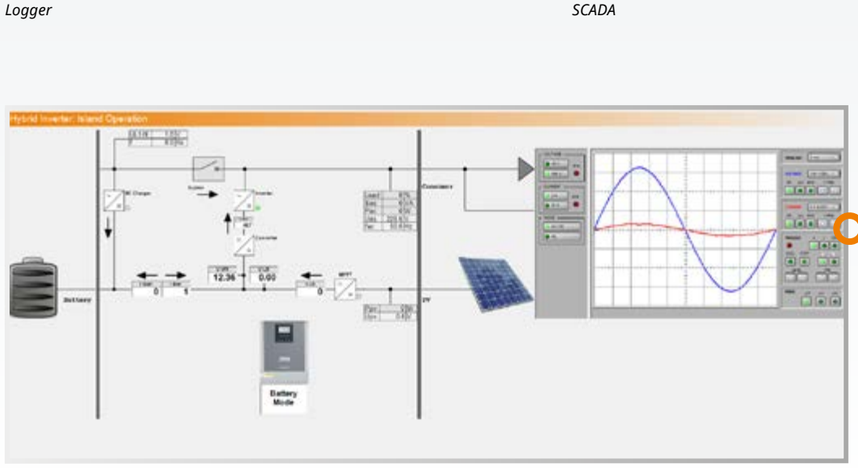
SCADA LINK



Logger



SCADA



Integrated virtual instrument: oscilloscope

Supervisory control and data acquisition (SCADA) is used to visualize the complex energy flows within the compact hybrid inverter and to represent the system's operating states. The integrated oscilloscope makes it possible to analyze the operation of the inverter and the quality of the modulated voltage. The variation of measured values over time can be recorded with the logger.

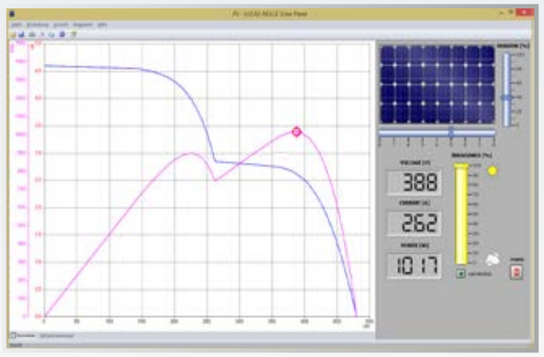
When the hybrid photovoltaic system is combined with the small wind turbine, the energy flows in the resulting microgrid can be visualized with SCADA.

Functions of the software

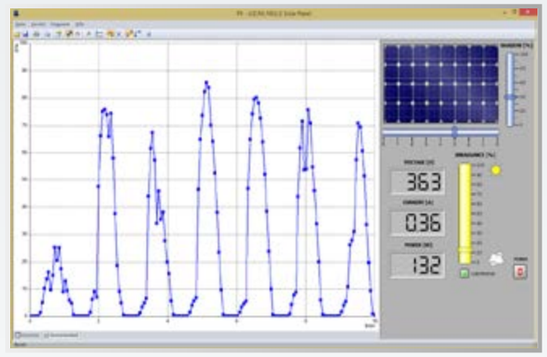
- Didactic SCADA for operation
- Display of measured values and operating states in real time
- Recording of graphs of the measured values over time
- Processing, analysis and export of graphs
- Can be expanded by any number of individual projects created with SCADA Designer

Order no. SO4001-3F (SCADA Designer) order no. SO4001-3H (SCADA Viewer)

SOLAR PANEL EMULATOR, 80 V



PV emulator with shading



Irradiance curve over a week

The solar panel emulator realistically simulates the operating behaviour of a solar panel system. In conjunction with the industrial hybrid inverter connected up, it acts just like a real solar panel. This permits reproducible results at all times in the laboratory by judiciously adjusting the operating points. Using the software provided, it is possible to explore every aspect of a solar panel. Besides setting the irradiance level between 0% and 100%, partial shading on the solar panel can be implemented and all the time-dependent characteristics found in the course of a day can be stored. This also includes graphically displaying the current operating point of the MPPT charge controller on the PV characteristic in the software of the solar panel emulator.

Benefits

- Reproducible results
- Indicates the operating point on the PV characteristic
- Partial shading of the solar panel
- Variation of irradiance over time

Order no. CO3208-1V

SOLAR MODULE WITH ADJUSTABLE ANGLE OF INCLINATION

The solar modules are well-suited for presentation in the lab and also for use outdoors. The adjustable inclination angle is used to adapt the module to the sun's radiation angle. The module can be connected in series or in parallel and the solar energy can be stored in an accumulator.

Benefits

- Outdoor operation
- Laboratory presentation
- Explore optimum alignment of solar modules

Order no. CO3208-1X

MICROGRID WITH SMALL WIND TURBINE

The Hybrid Photovoltaic training system can be expanded to include a small wind turbine in order to take into account the aspects of increasing security and independence of power supply on the basis of renewable energies in a microgrid. The structure of the overall system and the operation of the parallel charge controllers are considered.
Also taken into account are the dynamic variations of the wind and sun. The energy flows are analyzed with the help of SCADA using real wind and irradiance profiles.

Training contents

- Microgrid comprised of photovoltaic hybrid system and small wind turbine
- Increase in security and independence of power supply
- Parallel wind and PV charge controllers
- Evaluation of energy flows with SCADA

SOLAR PUMP SYSTEM EXPANSION

The combination of the solar pump system with the hybrid photovoltaic system makes it possible to pump well water even without solar irradiance since the hybrid system also provides a battery storage unit.

In addition to water pumps, other AC consumers can also be supplied by the hybrid system. The aim here is to match the components to the requirements and achieve prioritisation by setting the parameters accordingly.

Training contents

- Set-up of the solar pump system with energy storage
- Supply with water and electricity in one system
- Prioritising consumers

Order no. CO3208-6M

SOLAR-THERMAL WATER HEATING

Solar-thermal water heating

The EES 10 solar thermal water heating system provides the ideal prerequisites to investigate a modern and environmentally friendly system for heating water.

The trainer consists of a solar collector, diverse pumps, a water tank with built-in heat exchanger and optionally available washbasin for warm water use.
The EES 10 solar-thermal water heating system has a robust design for mobile use and is thus ideal for deployment in schools and training facilities of all kinds.

The students have to understand not only the circuit but the water lines and then work on programming the solar controller.

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Benefits

- Be able to identify the components of a solar-thermal water system
- Depiction of the components which are needed for an installation
- Installation, commissioning and control of a solar-thermal water heating system
- Measure the most important system parameters (pressure, temperature, water volume)
- Analysis of the efficiency
- Programming the solar controller and system monitoring

Order no. CO3610-4A
Order no. CO3610-4B – Supplementary equipment set

SOLAR-THERMAL WATER HEATING

Training contents

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- Depiction of the components which are needed for an installation
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- Measure the most important system parameters (pressure, temperature, water volume)
- Programming the solar controller and system monitoring

Training contents

- Determine and use the components of a hot water circuit
- Closed-loop control of the water temperature and operating principle of a safety mixing valve
- Determine and use the components of the cold water supply (dirt protection valve, meter, pressure relief safety valve)
- Measuring the water flow rate in a mixing valve
- Measuring the water temperatures (cold and hot)
- Water drain terminal

Order no. CO3610-4A
Order no. CO3610-4B – supplementary equipment set

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Ref. no.: K-E2-1202-EN
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01/22-EN (Printed in Germany)
Subject to technical amendments.