

POWER LABS ECOSYSTEM

TM





Overview

Along with technological development and the birth of Industry 4.0 the world needs better educated people. The traditional educational methods and approaches are no longer effective and do not provide the required knowledge and expertise to future specialists. The educational trainers should be transformed from a fixed, static trainer into open, flexible and software defined platforms.

Bitlismen's Power Labs Ecosystem comes to fulfill these needs. It is an ecosystem of energy related trainer/platforms which are designed to be open, flexible, expandable, reconfigurable and reprogrammable. The trainers have two parts software and hardware. The software is implemented using LabVIEW graphical programming language with an open source code. The hardware includes a reprogrammable NI myRIO platform for data acquisition, power analysis, monitoring and control. We can provide on-site installation assistance and training, so the students and professors can fully understand the trainer hardware and software structure and do further modifications if needed.

The ecosystem consists of:

- ✓ Traditional Power Generation Trainer
- ✓ Internal Combustion Power Generation Trainer (under development)
- ✓ Thermal Power Generation Trainer (under development)
- ✓ Solar Power Generation Trainer
- ✓ Wind Power Generation Trainer
- ✓ Solar & Wind Power Generation Trainer
- ✓ Hydro Power Generation Trainer
- ✓ Geothermal Power Generation Trainer (under development)
- ✓ Power Transmission Trainer
- ✓ Power Distribution Trainer
- ✓ Substation Automation Trainer
- ✓ Electromechanical Relay Protection Trainer
- ✓ Microprocessor Relay Protection Trainer
- ✓ Smart Grid Trainer



Benefits and Advantages

- ✓ Unlike the competitors, the trainer uses real (but small scale) components, to make the trainers to be as similar to real power plants as possible. This means after studying on our trainer, the student can easily understand any real power plant structure.
- ✓ Unlike the competitors, the trainer components have transparent enclosures to make them and the internal processes to be visible during operation and make the experiments more deductive, thus keeping students excited and involved during the process.
- ✓ The software has user friendly, easy to use and nice-looking user interface with graphical animations to be more attractive for the students.
- ✓ Unlike competitors which use only simple power meters and/or other standalone measuring devices the trainer implements power measurement and quality analysis on the reconfigurable myRIO and RIOSys platforms. It allows to have not only the RMS values of voltage, current, frequency, power factor etc., but as well as the real-time vector diagram, real-time sine waveforms of the voltages and currents, which makes much easier to understand how the components operates and how they affect into each other and power network itself thus making the system self-explanatory for students.
- ✓ Unlike competitors, the trainer is modular, meaning the components are free to move and can be interconnected by the students as per the need for each experiment. This allows the students to get fully involved in the process of interconnection of the components and understanding the aim and functionality of each of them. All the interconnections of components are done by students based on the straightforward instructions in the user manual thus students have better visibility and understanding of the entire system.
- ✓ Comprehensive and well-structured user manuals are provided for students and instructors. Each experiment has the following sections: Lab Objective, Prelab (theory associated to the experiment), Prelab Assignments (questions to the theory), Application Software Description, Step by Step Instructions, Experiments. Following all these sections the student will easily get a clear understanding of the aim of the experiment and the results he gets.
- ✓ In order to provide better security for the students and eliminate the risk of shock, unlike competitors who use 220V for connections from one to the other component, we use 12V AC and 24VDC, so even if students make wrong connections the trainer is still safe and will not harm them. In addition, our components have residual current circuit breakers and overcurrent circuit breakers thus any short circuits or wrong terminations by the students will be handled by the system.
- ✓ Unlike competitors, the trainer includes different types of loads resistive, capacitive and inductive. Each load has 3-phase input and there are 3 switchable stages to have different load configurations on each phase.
- ✓ Each trainer is compatible with other trainers of Power Labs Ecosystem™, so the customer will be able to get other trainers like traditional and renewable power generation, transmission and distribution trainers and operate them synchronously together having a smart microgrid system.
- ✓ The myRIO and RIOSys have state of the art technical specs and capabilities like real-time operating system, and reprogrammable FPGA.
- ✓ The system is software defined and fully open, meaning the LabVIEW source codes of all software components will be provided. This will add flexibility of adding custom labs to the trainer. The professors will be able to investigate the internal functionality and algorithms as well as be able to define new experiments, functionality and behavior.

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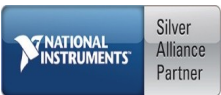
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TRADITIONAL POWER GENERATION TRAINER



