# Electric Power Technology Training Systems

Your future-proof foundation for
practical training in electrical engineering

FESTO

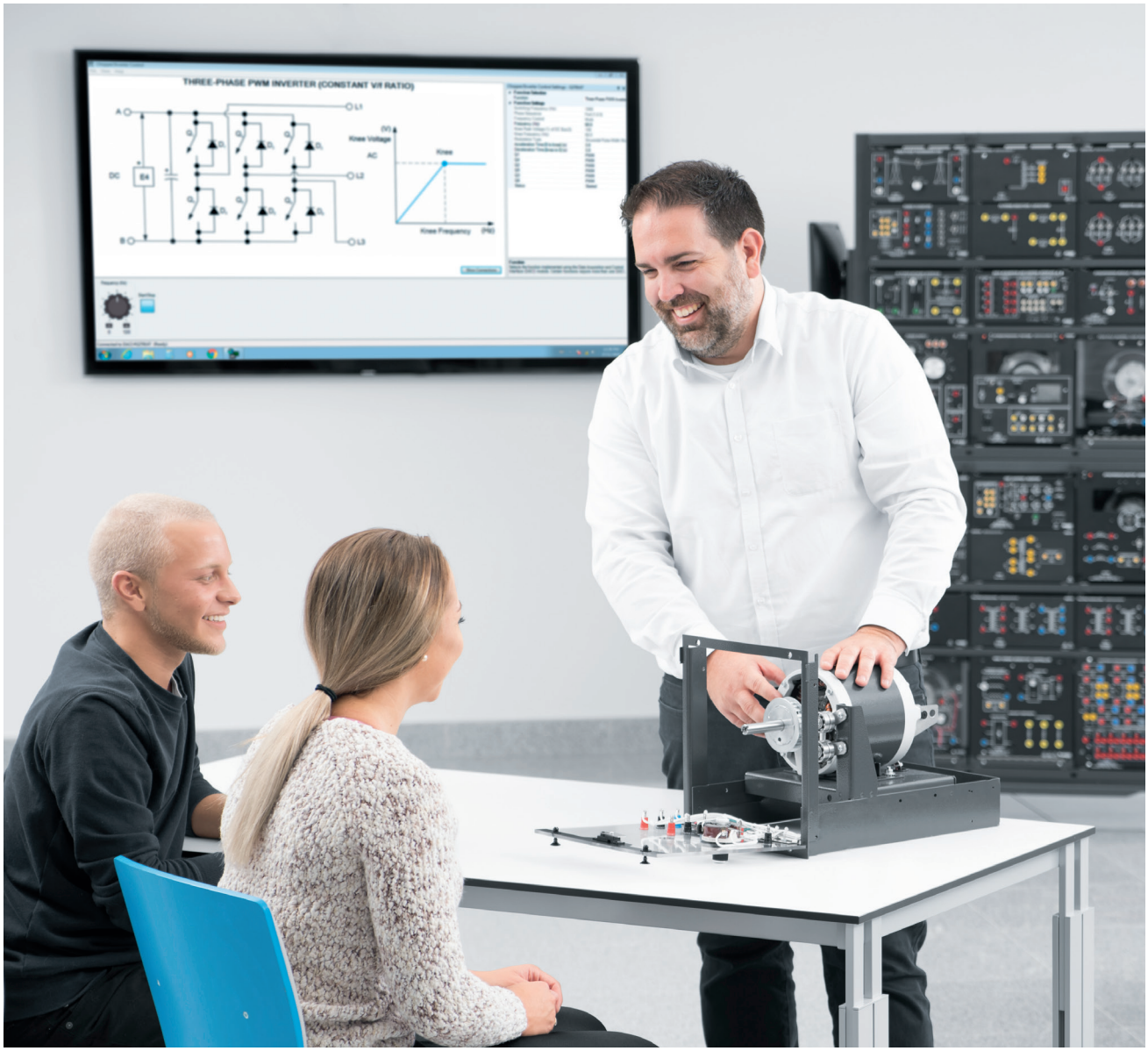
# Electricity is the essential necessity for a digitalized, interconnected world.

Current global challenges – such as urgent environmental concerns and rising energy costs – require us to rethink and transform the way we produce, transmit, distribute, store, and use energy in order to create a more energy-efficient and sustainable future. Accordingly, energy transition, electrification, eMobility, sustainability, energy efficiency, battery energy storage, and power grid modernization are key challenges to address.

