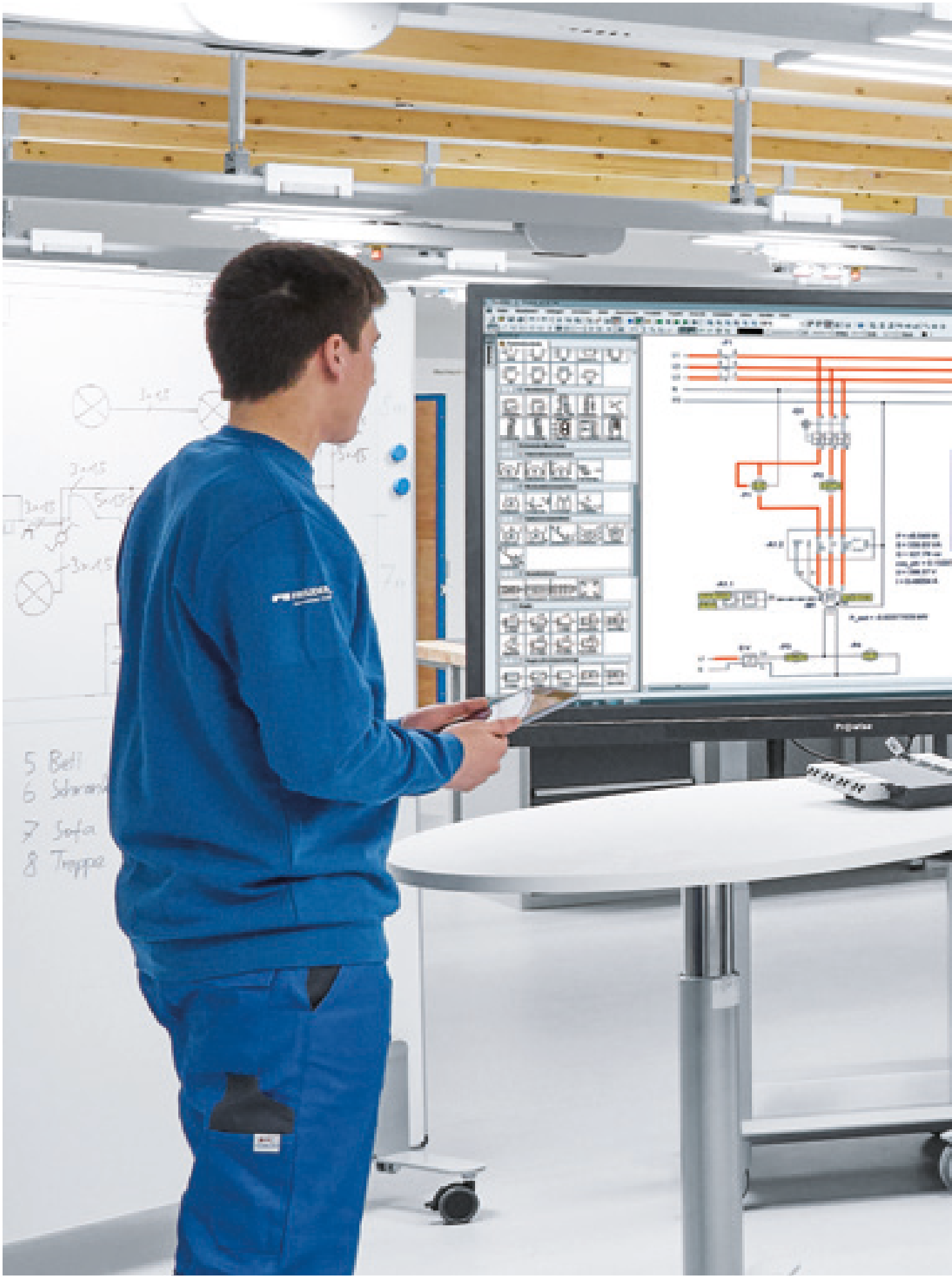
Electronics and Electrical Engineering

Learning solutions for basic and advanced training

FESTO



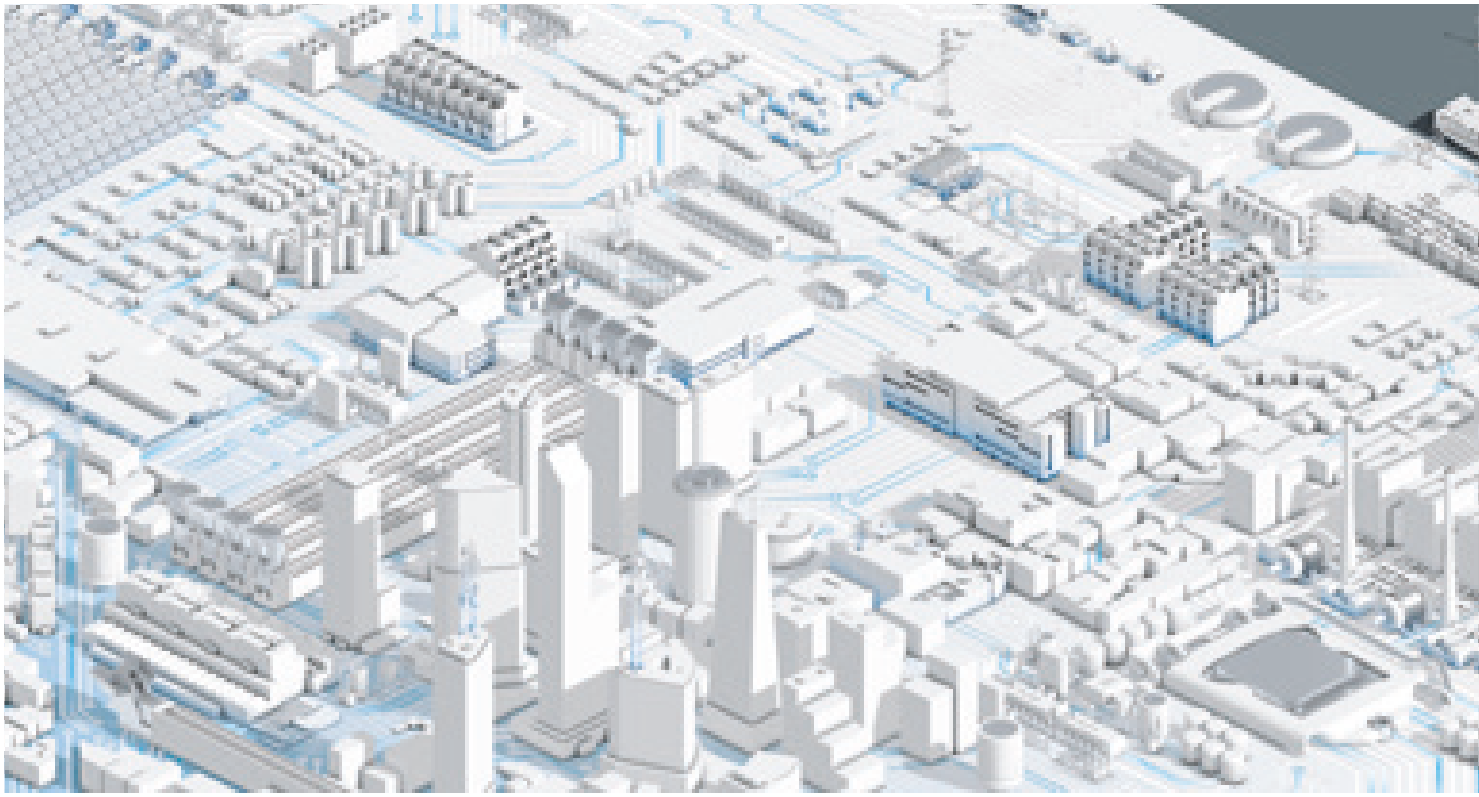
Content

CE

Some training solutions included in this product guide do not have a CE mark and cannot be ordered for delivery to Europe.

If you are located in a country where this marking is required, please contact your Festo sales representative before placing an order.

Discover a wide range of practical learning solutions in foundational technology fields …



Comprehensive solutions

Over the years, we have built a rich portfolio of learning solutions covering electrical engineering and electronics, justifiably, given their great importance in all areas of production, as well as process and factory automation.

The integration of the US-Canadian company Lab-Volt in 2014 further strengthened our expertise by adding new products specialized in electrical engineering, telecommunications, and electronics.

Modular design concepts

Instructors from all over the world have access to our broad spectrum of learning solutions. From self-contained training packages to full-fledged systems, modularity is the common denominator.

Modularity enables instructors to exactly match requirements and expand their solution over time, as needs evolve, without unnecessary duplication of equipment, optimizing the return on investment.

Safety rules!

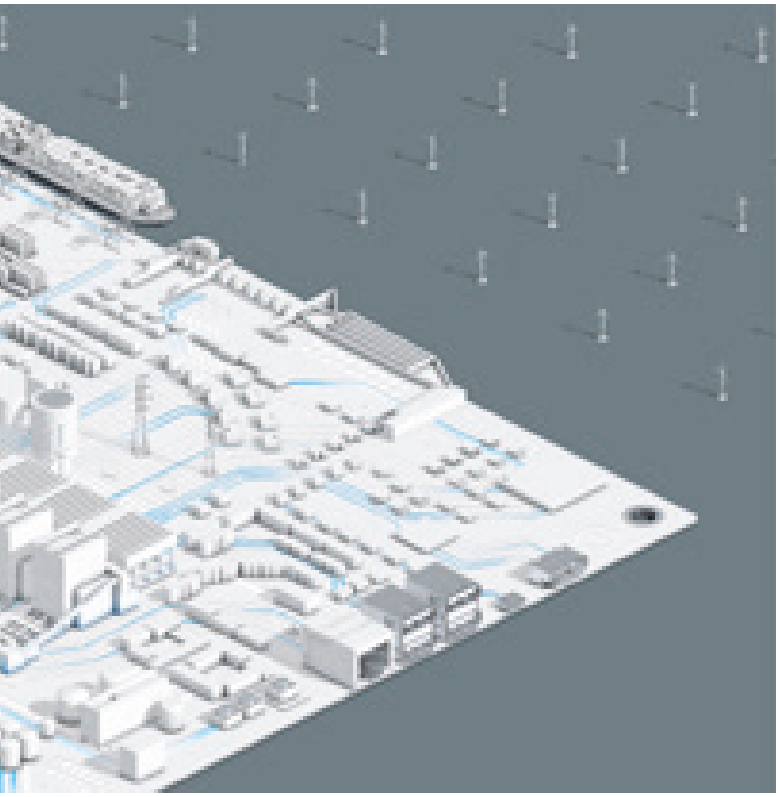
Electric currents can be hazardous and can cause damage or injury if not handled properly and carefully.

During the design phase of our learning systems, we paid special attention to safety features – from safe connection leads to new grounding methods – to avoid mishaps like electric shocks and short-circuits. Workbooks also tackle security procedures to instill safe work habits and techniques.

Success with seamless interconnection of learning methods

A broad array of products, including hardware, simulation software, web-based training products, and extensive curriculum, seamlessly interconnect to provide instructors with the most comprehensive, industrial-based training programs available worldwide.

… that answers extensive training requirements, from fundamentals to in-depth study of specialized topics



Qualification in foundational technologies

Electronics, electrical engineering, and telecommunications form the foundation of several technologies and important new topics, like renewable energies, Industry 4.0, and digitization in the industrial and domestic worlds.

Therefore, knowledge of these fundamental technologies – at varying degrees – is useful for a wide range of workers, and no longer strictly reserved for specialized occupations, like electrical engineers and electronics technicians.

Relevant and efficient learning solutions are key in the qualification of competent workers.

Learning solutions cover the following technology fields

Electricity and electronics learning solutions

Our FACET® electronics training system, and several training packages, help students learn electrical principles, electronic circuitry, and components. Solutions cover fundamentals, digital and communication electronics, and industrial electronics and electricity.

Electric power technology learning solutions

Our unique program in electric power technology addresses today's increasingly diversified training needs. Covered topics include electric machines and power circuits, motor controls and drives, power electronics, and renewable energies, as well as power generation, transmission, distribution, and protection.

Communications and radar technology learning solutions

This category encompasses training systems like satellite, microwave, antenna, digital and communications, and more. The systems are fully operational, enabling realistic learning in networks and protocols, baseband processing and modulation, transmission and propagation, and radar technology.

Holistic and Turnkey Training Solutions

Everything from a single source

Design, planning, and equipping of complete technology and training labs

Festo Didactic has set itself the goal of making learning even more effective, using its experience from 50 years of company history to develop learning solutions, as well as lab and workshop equipment, for the training sector.

We will support you with the conceptualization, planning, and equipping of your individual labs or workshops by means of a comprehensive range of learning systems and a broad spectrum of technologies in the area of technical training. Our range of products and services comprises complete learning systems, as well as industrial training and consultation.

The benefits for you

- Security during the planning process and professional consultation during the entire project
- State-of-the-art planning tools, as well as a range of products which are tailored to your requirements, ensure rapid and effective progress with projects
- Investment security and optimal utilization of laboratories customized for your training needs
- Professional lab design based on international standards
- State-of-the-art training equipment that combines Festo Didactic learning systems with products by other market leaders

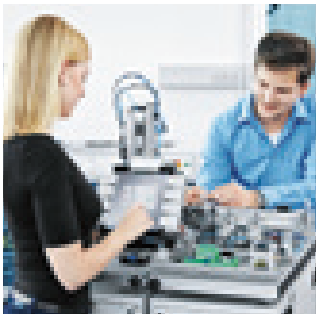
We offer a comprehensive scope of services, from project definition and conceptual planning, to installation of equipment and training for:
– Industrial training centers
– Vocational training centers
– Universities and colleges
– Sixth forms
– Advanced Placement (AP) courses
– Knowledge labs

Virtual Tour
➔ www.festo-turnkey-solutions.com

Effective learning environments for a positive learning experience

Essential technologies
Festo Didactic can develop customized mechatronics and automation training environment needs, such as:
– Electricity/Electronics and Drive Technology
– Virtual Mechatronics
– Partly Automated Systems
– Industry 4.0
– Fluidics
– Mechanical Engineering
– CAD/CAM/CNC

Electricity/Electronics and Drive Technology – Highlights
– Basic training packages as the very first step of education and training in Automation
– Ability to train in all aspects of Electricity and Electronics, including contact-based circuits and electrical drives
– Servo/stepper motors
– Connected Learning with Tec2Screen; an innovative learning methodology



Industry 4.0 – Highlights
– CP Factory with Industry 4.0 applications: CPS, RFID technology, NFC, Plug & Produce, standard interfaces, SOA, MES4 software, Augmented Reality
– CP Factory as a convertible factory with exceptional flexibility
– CP Factory Robot Cell for industrial robotics training

Flexible Room Concepts
Innovative workbenches

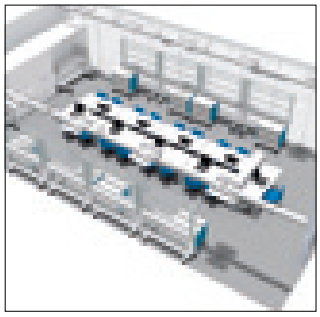
Equipping of learning rooms according to individual requirements

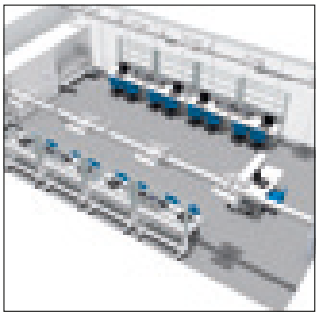
Flexible use of space
We will present you with an individual concept based on the spatial conditions and specific requirements of the location. In doing so, we will focus on cost-effective and optimal use of space, as well as multi-functional equipment. Training in the areas of electrical engineering, pneumatics, or mechatronics, as well as theoreti cal training or lectures, can take place in the same room. Using the ceiling system, industrial connectors, and universally mobile equipment, the room layout can be adapted in just a few minutes.

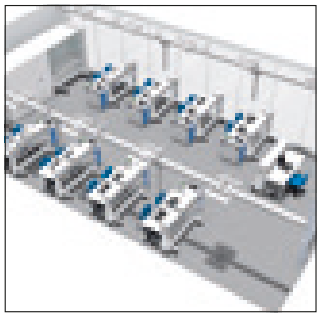
Efficient and versatile use of rooms saves space and cost.

The benefits for you
During the consultation you will profit from our years of experience not only with the training market, but also with installing various training centers, complete workshops, and labs. We will take into account the latest safety requirements, and our high quality standards guarantee a long service life.

We will be glad to provide an on-site concept and planning consultation.







Main components of room concept

Multi-functional teaching rooms
– Individual
– Flexible
– Cost-efficient

Our room concept offers individual options for your learning environment equipment. Mobile workbenches and utility supplies that you can fold back up into the ceiling ensure flexible and cost-efficient utilization of rooms.

Further information regarding flexible room concepts see:
→ www.festo-didactic.com

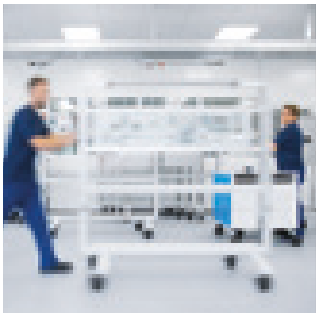
Storage
Both workbenches and equipment can be stored clearly and compactly in intelligent storage systems in the same room or in an adjoining room; an advantageous flexibility provided by our overall concept.

Workstation system
The mobile supports for the learning systems enable a high degree of flexibility with virtually unlimited options. The workbenches can be optimally adapted to any teaching situation, quickly and simply. This refitting option enables highly efficient space utilization, and therefore, the greatest possible cost efficiency and safety.

Power supply
The flexible ceiling system is a holistic concept for multi-functional rooms, which enables hands-on and theoretical teaching with appropriate utility supplies. With energy, compressed air, and a data connection directly at the learning location, the ceiling system is ideal for basic and specialized technical training.

Laboratory Furniture

Frameline
Mobile and flexible



The mobile solution

With the mobile workstation system, Frameline combines the Requirements of a highly flexible lab or classroom arrangement with multipurpose setup possibilities, such as electrical engineering and pneumatics trainings on the same furniture.

Space-saving
As the table legs are positioned at an angle to one another, the models can be set up back-to-back or parked one in front of the other in order to save space. This ensures that space is used as effectively as possible.

Flexible
Components with a range of different designs can be accommodated – whether they're an ER unit, a DIN A4 frame, or a profile plate. A mounting frame is available to suit all inserts.

Flexible tables
Frameline side tables provide a convenient and secure space for setting up devices and experiment materials. They provide extensive table space and ample leg room. Thanks to their sturdy, high-quality construction, the tables are guaranteed to be suitable for even strict requirements. They are also available with a fold-out table top for space-saving storage.

Safe storage
In keeping with the overall concept of flexibility, Frameline mobile containers provide storage furniture and a standing workstation all rolled into one.

The different models available provide a range of options for careful, logical storage of teaching materials and accessories.

As a result, the mobile container creates a structured workplace and saves time.

1 **Mobile Frameline, complete model without energy duct**
Mobile Frameline basic frame and setup with two DIN A4 lines and one ER line for individual lab and workshop design. Highly flexible and universal for basic and further technical training. Can be positioned back to back, space-saving storage of 3 frames compactly in a row at a depth of one meter also possible, including test setup. Compact design for extremely short setup times.
Dimensions (W x D x H):
1505 x 700 x 1953 – 2073 mm
Order no. **8075133**

2 **Frameline mobile folding table**
– Dimensions (W x D x H): 1500 x 700 x 750 mm, with four casters, two with parking brakes
– Table with four legs in accordance with DIN EN 1729, stable, welded design with light gray frame and legs made from precision profile steel tubing
– Maximum payload: 150 kg
– Folding tabletop for space-saving storage
– Tabletop with HPL coating
Order no. **8087150**

3 **Frameline, mobile container for A4 plates**
– Inside shelf, (W x D) 770 x 760 mm, with slotted mat at top and bottom providing two compartments for the storage of A4 plates
– Two hinged doors with 270° fittings, blue handles, and locking system
Order no. **8087154**

4 **Frameline, keyboard shelf**
For placement of computer keyboard and mouse.
– Bearing capacity 10 kg
– Supporting plate, 640 x 172 mm
– Swing arm length, 589 mm
– Swivel angle: 180°
– Tilt: 45°
Order no. **8087159**

5 **Frameline profile plate, 700 x 700 mm, removable**
– Slots in grid dimension 50 mm for fastening of Quick-Fix components
– Suspension for profile plate
– Profile plates can be stowed in the Frameline mobile container if required.
Order no. **8087160**

6 **Frameline mobile table**
– Dimensions (W x D x H): 1500 x 700 x 780 mm, with four casters, two with brakes
– Table with four legs in accordance with DIN EN 1729, stable, welded design with light gray frame and legs made from precision profile steel tubing
– Tabletop made from 25 mm, three-ply, quality chipboard E1 in accordance with DIN 68765, melamine resin coating in light gray, and additional overlay edges, with 3 mm ABS edge band, homogeneously sealed
– Table legs inwardly offset to be adapted to the Mobile Frameline
Order no. **8087149**

7 **Frameline, mobile container for motor test bench**
– Inside shelf, (W x D) 770 x 760 mm, with slotted mat at top and bottom providing two compartments: above for the storage of A4 plates, and below for the storage of motors and accessories
– Two hinged doors with 270° fittings, blue handles, and locking system
Order no. **8087156**

8 **Cable guide**
For a set of laboratory cables. Ensures that cables are kept neatly and in order. Dimensions (W x D x H):
150 x 136 x 63 mm
Order no. **535812**

9 **Frameline monitor mounting bracket**
Monitor folding arm, approx. length, 455 mm, including fall protection, max. weight 5 kg, infinitely adjustable in all directions.
Order no. **8087157**

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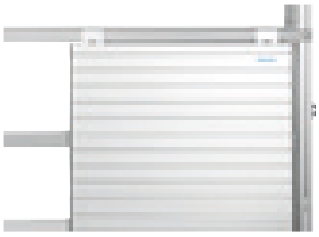

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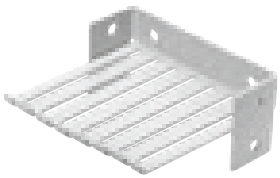

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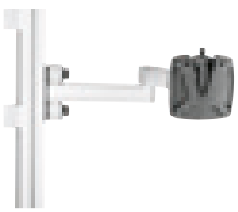

Stationary Learnline

Ergonomic and flexible

The stationary solution

With the stationary workstation system, Learnline combines the requirements for typical desk systems with high functionality. They provide ample desk space and legroom.

Move up into another dimension: profile columns as set-up space

Use the versatile profile columns as a set-up space, compatible with QuickFix, for equipment sets or for attaching additional components vertically.