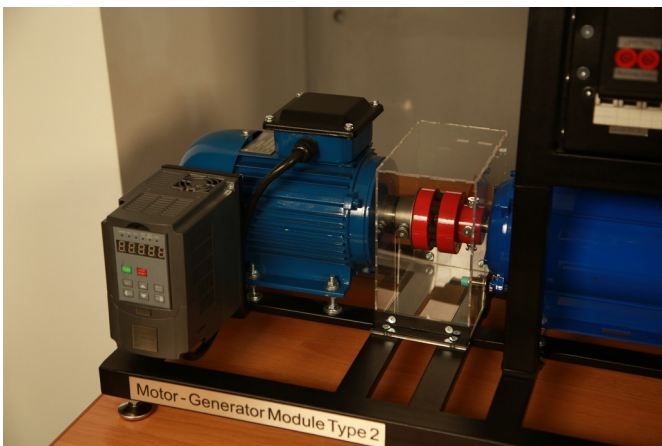
Overview

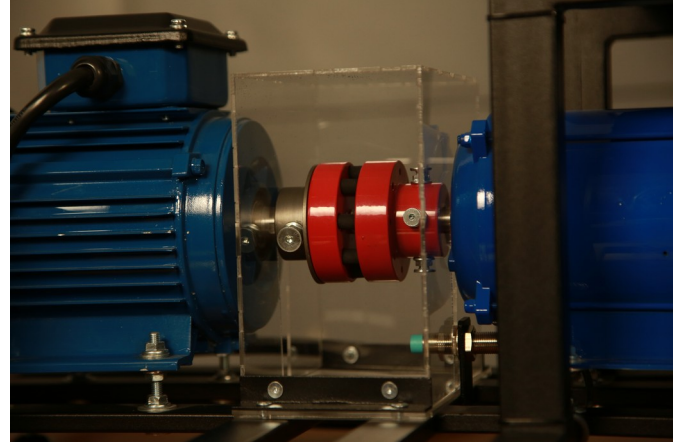
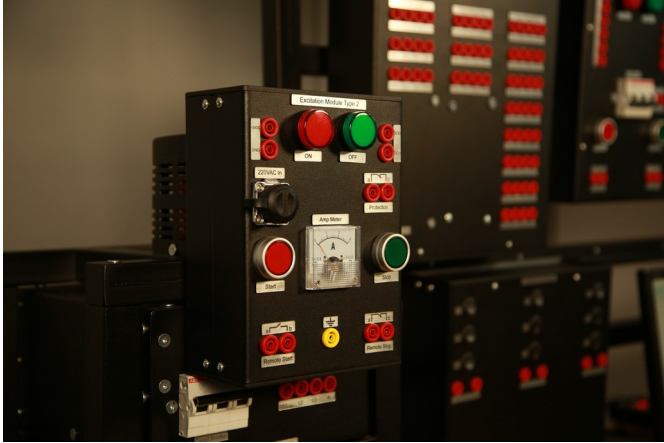
This option of the Traditional Power Generation Trainer can work in both off-grid and on-grid modes. It consists of a 3-phase synchronous generator moved by an asynchronous motor using a VFD. With the manually controlled excitation current and motor, it allows to investigate the generator performance in different mechanical energy. In off-grid mode it allows to investigate the supply of local loads, as well as voltage and frequency regulation. In on-grid mode it allows to implement the synchronization with the mains power grid both manually and automatically through the software.

List of Experiments

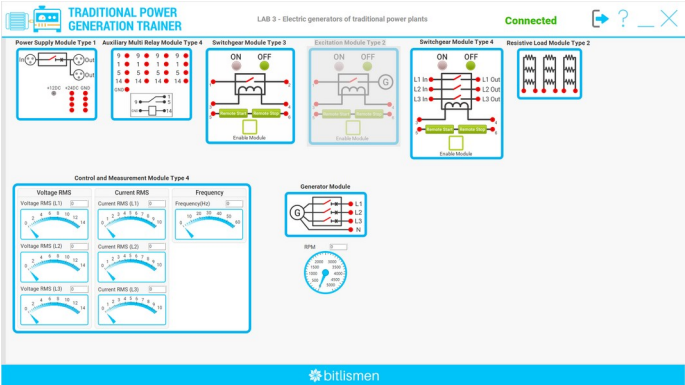
- ✓ Types of traditional power plants
- ✓ Energy sources and drive engines of traditional power plants
- ✓ Electric generators of traditional power plants
- ✓ Operation of autonomous traditional power plants
- ✓ Operation of on-grid traditional power plants
- ✓ Protection in traditional power plant in case of emergencies

Traditional Power Generation Trainer Hardware Pictures





Traditional Power Generation Trainer Software Screenshots



INTERNAL COMBUSTION POWER GENERATION TRAINER

Overview

The Internal Combustion Power Generation Trainer consists of an internal combustion engine, a 3-phase synchronous generators and loads. The trainer allows to investigate the working principles of an internal combustion engine and monitor the fuel consumption.

List of Experiments

- ✓ Structure and characteristics of internal combustion engines
- ✓ Structure and characteristics of generators used in internal combustion engine power plants
- ✓ Characteristics of electrical loads
- ✓ Characteristics of internal combustion engine power plants operating in an autonomous mode

SOLAR POWER GENERATION TRAINER



Overview

This option of the Solar Power Generation Trainer can work in both off-grid and on-grid modes. It consists of a PV panel and an array of halogen lamps as a sun simulator. The positions of both the PV panel and Sun Simulator can be controlled manually using joysticks. The trainer allows to simulate real light, daytime, yeartime and investigate the PV performance in different irradiation. In off-grid mode it allows to investigate the battery charging process using a DC charge controller and also the discharge using an AC-DC Inverter and loads. In on-grid mode it allows to implement the synchronization with the mains power grid using a Grid-tie inverter.

EXTRA FEATURES

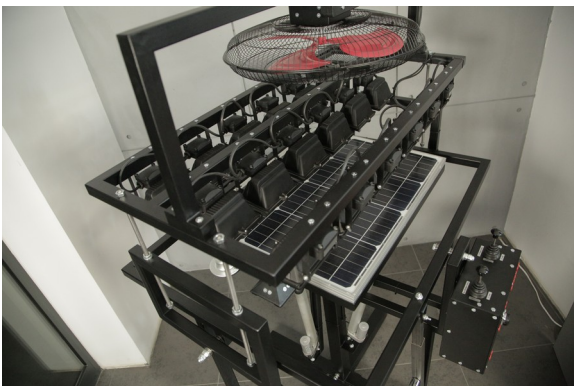
Optionally the trainer can also include: (to be specified during the order)

- Environment Simulation module
- Solar Tracker module.