Because of its versatility, cleanliness, and ease of control, electricity is used to power an increasing number of industrial, commercial, and domestic applications. Therefore, the already wide-ranging discipline of electrical engineering now intersects with a growing number of career paths – from electrical specialists to workers in other technical fields, directly impacting training and qualification requirements.

Consequently, electrical engineering and electrotechnology teachers are on the frontline when it comes to preparing an electrically skilled workforce to successfully tackle energy challenges, drive innovation, and implement required changes.

**These are inspiring times for teaching electrical engineering!**




## Share passion, foster talent in electrical engineering

The learning journey for engineering students generally begins in the lecture hall, but quickly progresses to hands-on experimentation – a key element in the knowledge acquisition and skill development process.

Experimentation can take place in various settings, and traditional lab facilities with physical systems are still predominant. But innovations in IT make distance learning, simulations, and remote access to hardware now possible.

So, how can you optimize practical training in electrical engineering? Our hands-on, versatile electric power technology training systems are the answer.

## Discover the...

Concept . . . . . 04
Courseware . . . . . 06
Hardware . . . . . 08
Software . . . . . 10
Examples . . . . . 12
Service . . . . . 13
Details . . . . . 14

# Your electrical engineering laboratory, your way

Stimulating environments are critical for supporting teaching and learning. Versatility is key, and it is what makes our electric power technology training systems the backbone of countless laboratories in technical schools, colleges, universities, research centers, and utility and industrial companies worldwide, all with differing requirements.

## A typical learning scenario

For any selected topic, students read through the theory provided in the courseware and become familiar with the practical experiments they will perform. During the lab session, they work with the hardware to implement the required electric power system. Software tools allow control of the hardware, manipulation of parameters, and data collection and analysis. If students don't have access to lab facilities, or simply want to prepare for a lab session, they can use the simulator. Students answer questions and take review quizzes. Finally, teachers are provided with answer keys to evaluate student work.

**Courseware**
Your selection of courses and exercises

**Hardware**
Your selection of workstations and modules

**Software**
Your selection of supporting computer tools

**Your customized training solution**

## Maximum modularity for maximum flexibility

Modularity is the guiding design principle for maximum flexibility; from modules to firmware functions, to turnkey courses and exercises.

+ Fulfill specific requirements and objectives
+ Upgrade your installations over time
+ Use the same hardware to teach several courses
+ Optimize floor space
+ Enjoy total freedom in the configuration of training systems and testbeds
+ Combine with complementary equipment to expand learning and research possibilities

## A benchmark platform

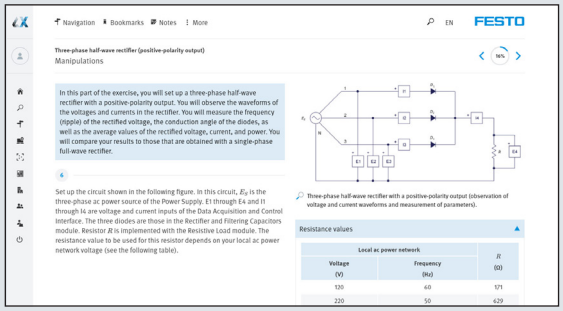
The concept of the electric power technology training solution was initially developed in the 1960s by Professor Théodore Wildi, a passionate Canadian electrical engineering teacher with an entrepreneurial spirit. He wanted to create an ideal lab facility for his students, but couldn't find equipment that lived up to his expectations. So, he decided to create his own training systems. Word quickly spread in the teaching community, and he soon began commercializing his systems.

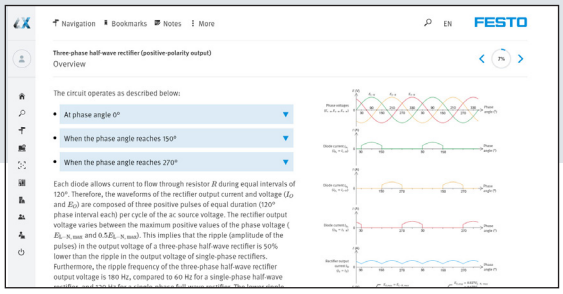
„ As a former teacher, I'm proud to continue the work of Professor Wildi to expand and keep it fully relevant for the next generation of students.“