Quality from Festo

We don't make compromises when it comes to quality. Workmanship and functionality are of the highest level.

The rigid design and the high-quality coating of the work surface and frame guarantee a long service life despite many stresses and strains. Learnline can handle the rigorous routine of everyday teaching.

1 **Basic stationary unit**
Stable and with a high-quality coating, the basic worktables are guaranteed to fulfill your high requirements. The height of the worktop ensures a comfortable working position when seated. For holding a mounting frame for profile plate set-up.
Dimensions: W 1512 x D 780 x H 760 mm
Order no. **535835**

2 **Mounting frame/Mounting sets for A4 mounting frame**
Versatile profile columns form the core of the Learnline system. They are used to mount the profile plate frame, to attach components, or as an alternative mounting surface for your training components. A4 mountings are mounted between the profile columns. Up to three rows of A4 mountings can be attached by means of two additional mounting sets for A4 mounting.
When mounting profile plates, order one mounting set per profile plate. When mounting A4 units, order one mounting set for A4 mounting for each additional row.
Mounting frame for A4 mounting frame
Order no. **8066141**
Mounting set for A4 mounting frame
Order no. **8065498**

3 **Cable guide**
For a set of laboratory cables. Ensures that cables are kept neatly and in order.
W 150 x D 136 x H 63 mm
Order no. **535812**

4 **Monitor bracket, short**
Monitor bracket for TFT and LCD monitors with drill holes in accordance with the VESA standard (distance between holes 75 x 75 mm or 100 x 100 mm).
– Short swivel arm for minimum distance to the mounting surface (approx. 8 cm)
– For mounting on Learnline mounting frames or fastening to a wall
– Rotatable up to 180°, tiltable up to 45°
– Supplied complete with mounting material
– Maximum load capacity 23 kg
Order no. **556292**

5 **Monitor bracket, long**
Monitor bracket for TFT and LCD monitors with drill holes in accordance with the VESA standard (distance between holes 75 x 75 mm or 100 x 100 mm)
– Long, telescopic, articulated arm for a large swivel angle
– Distance from mounting surface (approx. 8 – 38 cm)
– For mounting on Learnline mounting frames or fastening to a wall
– Rotatable up to 180°, tiltable up to 45°
– Supplied complete with mounting material
– Maximum load capacity 15 kg
Order no. **556293**

6/7/8 **Protective grounding for workbenches**
The products serve as protective grounding for workbenches as per the VDE 0100 standard. This is achieved by connecting accessible, conductive parts to each other by means of equipotential bonding conductors and by connecting all this to the PE conductor of the power supply.

6 **Grounding kit**
A grounding kit is required for connecting all conductive parts of one to two workbenches. The connector for the PE conductor of the power supply is included.
Order no. **8049368**

7 **Connection kit**
A connection kit is required for connecting a workbench to the PE conductor of the power supply.
Order no. **8049447**

8 **T connector for PE conductors**
A T connector lets you combine up to three PE conductors for connection to the power supply.
Order no. **8049442**

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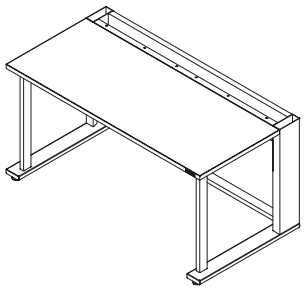

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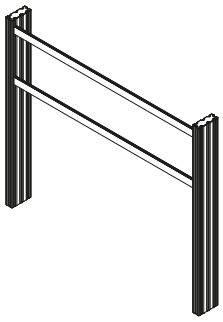

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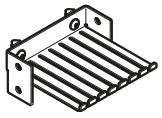

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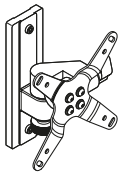

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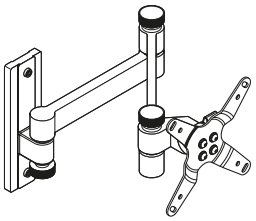

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Media

Digital learning

Multimedia learning aids for technical education and training

eLearning courses

Our eLearning courses are the perfect companion to traditional in-person learning, and offer an excellent introduction to fundamental technical topics.

The interactive multimedia structure enables students to work through the course topics on their own, thus offering scope for teachers, instructors and further training staff to be more flexible in how they structure their lessons and training sessions.

Additional practical examples and in-depth questions ensure a transfer of knowledge to the educational standards expected.

Our eLearning courses include spoken text to improve the learning process.

Connected Learning
Software and hardware, theory and practice, student and teacher – connected Learning promotes intuitive, interactive learning.

Our patented solution for Connected Learning: **Tec2Screen®**. Guaranteed fun, motivated learning!

Tec2Screen®
Our all-in-one device
- One device for everything: learning, measuring, open and closed-loop control, simulation, programming locations – in the teaching lab, on the go, at home, etc.
- Available everywhere: at digital learning at various locations – in the teaching lab, on the go, at home, etc.
- Present dry theory in an exciting multimedia format
- Get off to a flying start with the intuitive operating concept

Classroom Manager Vocational Training (VT)
The Classroom Manager Vocational Training learning management system manages all digital learning media such as Tec2Screen® courses, simulations, eLearning courses and self-made documents and materials in a central library. Trainers also have the option of preparing their own tests or questionnaires.

These learning media can be used by the trainer to create their own teaching units and assign them to the students individually according to their abilities.

The Classroom Manager VT also provides a clear and structured model of each student's learning progress. The system for continuously monitoring learning progress means you always have an overview of individual learning progress – allowing you to encourage and support the students very specifically.

Service package for Classroom Manager VT
- Initial provision of Classroom Manager VT for the purchased license level
- Training in a 30-minute expert webinar
- Adaptation of Classroom Manager VT to the corporate design of the customer (e.g. logo, colors)
- Extensive online help for the administrators
- Quarterly web sessions on innovations and functions of Classroom Manager VT

my|eCampus

myleCampus is an ideal solution whenever there is no separate learning management system available at the business or the functions of a learning management system (e.g. learning progress, user management) are not required to use the eLearning course.

At myleCampus you pass individual eLearning courses (no Tec2Screen courses/simulations are used). They are activated quickly and easily by means of a voucher in the self-created user account at myleCampus. The vouchers are valid for one year after activation.

System requirements
A permanent Internet connection and Flash Player or a corresponding browser plug-in are required to use the eLearning courses.

Visit our myleCampus at https://festo.my-e-campus.com/

my|eCampus
– You can find the order numbers for myleCampus vouchers on the detailed pages of the eLearning courses
– Valid for one year after activation
– Single use via myleCampus user account

Classroom Manager Vocational Training (VT)

Do you want to assign your students different training content, upload or create (external) training content and monitor your students' learning progress? Then the Classroom Manager Vocational Training learning management system is the right choice for you.

The new software as a solution cloud service offers a multitude of benefits: it doesn't need to be installed on or maintained within your own IT structure, the system updates are easy to install, and it can be accessed from anywhere. It also guarantees data security in accordance with the GDPR.

In the Classroom Manager VT, you can use both our eLearning courses and Tec2Screen® courses and simulations.

The Classroom Manager VT is available with a choice of license levels and subscription periods. The solution is thus rented for the term of the selected license.

License levels:
100 users at 10 workstations
200 users at 20 workstations
500 users at 50 workstations
1000 users at 100 workstations

Terms:
1 year
3 years
5 years

eLearning and Tec2Screen® courses must be ordered separately.

The service package for commissioning and customization must be included when ordering Classroom Manager VT for the first time.
– Initial provision of Classroom Manager VT for the purchased license level
– Training in a 30-minute expert webinar
– Adaptation of Classroom Manager VT to the corporate design of the customer (e.g. logo, colors)
– Extensive online help for the administrators
– Quarterly web sessions on innovations and functions of Classroom Manager VT

System requirements
A permanent Internet connection is required in order to use Classroom Manager VT.

Classroom Manager Vocational Training	8034067
Service package for Classroom Manager Vocational Training	8028154

Electrical protective measures

This interactive multimedia training program provides an introduction to the complex topic of protective measures. It explains what electrical protective measures are and how they are classified. Trainees will also become familiar with all the legal regulations in this area.

The measures that are effective in preventing direct and indirect contact are outlined using various specific examples and functional principles.

Finally, there is an explanation of how protective measures are tested and what actions should be taken in case of an accident involving electricity.

From the contents:
– The dangers of electricity
– Humans and electricity
– Electric shock hazards
– What are electrical protective measures and how are they classified?
– Protection levels
– Protective measures, protection classes
– Differences between DIN standards, VDE regulations and DIN-VDE standards, statutory requirements, and legal consequences.
– Definition and overview of protective measures to prevent direct contact
– Protection by insulating active components
– Protection by covering or cladding
– Protection by barriers
– Protection by distance
– Definition and overview of protective measures to prevent indirect contact
– Production by disconnecting power supply
– Mains systems (TN, TT, IT systems)
– Protection by disconnection
– Testing protective measures
– Measurement and measuring devices
– Safety and assistance
– Summary and questions to check understanding

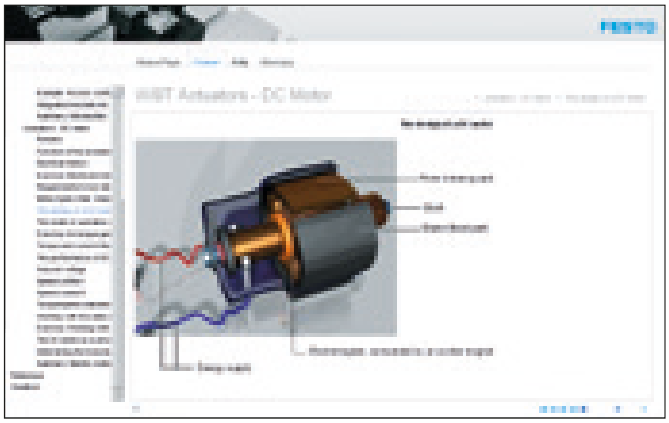
Single use via myleCampus
de/en/es/fr/zh

Order no.	**571118**

Licenses via Classroom Manager VT

Order no.	**8038116**

Actuators – DC motor



Using the everyday example of a car park access control system, the trainee learns the basics of a mechatronic system.

Building on this, the training program determines what function the actuators have in the controller. A DC motor is then studied in more detail as an example of a typical actuator, e.g., its structure and the laws which govern its operation. Further chapters cover speed control and the use of data sheets, as well as the transmission ratios which can be achieved by using a gearbox.

From the contents:
– The function of actuators in mechatronic systems
– Electric motors
– DC motor
– Torque and current
– Behavior of DC motors
– Induced voltage and speed control
– Characteristic torque/speed curve
– Working with data sheets
– Determining the transmission ratio

Single use via myleCampus
de/en/es/fr/el/zh

Order no.	**540953**

Licenses via Classroom Manager VT

Order no.	**8038124**

my|eCampus
– You can find the order numbers for myleCampus vouchers on the detailed pages of the eLearning courses
– Valid for one year after activation
– Single use via myleCampus user account

Classroom Manager Vocational Training
Provision of the eLearning and Tec2Screen courses in the following variants with the following terms:
– 100 users at 10 workstations
– 200 users at 20 workstations
– 500 users at 50 workstations
– 1000 users at 100 workstations
– 1 year, 2 years or 5 years

Electrical engineering 1

The “Electrical engineering 1” training program is one of a series of new programs in the field of electrical engineering and electronics. These programs are real-world oriented and authentically structured. Case studies from practice provide a concise illustration of the topicscovered. All training content is taught by means of audio clips. Additionally, the narrative text can be viewed on the sitemap.

Trainees experience a regular exchange of input and output, with phases of presentation and explanation alternating with phases of activity and interaction. This enhances motivation and learning.

Various tools are built-in to the training program, such as Excel worksheets, an integrated calculator, PDF files, and various downloads. The training programs contain both a comprehensive glossary and a full text search.

From the contents:
– Closed circuit
– Electrical conductivity
– Units and symbols
– Ohm’s Law
– Measuring in the circuit
– Voltage supplies
– The resistor as a component
– Series connection of resistors
– Parallel connection of resistors
– Voltage divider
– The resistor as a sensor
– Battery-powered screwdriver
– Measuring range extension
– Temperature controlled heating
– Level detection

A range of practical examples provide a reference point for real-world use:
– Battery-powered screwdriver (components and functions, voltage measurement, current measurement)
– Measuring range extension (voltage measurement, current measurement, high-voltage shunt)
– Temperature controlled heating (control diagram, switching on closed-loop controller, upper and lower switching value, controlled heating, switching value setting via potentiometer)
– Level detection (level detection with full and empty tank, test in operation)

Single use via myleCampus
de/en/es/fr/fi/et/sv/el/zh

Order no.	**549623**

Licenses via Classroom Manager VT

Order no.	**8038117**

Electrical engineering 2

The “Electrical engineering 2” training program is one of a series of new training programs in the field of electrical engineering and electronics. These programs are real-world oriented and authentically structured. Case studies from practice provide a concise illustration of the topics covered. All training content is taught by means of audio clips. Additionally, the narrative text can be viewed on the sitemap.

Various tools are built into the training program, such as Excel worksheets, an integrated calculator, PDF files and various downloads. The tratraining programs contain both a comprehensive glossary and a full text search.

From the contents:
– Electric charge
– Capacitor
– A capacitor in a DC circuit
– A capacitor in an AC circuit
– Applications of the capacitor
– Variable capacitor
– Coil
– A coil in a DC circuit
– A coil in an AC circuit
– Applications of the coil
– Physical variables
– Calculating with changing values
– Light switch-off delay
– Electrical behaviour of a grinder
– Power generation and transmission

A range of practical examples provide a reference point for real-world use:
– Light switch-off delay
– Electrical behaviour of a grinder (work, performance, efficiency)
– Power generation and transmission (generator 6 kV/10 kV, transformer 110 kV)

Single use via myleCampus
de/en/es/fr/fi/et/sv/el/zh

Order no.	**549626**

Licenses via Classroom Manager VT

Order no.	**8038118**

Electronics 1

The “Electronics 1” training program is one of a series of new programs in the field of electrical engineering and electronics. These programs are real-world oriented and authentically structured. Case studies from practice provide a concise illustration of the topics covered. All training content is taught by means of audio clips. Additionally, the narrative text can be viewed on the sitemap.

Trainees experience a regular exchange of input and output, with phases of presentation and explanation alternating with phases of activity and interaction. This enhances motivation and learning.

Various tools are built into the training program, such as Excel worksheets, an integrated calculator, PDF files and various downloads. The training programs contain both a comprehensive glossary and a full text search.

From the contents:
– Semiconductor technology
– Diodes
– Bipolar transistors
– Field-effect transistors

A range of practical examples provide a reference point for real-world use:
– Regulated power supply (transformer, rectifier, smoothing, voltage regulation by Zener diode, transistor amplifier, current limitation)
– Audio amplifier (components, FET preamplifier with volume controller, power end stage, loudspeaker with/without frequency shunt)
– Audio amplifier with sound control (preamplifier, power amplifier, low-pass, high-pass)

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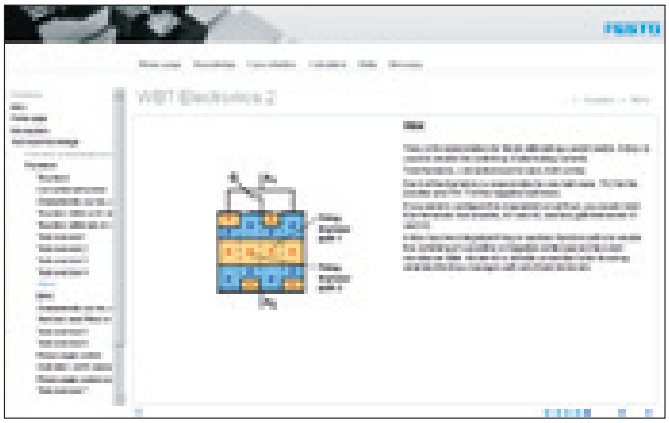
Order No. **549629**
Licenses via Classroom Manager VT
Order No. **8038119**

Electronics 2



The “Electronics 2” training program is one of a series of new programs in the field of electrical engineering and electronics. These programs are real-world oriented and authentically structured. Real case studies provide a concise illustration of the topics covered. All training content is taught using audio clips. Additionally, the narrative text can be viewed on the sitemap.

Various tools are built into the training program, such as Excel worksheets, an integrated calculator, PDF files and various downloads. The training programs contain both a comprehensive glossary and a full text search.

From the contents:
– Signal types
– Integrated circuits
– Operational amplifier (OpAmp)
– AC voltage of various frequencies
– Characteristic values of amplifying circuits
– Circuit technology of amplifiers
– Filters
– Bistable flip-flop
– Single flip-flop
– Sine wave generator
– Rectangle generator

A range of practical examples provide a reference point for real-world use:
– Thyristor-controlled drilling machine
– Brightness control using a triac
– Adjusting the speed of an electric screwdriver (linear, synchronous)

Single use via myleCampus
de/en/es/fr/fi/zh
Order No. **549632**
Licenses via Classroom Manager VT
Order No. **8038120**

my|eCampus
– You can find the order numbers for myleCampus vouchers on the detailed pages of the eLearning courses
– Valid for one year after activation
– Single use via myleCampus user account

Classroom Manager Vocational Training
Provision of the eLearning and Tec2Screen courses in the following variants with the following terms:
– 100 users at 10 workstations
– 200 users at 20 workstations
– 500 users at 50 workstations
– 1000 users at 100 workstations
– 1 year, 2 years or 5 years

Electric drives 1

The “Electric drives 1” interactive multimedia training program provides an engaging introduction to the world of electric motors.

The first section sets out the basic principles of electric drives. The second section illustrates the construction and functioning of DC motors, while the third section deals with the special features of AC motors.

From the contents:
– Basic principles of electric drives
– Familiarization with different motor types (stepper motor, asynchronous motor, universal motor)
– Mechanical principles (conversion of mechanical/electrical energy, motor - generator, circuit diagram and current direction, transmission variables (force, mechanical power, efficiency etc.), definitions of torque and speed)
– Electronic principles (basic principle of the motor, Lorentz force using the example of a conduction loop, electrical and magnetic fields, occurrence of torque, right-hand rule)
– Familiarization with different DC motors
– General (functional principles, commutation, technical data, brushless DC motor, load dependency, difference between series and parallel connection)
– Parallel connection behaviour
– AC motors
– Difference in power supply (DC, AC, three-phase AC)
– Familiarization with different AC motors
– General functional principle (difference between synchronous and asynchronous motor), technical data, rating plate, characteristic curves and their interpretation, definition of reactive, apparent, and effective power)
– Single-phase AC motor
– Three-phase AC motor special cases (stepper motors)
– Summary and review exercises

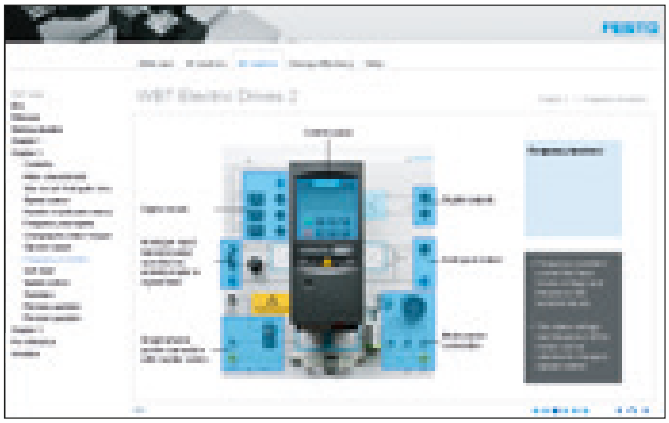
Single use via myleCampus
de/en/es/fr/zh

Order no.	**571120**

Licenses via Classroom Manager VT

Order no.	**8038125**

Electric drives 2



The training program “Electric drives 2” further explores the material covered in “Electric drives 1” and also includes new topic areas.

This training program is suitable for beginners and advanced students. The first two chapters address the topic of controlling DC and AC motors. The third chapter focuses on the energy efficiency of electric drives, looking at economic and environmental aspects.