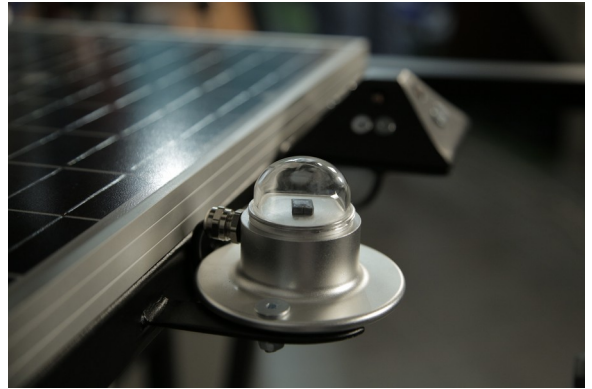
List of Experiments

- ✓ Structure and design of a solar photovoltaic power plant
- ✓ Study of photovoltaic solar panels
- ✓ Operation of the solar power station in battery charging mode
- ✓ Autonomous operation of a solar power plant supplying a load
- ✓ Operation of on-grid solar power plant
- ✓ Protection in solar power plant in case of emergencies

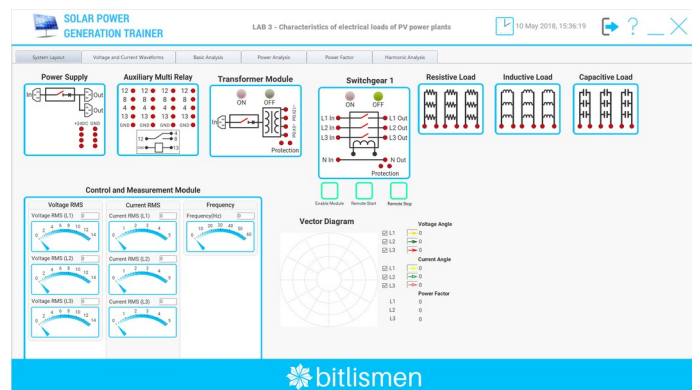
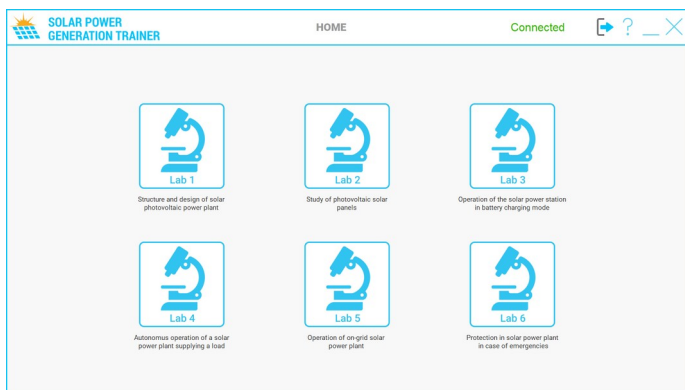
Solar Power Generation Trainer Hardware Pictures







Solar Power Generation Trainer Software Screenshots



WIND POWER GENERATION TRAINER



Overview

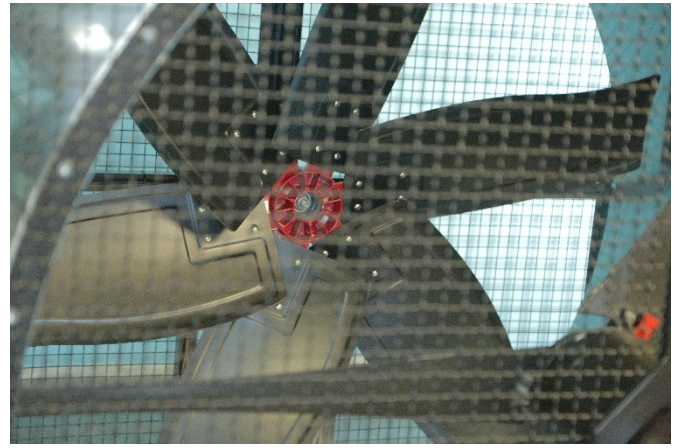
This option of the Wind Power Generation Trainer can work in both off-grid and on-grid modes. It consists of a wind tunnel and a real wind turbine-generator set. The trainer allows to simulate real wind and investigate the generator performance in different wind speeds. In off-grid mode it allows to investigate the battery charging process using an AC charge controller and also the discharge using an AC-DC Inverter and loads. In on-grid mode it allows to implement the synchronization with the mains power grid both manually and automatically through software.

List of Experiments

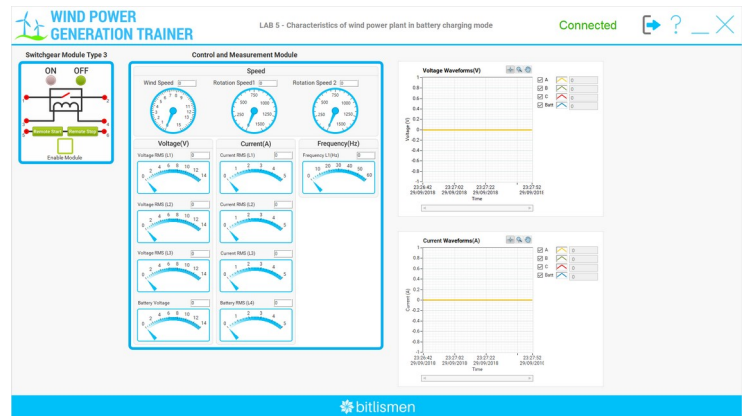
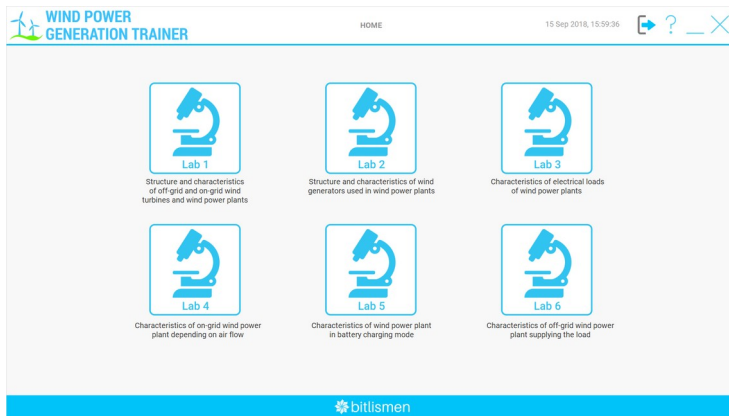
- ✓ Structure and characteristics of wind turbines and wind power plants working off-grid.
 - ✓ Structure and characteristics of wind generators used in wind power plants.
 - ✓ Characteristics of electrical loads of wind power plants.
 - ✓ Characteristics of on-grid wind power plant depending on airflow.
 - ✓ Characteristics of wind power plant in battery charging mode.
 - ✓ Characteristics of off-grid wind power plant supplying the load.
- Protection in wind power plant in case of emergencies