Mathieu Plourde, professional engineer and product manager of electric power technology learning solutions, Festo Didactic

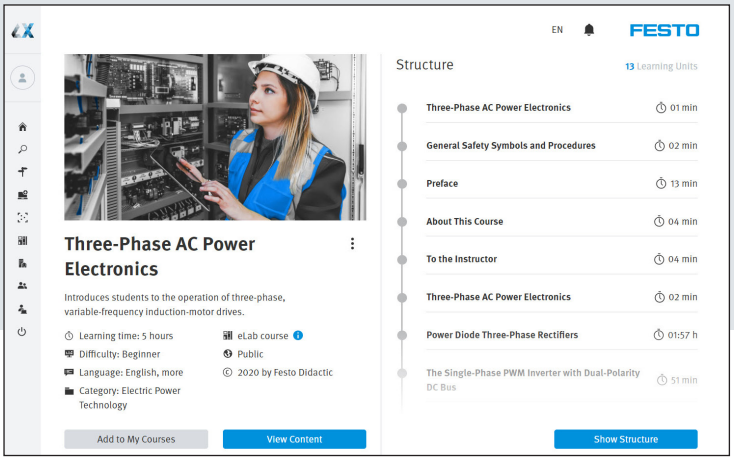
# A priority on learning content

The value of educational equipment is only fully realized by superior learning activities. It takes time for teachers to develop course planst, teaching material, and lab experiments; yet the fast pace of technological developments demands sustaining equally fast courseware updates and augmentations.




Our courses are available as eLab courses on Festo LX, the eLearning portal from Festo, or in PDF or print format. Shown: screens from the eLab course “Three-Phase AC Power Electronics.”




## Key program facts

Currently 44 courses
› 150 experiments
› 300 hours of lab experimentation
Categories:

- Basics of electric power
- Rotating machines
- Smart grid
- Power electronics
- Industrial controls
- Renewable energies

New courses are added regularly to keep pace with technological advances.

## A comprehensive, turnkey course program

A rich collection of courses systematically builds student knowledge and skills in electric power technology. Courses are organized in an increasingly complex order, beginning with fundamentals before moving on to more advanced topics.

The modularity of the courseware gives teachers full flexibility over its integration in their course plans. For example, they can choose complete learning paths; select specific topics to enhance existing courses; or even fully customize content to fit their own specific programs.

▶ See the list of available courses on page 14.

## Tried and tested learning activities

Each course has specific topic coverage, learning objectives, and a list of required hardware. Illustrated courseware conveys theory in a straightforward manner and accompanies students step-by-step through practical experiments for enhanced student autonomy during lab sessions.

Our educational and technical specialists follow a rigorous process, often involving experienced teachers in the early stages of course development to ensure maximal pedagogical relevance.

Our process for creating a new course around a new topic:

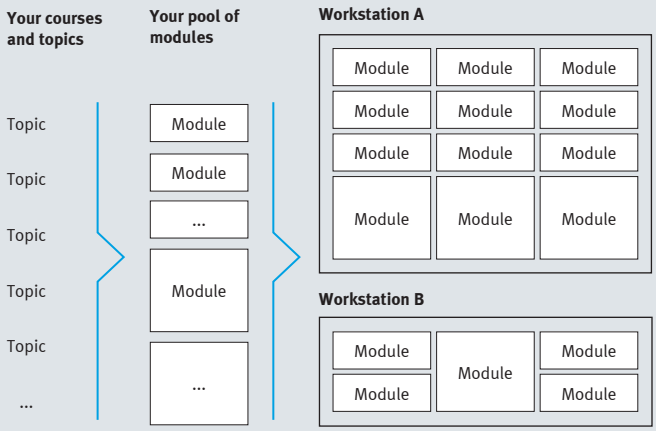
- Determine learning objectives and targeted competencies
- Develop optimal course structure
- Write theory and corresponding practical exercises
- Establish the learning solution model
- Select and design the equipment
- Fine-tune the course content

# A myriad of combinations for emulating electric power systems

The ability to insert a multitude of modules – motors, loads, filters, batteries, power supplies, inverters, transformers, controllers, etc. – into hands-on workstations, allows you to replicate a wide range of system topologies, from simple to complex applications. Wire the modules to create electrical circuits and start experimenting!