From the contents:

Controlling DC motors
– Armature reaction
– Speed control
– Four-quadrant operation

Controlling AC motors
– Motor characteristic curve
– Open-loop and closed-loop speed control
– Frequency converters
– Smooth start-up

Energy efficiency
– Economic aspects
– Degree of efficiency
– Minimizing losses
– Reliability
– Energy efficiency measures
– Environmental aspects
– Merits of electric motors

Single use via myleCampus
de/en/es/fr/zh

Order no.	**573775**

Licenses via Classroom Manager VT

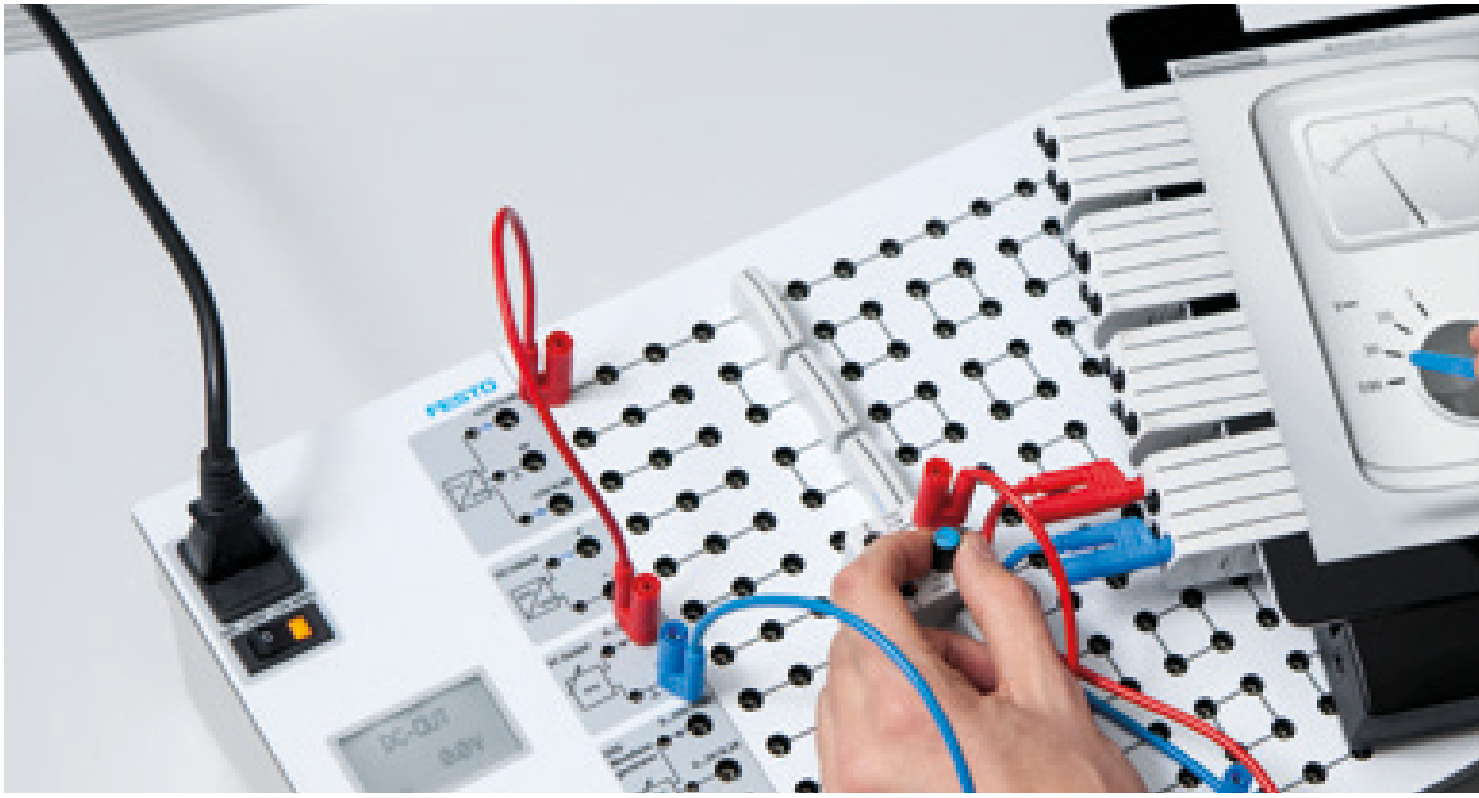
Order no.	**8038126**

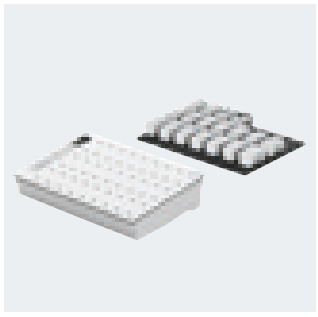
my|eCampus
– You can find the order numbers for myleCampus vouchers on the detailed pages of the eLearning courses
– Valid for one year after activation
– Single use via myleCampus user account

Classroom Manager Vocational Training
Provision of the eLearning and Tec2Screen courses in the following variants with the following terms:
– 100 users at 10 workstations
– 200 users at 20 workstations
– 500 users at 50 workstations
– 1000 users at 100 workstations
– 1 year, 2 years or 5 years

Tec2Screen®

Connected Learning for electrical engineering and electronics





The concept consists of:
– Tec2Screen® app
– Courses
– Simulations
– Connects
– Tec2Screen® hardware

You will also need Classroom Manager VT with the full range of learning management system functions, as this manages the Tec2Screen® system. You can also use the free Tec2Screen® Manager download without LMS functions.

Exciting courses for explorative learning
Videos, animations, measuring exercises, and test assignments inspire students to explore and discover. The measuring instruments integrated into the courses additionally make interactive troubleshooting exciting.

Completing the courses offline outside of the lab, is also possible, so that technical knowledge can be learned anywhere at any time.

Tec2Screen® courses
on the following main topics:

Direct Current Technology, e.g.
– Ohm's Law, Power, Work, Energy
– Resistors, Consumers

Alternating Current Technology, e.g.
– Characteristics
– RC Elements

Digital Technology, e.g.
– Basic Logic Functions
– Bistable Multivibrators

Understand the real world better thanks to simulations
As a component of modern training systems, the Tec2Screen® simulations can be used to test and simulate controllers and applications for PLC technology under realistic conditions. The new knowledge encourages practical and safe experimenting without real consequences or the need to purchase additional hardware.

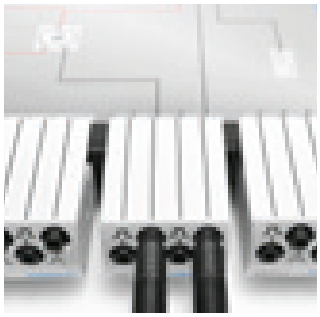
What actually is Connected Learning?

Learning methods which frequently supplement and support each other and include the following:
– Practical learning
– Classroom-based learning
– Self-learning

With **Connected Learning**, these methods are fused into a single form of learning. The virtual and the real world are seamlessly integrated. Software and hardware, theory and practice, learner and teacher – Connected Learning promotes intuitive, interactive learning.

Our patented solution for Connected Learning: **Tec2Screen®**. Fun and motivation while learning are guaranteed!

Overview of all Tec2Screen® courses at:
→ www.tec2screen.com

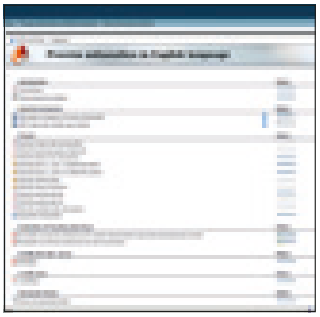


New interfaces: Connects
To explore the connection between the real and the virtual world, we have developed the Connects – plug-in interface modules with a patented interface. The Connects enable direct interaction between software and hardware, and thus direct interaction between theory and practice.

Unique: the signal flow is completely transparent and easy to follow.

The hardware
As a basic unit, the Tec2Screen® base links the iPad® with the patented Connects. The iPad® can also be used as a fully functional tablet, independently of the Tec2Screen®, in the classroom and elsewhere.

Festo Didactic won the 2015 iF Design Award for the Tec2Screen®.



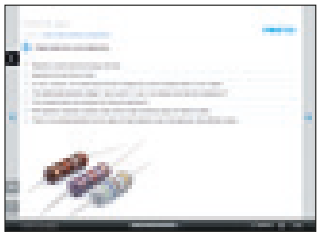
Tec2Screen Manager or …
Tec2Screen® Manager allows you to use the courses and simulations on your iPad® and for offline learning.

Tec2Screen® Manager is available for the 20 user/20 workstation license level.

… the learning management system
The Classroom Manager VT manages courses and simulations, as well as self-made documents and materials. The trainer assigns these to the students individually and can simultaneously record their learning progress.

Tec2Screen® courses

Direct current technology



Direct Current Technology

Ohm's Law, Power, Work, Energy

Training content
Basic electrical variables
– Voltage, current, charge
– Measuring voltage and current

Ohm's law
– Deriving Ohm's law from measurements and applying it
– The resistor as a component: designs, value ranges, color coding

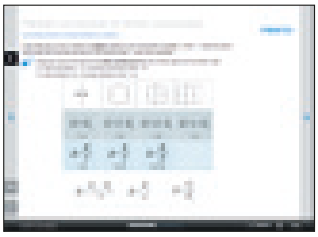
Power, work, energy
– Learning about the terms power and work and how to calculate them
– Calculating costs when using electrical energy

Required Connects
– 2x Multimeter Connect
– 1x Analog In Connect

For Classroom Manager VT
Order no. **8028129**
For Tec2Screen® Manager
Order no. **8118217**

The accessories mentioned below are required to conduct the courses.

– 1x Equipment set TP 1011 Fundamentals of electrical engineering/ electronics



Direct Current Technology

Resistors, Consumers

Training content
Connecting ohmic resistors/ consumers in series
– Laws governing the series connection of ohmic consumers
– Calculating components and equivalent resistances
– Line resistances and voltage drop
– Series resistors for bulbs or LEDs

Connecting ohmic resistors/ consumers in parallel
– Laws governing the parallel connection of ohmic consumers
– Calculating components and equivalent resistances
– Power ratings of voltage sources

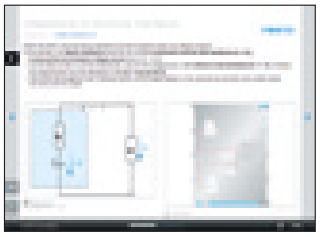
Mixed circuits
– Practice: Deriving laws from measurements
– Kirchhoff's second law
– Kirchhoff's first law
– Resistor networks
– Potentials and potential differences

Required Connects
– 1x Multimeter Connect
– 1x Analog In Connect

For Classroom Manager VT
Order no. **8034077**
For Tec2Screen® Manager
Order no. **8118219**

The accessories mentioned below are required to conduct the courses.

– 1x Equipment set TP 1011 Fundamentals of electrical engineering/ electronics



Direct Current Technology

Voltage Sources, Adaptations

Training content
Voltage sources: series connection
– Internal resistance
– Load conditions

Voltage sources: parallel connection
– Even and uneven voltage
– Even and uneven internal resistances
– With and without load resistance

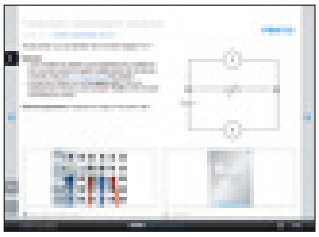
Adaptations
– Interfaces between electrical circuits
– Voltage adaptation
– Power adaptation
– Current adaptation

Required Connects
– 2x Multimeter Connect
– 1x Analog In Connect

For Classroom Manager VT
Order no. **8034079**
For Tec2Screen® Manager
Order no. **8118221**

The accessories mentioned below are required to conduct the courses.

– 1x Equipment set TP 1011 Fundamentals of electrical engineering/ electronics



Direct Current Technology

Capacitors, Parameter-Dependent Resistors, Measuring

Training content
Capacitors in DC circuits
– Functional principle and designs
– Calculating capacitance
– Permittivity and dielectric properties
– Electrolytic capacitors
– Charge and discharge curves
– Typical applications
– Series and parallel connection
– Capacitors as energy storage devices

Parameter-dependent resistors
– Non-linear, voltage-dependent, temperature-dependent, light-dependent resistors
– Characteristics, applications, characteristic curves
– Components for protective circuits, alarm systems

Measuring and measuring errors
– Multimeters: designs, safety, resolution, accuracy
– Direct and indirect measuring of resistance values
– Measuring circuits and measuring errors

Required Connects
– 2x Multimeter Connect
– 1x Analog In Connect

For Classroom Manager VT
Order no. **8034078**
For Tec2Screen® Manager
Order no. **8118219**

The accessories mentioned below are required to conduct the courses.

– 1x Equipment set TP 1011 Fundamentals of electrical engineering/ electronics

Tec2Screen® courses
Alternating current technology

Alternating Current Technology

Characteristics

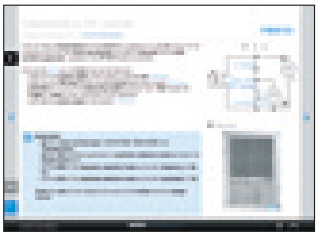
Training content
– Generation of alternating current
– Signal shapes (sine, rectangular, triangular, sawtooth)
– Presentation forms: Pointer diagram and linear representation
– Frequency, period, amplitude, momentary values
– Current intensity and power (without phase shift)

Required Connects
– 1x Analog In Connect

For Classroom Manager VT
Order no. **8028116**
For Tec2Screen® Manager
Order no. **8118222**

The accessories mentioned below are required to conduct the courses.

– 1x Equipment set TP 1011 Fundamentals of electrical engineering/ electronics
– 4 mm Safety laboratory cables



Alternating Current Technology

Capacitors I

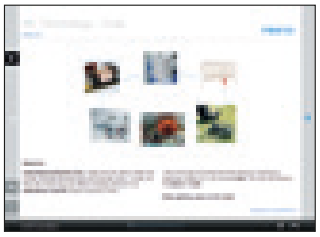
Training content
– Charging and discharging with rectangular voltage
– Measuring voltage and current at the capacitor with an oscilloscope
– Measuring and calculating phase shift of sine signals
– Frequency-dependent reactance
– Direct and indirect measuring procedures
– Power types at the capacitor with alternating current
– Calculating reactive power

Required Connects
– 1x Analog In Connect

For Classroom Manager VT
Order no. **8074467**
For Tec2Screen® Manager
Order no. **8118223**

The accessories mentioned below are required to conduct the courses.

– 1x Equipment set TP 1011 Fundamentals of electrical engineering/ electronics
– 4 mm Safety laboratory cables



Alternating Current Technology

Coils

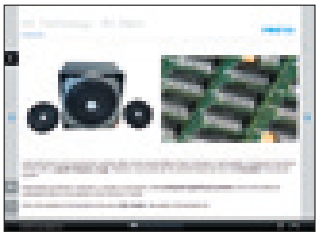
Training content
– Application ranges, types and applications of coils
– Electromagnetism
– Types of electromagnetic induction
– Measuring voltage and current of a coil with the oscilloscope
– Measuring and calculating phase shift of sine signals
– Measuring and calculating frequency-dependent reactance
– Calculating reactive power
– Calculating inductance
– Constructive influencing variables of an inductance

Required Connects
– 1x Analog In Connect

For Classroom Manager VT
Order no. **8074469**
For Tec2Screen® Manager
Order no. **8118224**

The accessories mentioned below are required to conduct the courses.

– 1x Equipment set TP 1011 Fundamentals of electrical engineering/ electronics
– 4 mm Safety laboratory cables



Alternating Current Technology

RC Elements

Training content
– Resistor for alternating current: ohmic, capacitive and inductive resistors
– Phase shift
– Design and function of a low-pass filter
– Design and function of a high-pass filter
– Cut-off frequency of a filter

Required Connects
– 1x Analog In Connect

For Classroom Manager VT
Order no. **8034082**
For Tec2Screen® Manager
Order no. **8118225**

The accessories mentioned below are required to conduct the courses.

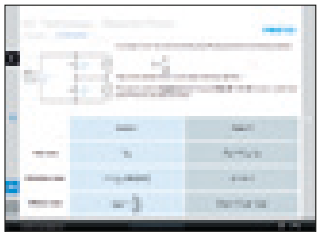
– 1x Equipment set TP 1011 Fundamentals of electrical engineering/ electronics
– 4 mm Safety laboratory cables

Tec2Screen® Manager
Free of charge as a download when ordering a course.

Available license level:
– 20 users at 20 workstations

Classroom Manager Vocational Training
Learning management system, subject to a fee
Available license levels:
– 100 users at 10 workstations
– 200 users at 20 workstations
– 500 users at 50 workstations
– 1000 users at 100 workstations
Available terms:
– 1 year
– 3 years
– 5 years

Tec2Screen® courses
Alternating current technology



Alternating Current Technology

Electric Power

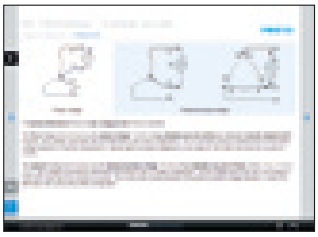
Training content
– Measuring and calculating effective power
– Capacitive and inductive reactive power
– Apparent power
– Phase shift φ (phi) between active and reactive power
– Power factor: Ratio between the active power and the apparent power
– Reactive power using electric motor as an example

Required Connects
– 1x Analog In Connect

For Classroom Manager VT
Order no. **8034084**
For Tec2Screen® Manager
Order no. **8118226**

The accessories mentioned below are required to conduct the courses.

– 1x Equipment set TP 1011 Fundamentals of electrical engineering/ electronics
– 4 mm Safety laboratory cables



Alternating Current Technology

Three-Phase Systems

Training content
– Generating three-phase current
– Presenting three-phase alternating current
– Star and delta circuits in generators and consumers
– Standardized casing colors for three-phase wires
– Circuit symbols
– Phase voltage and phase-to-phase voltage
– Concatenation factor (ratio of phase voltage to phase-to-phase voltage)
– Phase shift

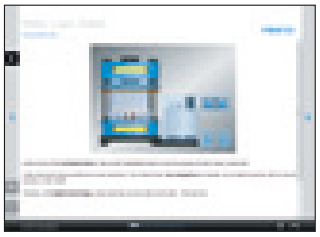
Required Connects
– 1x Analog In Connect

For Classroom Manager VT
Order no. **8034085**
For Tec2Screen® Manager
Order no. **8118227**

The accessories mentioned below are required to conduct the courses.

– 1x Equipment set TP 1011 Fundamentals of electrical engineering/ electronics
– 4 mm Safety laboratory cables

Tec2Screen® courses
Digital technology



Digital Technology

Basic Logic Functions

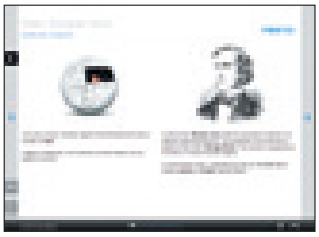
Training content
– Statements and variables
– Truth tables
– AND function
– OR function
– NOT function
– XOR function
– NAND function
– NOR function

Required Connects
– 2x Digital I/O TTL (5 V) Connect

For Classroom Manager VT
Order no. **8046971**
For Tec2Screen® Manager
Order no. **8118212**

The accessories mentioned below are required to conduct the courses.

– 1x Equipment set TP 1012 Basic principles of digital technology
– 2 mm Safety laboratory cables
– 4x 4 mm – 2 mm safety measuring adapter



Digital Technology

Boolean Laws

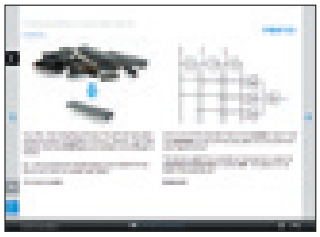
Training content
Boolean laws
– Commutative law
– Associative law
– Distributive law
– De Morgan's laws
Simple Boolean relationships

Required Connects
– 2x Digital I/O TTL (5 V) Connect

For Classroom Manager VT
Order no. **8046972**
For Tec2Screen® Manager
Order no. **8118213**

The accessories mentioned below are required to conduct the courses.

– 1x Equipment set TP 1012 Basic principles of digital technology
– 2 mm Safety laboratory cables
– 4x 4 mm – 2 mm safety measuring adapter



Digital Technology

Disjunctive and Conjunctive Normal Form

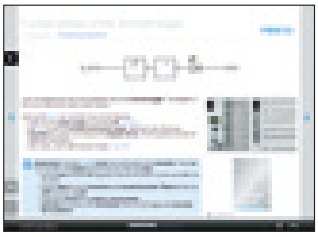
Training content
– Optimising logic circuits
– Disjunctive normal form
– Conjunctive normal form
– Karnaugh maps

Required Connects
– 2x Digital I/O TTL (5 V) Connect

For Classroom Manager VT
Order no. **8046973**
For Tec2Screen® Manager
Order no. **8118214**

The accessories mentioned below are required to conduct the courses.

– 1x Equipment set TP 1012
  Basic principles of digital technology
– 2 mm Safety laboratory cables
– 4x 4 mm – 2 mm safety measuring adapter



Digital Technology

Schmitt Triggers, Astable and Monostable Multivibrators

Training content
Schmitt trigger
– Function and application, e.g. distorted signals
– Trigger levels and hysteresis
– Characteristic curves
– Debouncing switches

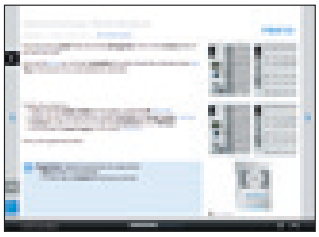
Astable and monostable multivibrators
– Function and application
– Edge control
– Retriggerability

Required Connects
– 2x Digital I/O TTL (5 V) Connect

For Classroom Manager VT
Order no. **8046991**
For Tec2Screen® Manager
Order no. **8118215**

The accessories mentioned below are required to conduct the courses.

– 1x Equipment set TP 1012
  Basic principles of digital technology
– 2 mm Safety laboratory cables
– 4x 4 mm – 2 mm safety measuring adapter



Digital Technology

Bistable Multivibrators

Training content
– Asynchronous multivibrators
– State-controlled synchronous multivibrators
– Edge-triggered synchronous multivibrators
– RS flip-flop, D flip-flop, JK flip-flop, T flip-flop, JKMS flip-flop

Required Connects
– 2x Digital I/O TTL (5 V) Connect

For Classroom Manager VT
Order no. **8046994**
For Tec2Screen® Manager
Order no. **8118216**

The accessories mentioned below are required to conduct the courses.

– 1x Equipment set TP 1012
  Basic principles of digital technology
– 2 mm Safety laboratory cables
– 4x 4 mm – 2 mm safety measuring adapter

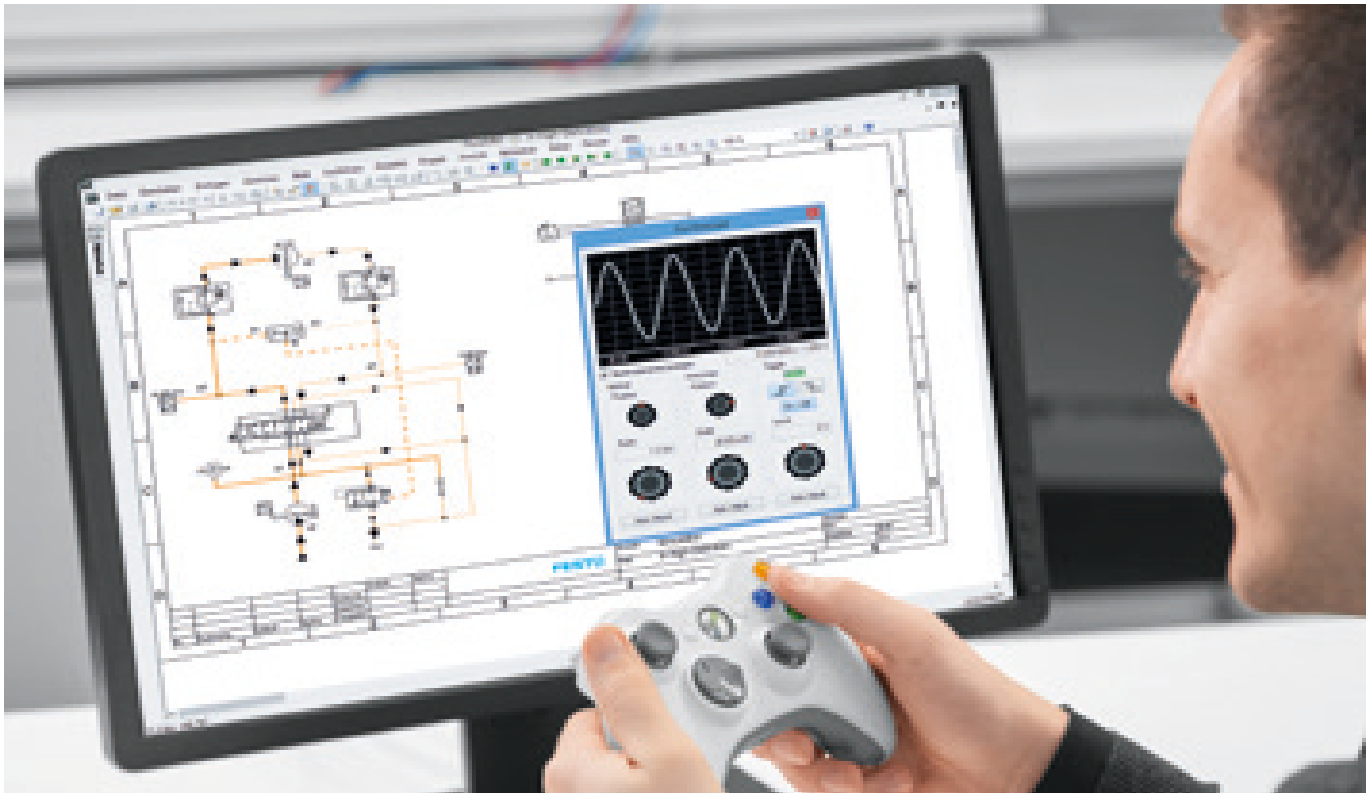
Tec2Screen® Manager
Free of charge as a download when ordering a course.