Wind Power Generation Trainer Hardware Pictures





Wind Power Generation Trainer Software Screenshots



SOLAR&WIND POWER GENERATION TRAINER



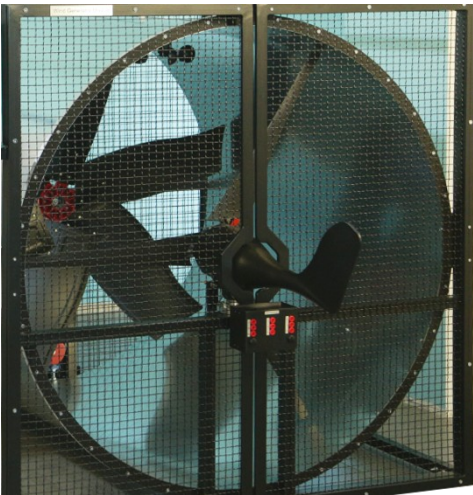
Overview

This trainer allows to investigate the synchronous operation of Solar Power Generation and Wind Power generation as small microgrid. The solar part consists of a PV panel and an array of halogen lamps as a sun simulator. The positions of both the PV panel and Sun Simulator can be controlled manually using joysticks. It to simulate real light, daytime, yeartime and investigate the PV performance in different irradiation. The wind part consists of a wind tunnel and a real wind turbine-generator set. It allows to simulate real wind and investigate the generator performance in different wind speeds. In off-grid mode it allows to investigate the battery charging process using a DC charge controller and also the discharge using an AC-DC Inverter and loads. In on-grid mode it allows to implement the synchronization with the Wind Power Generation using a Grid-tie inverter.

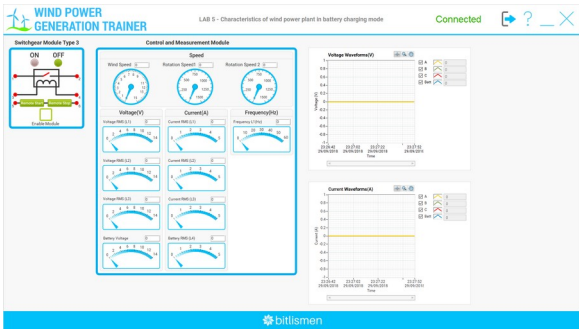
List of Experiments

- ✓ Structure and design of a solar photovoltaic power plants
- ✓ Study of photovoltaic solar panels
- ✓ Operation of the solar power station in battery charging mode
- ✓ Autonomous operation of a solar power plant supplying a load
- ✓ Protection in solar power plant in case of emergencies
- ✓ Structure and characteristics of wind turbines and wind power plants working off-grid
- ✓ Structure and characteristics of wind generators used in wind power plants.
- ✓ Characteristics of electrical loads of wind power plants.
- ✓ Characteristics of wind power plant in battery charging mode.
- ✓ Characteristics of off-grid wind power plant supplying the load.
- ✓ Protection in wind power plant in case of emergencies
- ✓ Operation of PV and Wind systems in synchronized mode.

Solar&Wind Power Generation Trainer Hardware Pictures



Solar&Wind Power Generation Trainer Software Screenshots



HYDRO POWER GENERATION TRAINER



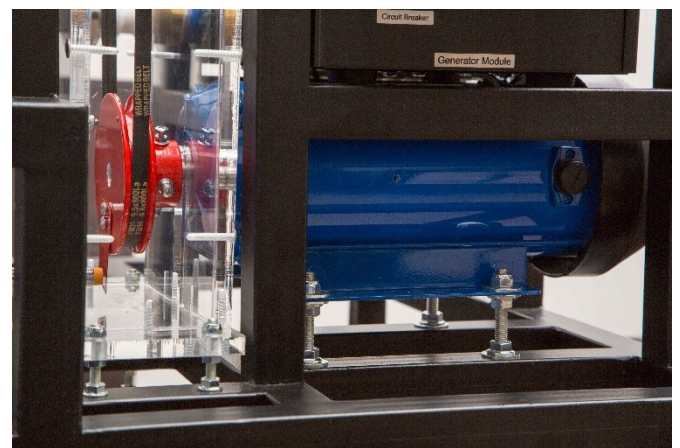
Overview

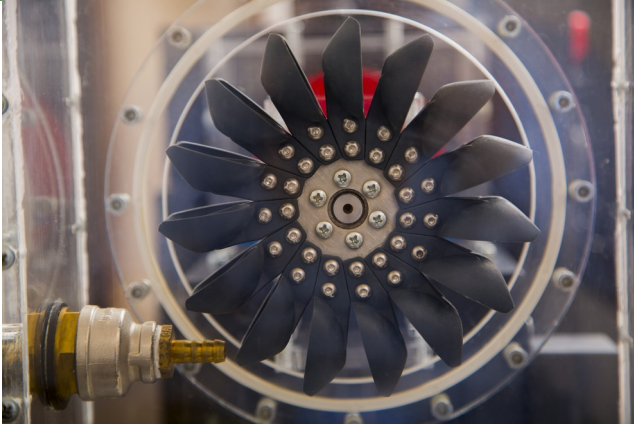
This option of the Hydro Power Generation Trainer can work in both off-grid and on-grid modes. It consists of a 3-phase synchronous generator moved by a real Pelton turbine. The trainer simulates real water flow using a pump. With the manually controlled valves, it allows to simulate different water flow and head pressure and investigate the generator performance in different conditions. In off-grid mode it allows to investigate the supply of local loads, as well as voltage and frequency regulation. In on-grid mode it allows to implement the synchronization with the mains power grid both manually and automatically through the software.