## Complete creative freedom

To equip your lab, you can select modules one by one or start with a pre-set, yet fully customizable, system. For example, the Power Electronics Training System can be expanded to study hydropower electricity generation and high-voltage DC transmission systems by purchasing a few additional modules. All modules can be used in various setups; this modular versatility avoids equipment duplication.




## Designed for education

Sturdy, enamel-coated, steel hardware is designed to endure years of lab usage. Open-frame construction enables the observation of components and facilitates repairs. Silk-screened electrical symbols provide clear component identification. Test points are accessible throughout the systems, and motors are oversized for greater pedagogical value.

## Safe

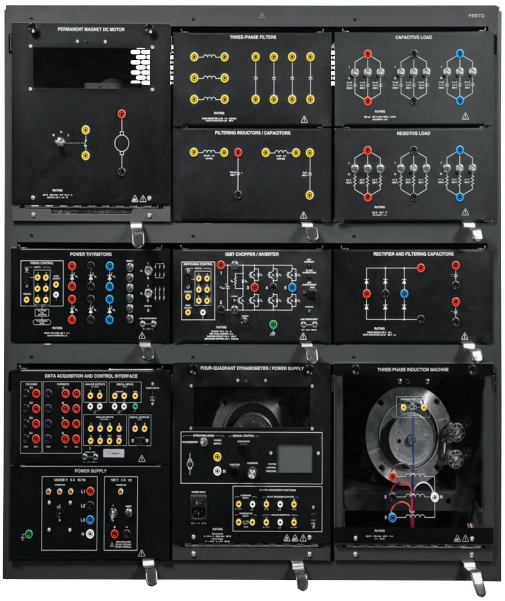
Live parts of the connection leads are concealed and insulated to avoid electric shock hazards, while lockable workstations integrate a grounding rail system for complete electrical safety. Safety procedures detailed in the workbooks instill safe work practices.

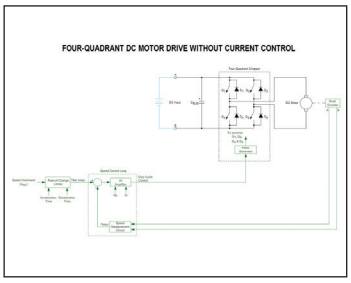
## High quality

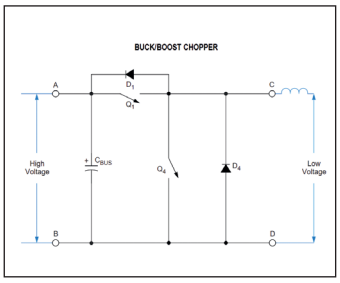
We produce and test all equipment in our own ISO-certified plant, according to strict quality standards. Most modules are equipped with a combination of protections against overcurrent, overheating, and/or overvoltage.

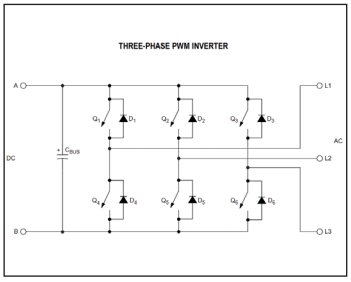
+ Equipment maintains precision and accuracy over time
+ Easy maintenance and repair
+ Enhanced service life
+ Minimized lab downtime
+ Smaller environmental footprint
+ Higher return on investment

▶ Popular system configurations and modules on page 15.





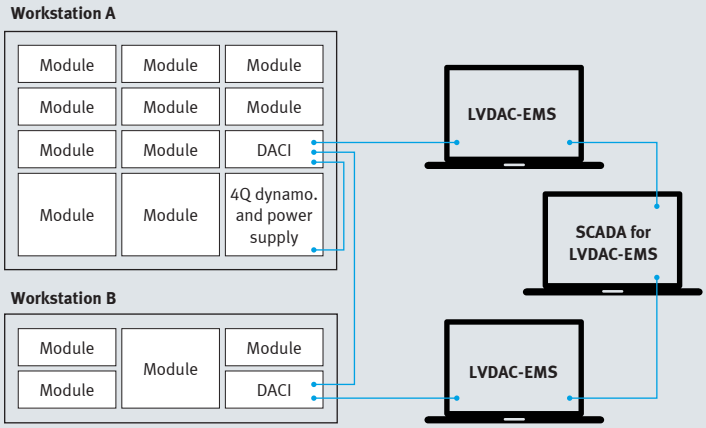

The Power Electronics Training System creates subject-relevant electrical systems to explore topics such as PWM inverters, buck-boost choppers, and four-quadrant DC motor drives.