Available license level:
– 20 users at 20 workstations

Classroom Manager Vocational Training
Learning management system, subject to a fee
Available license levels:
– 100 users at 10 workstations
– 200 users at 20 workstations
– 500 users at 50 workstations
– 1000 users at 100 workstations
Available terms:
– 1 year
– 3 years
– 5 years

FluidSIM® 5

Pneumatics/hydraulics/electrical engineering



For more than 20 years, FluidSIM® has been the world's leading circuit diagram design and simulation program for pneumatics, hydraulics, and now also for electrical engineering. Being able to freely design control systems is motivating, and promotes creativity and focus. Beyond that, FluidSIM® provides teachers with a wealth of text, images, and videos for multimedia-based lesson planning. Experience real-time simulations with apprentices, specialists, or students and celebrate successful learning at all levels!

One tool for all needs
As a teacher and trainer, you are the expert who masters tasks that are needed to prepare effective lessons, which is why FluidSIM® 5 offers the expert mode. Your trainees should initially concentrate on the essentials. They can work and learn successfully in the standard mode, which has a reduced range of functions and offers advantages for the learning process.

Testing in real time
Whether in a training environment or in an engineering office, the simulation of control systems and processes has long been standard in industry, helping to minimize losses due to crashes and ensuring greater efficiency and improved quality. The parameters of all components are identical to those of the training packages from Festo Didactic and can be fully adapted to the characteristics of other components.

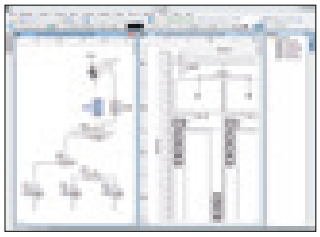
The many aspects of GRAFCET
GRAFCET long-ago replaced the displacement-step diagram in training. FluidSIM® 5 does even more with GRAFCET:
– Editing – for documentation conforming to standards
– Visualizing – for maximum clarity
– Monitoring – colored signals indicate where the process is running correctly or not at all
– Control – for manufacturer-neutral control of all fluid systems and electrical systems

Speed made visible
The new simulation core of FluidSIM® 5 achieves simulation rates up to 10 kHz. The parameters of all actuators can be precisely adjusted. FluidSIM® 5 writes the simulation results in millisecond cycles and delivers them as a text file! The new simulated oscilloscopes make frequencies up to 100 kHz visible.

Learning with fun and success
Theory is necessary for learning, but real practice provides motivation and promotes successful learning! In many situations, FluidSIM® 5 can easily be used as a controller for the real system: the EasyPort makes it possible – convenient, digital; and analog! New: with the joystick, FluidSIM® 5 is not only fun, but it now also allows several switches and valves to be operated simultaneously.

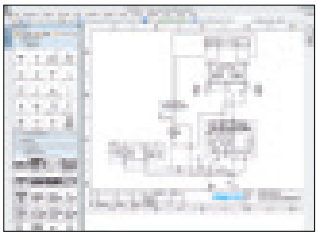
Wide range – maximum convenience
Pneumatics, hydraulics, electrical engineering: the libraries are available separately or together in the same program. The user decides which of the libraries to use in the program. All technologies interact optimally in a circuit diagram or project.

Flexible installation and use
Online registration, network license, usage at home: FluidSIM® 5 offers many license models that facilitate economical learning scenarios in a school or in a company. A new learner administration function even allows you to provide and monitor licenses for learning groups and to use the software at home.



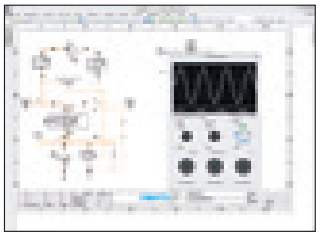
Professional CAD according to standards
– Convenient drawing with alignment lines and new snap functions
– Easy insertion of new symbols into existing connections
– Variable drawing frames
– Continuous scaling and rotation
– Dimensioning functions
– Intersection calculation of lines, rectangles and ellipses

Completely according to standards
– All symbols to DIN ISO 1219 or DIN EN 81346-2
– Connection identification according to new equipment identifier
– GRAFCET according to the current standard



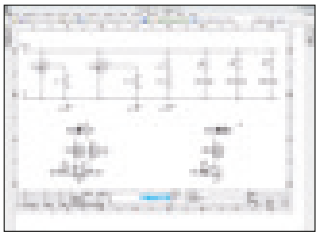
Libraries for new technologies
– Libraries for all levels of pneumatics and hydraulics training packages, including control technology and proportional technology
– New: drives in pneumatics
– Vacuum technology
– Sensors in pneumatics
– Safety in pneumatic systems
– Mobile hydraulics
– Electrical engineering, electronics
– Circuits with contacts

GRAFCET in various modes
– GrafEdit: create GRAFCETs in compliance with the standard
– GrafView: visualize the control sequence represented as a GRAFCET
– GrafControl: control the process with the GRAFCET, including error simulation and process monitoring
– GrafPLC



Simulation in high definition
– Signal processing up to 10 kHz
– Virtual oscilloscope for frequencies up to 100 kHz
– Simultaneous simulation of all circuits in a project
– Simulated values can be shown at run-time
– Several switches can be operated with the joystick

Learning material included
– Slides, pictures, animations, sectional drawings, video sequences
– Description of the physical-mathematical simulation models
– Training program for FluidSIM® beginners
– Details of all components at the push of a button
– Completed sample presentations for your training course
– Language changeover at run-time
– Multilingual (standard German/ English)



Convenient documentation
– Project administration, drawing sheets
– Individual drawing frames in all sizes
– Automatic bills of materials, flow path numbering, switching element tables, terminal diagrams, cables, wiring lists, and tubing lists
– Exports into all common formats

FluidSIM® for homework
– New expansion for administering external users over the Internet
– Administration of learning groups
– Integrated chat functions
– Simple administration by the tutor
– New licensing solutions allow working with the full version from home

We can meet your needs
Multiple licenses for local or network installation with as many licences as you necessary.

Electrical engineering
Local installation,
single license de/en/es/fr/pt/ro/ru
Order no. **8088625**
Network installation,
single license de/en/es/fr/pt/ro/ru
Order no. **8024362**

Pneumatik
Local installation,
single license de/en/es/fr/pt/ro/ru
Order no. **8088623**
Network installation,
single license de/en/es/fr/pt/ro/ru
Order no. **8024360**

Hydraulics
Local installation,
single license de/en/es/fr/pt/ro/ru
Order no. **8088624**
Network installation,
single license de/en/es/fr/pt/ro/ru
Order no. **8024361**

Recommended accessories:
X-Box Controller
without cable 8032252

Automotive mechatronics
All the components of TP 1011 ➔ page 50 and TP 1025 ➔ page 53 are included in the electrical engineering library FluidSIM® 5. This library also contains extensive teaching material, adapted to the first year of training for automotive mechatronics technicians.

System requirements
– Windows 10
– Processor with at least 1 gigahertz
– At least 1 GB RAM
– Dual core processor (recommended)

New languages – free of charge
In the future, you will receive new language variants free of charge on the Internet. They can be integrated into your existing version via an update.

Visit us on the Internet.
There you will find all the information you need on currently available versions and updates for existing FluidSIM® users.

Teachware

Teaching materials for basic and advanced training

Theory and practice, our range

– Electronics and Electrical Engineering
– Electric power technology
– Power transmission and distribution
– Industrial controls
– Protective relaying
– Automation technology/PLC
– Fluid power

A wide range of different teaching materials for ongoing basic and advanced training are available for these topics.

Technical literature and textbooks
The technical literature and textbooks provide the basis for studying technologies and processes. For trainers and teachers, they are essential for preparing courses. They also provide practical exercises with professional guidelines for those who do not enjoy self-study on a PC.

Workbooks
For more than 50 years, Festo Didactic has been at the forefront of industrial training with training packages with equipment sets and tailored workbooks that include exercises and sample solutions (including CD-ROM). The exercises are based on real industrial practices and have been successfully implemented in a wide range of specialized training.

Dictionaries and manuals
Symbols, rules, standards, formulae, etc. You don't need to have everything in your head, but you do need to know where to find it!

Legal security

Festo Didactic's teaching materials are already in widespread use for a diverse range of purposes. With the new licenses, the legal basis for individualized use has now been established. From now on, users have the option of choosing one of three types of license, to ensure an optimized – and legally secure – use of Festo's teaching materials tailored to your needs.

Choose from the following types of license:

Campus license
The standard option for commercial (professional) use. Ideal for all those wishing to use the training materials at a single location.

Enterprise license
For large (international) companies and educational institutions with multiple locations.

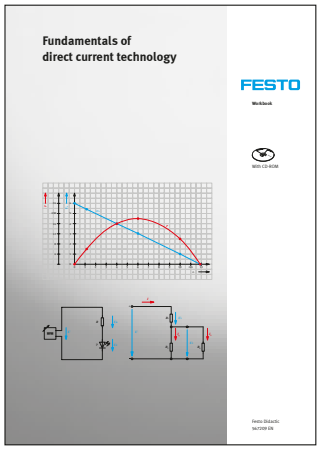
For information on each of the license types, please see the following table.

Note:
– The license types are valid for all Festo Didactic training materials.
– The full rights of use are set out in the legal information contained in the purchased training materials.

Properties	Campus license	Enterprise license
Scope of delivery	Teaching material (workbook with multimedia CD-ROM*)	As agreed
Document protection	–	–
Document can be modified	X	X
Reproduction rights	X	X
Multilingual version*	–	X*
Target group	Commercial/educational organizations (single location)	Commercial/educational organizations (multiple locations)
Shop	FESTO	FESTO

* The languages offered vary depending on the training material.

Electrical Engineering and Electronics
Workbooks



Fundamentals of direct current technology

The fundamentals of direct current technology provide an introduction to the world of electrical engineering/electronics. The content is explained and elaborated in realistic projects. The primary focus is on the explanation of the basic variables, behaviour and relationships and the recording of these using measurements.

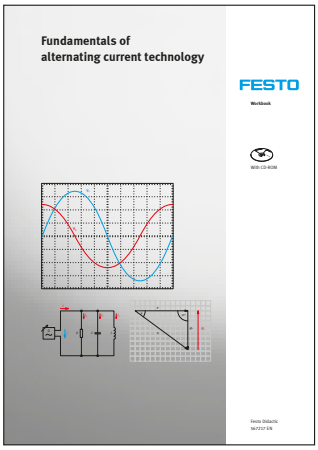
Among the variables covered are voltage, current, resistance and conductance as well as energy and capacity. Ohm's law is explained in detail. Particular emphasis is placed on the use of measuring devices. The circuit examples include series and parallel connection, voltage divider, bridge circuit and voltage sources.

The workbook contains:
– Solutions
– Didactic notes
– Worksheets for the student
– Multimedia CD-ROM with graphics

C. Löffler
Edition 2010, 300 pages, in color, in folder.

Campus license (➔ Page 31):

de	**567207**
en	**567209**
es	**567211**
fr	**567213**



Fundamentals of alternating current technology

The workbook for fundamentals of AC technology continues the introduction to electrical engineering/electronics components and systems with topics relating to AC technology. The main topics covered are the electric field and induction, and the resulting behavior of components in the AC circuit.

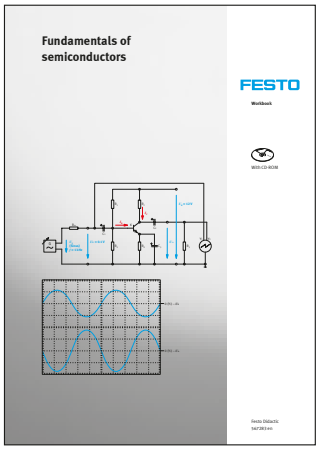
Topics such as the capacitor and coil in the DC and AC circuit, as well as the series and parallel connection of resistor, coil and capacitor are covered in project exercises. The variables and relationships of active resistance, reactance, and impedance, and the topic of phase shift of current and voltage are covered in detail.

The workbook contains:
– Solutions
– Didactic notes
– Worksheets for the student
– Multimedia CD-ROM with graphics

C. Löffler
Edition 2010, 290 pages, in color, in folder.

Campus license (➔ Page 31):

de	**567215**
en	**567217**
es	**567219**
fr	**567221**



Fundamentals of semiconductors

The third volume of the fundamentals of electrical engineering/electronics deals with semiconductors. covering the design and mode of operation of modern semiconductors, with their application demonstrated in project exercises.

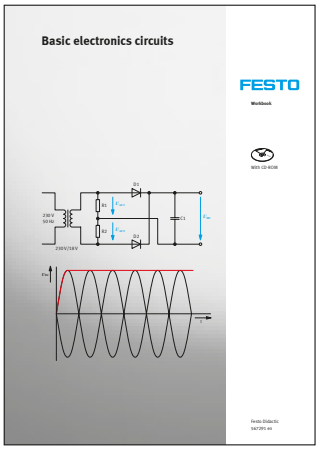
As an introduction to the topic, different diodes, such as the semiconductor diode, Zener diode, and LED are considered and the basic concepts are worked out. Content including PN junction, reverse voltage, or conducting state current is demonstrated both theoretically and, where possible, using measurements. The topic of transistors is also explained using bipolar and unipolar transistors. The book also covers power electronics components, such as diac, triac, and thyristor.

The workbook contains:
– Solutions
– Didactic notes
– Worksheets for the student
– Multimedia CD-ROM with graphics

M. Wäschle
Edition 2010, 208 pages, in color, in folder.

Campus license (➔ Page 31):

de	**567281**
en	**567283**
es	**567285**
fr	**567287**



Basic electronics circuits

The workbook for basic electronics circuits completes the series of workbooks for the fundamentals of electrical engineering/electronics. Particular emphasis is placed on the analytical examination of the interaction between the components already covered in the first three books on the fundamentals.

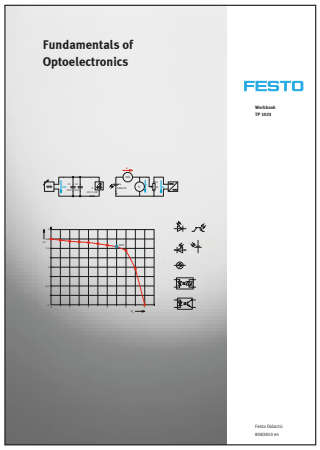
The content includes project exercises with selected basic circuits, in which the design is first developed and then analyzed on the basis of measurement technology. The circuits include power supply unit circuits, amplifier circuits, flip-flops, and power electronics circuits, as well as circuits commonly used in industrial practice.

The workbook contains:
– Solutions
– Didactic notes
– Worksheets for the student
– Multimedia CD-ROM with graphics

K.-H. Drüke
Edition 2011, 382 pages, in color, in folder.

Campus license (➔ Page 31):

de	**567289**
en	**567291**
es	**567293**
fr	**567295**



Fundamentals of optoelectronics

The primary objective of this workbook is the set-up and analysis of optoelectronic components, as well as a selection of basic circuits.
The circuits include twilight switches, light barriers, infrared remote controls, fiber-optic cables for data transmission, and power supply circuits. This direct interaction of theory and practice ensures fast progress and sustainable learning.

The workbook contains:
– Sample solutions
– Educational instructions
– Data storage medium with PDF files
– Worksheets for learners

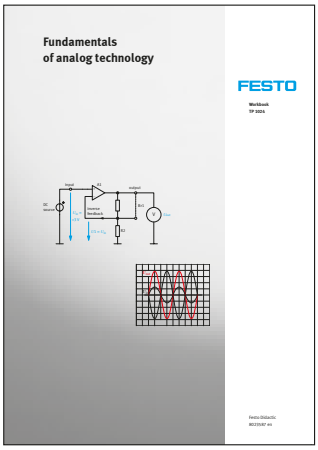
The worksheets support the learner in the information and planning phase as well as with execution, monitoring and documentation.

All exercises require independent performance, evaluation and documentation from the learner.

K.H. Drüke
Edition 2018, 120 pages, in color, in folder.

Campus license (➔ Page 31):

de	**8081038**
en	**8083810**



Fundamentals of analog technology

The workbook imparts knowledge about the structure, function and characteristics of operational amplifiers.

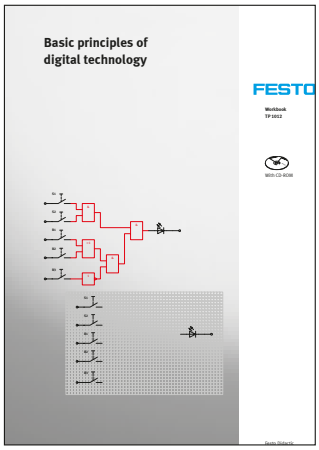
Five projects are specifically targeted at the topic of operational amplifiers and their application as impedance converters, computing amplifiers, sawtooth wave generators, voltage controllers and power amplifiers.

The workbook contains:
– Sample solutions
– Training notes
– Worksheets for the student
– USB stick

K.-H. Drüke
Edition 2015, 222 pages, in color, with USB Stick, in folder.

Campus license (➔ Page 31):

de	**8023586**
en	**8023587**
es	**8023588**
fr	**8023589**



Basic principles of digital technology

The basic principles of digital technology workbook provides an introduction to the world of digital signals and their interconnection. The primary focus is on the explanation of the basic variables, behavior, and relationships.

The content is project exercises with selected basic circuits, in which the design is first developed and then analyzed on the basis of measurement technology. The contents include elementary logic modules and logic circuits, Schmitt triggers, trigger circuits, flipflops, counting circuits, data conversion, and arithmetic circuits.

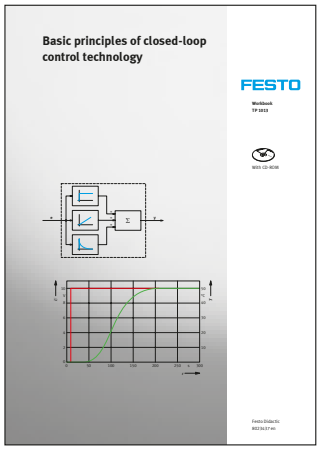
The workbook contains:
– Sample solutions
– Training notes
– Worksheets for the student
– Multimedia CD-ROM with graphics

S. Enderle
Edition 2012, 200 pages, in color, in folder.

Campus license (➔ Page 31):

de	**8023432**
en	**8023433**
es	**8023434**
fr	**8023435**

Electrical Engineering and Electronics
Workbooks



Basic principles of closed-loop control technology

The optimum introduction to the world of closed-loop systems is provided by the workbook, Basic principles of closed-loop systems. Basic terms are explained through examples, with the focus then shifting to behaviors, and relationships. Special focus is given to the topics of behavior, and analysis of control processes.

The content includes project exercises with selected basic circuits, in which the design is first developed and then analyzed on the basis of measurement technology. Training content, includes structure of a control circuit, spring responses and dynamic behavior, Bode diagram, controlled system modeling, positive and negative feedback, and two and three-step controllers as well as P, PI, and PID controllers.

The workbook contains:
– Sample solutions
– Training notes
– Worksheets for the student
– Multimedia CD-ROM with graphics

J. Helmich
Edition 2013, 170 pages, in color, in folder.

Campus license (➔ Page 31):

de	**8023436**
en	**8023437**
es	**8023438**
fr	**8023439**

Introduction to microcontroller programming

This 50-hour course teaches the basics of developing projects based on microcontrollers using Flowcode software.

The aim of this course is to introduce the concepts of developing electronic systems using microcontrollers.

Students learn what a microcontroller is, how to construct circuits and systems based on microcontrollers, and how to program microcontrollers.

The course is suitable for BTEC National in Engineering unit 6, Microcontroller systems for engineers.

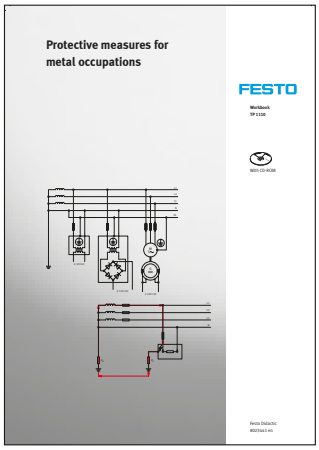
Table of contents:
– Introduction
– Intro to microcontrollers
– Using E-blocks
– Flowcode – first program
– Flowcode – examples
– Programming exercises
– Arduino adjustments

Matrix Technology Solution Limited
Edition 06/2018, 80 pages, in color, in folder.

Campus license (➔ Page 31):

de	**8128594**
en	**8094009**

Building System Technology
Workbooks



Protective measures for metal occupations

The workbook “Electrical protective measures for metalworking occupations” deals with the topic of hazardous situations caused by electrical systems.

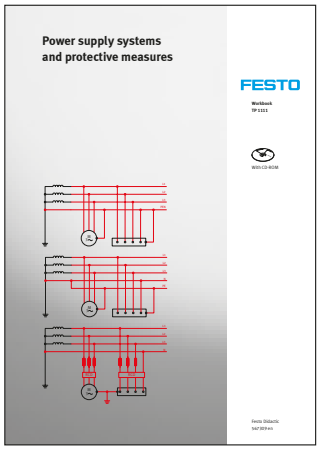
It addresses the emergence of hazards and the measures for preventing dangerous situations on the basis of realistic examples. It explains different mains systems as well as measures for protecting against direct and indirect contact and against electric shock (including in case of a fault).

The workbook contains:
– Sample solutions
– Training notes
– Worksheets for students
– Multimedia CD-ROM with graphics

J. Stumpp
Edition 2014, 110 pages, in color, in folder.

Campus license (➔ Page 31):

de	**8023440**
en	**8023441**
es	**8023442**
fr	**8023443**



Power supply systems and protective measures

The workbook for power supply systems and protective measures covers in detail the topic of the safety of electrical systems in accordance with DIN VDE.

The specific conditions and the measures for avoiding dangerous situations are explored using realistic situations. Different types of networks (TN-C, TN-CS, TT and IT network), protection against direct and indirect contact, protection against electric shock (including in the event of a fault), protection through RCD, and initial and repeat testing of electrical systems and devices are explained in project form.