List of Experiments

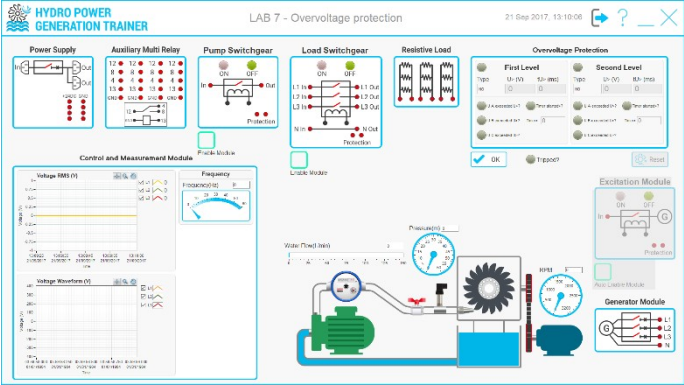
- ✓ Structure of the Turbine
- ✓ Structure of the Generator
- ✓ Measurement of the Generated Current, Voltage and Power
- ✓ Main Characteristics of the turbine
- ✓ Main Characteristics of the generator
- ✓ Main characteristics of off-grid hydro power plant
- ✓ Main characteristics of on-grid hydro power plant
- ✓ Protection in hydro power plant in case of emergencies

Hydro Power Generation Trainer Hardware Pictures





Hydro Power Generation Trainer Software Screenshots



POWER TRANSMISSION TRAINER



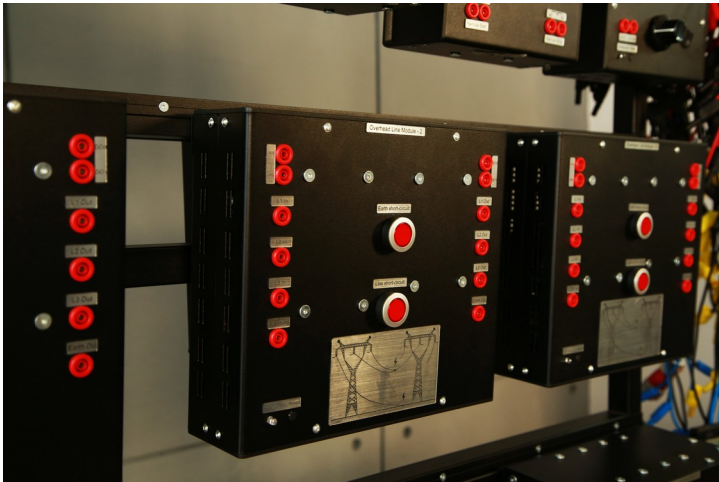
Overview

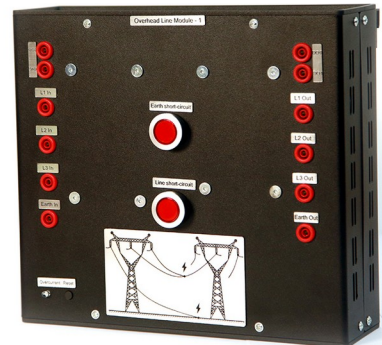
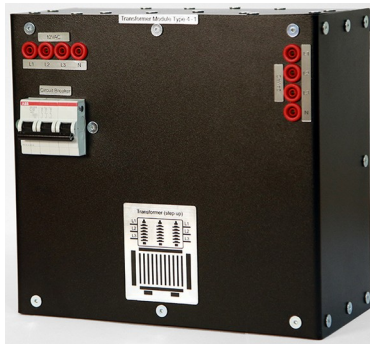
The Power Transmission Trainer consists of step-up and step-down transformers, overhead line models and loads. It allows to simulate real AC transmission lines and investigate mechanisms of decreasing the losses on the lines, protection from real-simulated earth-short circuits and line-to-line short circuits, and reactive power compensation. It allows also to investigate the power transformer characteristics.

List of Experiments

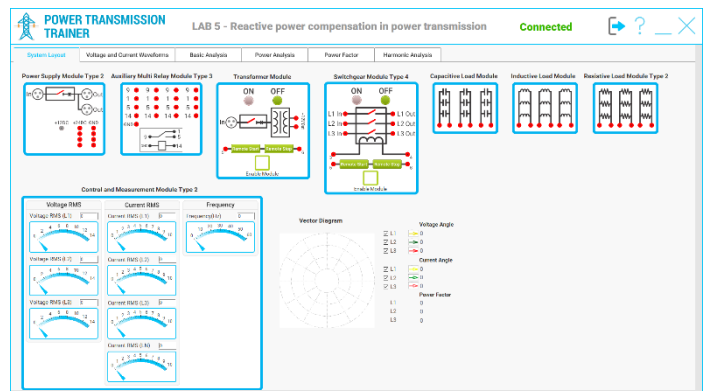
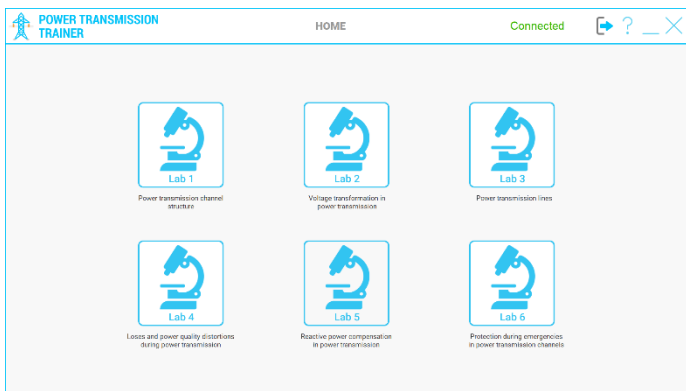
- ✓ Power transmission channel structure
- ✓ Voltage transformation in power transmission
- ✓ Losses and power quality distortions during power transmission
- ✓ Reactive power compensation in power transmission
- ✓ Protection during emergencies in power transmission channels