# Added flexibility through technology

Digitalization transforms electrical engineering laboratories. New technologies offer more ways to increase the efficiency of hands-on sessions, facilitate data collection and analysis, decrease the need for accessories, make hardware more flexible, and allow for remote learning and training.

## Networkable, smart hardware

Two computerized modules – the Data Acquisition and Control Interface (DACI) and the Four-Quadrant Dynamometer/Power Supply – form the cornerstone of a digital electrical engineering lab based on our electric power technology training systems. These two modules are unparalleled allies for teaching and conducting experiments in electromechanics, power electronics, renewable energies, and power management.




## Instrumentation, data acquisition and control

Computer-based instrumentation decreases the need for physical measuring instruments and speeds up data processing. LVDAC-EMS, our free, multipurpose software, assists students during the experiments, providing access to the computerized control functions of the DACI and four-quadrant dynamometer, and offering a set of virtual instruments to measure, observe, analyze, and control electrical and mechanical parameters of a workstation.

## A SCADA system achitecture

Supervisory control and data acquisition (SCADA) has many applications in electric power technology. The software program, SCADA for LVDAC-EMS, uses the OPC server protocol to allow multiple workstations to be monitored and controlled over a local network from a supervisory computer.

▶ Download LVDAC-EMS for free → labvolt.festo.com

## Ready for remote lab scenarios

Computerized hardware and software enable remote control and operation of the physical training systems located in a laboratory. Contact us if you would like to offer such a training scenario.

## Simulation for distance learning or lab preparation

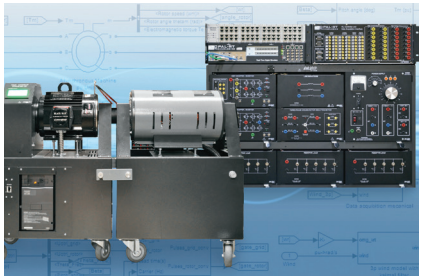
LVSIM-EMS simulates the electrical and mechanical characteristics of actual hardware modules, enabling students to perform experiments using virtual, interactive equipment that precisely reproduces the physical training systems. Students can set up a workstation, wire modules to create circuits, perform experiments, control hardware, and record measurements with the embedded LVDAC-EMS tools.

▶ Try the online version for free → lvsim.labvolt.com
▶ Watch videos to get started: → bitly.com/LVSIM-EMS-videos

# Get inspired!

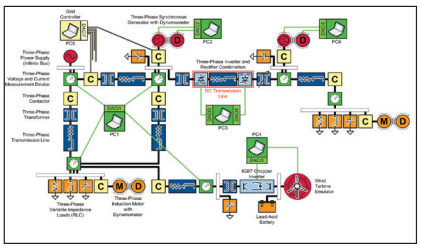
## Exploring the basics of electrical engineering

Designed for versatility and future expansion, the room shown here allows the study of fundamentals, such as electromechanical systems, industrial controls, and electrical machines, additionally providing an overview of topics related to the modernization of electrical networks: power electronics, smart grid power transmission, and domestic energy production.