The workbook contains:
– Solutions
– Didactic notes
– Worksheets for the student
– Multimedia CD-ROM with graphics

J. Stumpp
Edition 2012, 230 pages, in color, in folder.

Campus license (➔ Page 31):

de	**567307**
en	**567309**
es	**567311**
fr	**567313**

Basic principles of electrical installation

The basics of electrical installation are taught using the example of practical projects with planning, setup and testing of different basic circuits.

Training content:
– Planning and normative principles
– Circuit diagrams and circuit symbols
– Basic circuits
– Taught using practical project exercises

The workbook contains:
– Solutions
– Didactic notes
– Worksheets for the student
– Multimedia CD-ROM with graphics

The worksheets support the learner in the information and planning phase as well as with execution, monitoring and documentation.

All exercises require independent performance, evaluation and documentation from the learner.

Campus license (➔ Page 31):

de	**8074437**
en	**8113396**
es	**8113397**

Energy-efficient lighting engineering

Different lamps are compared in terms of mode of operation, light produced, industrial energy efficiency and dimming processes.

Training content:
– Method of operation of lamps
– Industrial energy efficiency of lamps
– Light and light temperature
– Dimming properties
– Taught using practical project exercises

The workbook contains:
– Solutions
– Didactic notes
– Worksheets for the student
– Multimedia CD-ROM with graphics

The worksheets support the learner in the information and planning phase as well as with execution, monitoring and documentation.

Campus license (➔ Page 31):

de	**8074441**
en	**8113398**
es	**8113399**

Fluorescent lamps

The workbook introduces fluorescent lamp circuits and emergency light modules. Particular attention is paid to the design and function of the lamps and components.

Training content:
– Mode of operation of fluorescent lamps
– Function of the components
– Circuits with fluorescent lamps
– Emergency light
– Taught using practical project exercises

The workbook contains:
– Solutions
– Didactic notes
– Worksheets for the student
– Multimedia CD-ROM with graphics

Campus license (➔ Page 31):

de	**8074442**
en	**8113400**
es	**8113401**

High-pressure discharge lamps

Mainly used for street and industrial lighting as well as floodlighting systems.

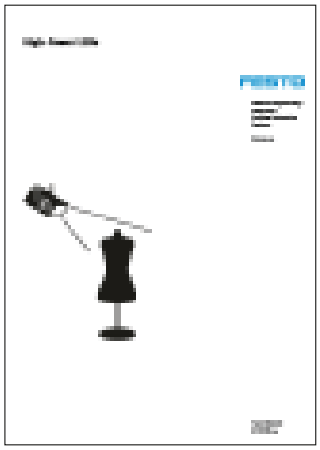
The work book provides practical project exercises for an introduction to high-pressure discharge lamps. Particular attention is paid to the mode of operation of the lamps and the light they produce, as well as to comparing them and their industrial energy efficiency.

Training content:
– Types of high-pressure discharge lamps
– Industrial energy efficiency of high-pressure discharge lamps
– Circuitry of high-pressure discharge lamps
– Application areas of high-pressure discharge lamps
– Taught using practical project exercises

Campus license (➔ Page 31):

de	**8074439**
en	**8111397**
es	**8111398**

Building System Technology
Workbooks



High-power LEDs

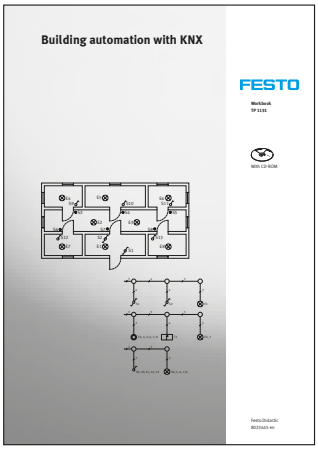
The most modern and energy efficient way of lighting.

The work book provides practical project exercises for an introduction to high-power LEDs. Particular attention is paid to the mode of operation of the LEDs, the light they produce as well as industrial energy efficiency.

Training content:
– Method of operation of LEDs
– Industrial energy efficiency of LEDs
– Dimming LEDs
– Light and light temperature
– Taught using practical project exercises

Campus license (➔ Page 31):

de	**8074440**
en	**8111399**
es	**8111400**



Building automation with KNX

Modern buildings demand a wide variety of technologies, the most important being intelligent building automation, as a modern building cannot function without it.

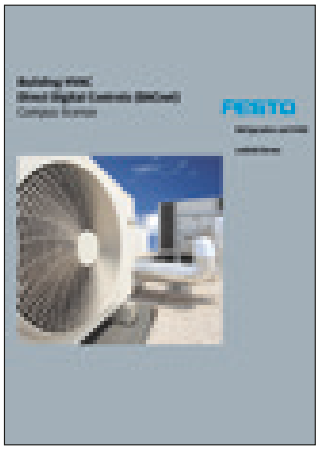
The workbook for the basic principles of building automation introduces the relevant topics in realistic projects. Focus is on the software tools, equipment, and configuration, as well as their interaction and extended options.

The workbook contains:
– Solutions
– Didactic notes
– Worksheets for the student
– Multimedia CD-ROM with graphics

N. Karlsson
Edition 2013, 110 pages, in color, in folder

Campus license (➔ Page 31):

de	**8023444**
en	**8023445**
es	**8023446**



Building HVAC Controls (BACnet)

This workbook introduces students to the basic principles of heating, ventilation, and air conditioning (HVAC). It covers components used in HVAC systems, and teaches skills required to work in the HVAC field. Throughout the activities, students develop practical knowledge on how to install, maintain, and troubleshoot HVAC systems. They become familiar with a variety of HVAC systems.

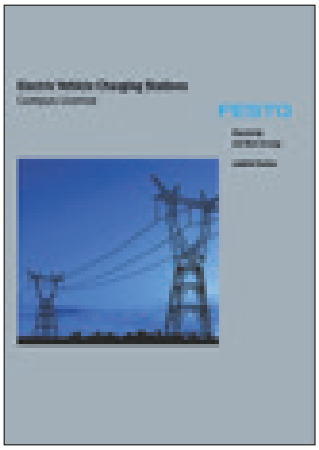
Training content:
– Describe the operation of HVAC systems, sub-systems, and components
– Wire HVAC control circuits
– Read and understand technical documents such as wiring diagrams
– Troubleshoot malfunctions and determine how to correct them

The workbook contains:
– Solutions
– Didactic notes
– Worksheets for the student
– Multimedia CD-ROM with graphics

Edition 2017, 170 pages, in color

Campus license (➔ Page 31):

de	**793120**
en	**793119**
es	**793122**



Electric Vehicle Charging Stations

The following lab exercises are included:
– Electric Vehicles and Electric Vehicle Service Equipment
– Basic Charging Station Components and Operation
– Advanced Charging Stations
– Commissioning and Testing
– Troubleshooting Project

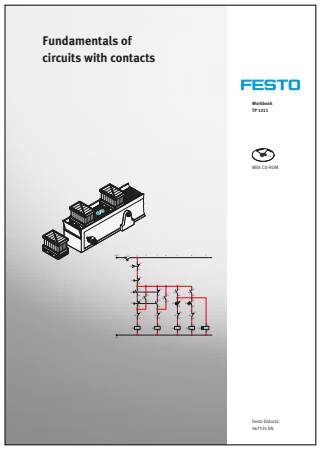
The workbook contains:
– Exercises and sample solutions
– Didactic recommendations
– Worksheets for learners
– Multimedia CD-ROM with graphics

The exercises are based on the training content and the hardware components of the training system.

Campus license (➔ Page 31):

de	**8096874**
en	**8096870**
es	on request
fr	on request

Electric Drive Technology
Workbooks



Fundamentals of circuits with contacts

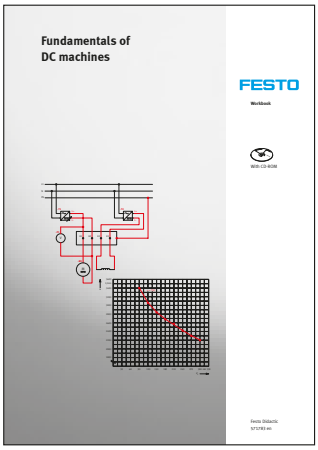
Contactor controls still have their place despite increasing automation and increasingly cost-effective control electronics. The workbook for the fundamentals of circuits with contacts covers the specific topics relating to relays and contactor controls in six realistic projects plus an additional project for soft starters. The control circuit with topics such as self-latching loop and locking plays just as important a role here as the primary circuit with the circuits for asynchronous three-phase motors, from simple starting to star-delta reversing circuit.

The workbook contains:
– Solutions
– Didactic notes
– Worksheets for the student
– Multimedia CD-ROM with graphics

J. Stumpp
Edition 2010, 120 pages, in color, in folder.

Campus license (➔ Page 31):

de	**570901**
en	**567315**
es	**567317**
fr	**567319**



Fundamentals of DC machines

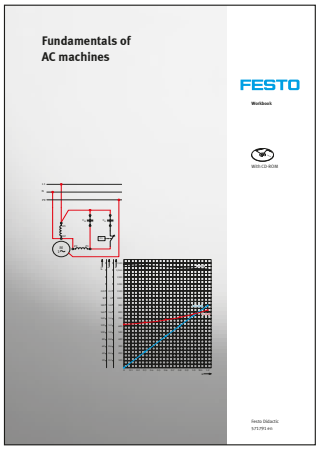
In drive technology, DC drives currently play a major role in mobile drive solutions. The workbook for the fundamentals of DC machines covers the specific topics relating to DC drives. The content is first elaborated theoretically and then consolidated in exercises. In addition to the design of the machines, their circuitry and areas of application are demonstrated in realistic projects.

The workbook contains:
– Solutions
– Didactic notes
– Worksheets for the student
– Multimedia CD-ROM with graphics

J. Stumpp
Edition 2011, 150 pages, in color, in folder.

Campus license (➔ Page 31):

de	**571781**
en	**571783**
es	**571785**



Fundamentals of AC machines

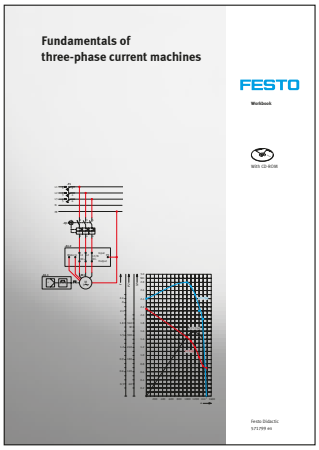
We come into contact with AC drives every day, as these motors are commonly used in household appliances and electric handheld tools in particular. The workbook for the fundamentals of AC machines introduces the topics relating to AC motors in realistic projects. Particular emphasis is placed on design, circuitry and areas of application. Control questions on the content facilitate the assessment of learning success.

The workbook contains:
– Solutions
– Didactic notes
– Worksheets for the student
– Multimedia CD-ROM with graphics

J. Stumpp
Edition 2011, 152 pages, in color, in folder.

Campus license (➔ Page 31):

de	**571789**
en	**571791**
es	**571793**



Fundamentals of three-phase current machines

The sturdy design and wide range of applications thanks to modern power electronics have contributed to three-phase motors becoming the standard drives for industrial applications. In the workbook for the fundamentals of three-phase current machines, the design, connection and areas of application are explained on the basis of realistic project exercises. The machines are exposed to a wide range of simulated load situations in order to determine their options.

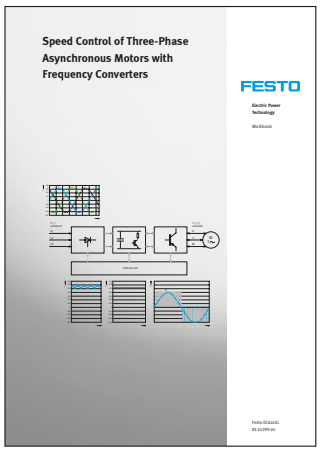
The workbook contains:
– Solutions
– Didactic notes
– Worksheets for the student
– Multimedia CD-ROM with graphics

J. Stumpp
Edition 2011, 166 pages, in color, in folder.

Campus license (➔ Page 31):

de	**571797**
en	**571799**
es	**571801**
fr	**571803**

Electric Drive Technology
Workbooks



Speed control of three-phase asynchronous motors with frequency converters

Frequency converters are power electronic devices. They convert the fixed mains voltage with a fixed frequency into a three-phase system with a variable voltage and frequency. This makes it possible to control or regulate the speed of three-phase motors infinitely variably.

Frequency converters with a DC voltage intermediate circuit are used most frequently. The descriptions in the work book are therefore restricted to frequency converters with this design principle.

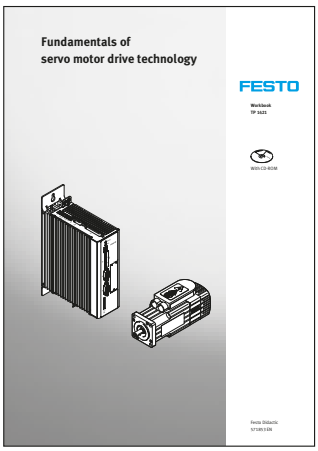
The following contents are communicated in 12 application-oriented project exercises: function, applications, energy optimization and programming.

The workbook contains:
– Sample solutions
– Training notes
– Worksheets for students
– USB memory stick with PDF files

Wolfgang Kelz
Edition 2019, 158 pages, in color, in folder.

Campus license (➔ Page 31):

de	**8114398**
en	**8114399**
es	**8114400**
fr	**8114401**



Fundamentals of servo motor drive technology

Servo drives play a particularly important role in automation, as due to today's state-of-the-art controller technology, they have developed into the standard drive. The workbook for the fundamentals of servo motor drive technology uses practical exercises to provide a detailed introduction to the topics relating to modern servo drives.

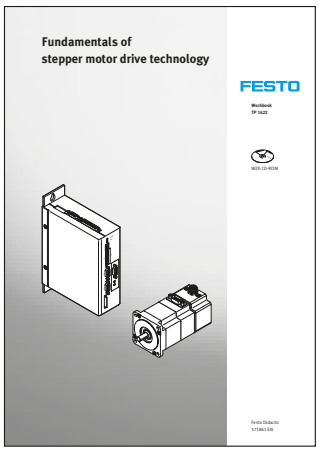
The topics covered include the design and commissioning of a servo drive, RPM regulation, regulating torque, and homing as well as additional content, such as positioning with variable speeds, acceleration, braking and positioning tasks.

The workbook contains:
– Solutions
– Didactic notes
– Worksheets for the student
– Multimedia CD-ROM with graphics

F. Ebel, M. Pany
Edition 2010, 192 pages, in color, in folder.

Campus license (➔ Page 31):

de	**571851**
en	**571853**
es	**571855**
fr	**571857**



Basic principles of stepper motor drive technology

The workbook for the basic principles of stepper motor drive technology uses practical exercises to provide a detailed introduction to the topics relating to modern stepper motor drives.

In addition to basic content, including design and commissioning of stepper motor drives, practical topics, such as homing, speeds, positioning, acceleration, and braking ramps play an important role as well. More detailed content is also covered, i.e., current reduction for stepper motor drives.

The workbook contains:
– Sample solutions
– Training notes
– Worksheets for the student
– Multimedia CD-ROM with graphics

F. Ebel, M. Pany
Edition 2010, 194 pages, in color, in folder.

Campus license (➔ Page 31):

de	**571859**
en	**571861**
es	**571863**

Glossary of electrical drive technology

Modern drive technology is characterized by the increased integration of electrical and mechanical components into drive systems. New and improved drive capabilities can be achieved through the use of compact power electronics, innovative motor concepts, optimized mechanical components, new materials, and high-performance communication technology.

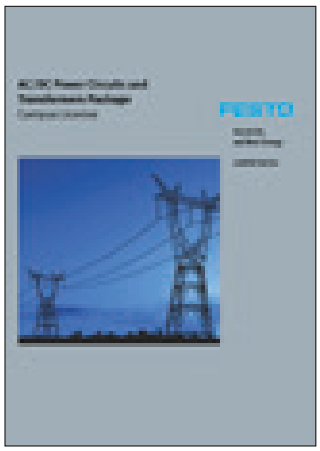
This book lists the main concepts in glossary format and provides brief explanations to facilitate a better understanding of these drives. However since there is more to an electrical drive that just the electric motor, it also touches on areas such as measurement systems, power electronics, gearboxes, controllers, and components for transmitting power.

S. Hesse
Edition 2004, 200 pages, in color, in folder.

Campus license (➔ Page 31):

de	**539265**

Electric Power Technology
Workbooks



AC and DC Power Circuits and Transformers Complete Package

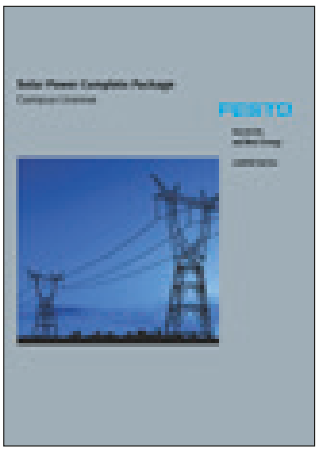
Workbooks included:
– DC Power Circuits
– Single-Phase AC Power Circuits
– Three-Phase AC Power Circuits
– Single-Phase Power Transformer
– Three-Phase Transformer Banks

The workbooks contain:
– Exercises and sample solutions
– Didactic recommendations
– Worksheets for the student
– Multimedia CD-ROM with graphics

The exercises are based on the training content and the hardware components of the training system.

Campus license (➔ Page 31):

de	on request
en	**8093410**
es	on request
fr	on request



Solar Power Complete Package

Workbooks included:
– Solar Power
– Photovoltaic Systems

Solar Power
– The Diode
– The Solar Panel (Photovoltaic Panel)
– Effect of Temperature on Solar Panel Performance
– Storing Energy from Solar Panels into Batteries
– Effect of Shading on Solar Panel Operation
– Solar Panel Orientation
– Solar Panel Performance vs. Insolation

Photovoltaic Systems
– Stand-Alone PV Systems for side-by-side Loads
– Use of an MPPT Charge Controller in Stand-Alone PV Systems
– Stand-Alone PV Systems for AC Loads
– Grid-Tied PV Systems

The workbook contains:
– Exercises and sample solutions
– Didactic recommendations
– Worksheets for the student
– Multimedia CD-ROM with graphics

The exercises are based on the training content and the hardware components of the training system.

Campus license (➔ Page 31):

de	**798367**
en	**596125**
fr	**8096492**

Wind Power Complete Package

Workbooks included:
– Introduction to Wind Power
– Wind Power Systems

Introduction to Wind Power
– Voltage-Speed Characteristic of a Wind Turbine Generator
– Torque-Current Characteristic of a Wind Turbine Generator
– Power vs. Wind Speed
– Storing Energy from a Wind Turbine into Batteries

Wind Power Systems
– Stand-Alone Wind Power Systems for side-by-side Loads
– Stand-Alone Wind Power Systems for AC Loads

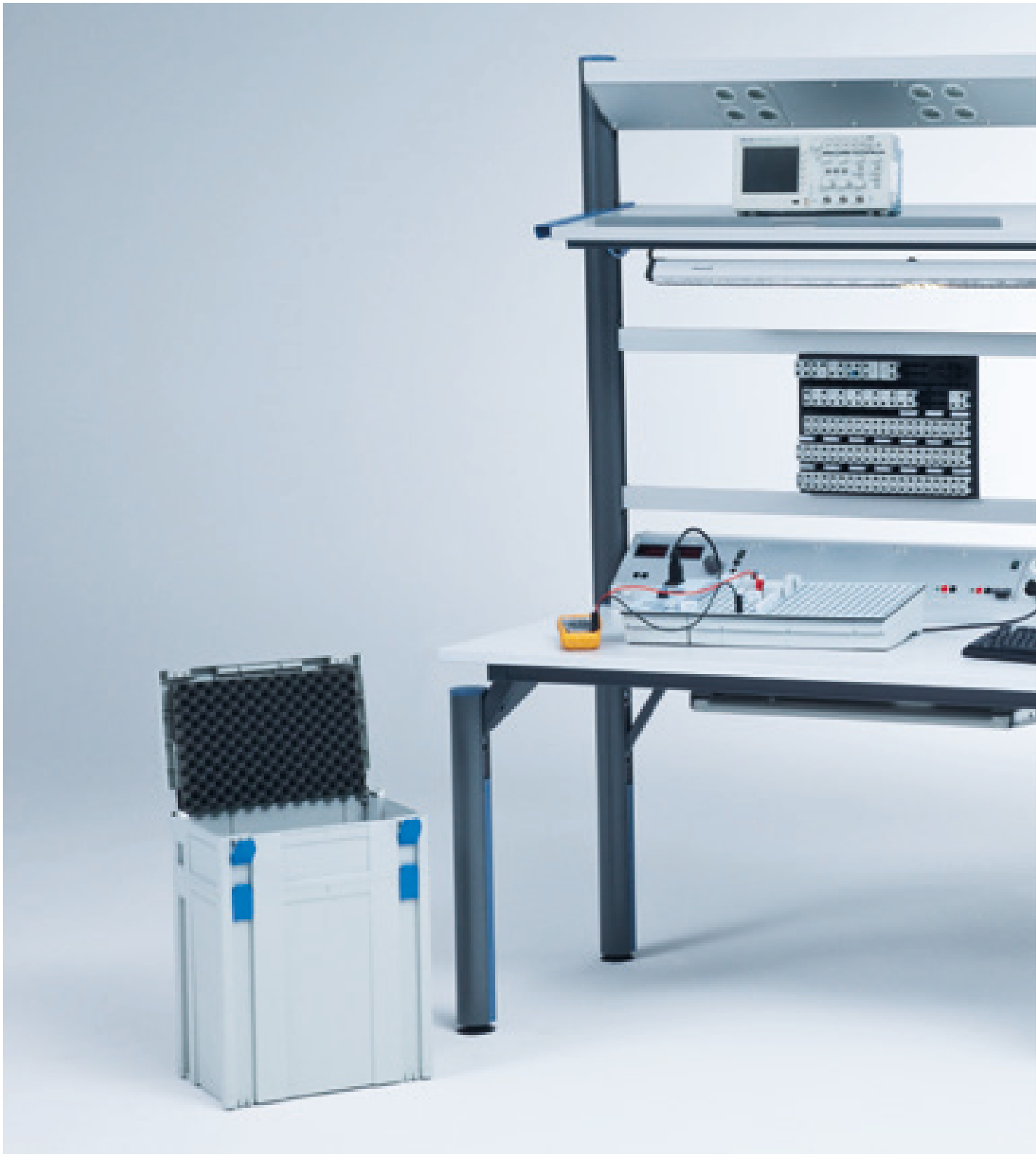
The workbook contains:
– Exercises and sample solutions
– Didactic recommendations
– Worksheets for the student
– Multimedia CD-ROM with graphics

The exercises are based on the training content and the hardware components of the training system.