Power Transmission Trainer Hardware Pictures





Power Transmission Trainer Software Screenshots



POWER DISTRIBUTION TRAINER



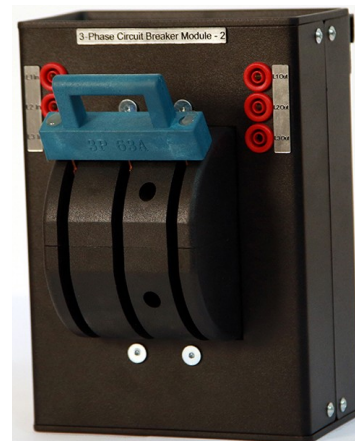
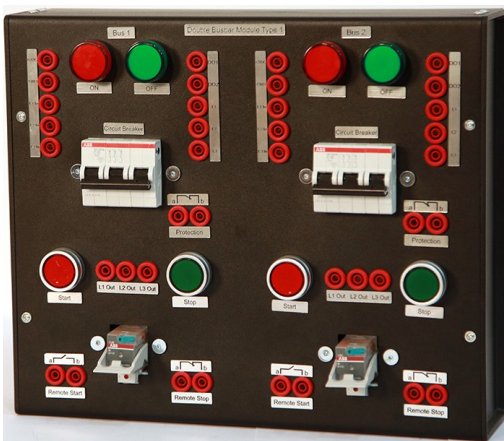
Overview

The Power Distribution Trainer is a combination of physical models of power busbars and switchgears. It allows investigate the control mechanisms of different buses and investigate the system behavior in case of different emergency situations.

List of Experiments

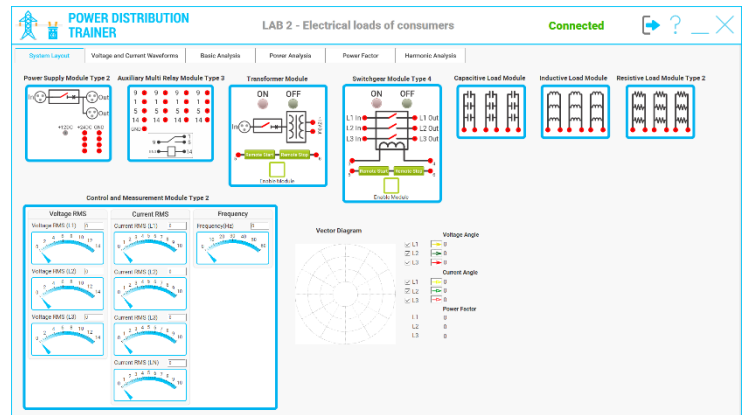
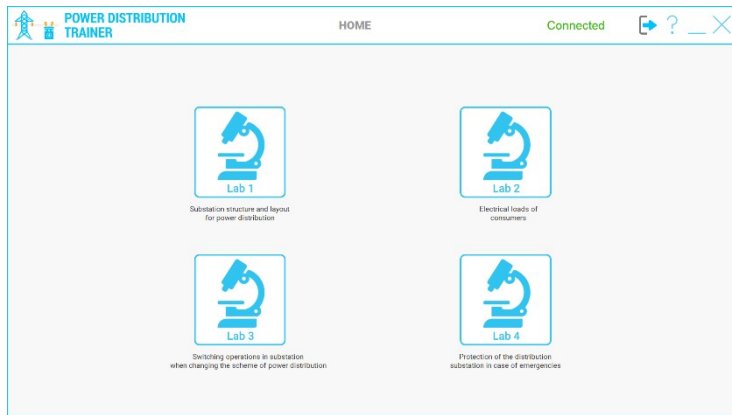
- ✓ Substation structure and layout for power distribution
- ✓ Electrical loads of consumers
- ✓ Switching operations in substation when changing the scheme of power distribution
- ✓ Protection of the distribution substation in case of emergencies

Power Distribution Trainer Hardware Pictures





Power Distribution Trainer Software Screenshots



SUBSTATION AUTOMATION TRAINER



Overview

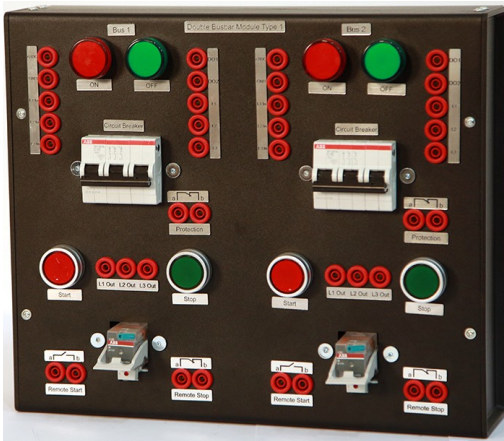
The Substation Automation Trainer is a small model of a distribution substation. It includes small scale modules for switchgears, busbars, circuit breakers, transformers and loads.

It allows to study basics of substation automation system. It allows to investigate how the monitoring and control (RTU) system is implemented in hardware using NI myRIO platform. The educational trainer is a part of a real SCADA system.