## Add real-time prototyping and Hardware-in-the-Loop (HIL) scenarios

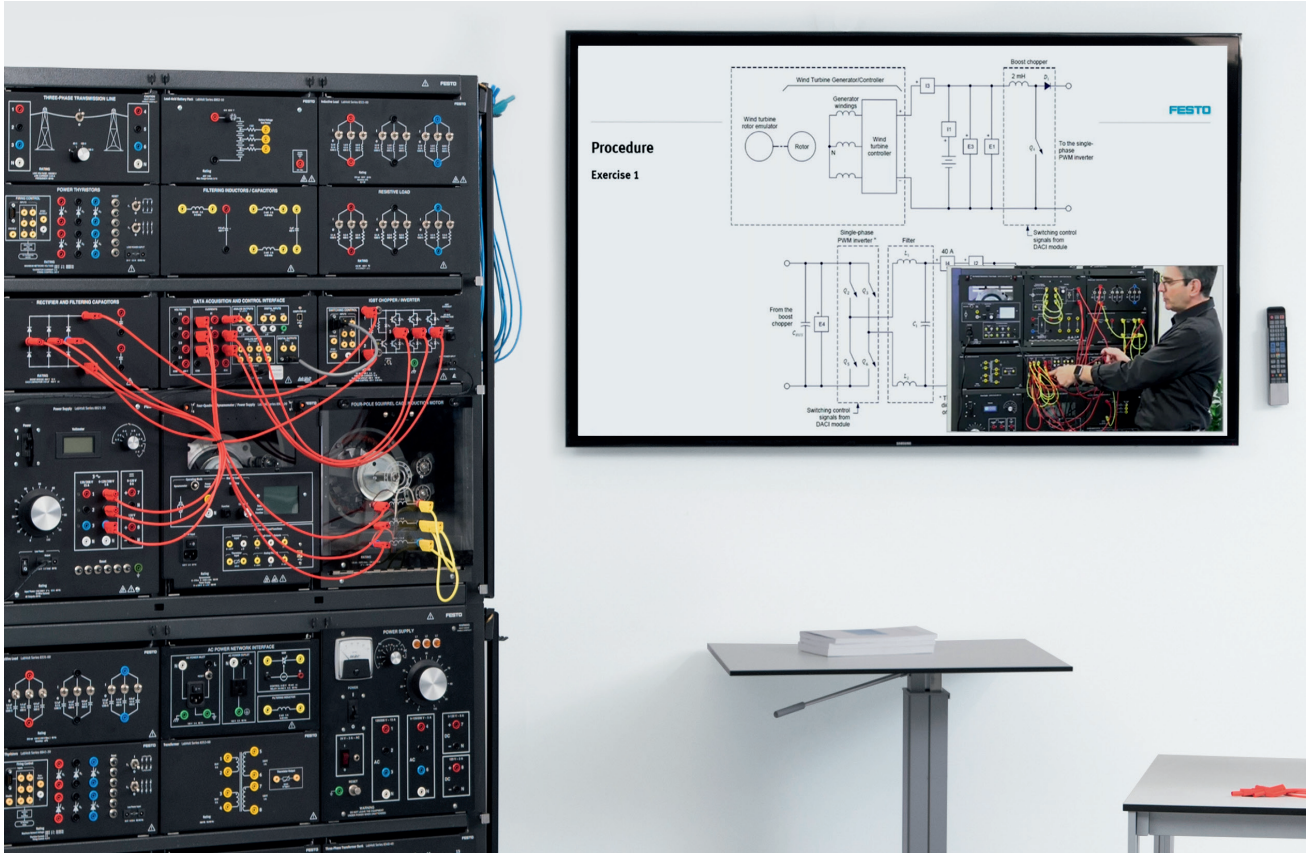
Our strategic partnership with Opal-RT resulted in the development of the “Real-Time HIL/RCP Laboratory,” a seamless integration of hardware and software designed to conduct experiments in the field of electrical machinery, power converters, and wind energy generation.→ bitly.com/ems-HIL-RCP-lab



## A compact, advanced power engineering and renewable energy lab

The Smart Electric Power System Lab at the Technical College of New Jersey, USA recreates a fully functional power grid with all its diverse components and technologies, allowing students to manipulate the parameters and topology of a physical power system. This system – three custom workstations – is the result of close cooperation with Dr. Anthony Deese and our engineering team. → bitly.com/ems-SEPS-lab

# For optimal returns on investment




## All the support you need to make your lab an ideal learning environment

Our service team strives to maximize the value of our products for teachers and learners, while minimizing equipment downtime.