Campus license (➔ Page 31):

de	**798369**
en	**596126**
fr	**8096504**

Electricity and Electronics

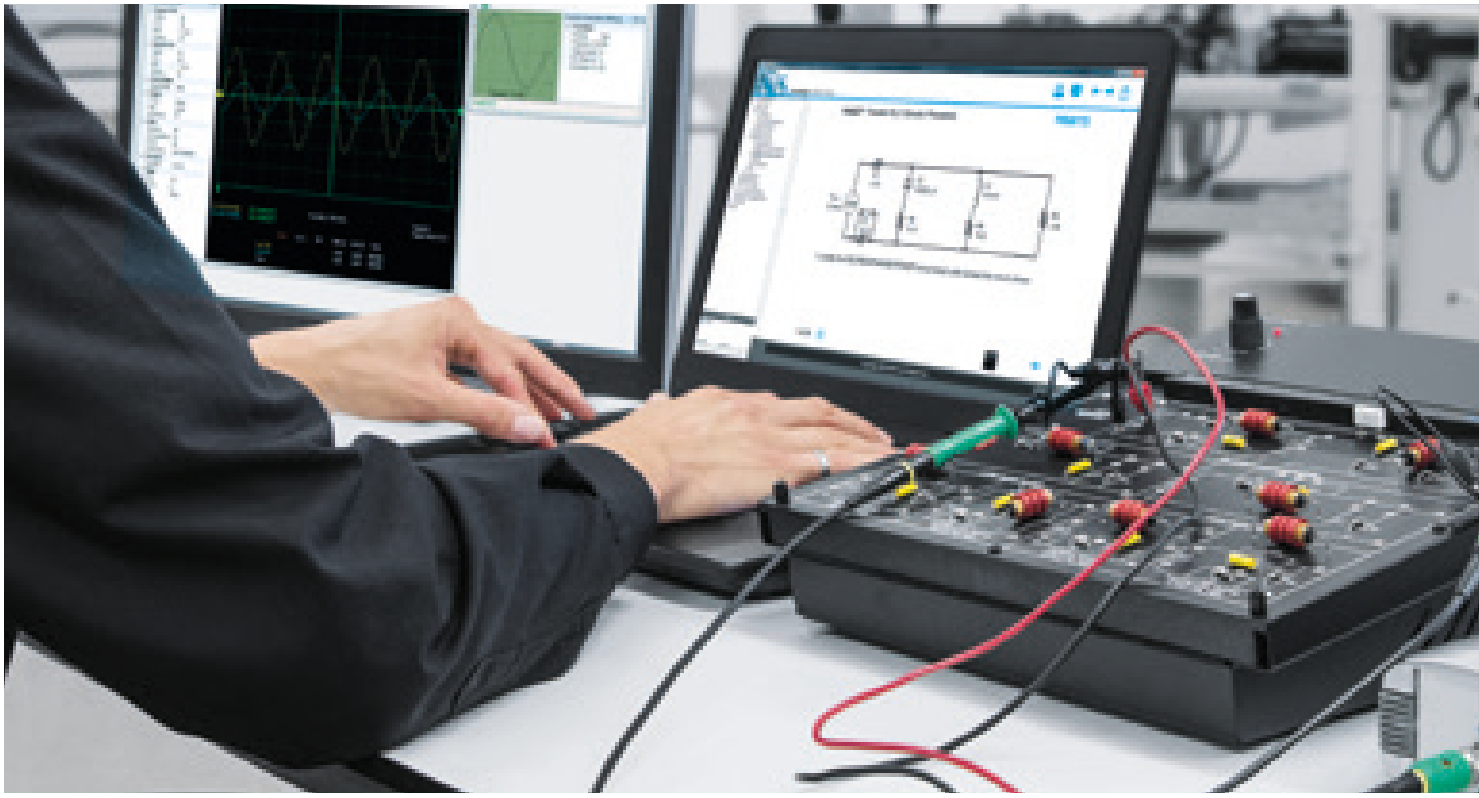


CE

Some training solutions included in this product guide do not have a CE mark and cannot be ordered for delivery to Europe.

If you are located in a country where this marking is required, please contact your Festo sales representative before placing an order.

Electronics Training System FACET®



FACET® with Festo LX –
A completely integrated system

The FACET® with Festo LX training system is a unique combination of hardware and software, providing a complete learning solution for Electronics training.

This modular training system encompasses four areas of electronics:
– Basic principles of Electricity and Electronics
– Digital and Microprocessor Electronics
– Industrial Electronics
– Communications

System overview
The FACET® training workstation consists of a base unit and your choice in a series of 30 boards to choose from, covering a wide range of electronics topics.

Each board comes with comprehensive, hands-on instruction with theory and practice. A collection of 30 courses is available as connected learning courses on Festo LX, our online portal for individualized learning experiences. Courseware is also available in print or PDF format.

Festo LX allows for individualized learning, learner management, learning analytics, equipment management, competency management, course edition, connected and mobile learning, evaluation, and more.

Conventional or virtual instrumentation is required to complete the training set up.

Flexibility in delivery
To accommodate a variety of training situations, the system offers multiple configurations. Whichever you plan to use, FACET® workstation can be ordered as a stand-alone or USB-connected version.

When combined with Festo LX, FACET® becomes a totally connected learning system for electronics that enhances learning speed and retention.

FACET® is suitable for a multitude of training purposes in educational, industrial, R&D and training laboratories.

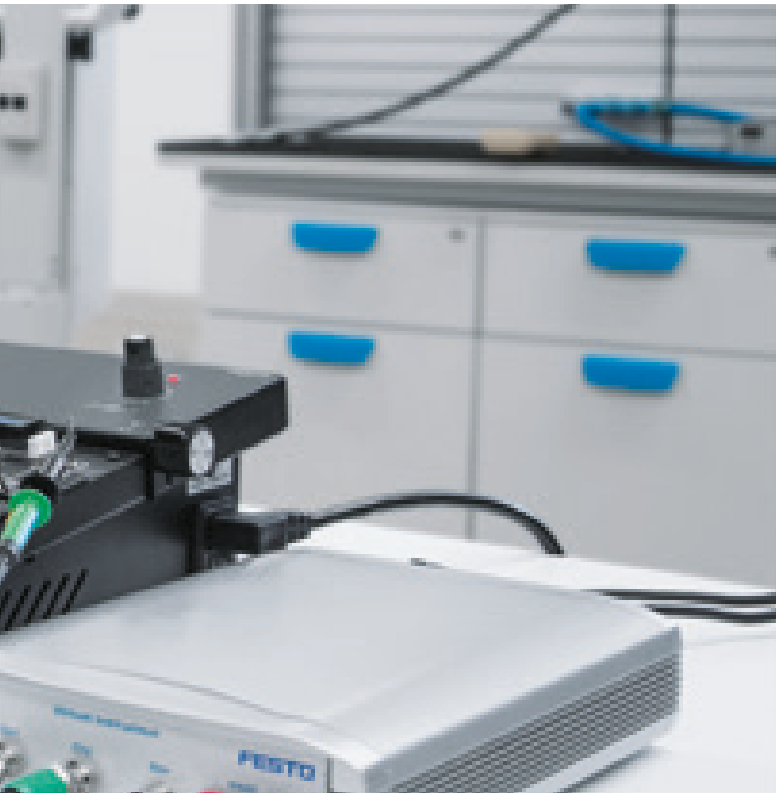
Rugged construction for durability
The hardware components of the FACET® system are highly safe and designed for durability.

A complete electronic workstation is formed when a training board is inserted into the base unit. The built-in guide and stopper protects the unit from damage.

The unique zero insertion force (ZIF) connector with a lockable knob insures the integrity of the connection. The connector is gold-plated for added durability.

Power is distributed to the board by the base unit, which is fully protected against short circuits, reverse voltage and overcurrent.

The fact that there is no high voltage makes the system completely safe for students.



The FACET® System at a glance

A complete FACET® training station consists of:
- FACET® Base Unit:
  Manual or USB
- FACET® Circuit Boards:
  Choice of 30 topics
- Instrumentation:
  The Virtual Instrument Package
  or
  Conventional instrumentation that includes: multimeter, dual-trace oscilloscope, and signal generator
- Courseware:
  available as digital learning courses on Festo LX, or in print or PDF formats
- Accessory kit

The Boards – learning optimization
The Boards are made of quality grade PCB mounted on a sturdy polystyrene tray for added rigidity. Durable, industrial-grade components are capable of withstanding millions of cycles of operation. Prewired circuits minimize wiring time.

The components are clearly identified with silk-screened circuits. Active components are mounted on sockets for easy replacement.

Learning with hands-on
FACET® incorporates built-in circuit modification and fault insertion capabilities. Circuits can be faulted to teach real-world troubleshooting. Students must then locate, isolate, and troubleshoot the malfunction through a series of troubleshooting steps, including the use of test instruments. Up to twenty circuit modifications and twelve faults are introduced from the base unit, reducing the need for connecting leads and allowing practical assessment of a student's understanding of a circuit.

Features
- Durable construction where mechanical components are capable of millions of cycles of operation
- Voltage regulation and protection against over-voltage and short circuit conditions for safety in training
- Gold-plated zero insertion force (ZIF) connector technology
- Silk-screened circuit and component identification
- Circuit boards mounted in sturdy trays for easy handling and connection to base unit
- Minimal wiring required saves lab time
- Variety of industrial-grade components provide broad, hands-on, real-world training experience
- Student-controlled circuit modification capability
- Instructor-controlled fault insertion capability
- Computer-activated circuit modification and fault insertion capability (computer-controlled system)

The FACET® Curriculum

Digital learning courses

The FACET® curriculum consists of 30 courses, each carefully designed to foster recognition, understanding, experimentation, troubleshooting, application, and evaluation of analog and digital electronics circuitry.

Rich in comprehensive content and competency-based, hands-on learning activities, each course gives students critical skills in one or more of the key areas of electronics study

Courses are designed to be self-paced, autonomous training.

Available topics:

Basic Electricity and Electronics
- DC Fundamentals
- DC Network Theorems
- AC 1 Fundamentals
- AC 2 Fundamentals
- Semiconductor Devices
- Transistor Amplifier Circuits
- Transistor Power Amplifiers
- Transistor Feedback Circuits
- Power Supply Regulation Circuits
- Operational Amplifier Fundamentals
- Operational Amplifier Applications

Digital and Microprocessor Electronics
- Digital Logic Fundamentals
- Digital Circuit Fundamentals 1
- Digital Circuit Fundamentals 2
- 32-Bit Microprocessor
- Digital Signal Processor
- Microprocessor Application Board

Industrial Electronics
- Transducer Fundamentals
- Magnetism/Electromagnetism
- Motors, Generators, and Controls
- Power Transistors and GTO Thyristors
- FET Fundamentals
- Thyristor and Power Control Circuits
- Breadboard

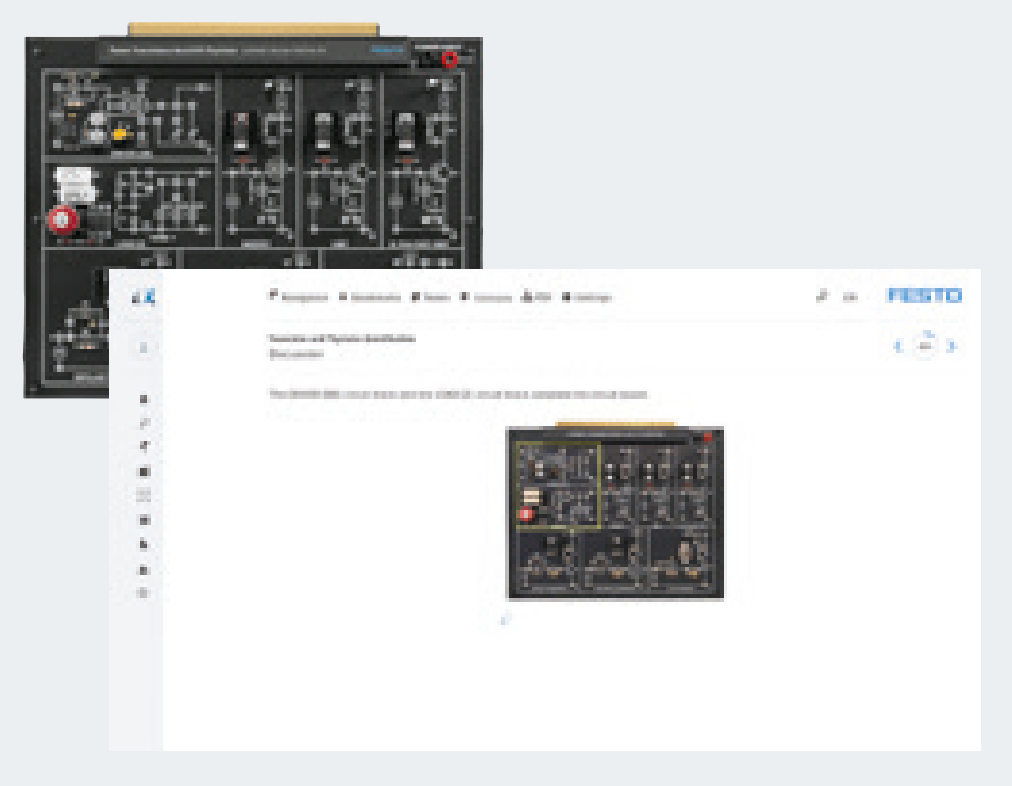
Communications Systems
- Analog Communications
- Digital Communications 1
- Digital Communications 2
- Fiber Optic Communications
- Transmission Lines
- QPSK/OQPSK/DPSK

Complete bundle for FACET **On request**

A program designed for student achievement

Conforming to the highest measures of educational quality, the FACET® curriculum is designed to facilitate and reinforce progressive mastery of the course material. The courseware provides an extensive array of instructional benefits, including:

- An outline of the principles and concepts covered in each course helps to clarify course content and focus.
- General and specific objectives stated in each unit help define learning outcomes and expectations for students.
- Topic discussions help to foster thorough comprehension.
- Hands-on activities engender dynamic and retentive learning.
- Emphasis on, and definition of new words and phrases throughout the text, helps students to develop comfort and familiarity with highly technical terms.
- Equipment lists support students' efforts to efficiently organize time and materials.
- Students receive constant feedback with a review test and competency ratings with each exercise, comprehensive unit tests, and additional questions on new material.
- Online data collection of exercise results, quizzes, and unit tests facilitates instant feedback to students.
- Troubleshooting skills development is facilitated through 12 instructor-or computer-activated fault switches and 20 circuit-modification switches.

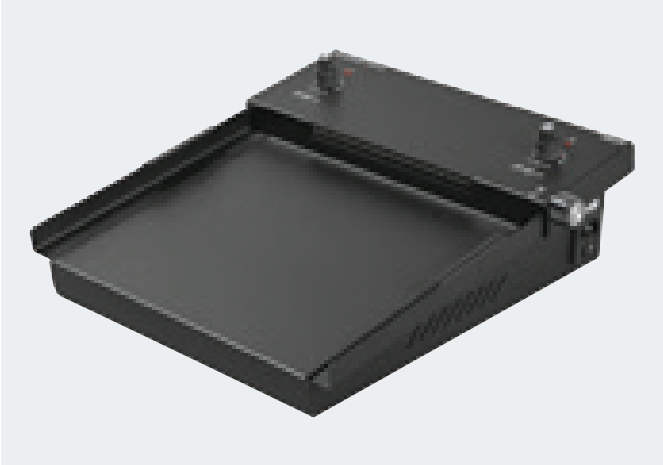


Connected learning
The courses enhances learning speed and retention by featuring interactive multimedia courseware with hand-on exercises on pre-wired circuit boards.

For circuit comprehension and analysis
Students perform experiments on a wide range of electronics and electricity training modules that combine theory and application with live connection to base unit and board. This provides practical skills training over a full curriculum on electronic/electricity subjects.

Supportive
The instructor guide and supportive pre- and post-tests provide both instructors and students with an extensive overview and working knowledge of electricity, analog, and digital electronics.

The FACET® Base Units



1 Computerized Base Unit 91000-5x **580867**

2 Manual Base Unit 91000-3x **580866**

1 **Computerized Base Unit**
The computerized base unit is linked to the computer automatically by the courseware when needed, and can also be activated via a USB port by the teacher through password-protected software. The computerized base unit contains 32 relays controlled by commands from the student's computer. **C**ircuit **M**odifications (CM) and faults are switched in and out automatically by the software.

A message on the student's computer screen indicates that a CM or fault is activated. In the troubleshooting exercises, faults are also inserted automatically by the computer, thereby freeing the instructor to assist students with individual activities.

2 **Manual Base Unit**
The Manual Base Unit contains a total of 32 **C**ircuit **M**odification (CM) and fault switches. Students manually select CM switches as the course progresses, while the protected fault switches are reserved for Instructor use by means of an integrated, locking-cover assembly.

The FACET® base units provide voltage supply with protection and conditioning circuitry to run each FACET® board.

Specific features of all FACET® base units include:
- Distributed +15 and -15 V DC, and variable ±10 V DC power to the various circuit training boards. Coarse and fine controls are provided to adjust the variable DC supplies.
- Self-protection against short circuit, reverse voltage, and overcurrent conditions.
- Long-life ZIF connector, with a rotary knob that locks the training board into the base unit. The ZIF connector itself is protected from damage by built-in stops.
- The fingers on the connectors are gold-plated for added durability.
- Included is an accessory kit containing terminal posts, connectors, adapters, and patch cords required to perform experiments on the FACET® training board.

Necessary accessories, also order:

Power cable with IEC connector at one end and country-specific plug at other end.

Connector as per CEE 7 for DE, FR, NO, SE, FI, PT, ES, AT, NL, BE, GR, TR, IT, DK, IR, ID
Order no. **582146**

Connector as per NEMA 5-15 for US, CA, Central America, BR, CO, EC, KR, TW, TH, PH, JP
Order no. **582145**

Connector as per BS 1363 for GB, IE, MY, SG, UA, HK, AE
Order no. **582148**

Connector as per AS-3112 for AU, NZ, CN, AR
Order no. **582147**

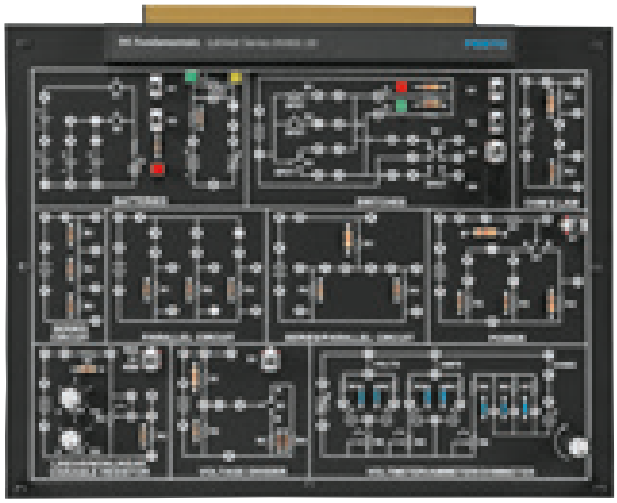
Connector as per SEV 1011 for CH
Order no. **582150**

Connector as per CEI 23-50 for IT
Order no. **582151**

Connector as per NBR 14136 for BR
Order no. **582152**

Other plug types are available on request.

DC Fundamentals
Circuit Board 91001



The DC Fundamentals Training Circuit Board is used by students to perform practical exercises that demonstrate DC principles. Students will become familiar with all the components to be able to successfully identify and isolate the circuit blocks on the training board and perform trouble-shooting exercises.

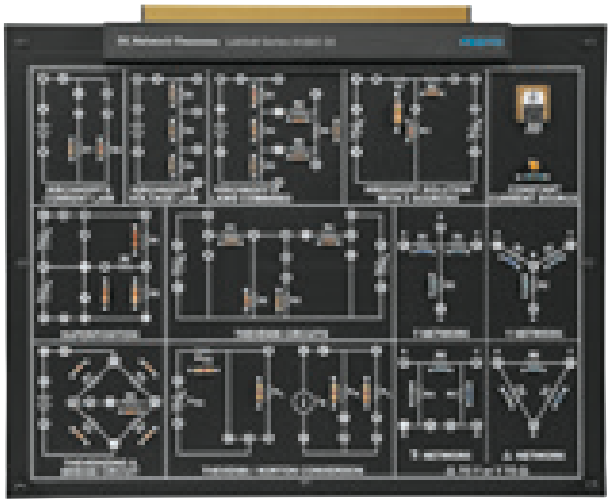
Topic Coverage
- Instrument Familiarization
- FACET® Base Unit Familiarization
- DC Fundamentals Circuit Board Familiarization
- Symbols and Schematics
- Basic Safety Rules
- Electrical Safety Rules
- Circuit Resistance, Circuit Current, Circuit Voltage
- DC Power Sources in Series and in Parallel Series
- Opposing DC Sources
- Identify Types of Switches
- Switching Concepts
- Ohm's Law: Circuit Resistance, Circuit Current, Circuit Voltage
- Resistance, Current, and Voltage in a Series Resistive Circuit
- Resistance, Voltage, and Current in a Parallel Resistive Circuit
- Resistance, Voltage, and Current in a Series-Parallel Resistive Circuit
- Power in a Series, Parallel, and Series-Parallel Resistive Circuit
- The Rheostat
- The Potentiometer
- Voltage and Current Dividers
- The DC Ammeter/ Ohmmeter/ Voltmeter
- Troubleshooting DC Circuits 1

DC Fundamentals 91001 en	**580877**
DC Fundamentals 91001 fr	**580878**
DC Fundamentals 91001 es	**580879**

Workbooks, also order:

Student Manual, en	580644
Instructor Guide, en	580647

DC Network Theorems
Circuit Board 91002



Consisting of nine training circuit blocks and a constant-source current block, the DC Network Theorems Circuit Board enables students to perform practical exercises that demonstrate theoretical DC principles. When a circuit has two voltage sources in different branches, theorems are used to solve for voltage and/or current in these circuits where Ohm's Law cannot be applied.