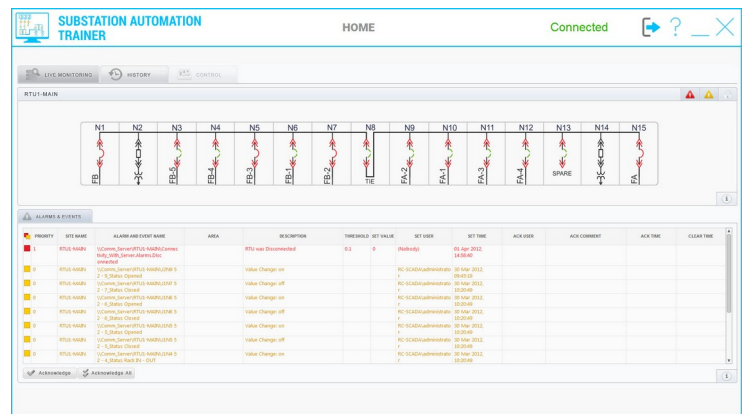
Features

- ✓ Remote monitoring and control of switchgears
- ✓ Remote monitoring and power quality analyses
- ✓ Remote monitoring of protection
- ✓ Alarms & Events handling
- ✓ Real-time data monitoring
- ✓ Communication through DNP3.0 protocol
- ✓ Historical data storage in database

Substation Automation Trainer Hardware Pictures







ELECTROMECHANICAL RELAY PROTECTION TRAINER



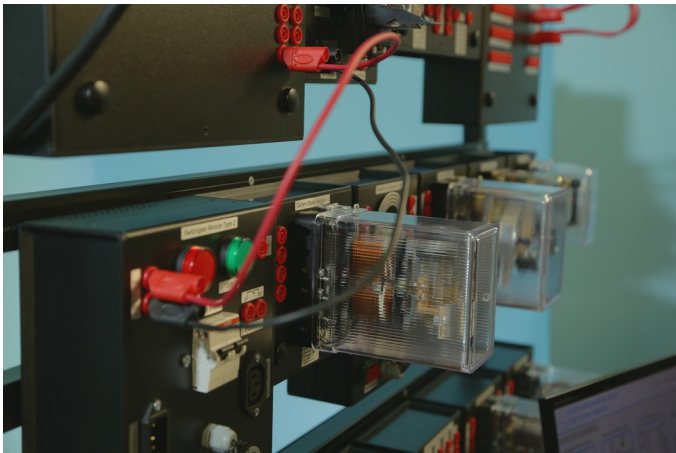
Overview

This option of the Electromechanical Relay Protection Trainer is a combination of different types of electromechanical relays and a DC generator. This trainer allows to concentrate on different protection circuits that are used in different points of real power network. It allows to investigate the relays as separate equipment, as well as their use in advanced protection circuits with and without the generator.

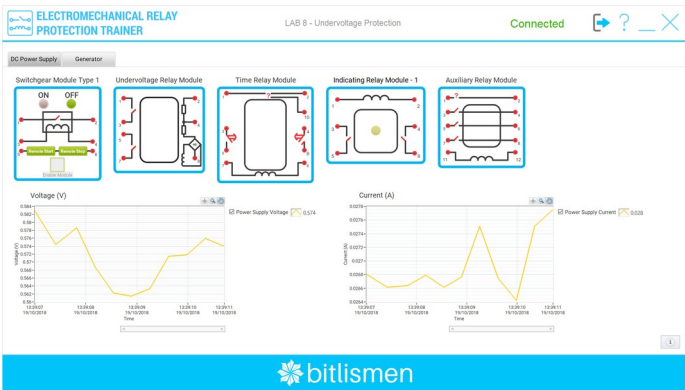
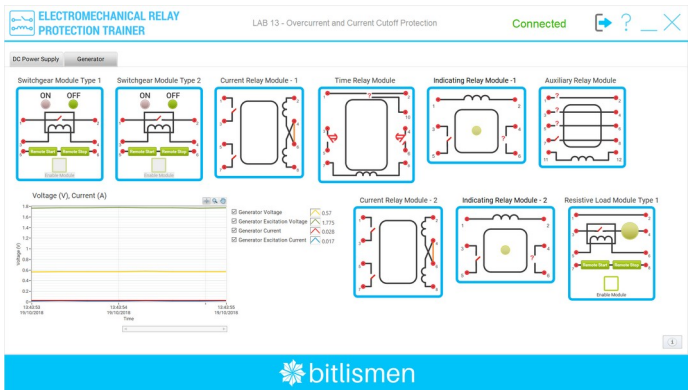
List of Experiments

- ✓ Indicating Relay
- ✓ Auxiliary Relay
- ✓ Time Relay
- ✓ Undervoltage Relay
- ✓ Overvoltage Relay
- ✓ Overcurrent Relay
- ✓ Reverse Power Protection (simulated)
- ✓ Undervoltage Protection
- ✓ Undervoltage Protection (with Generator)
- ✓ Overvoltage Protection
- ✓ Overvoltage Protection (with Generator)
- ✓ Under and Overvoltage Protection
- ✓ Under and Overvoltage Protection (with Generator)
- ✓ Overcurrent Protection
- ✓ Overcurrent Protection (with Generator)
- ✓ Current Cutoff Protection
- ✓ Current Cutoff Protection (with Generator)
- ✓ Overcurrent and Current Cutoff Protection
- ✓ Overcurrent and Current Cutoff Protection (with Generator)
- ✓ Thermal Relay Protection

Electromechanical Relay Protection Hardware Pictures



Electromechanical Relay Protection Software Screenshots



MICROPROCESSOR RELAY PROTECTION TRAINER

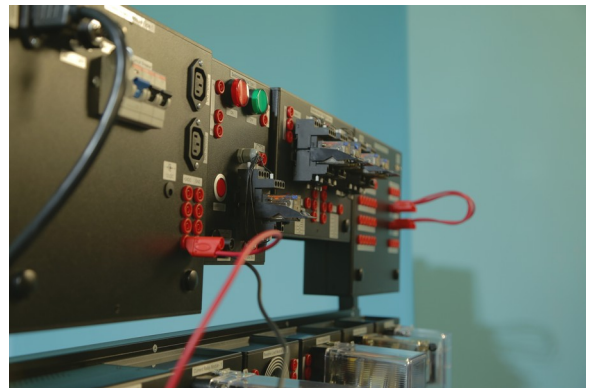
Overview

The Trainer is based on NI myRIO platform. It is a combination of different types of protection algorithms. This trainer allows to concentrate on different protection circuits and algorithms that are used in different points of real power network. It allows to investigate the logic behind every protection as well as adding new types of custom algorithms using graphical programming language LabVIEW.