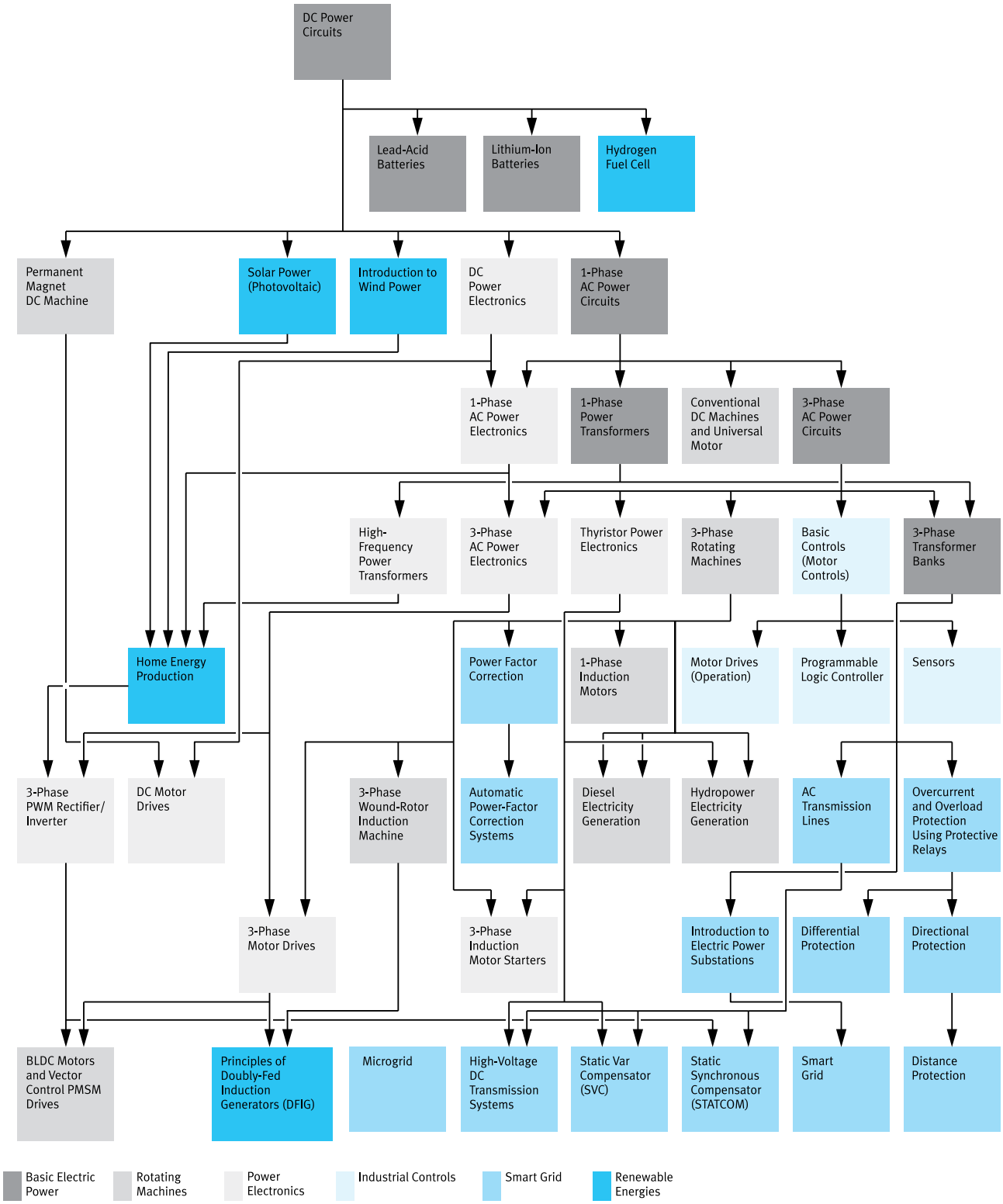
Training specialists offer “Train-the-trainer” sessions – conducted online or onsite at your facilities – to familiarize teachers and instructors with the hardware, software, and courseware. This training facilitates the introduction of the training systems into the classroom.

Room planning, as well as installation, commissioning, maintenance, and troubleshooting of your equipment, are among the many other services offered by our technical experts.

With the engineering department, production floor, and product management all under one roof, customer service promptly solves technical problems and offers a repair service at the factory. This synergy also enables us to customize solutions in order to answer special objectives and projects.