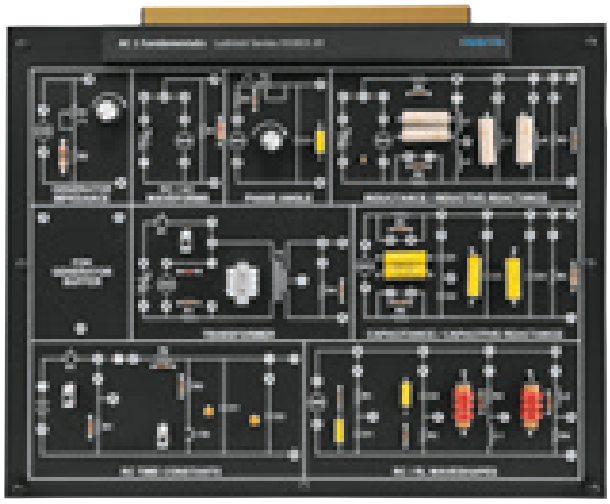
Topic Coverage
- Component Location and Identification
- Circuit Board Operation
- Currents and Node Currents in a Two-Element Branch Circuit
- Voltages in a Three-Element Series Circuit
- Algebraic Sum of Voltages in a Series Circuit
- Generating Loop Equations
- Generating Node Equations
- Kirchhoff's Voltage and Current Law with a Two-Source Circuit
- Mesh Solutions of a Two-Source Circuit
- Superposition Solution for a Two-Source Circuit
- Millman's Theorem Solution for Two-Source Circuit
- Thevenizing a Single-Source and a Dual-Source Network
- Thevenin Resistance (R_{th}) and Thevenin Voltage (V_{th}) of a Bridge Circuit
- Thevenin to Norton Conversion
- Norton to Thevenin Conversion
- Tee and Wye or Pi and Delta Networks
- Transformation of Delta and Wye Networks
- Troubleshooting Basics
- Troubleshooting DC Networks

DC Network Theorems 91002 en	**580889**
DC Network Theorems 91002 fr	**580890**
DC Network Theorems 91002 es	**580891**

Workbooks, also order:

Student Manual, en	589693
Instructor Guide, en	580655

AC 1 Fundamentals
Circuit Board 91003



This Circuit Board contains nine circuit blocks on which students perform varied troubleshooting exercises in the AC 1 Fundamentals program. Students identify and isolate the following circuits: Generator Impedance, AC/DC Waveforms, Phase Angle, Inductance/Inductive Reactance, Transformer, Capacitance/Capacitive Reactance, RC Time Constants, and RC/RL Wave Shapes.

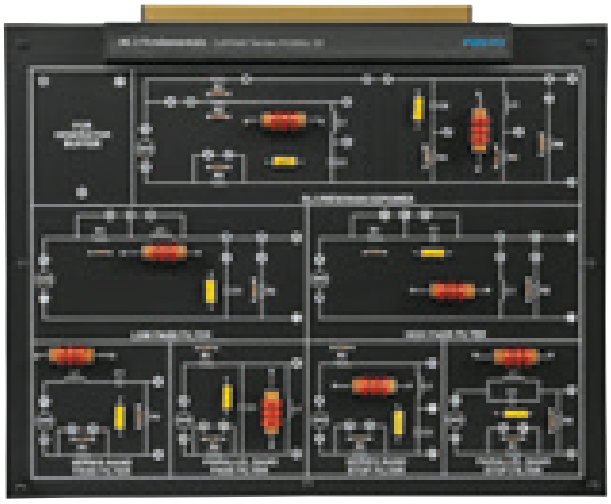
Topic Coverage
- The Oscilloscope
- The AC Waveform Generator
- AC Amplitude Measurement
- Measuring AC Voltage, Current, and Impedance with an Oscilloscope
- Measuring and Setting Frequency
- Inductors
- Phase Angle
- Inductors in Series and in Parallel
- Fundamentals of Inductive Reactance
- Inductive Reactance and Impedance
- Series and Parallel RL Circuits
- What is an Electromagnet?
- Transformer Windings
- Mutual Inductance
- Transformer Turns and Voltage Ratios
- Transformer Secondary Loading
- Capacitors
- Capacitors in Series and in Parallel
- Fundamentals of Capacitive Reactance
- Series and Parallel RC Circuits
- RC Time Constants
- RC/RL Waveshapes
- Troubleshooting Basics
- Troubleshooting the AC 1 Fundamentals Circuit Board

AC 1 Fundamentals 91003 en	**580901**
AC 1 Fundamentals 91003 fr	**580902**
AC 1 Fundamentals 91003 es	**580903**

Workbooks, also order:

Student Manual, en	580661
Instructor Guide, en	580664

AC 2 Fundamentals
Circuit Board 91004



The AC 2 Fundamentals Circuit Board is designed as a continuation of the AC 1 Fundamentals program.

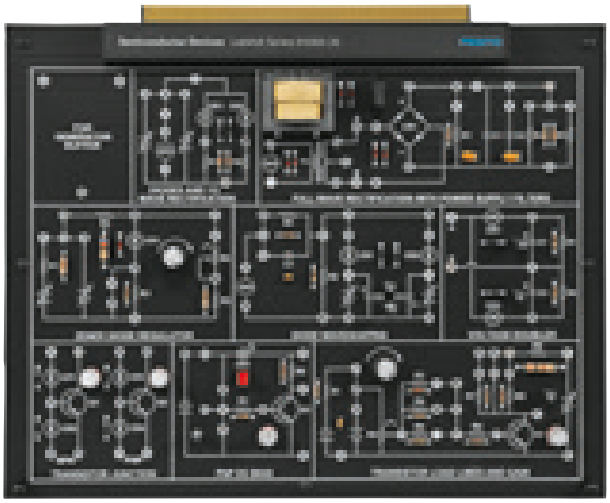
Topic Coverage
- Series RLC Circuits
- Parallel RLC Circuits
- Series Resonant Circuits
- Q and Bandwidth of a Series RLC Circuit
- Resonant Frequency in a Parallel LC Circuit
- Q and Bandwidth
- Power Division
- Power Factor
- Low-Pass Filters
- High-Pass Filters
- Band-Pass Filters
- Band-Stop Filters
- Troubleshooting Basics
- Troubleshooting the AC 2 Fundamentals Circuit Board

AC 2 Fundamentals 91004 en	**580913**
AC 2 Fundamentals 91004 fr	**580914**
AC 2 Fundamentals 91004 es	**580915**

Workbooks, also order:

Student Manual, en	580670
Instructor Guide, en	580673

Semiconductor Devices
Circuit Board 91005



The Semiconductor Devices Circuit Board contains nine circuit blocks pertaining to skills training in semiconductor circuits.

After completion of the FACET® programs in AC and DC Fundamentals and AC and DC Circuits and Analysis, students are ready to train on the Semiconductor Board.

Students in this program will be responsible for analyzing and troubleshooting the following circuits: Diodes and Half-wave Rectification, Full-wave Rectification with Power Supply Filters, Zener Diode Regulator, Diode Waveshaping, Voltage Doubler, Transistor Junction, PNP DC Bias, and Transistor Load Lines and Gain.

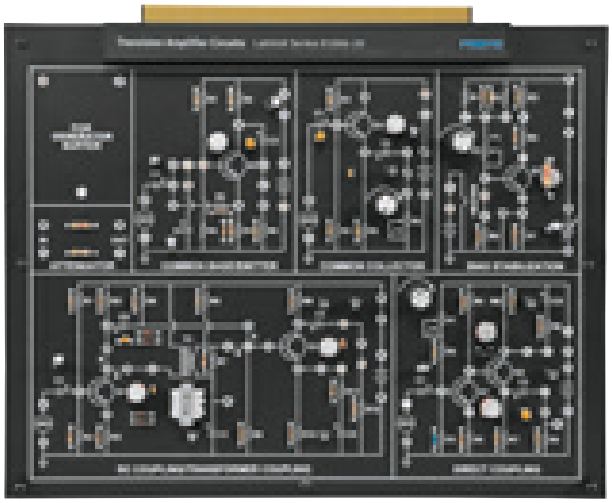
Topic Coverage
- Semiconductor Component Identification
- Control of a Semiconductor Switch
- Diode and DC Characteristics
- Half-Wave Rectification
- Full-Wave Diode Bridge Rectification
- Power Supply Filtering
- Voltage Doubler
- Diode Waveshaping
- The Zener Diode
- Zener Diode Voltage Regulation
- Testing the Junctions of a Transistor
- PNP Transistor Current Control Circuit
- Emitter-Base Bias Potentials
- Collector Current vs. Base Bias
- Transistor DC Circuit Voltages
- Transistor Load Lines
- Troubleshooting Basics
- Troubleshooting the Semiconductor Devices Circuit Board

Semiconductor Devices 91005 en	**580925**
Semiconductor Devices 91005 fr	**580926**
Semiconductor Devices 91005 es	**580927**

Workbooks, also order:

Student Manual, en	589694
Instructor Guide, en	580681

Transistor Amplifier Circuits
Circuit Board 91006



The Transistor Amplifier Circuits Board allows students to perform practical exercises that demonstrate transistor amplifier principles.

Students will identify and isolate faults within the following six circuit blocks: Attenuator, Common Base/ Emitter, Common Collector, Bias Stabilization, RC Coupling/Transformer Coupling, and Direct Coupling.

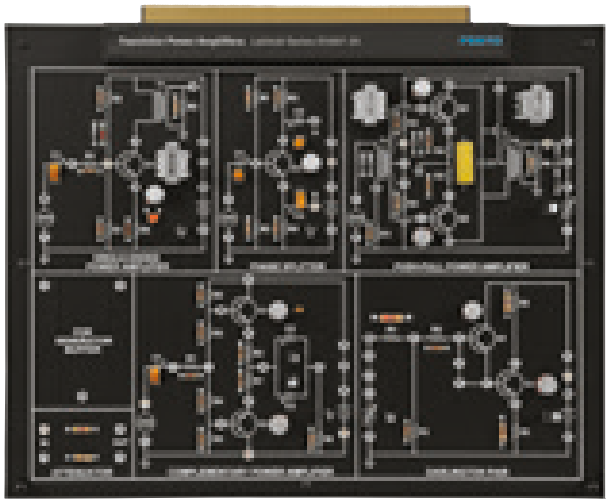
Topic Coverage
- Circuit Location and Identification
- Multistage Amplifier Introduction
- Common Base Circuit DC Operation
- Common Base Circuit AC Operation
- Common Emitter Circuit DC Operation/AC Operation
- Common Collector Circuit DC Operation/AC Operation
- Temperature Effect on Fixed Bias Circuit and Voltage Divider Bias Circuit
- Transistor Parameters Familiarization
- Using the Transistor Specification Sheet
- RC Coupled Amplifier DC Operation
- RC Coupled Amplifier AC Voltage Gain and Phase Relationship
- RC Coupled Amplifier Frequency Response
- Transformer Coupled Amplifier DC Operation/ AC Operation/ Frequency Response
- Direct Coupled Amplifier DC Operation/AC Operation
- Direct Coupled Amplifier Frequency Response
- Troubleshooting Basics
- Troubleshooting Transistor Amplifier Circuits

Transistor Amplifier Circuits 91006 en	**580937**
Transistor Amplifier Circuits 91006 fr	**580938**
Transistor Amplifier Circuits 91006 es	**580939**

Workbooks, also order:

Student Manual, en	580687
Instructor Guide, en	580690

Transistor Power Amplifiers
Circuit Board 91007



The Transistor Power Amplifiers Circuit Board is designed to teach troubleshooting of transistor power amplifier circuitry.

Training on this Circuit Board includes identifying and isolating the following circuits: Single-Ended Power Amplifier, Phase Splitter, Push-Pull Power Amplifier, Attenuator, Complementary Power Amplifier, and Darlington Pair.

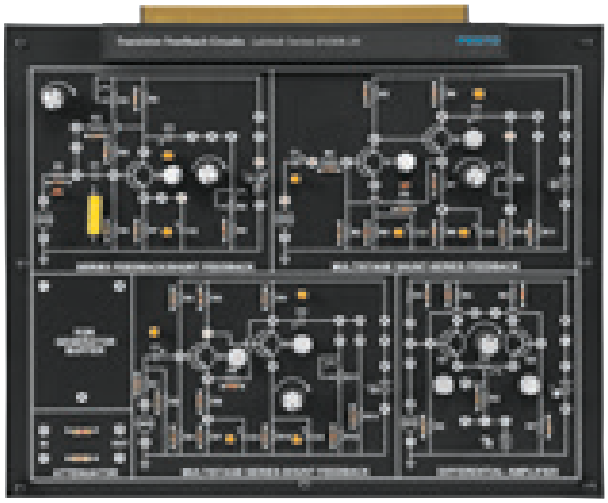
Topic Coverage
- Circuit Location and Identification
- Transistor Power Amplifier Introduction
- Single-Ended Power Amplifier DC Operation
- Single-Ended Power Amplifier AC Voltage Gain and Power Gain
- Phase Splitter DC Operation
- Voltage Gain and Input/Output Signal Phase Relationship
- Push-Pull Power Amplifier DC Operation
- Push-Pull Power Amplifier AC Voltage and Power Gain
- Complementary Power Amplifier DC Operation
- Complementary Power Amplifier AC Voltage Gain and Power Gain
- Darlington Pair Current Gain Characteristics
- Darlington Pair Input and Output Impedance
- Troubleshooting Basics
- Troubleshooting Transistor Power Amplifiers

Transistor Power Amplifiers 91007 en	**580949**
Transistor Power Amplifiers 91007 fr	**580950**
Transistor Power Amplifiers 91007 es	**580951**

Workbooks, also order:

Student Manual, en	589695
Instructor Guide, en	580698

Transistor Feedback Circuits
Circuit Board 91008



The Transistor Feedback Circuit Board enables students to perform practical exercises that demonstrate Transistor Feedback principles.

The circuits found on this board include: Series Feedback/Shunt Feedback, Multistage Shunt-Series Feedback, Attenuator, Multistage Series-Shunt Feedback, and the Differential Amplifier.

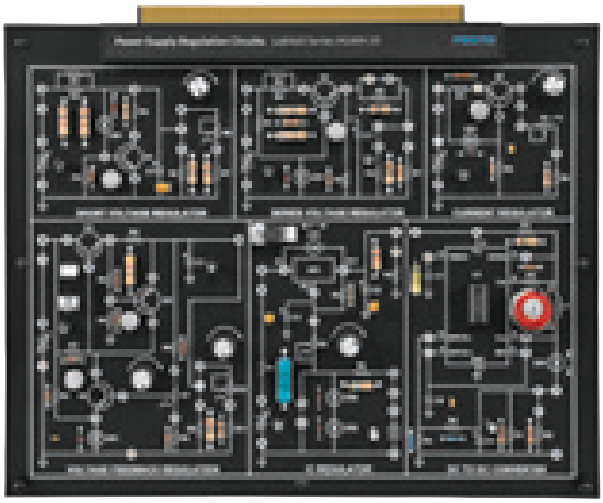
Topic Coverage
- Component Location and Identification
- Series Feedback Amplifier Operation
- The Effect of Feedback on AC Gain
- The Effect of Negative Series Feedback on Bandwidth
- The Effect of Series Feedback on Input and Output Impedance
- The Effect of Shunt Feedback on AC Gain
- The Effect of Shunt Feedback on Bandwidth
- The Effect of Shunt Feedback on Input and Output Impedance
- Shunt-Series Multistage Amplifier Current Gain
- Shunt-Series Multistage Amplifier Output Gain
- Shunt-Series Multistage Amplifier Voltage Gain
- Shunt-Series Multistage Amplifier Output Impedance
- Differential Amplifier Operation
- Single-Ended and Differential Gain Characteristics
- Common Mode Gain and Rejection Ratio
- Troubleshooting Basics
- Troubleshooting Feedback Amplifier Circuits

Transistor Feedback Circuits 91008 en	**580961**
Transistor Feedback Circuits 91008 fr	**580962**
Transistor Feedback Circuits 91008 es	**580963**

Workbooks, also order:

Student Manual, en	589696
Instructor Guide, en	580706

Power Supply Regulation Circuits
Circuit Board 91009



The Power Supply Regulation Circuits Board provides comprehensive, hands-on instruction in the terminology, principles, and applications of power supply regulation circuits.

Following a carefully designed instructional program, students will become familiar with all components of the board; will be able to isolate, identify, and test a series of circuits; and will perform troubleshooting exercises to demonstrate mastery of the course objectives.

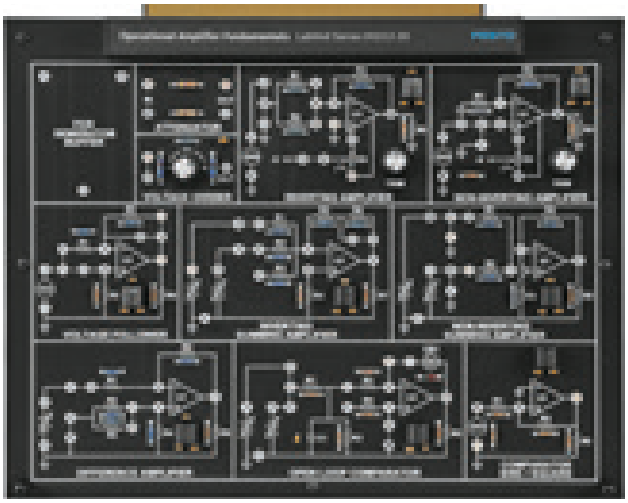
Topic Coverage
- Circuit Location and Identification
- Power Supply Regulator Introduction
- Shunt Regulator Operation
- Line Regulation
- Load Regulation
- Series Regulator Operation
- Voltage Feedback Regulator Operation
- Voltage Feedback Load Regulation
- Foldback Current Limiting Active Protection Circuit
- Current Regulator Operation
- Current Regulator Line Regulation
- Current Regulator Load Regulation
- Three-Pin IC Regulator Operation and Voltage Regulation
- Three-Pin IC Current Regulation and Power Efficiency
- DC-to-DC Converter Operating Characteristics
- DC-to-DC Converter Voltage Regulation and Efficiency
- Troubleshooting Basics
- Troubleshooting Power Supply Regulation Circuits

Power Supply Regulation Circuits 91009 en	**580973**
Power Supply Regulation Circuits 91009 fr	**580974**
Power Supply Regulation Circuits 91009 es	**580975**

Workbooks, also order:

Student Manual, en	589697
Instructor Guide, en	580714

Operational Amplifier Fundamentals
Circuit Board 91012



The Operational Amplifier Fundamentals Circuit Board provides comprehensive, hands-on instruction in the terminology, principles, and applications of the circuitry used in analog applications.

Following a carefully designed instructional program, students will become familiar with all components of the board; will be able to isolate, identify, and test a series of circuits; and will perform troubleshooting exercises to demonstrate mastery of the course objectives.

Topic Coverage
- Operational Amplifier Types and Packages
- Circuit Board Recognition and Description
- Basic Operational Amplifier Characteristics and Parameters
- DC, AC, and other Characteristics of the Inverting Amplifier
- DC, AC, and other Characteristics of the Non-inverting Amplifier
- The Voltage Follower DC Operation
- The Inverting Gain-of-One Amplifier
- The Voltage Follower AC Operation
- Inverting Summing Amplifier Operation
- Summing, Scaling, and Averaging
- Non-Inverting Summing Amplifier Operation
- Summing Amplifier Configurations
- Difference Amplifier DC Operation
- Difference Amplifier AC Operation
- Open-Loop Operation
- Zener-Clamped Operation
- The Sine Wave to Square Wave Converter
- Troubleshooting Basics
- Troubleshooting Operational Amplifier Circuits

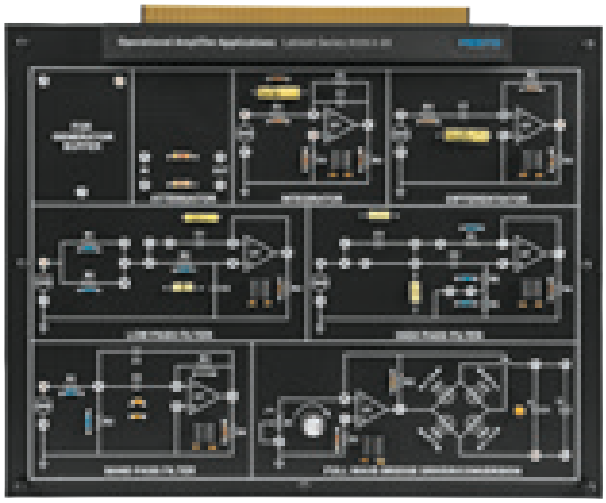
Operational Amplifier Fundamentals 91012 en	**581009**
Operational Amplifier Fundamentals 91012 fr	**581010**
Operational Amplifier Fundamentals 91012 es	**581011**

Workbooks, also order:

Student Manual, en	580736
Instructor Guide, en	580739

Operational Amplifier Applications

Circuit Board 91013



The Operational Amplifier Applications course provides comprehensive, hands-on instruction in the terminology, principles, and applications of operational amplifiers.

Following a carefully designed instructional program, students will become familiar with all components of the board; will be able to isolate, identify, and test a series of circuits; and will perform troubleshooting exercises to demonstrate mastery of the course objectives.

Topic Coverage
- Component Location and Identification
- Band-Pass Filter Operation
- The Integrator
- The Differentiator
- Low-Pass Filter Frequency Response
- Low-Pass Filter Phase and Transient Response
- High-Pass Filter Frequency Response
- High-Pass Filter Phase and Transient Response
- Band-Pass Filter Frequency Response
- Band-Pass Filter Phase Response
- DC Characteristics of an Active Voltage-to-Current Converter
- AC Characteristics of an Active
- RMS or Average Calibrated Voltage-to-Current Converter
- Troubleshooting Basics
- Troubleshooting Operational Amplifier Circuits

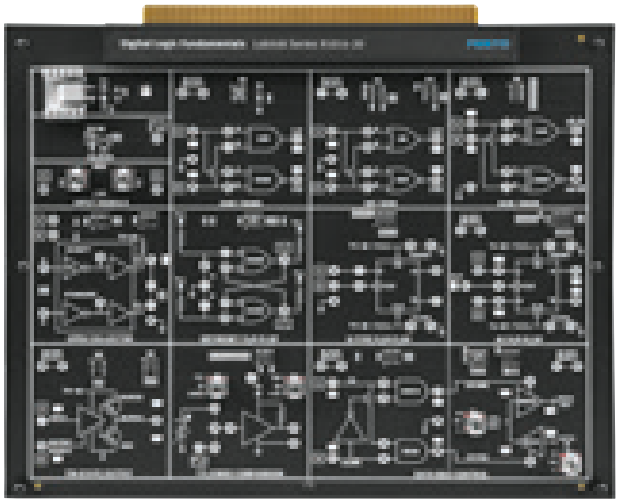
Operational Amplifier Applications 91013 en	**581021**
Operational Amplifier Applications 91013 fr	**581022**
Operational Amplifier Applications 91013 es	**581023**

Workbooks, also order:

Student Manual, en	589700
Instructor Guide, en	580747

Digital Logic Fundamentals

Circuit Board 91014



The Digital Logic Fundamentals course provides comprehensive, hands-on instruction in the terminology, principles, and applications of digital logic circuits.