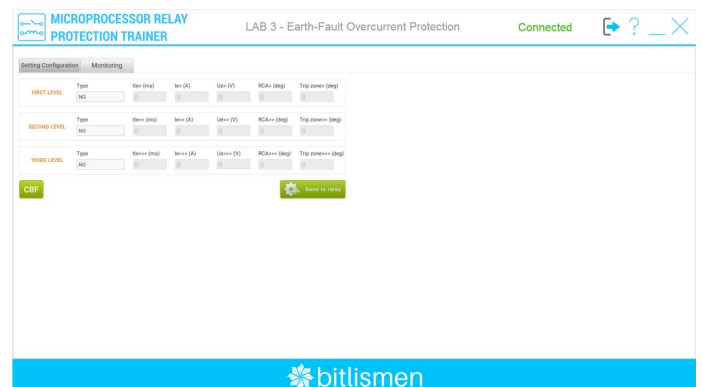
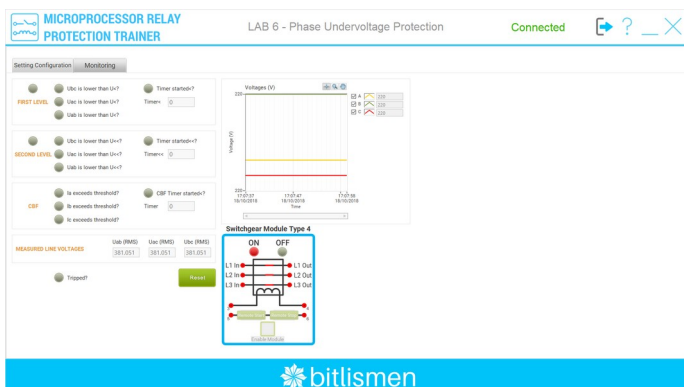
List of Experiments

- ✓ Three Phase Undercurrent Protection
- ✓ Three Phase Overcurrent Protection
- ✓ Earth-Fault Overcurrent Protection
- ✓ Voltage Controlled Overcurrent Protection
- ✓ Phase Overvoltage Protection
- ✓ Phase Undervoltage Protection
- ✓ Residual Overvoltage Protection
- ✓ Over/Under Frequency Protection
- ✓ Directional Power Protection

Microprocessor Relay Protection Trainer Hardware Pictures



Microprocessor Relay Protection Trainer Software Screenshots

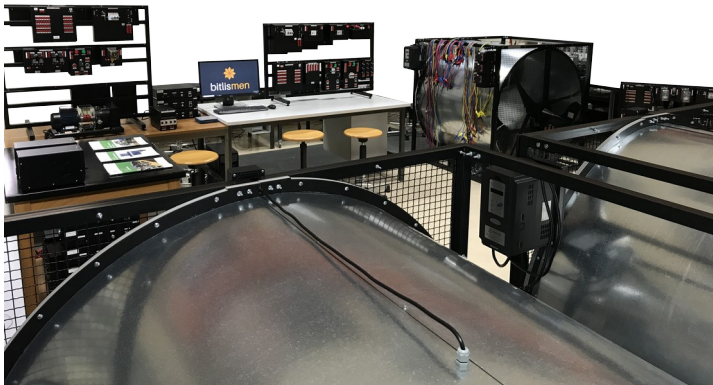


SMART GRID TRAINER

Overview

When having Power Labs Ecosystem Trainers, with a use of the Smart Grid Software it is possible to have a Smart Grid system.

The system allows to study the main concepts of smart grid, to explore its benefits and advantages in power network. The system includes a chain of power network (traditional, hydro, wind and solar power generations, power transmission and power distribution, etc.). The system is being monitored and controlled from the SCADA software.



Features

- ✓ Fault protection on generation plants
- ✓ Synchronization between generating plants
- ✓ Switching of generation sources in case of consumption increase (energy management)
- ✓ Power transmission monitoring and fault protection
- ✓ Power distribution monitoring, control and fault protection
- ✓ Remote control and monitoring of switchgears
- ✓ Automatic emergency control of switchgears
- ✓ Power consumption measurement and power quality analyses
- ✓ Power consumption tariffs
- ✓ Alarms & Event and Historical data Handling

Key Benefits

- ✓ Wind tunnel for real wind simulation
- ✓ Real solar panel with sun simulator
- ✓ Real hydro turbine with a pump for flow simulation
- ✓ Real 3-phase synchronous generator
- ✓ Transparent electromechanical relays
- ✓ Open source software platform for future modifications
- ✓ Low voltage usage to avoid shock to the users
- ✓ Advanced safety measures in the whole trainer to avoid damages due to incorrect terminations.

Required Trainers

- ✓ Traditional Power Generation
- ✓ Hydro Power Generation
- ✓ Solar Power Generation
- ✓ Wind Power Generation
- ✓ Power Transmission
- ✓ Power Distribution
- ✓ Electromechanical and Microprocessor Relay Protection
- ✓ Substation Automation

Smart Grid Software Screenshots and Hardware Pictures