**Whenever you need support, we are just an email or a phone call away!**

# Courses of the electric power technology training program



# Pre-set systems, modules, and firmware functions

## Pre-set training systems*

- DC and AC Power Circuits (8010-1)
- Solar Power (8010-2)
- Small-Scale Wind Power Electricity Generation (8010-3)
- Lead-Acid Batteries (8010-4)
- Basic Renewable Energies (8010-5)
- DC Power Electronics (8010-6)
- Home Energy Production (8010-7)
- Hydrogen Fuel Cell (8010-8)
- Electromechanical Systems (8010-9)
- Power Electronics (8010-A)
- AC Power Transmission (8010-B)
- Smart Grid Technologies (8010-C)
- DFIG Principles (8010-D)
- Power Transmission Smart Grid Technologies (8010-E)
- Smart Grid (8010-F)
- Hydropower Electricity Generation (8010-G) **NEW**
- BLDC Motors and Vector Control PMSM Drives (8010-J) **NEW**
- Electric Power Substations (8010-K) **NEW**
- Numerical Protective Relays (8010-L) **NEW**
- Microgrid (8010-M) **NEW**
- Li-Ion Batteries (8010-N) **NEW**

* Pre-set systems combine necessary hardware and courseware to cover specific topics. They can also be combined and/or customized to answer specific training needs. The number in parentheses refers to the model number in the LV Series line.

## Modules**

**Loads and filters**
- Inductive Load
- Capacitive Load
- Resistive Load
- Electronic Load
- Filtering Inductors/Capacitors
- Three-Phase Filter
- Line Inductors
- Rectifier and Filtering Capacitors
- Traffic Lights

**Batteries, renewable energy**
- Lead-Acid Batteries
- Solar Panel Test Bench
- Lead-Acid Battery Pack
- Ni-MH Batteries
- Hydrogen Fuel Cell
- Monocrystalline Silicon Solar Panel

**Transformers, power transmission**
- Three-Phase Transmission Line
- SVC Reactors/Thyristor Switched Capacitors
- Three-Phase Transformer Bank
- Regulating Autotransformer
- Transformer
- Three-Phase Transformer

**Switching devices, power electronics**
- Insulated DC-to-DC Converter
- IGBT Chopper/Inverter
- Power Thyristors
- Synchronizing Module/Three-Phase Contactor
- Fault Module

**Motors, generators**
- DC Motor/GeneratorH
- Permanent Magnet DC Motor
- Wind Turbine Demonstrator
- Wind Turbine Generator/Controller
- Four-Pole Squirrel Cage Motor
- Universal Motor
- Three-Phase Wound Rotor Induction Machine
- Three-Phase Synchronous Motor/Generator
- Permanent Magnet Synchronous Machine
- Capacitor-Start Motor

**Protective relaying**
- Circuit Breakers and Disconnecting Switches
- Numerical Distance Relay
- Numerical Directional Overcurrent Relay
- Numerical Differential Protective Relay

**Power supplies, DACI**
- AC power Network Interface
- 24V AC Power Supply
- Three-Phase Power Supply
- Power Supply/Ethernet Switch
- Four-Quadrant Dynamometer/Power Supply (see available firmware functions)
- Data Acquisition and Control Interface (DACI) (see available firmware functions)

**Modules are described on our website, and new modules are added regularly.

## Firmware functions***

**Data acquisition and control interface module**
Computer-Based instrumentation, chopper/inverter, thyristor, home energy production, three-phase PWM rectifier/inverter, BLDC motor/PMSM, HVDC transmission system, SVC, synchronous generator, STATCOM, synchroscope, software development kit (SDK)

**Four-quadrant dynamometer and power supply module:**
Manual control, computer-based control, turbine emulator, lead-acid battery charger, Ni-MH battery chargers, solar panel emulator, software development kit (SDK)

***Firmware functions can be purchased individually or in packages.

# Three easy steps to turn your project into reality

Whether you plan to equip a new laboratory or to expand or update existing installations, we will guide you towards the creation of a perfectly-matched solution so that you get maximum returns on your investment.

**Step 1**
**Gather the project specifications.**
Which topics do you want to teach? What competencies do you want to foster? Who are your students? Write up all your requirements (space constraints, time frame, budget, remote/virtual options, etc.). List any existing lab equipment. Include your current needs, as well as those needs you can reasonably foresee.

**Step 2**
**Consult our website.**
Look at the course flowchart and identify your relevant topics. Then dive into some reading samples for detailed topic coverage. Explore popular system configurations to see how well they fit your needs – this is a good starting point for customization.

**Step 3**
**Seek inpiration and guidance.**
Over the years, we have been involved in thousands of educational endeavors of all scopes around the world. Our experience can fuel the success of your projects. We will guide you through the selection of hardware, software, and courseware to create a personalized offering.

**Ready?**
**Start here: labvolt.festo.com**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