Following a carefully designed instructional program, students will become familiar with all components of the board; will be able to isolate, identify, and test a series of circuits; and will perform troubleshooting exercises to demonstrate mastery of the course objectives.

Topic Coverage
- Component Location and Identification
- Operation of General Circuits
- IC Package Fundamentals
- AND/NAND Logic Functions
- OR/NOR Logic Functions
- Exclusive OR and NOR Gates
- Dynamic Response of XOR/XNOR Logic Gates
- DC Operation of a NOT and an OR-TIE
- Transfer Characteristics of a Schmitt and a Standard LS TTL Gate
- Set/Reset Flip-Flop
- D-Type Flip-Flop
- Static JK Flip-Flop Operation
- Dynamic Operation of a JK Flip-Flop
- Output Enable Control of a Tri-State Gate
- Sink and Source Control of a Tri-State Gate
- Static Trigger Levels of a TTL and CMOS
- Dynamic Transfer Characteristics of TTL and CMOS
- Static Control of a Data Bus
- Dynamic Control of a Data Bus
- Troubleshooting Basics
- Troubleshooting Digital Circuits

Digital Logic Fundamentals 91014 en	**581033**
Digital Logic Fundamentals 91014 fr	**581034**
Digital Logic Fundamentals 91014 es	**581035**

Workbooks, also order:

Student Manual, en	589691
Instructor Guide, en	589692

Digital Circuit Fundamentals 1
Circuit Board 91015

The Digital Circuit Fundamentals 1 course provides comprehensive, hands-on instruction in the terminology, principles, and applications of digital circuits.

Following a carefully designed instructional program, students will become familiar with all components of the board; will be able to isolate, identify and test a series of circuits; and will perform troubleshooting exercises to demonstrate mastery of the course objectives.

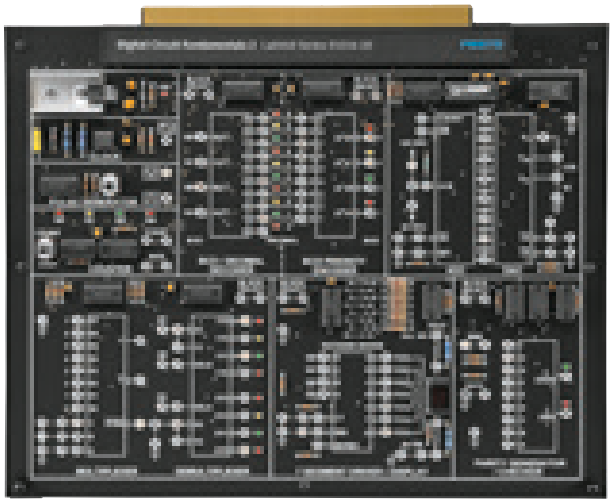
Topic Coverage
- Component Location and Identification
- Operation of General Circuits
- IC Package Fundamentals
- Basic Counter Control Functions
- Ripple Counter Waveforms
- Synchronous Counter Circuit Waveforms
- Synchronous Counter Circuit Glue Logic
- Basic Operating Modes of the Shift Register
- Shift Register Circuit Waveforms
- Fundamental Binary Addition
- Binary Addition with Input and Output Carry
- Fundamental Binary Comparisons
- Comparators and Counter Modulus Control
- Troubleshooting Basics
- Troubleshooting Digital Circuits
- The 74LS193 Counter
- The 74LS283 4-Bit Adder
- The 74LS194 Shift Register
- The 74LS285 Comparator

Digital Circuit Fundamentals 1, 91015 en	**581045**
Digital Circuit Fundamentals 1, 91015 fr	**581046**
Digital Circuit Fundamentals 1, 91015 es	**581047**

Workbooks, also order:

Student Manual, en	585383
Instructor Guide, en	580763

Digital Circuit Fundamentals 2
Circuit Board 91016



The Digital Circuit Fundamentals 2 course provides comprehensive, hands-on instruction in the terminology, principles, and applications of digital circuits.

Following a carefully designed instructional program, students will become familiar with all components of the board; will be able to isolate, identify and test a series of circuits; and will perform troubleshooting exercises to demonstrate mastery of the course objectives.

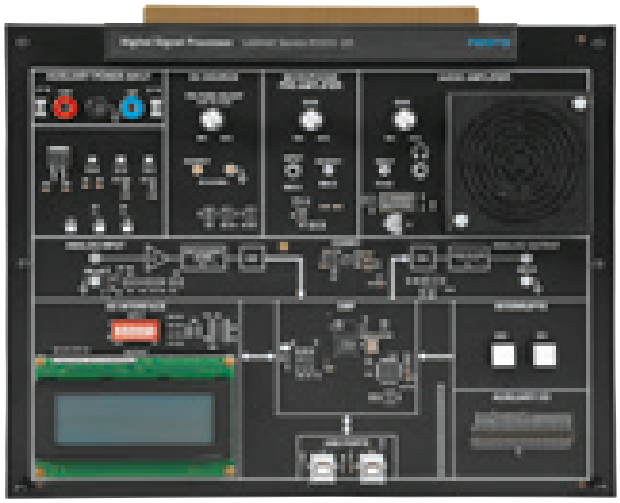
Topic Coverage
- Component Location and Identification
- Operation of General Circuits
- IC Package Fundamentals
- Fundamental BCD Decoder Operation
- Fundamental Priority Encoder Operation
- Fundamental ADC Operation
- Fundamental DAC Operation
- Data Selector and Multiplexer
- The LS151 Multiplexer and LS155 Demultiplexer
- 1-Line-to-8-Line Demultiplexer
- LED Decoder/Driver
- 7-Segment LED Display
- ODD and EVEN Parity
- Parity Generator/Checker Glue Logic
- Troubleshooting MSI IC Circuits
- Troubleshooting Basics
- Troubleshooting Digital Circuits

Digital Circuit Fundamentals 2, 91016 en	**581057**
Digital Circuit Fundamentals 2, 91016 fr	**581058**
Digital Circuit Fundamentals 2, 91016 es	**581059**

Workbooks, also order:

Student Manual, en	589701
Instructor Guide, en	580771

Digital Signal Processor
Circuit Board 91031



The Digital Signal Processor circuit board introduces students to the vast field of digital signal processing and applications.

The courseware covers the basic concepts of digital signal processing, as well as DSP architectures, memory, addressing, I/O, and peripherals. It also presents several essential aspects of real-time DSP processing, such as sampling, A/D and D/A conversion, and the Fast- Fourier Transform.

A version of Code Composer Studio, a typical Integrated Development Environment (IDE) used to develop, debug, and compile DSP applications, is bundled with the board. The source code for the applications used in the courseware is also included.

Practical techniques such as the use of library functions, DSP application optimization, and digital filtering algorithms, are also covered in the courseware.

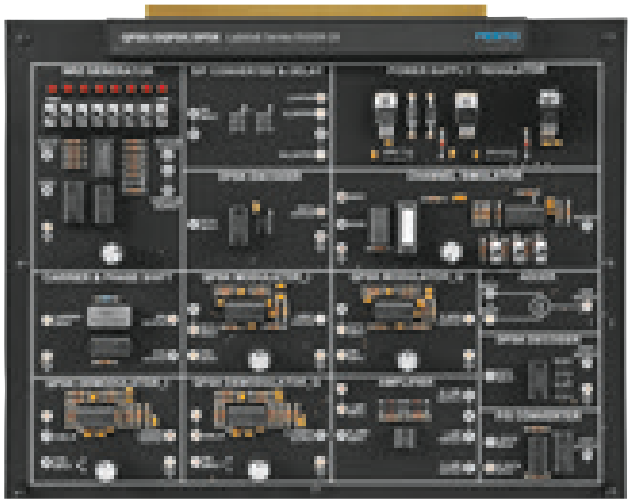
Topic Coverage
- Familiarization with DSPs and DSP programming, overview of the DSP Circuit Board, the Integrated Development Environment (IDE) and Project Structure
- DSP Architecture, Processor Arithmetic, the Data Computation Unit, Memory, and Addressing
- I/O and Peripherals, an Application Using I/Os and Peripherals
- DSP Real-time Processing, Sampling and Analog-to-Digital/ Digital-to-Analog Conversion, the Fast Fourier transform (FFT), Optimizing DSP applications
- Signal Processing Applications, FIR and IIR Filters

Digital Signal Processor 91031 en	**585736**
Digital Signal Processor 91031 fr	**585737**

Workbooks, also order:

Student Manual, en	583850
Instructor Guide, en	583851

QPSK/OQPSK/DPSK
Circuit Board 91029



Phase-shift keying (PSK) is a method of digital communication in which the phase of a transmitted signal is varied to convey information. The QPSK/OQPSK/DPSK board provides students with the theory and measurement skills required to implement and test different types of PSK modulation and demodulation techniques used in pulse-coded modulation (PCM) schemes.

Courseware covers the principles and operational characteristics of unipolar and bipolar signals in a baseband transmission, measurement and comparison of BPSK, QPSK, OQPSK, and DPSK signals in the time and frequency domains using an oscilloscope and spectrum analyzer, respectively, and familiarization with all components of the board, including isolation, identification, and testing of a series of circuits.

Students will perform troubleshooting exercises to demonstrate mastery of the course objectives.

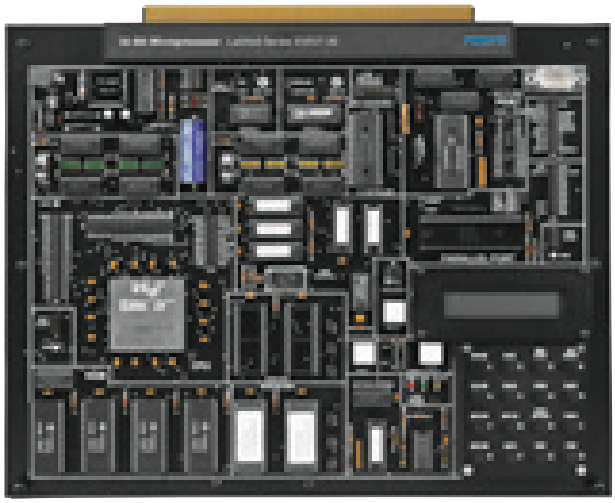
Topic Coverage
- Digital modulation
- Baseband and Passband signals
- Partitioning of pulse streams
- Signal constellations for MPSK
- General MPSK equations
- Heterodyning baseband signals with a carrier
- Unipolar and bipolar signals in time and frequency domains
- Binary PSK (BPSK), Quadratic PSK (QPSK), and Offset QPSK (OQPSK) modulation and demodulation
- Differential PSK (DPSK) encoding and decoding

QPSK/OQPSK/DPSK 91029 en	**581201**
QPSK/OQPSK/DPSK 91029 es	**581202**

Workbooks, also order:

Student Manual, en	580433
Instructor Guide, en	580439

32-Bit Microprocessor
Circuit Board 91017



This board provide comprehensive, hands-on instruction in the terminology, principles and applications of 32-bit µC microprocessor systems.

The 80386DX CPU is used to demonstrate microprocessor, memory, I/O concepts, analog systems via converters, as well as serial and parallel protocols.

A keypad and a LCD display allow direct user interaction with the CPU. An on-board logic probe, single bus cycle execution mode, and the practical, hands-on approach of the courseware guide students.

This board can be interfaced with higher-level FACET® boards, such as Transducer Fundamentals; Motors, Generators and Controls; and Fiber Optic Communications. It can also interface with Application board 91062 for additional exercises.

Topic Coverage
- Circuit Board Introduction and Operation
- Bus States
- 32-Bit Bus Transfers
- Read and Write Cycles
- CPU Initialization
- Memory Control Signals
- Memory Address Decoding
- Memory Data Transfers
- DAC and ADC Ports
- PPI and Keypad Interface
- Display and Serial Ports
- Maskable and Non-Maskable Interrupts
- Exceptions
- Immediate, Register, and Memory Addressing Modes
- Instruction formats
- 80386 CPU Instructions

32-Bit Microprocessor 91017 en	**581069**
32-Bit Microprocessor 91017 fr	**581070**
32-Bit Microprocessor 91017 es	**581071**

Workbooks, also order:

Student Manual, en	589702
Instructor Guide, en	580779

Microprocessor Application Board
Circuit Board 91602

This Circuit Board is an add-on to the 32-Bit Microprocessor (Model 91017). It allows students to study how microprocessors can control and communicate with external devices. The Application Board has two application circuits: a DC Motor Controller, and a Temperature Controller.

The DC Motor Controller has a motor whose speed and direction of rotation can be controlled by the microprocessor. Mounted on the motor's shaft is a fan blade that makes it easier for students to see the direction of rotation. The motor's shaft also has an encoder disk with optical interrupter that provides feedback on the motor speed to the microprocessor, allowing closed-loop control of the motor speed.

The Temperature Controller uses two temperature transducers whose output current is a function of their temperature. One transducer is thermally bonded to a resistor that is used as a heater. The microprocessor controls the turning on and turning off of the heater, whose status is indicated by an LED indicator. The other transducer is used as a room temperature reference, allowing the microprocessor to perform closed-loop control of the temperature.

The course can be performed through the interactive computer-based learning (CBL) provided with the Circuit Board 91017 course, or in a conventional way by using the manuals provided with the Circuit Board 91017 course.

Microprocessor Application Board 91602 en	**581224**

Workbooks, also order:

Student Manual, en	585395

Breadboard
Circuit Board 91091

The Breadboard is a complement to Digital Logic Fundamentals (Model 91014). The Breadboard module consists of three printed circuit boards designed so that students can easily connect and change circuits without the need to solder components.

Students gain the understanding of the physical characteristics of components like pinouts, size, power, and impedance voltage limits. The breadboard comes with all the leads and components required to connect the studied circuits. These circuits include astable, bistable, and monostable multibrators, as well as Schmitt trigger (wave-squaring) circuits. A voltage source powered from the base unit provides the voltages required to power the circuits. These voltages are accessible from an additional solderless breadboard.

The practical, hands-on approach of the courseware guides students in the observation and measurement of signals with an oscilloscope. As a prerequisite, students should be familiar with the operation of bipolar transistor circuits.

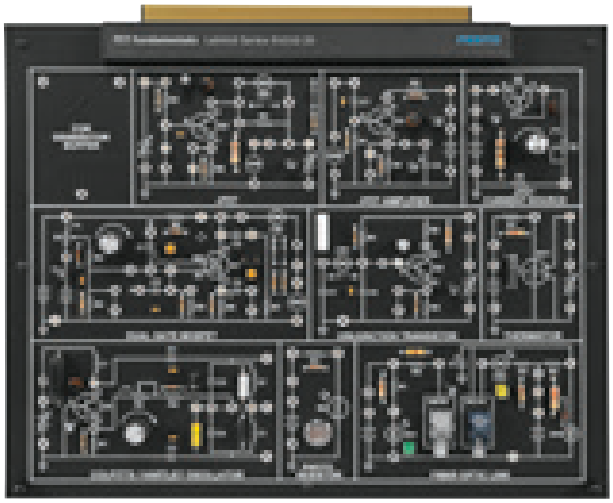
Topic Coverage
- Astable Multivibrator
- Bistable Multivibrator
- Monostable Multivibrator
- Schmitt Trigger

Breadboard 91091 en	**581221**
Breadboard 91091 fr	**581222**
Breadboard 91091 es	**581223**

Workbooks, also order:

Student Manual, en	580399
Instructor Guide, en	580400

FET Fundamentals
Circuit Board 91010



The FET Fundamentals course provides comprehensive, hands-on instruction in the terminology, principles and applications of JFET, MOSFET, and UJT. Following a carefully designed instructional program, students will become familiar with all components of the board; will be able to isolate, identify, and test a series of circuits; and will perform troubleshooting exercises to demonstrate mastery of the course objectives.

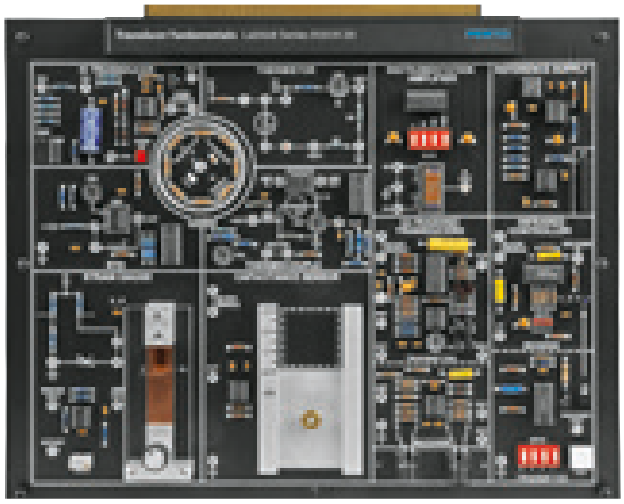
Topic Coverage
- Component Location and Identification
- Unijunction Oscillator Operation
- JFET Operating Characteristics
- The Effect of Gate Bias on Pinch-off
- JFET Dynamic Characteristic Curves
- JFET Amplifier DC Operation
- JFET Amplifier Voltage Gain
- JFET Current Source DC Operation
- JFET Current Source Power and Load Voltage Variation
- Zero Bias Characteristic of a MOSFET
- MOSFET Modes of Operation
- MOSFET Voltage Amplifier
- Dual Gate MOSFET Mixer
- UJT Operating Characteristics
- UJT Waveform Generation
- Hartley Oscillator Operation
- Colpitts Oscillator Operation
- Thermistor Operation
- Photoresistor Operation
- Fiber Optic Light Transfer
- Troubleshooting Basics
- Troubleshooting FET Circuits
- FET Specification Sheets
- Unijunction Transistor Specification Sheets
- Transducer Specification Sheets

FET Fundamentals 91010 en	**580985**
FET Fundamentals 91010 fr	**580986**
FET Fundamentals 91010 es	**580987**

Workbooks, also order:

Student Manual, en	589698
Instructor Guide, en	580722

Transducer Fundamentals
Circuit Board 91019



The Transducer Fundamentals course guides students through the circuits and devices used to interface computer and control circuits. Students learn the principles of input and output transducers and how physical quantities, such as heat, position, proximity, and force, are converted to electrical signals for detection and processing.

This circuit board can be interfaced with the 32-Bit Microprocessor circuit board to demonstrate the principles of data acquisition and microprocessor control.

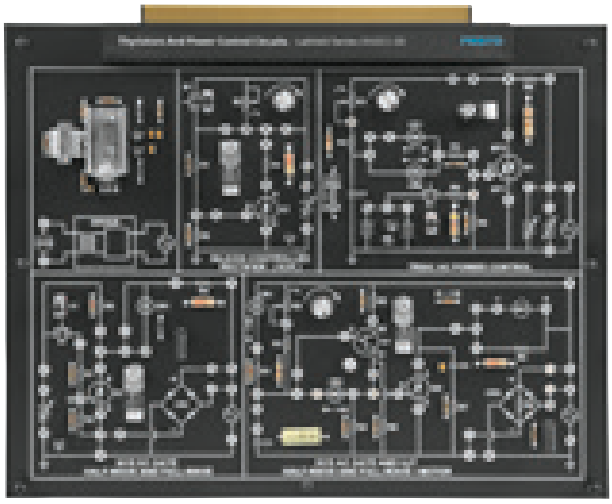
Topic Coverage
- Introduction to Transducers
- Introduction to the Circuit Board
- Temperature Measurement
- Temperature Control
- Thermistor Characteristics
- Resistance Temperature Detector (RTD) Characteristics
- Thermocouple Characteristics
- Capacitance Sensor
- Touch and Position Sensing
- Strain Gauge Characteristics
- Bending Beam Load Cell (Strain Gauge)
- Ultrasonic Principles
- Distance Measurement
- Infrared Transmission/Reception
- IR Remote Control
- Force Measurement
- Computerized Temperature Control and Measurement and Computerized Force Measurement:These exercises and computer interface require the optional 32-Bit Microprocessor board (91017) plus, accessories: 9 V Power Supply (91730), and Flat Ribbon Cable (91627)
- Troubleshooting Transducer Circuits

Transducer Fundamentals 91019 en	**581096**
Transducer Fundamentals 91019 fr	**581097**
Transducer Fundamentals 91019 es	**581098**

Workbooks, also order:

Student Manual, en	589704
Instructor Guide, en	580795

Thyristor and Power Control Circuits
Circuit Board 91011



The Thyristor and Power Control Circuits course provides comprehensive, hands-on instruction in the fundamental terminology, principles, and applications of thyristor and power control circuits.

Following a carefully designed instructional program, students will become familiar with all components of the board; will be able to isolate, identify, and test a series of circuits; and will perform troubleshooting exercises to demonstrate mastery of the course objectives.

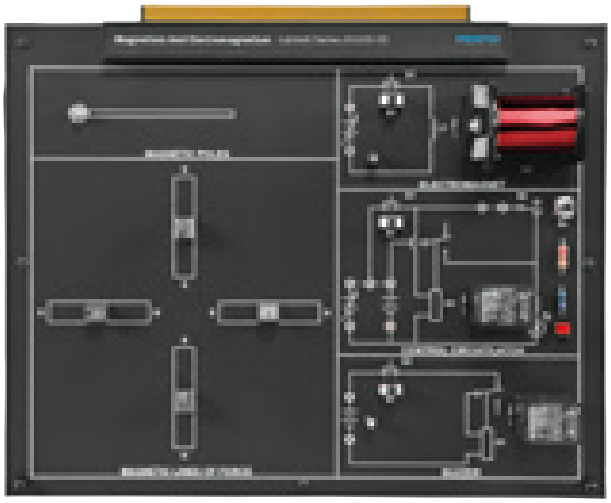
Topic Coverage
- Thyristor Component Familiarization
- Thyristor Circuit Fundamentals
- Test a Silicon-Controlled Rectifier (SCR)
- SCR DC Operation
- Gate Trigger Voltage and Holding Current
- SCR Half-Wave Rectifier
- SCR Control of a Half-Wave Rectifier
- SCR Control of a Full-Wave Rectifier
- Half-Wave Phase Control
- Full-Wave Phase Control
- UJT Characteristics
- UJT Half-Wave and Full-Wave Phase Control
- Bidirectional Conduction
- The Four Triggering Modes
- Half-Wave Phase Control
- Full-Wave Phase Control
- Troubleshooting Basics
- Troubleshooting Thyristor and Power Control Circuits

Thyristor and Power Control Circuits 91011 en	**580997**
Thyristor and Power Control Circuits 91011 fr	**580998**
Thyristor and Power Control Circuits 91011 es	**580999**

Workbooks, also order:

Student Manual, en	589699
Instructor Guide, en	580730

Magnetism/Electromagnetism
Circuit Board 91020



The Magnetism/Electromagnetism course is an extension of the AC 1 Fundamentals training board that provides comprehensive, hands-on instruction in the terminology, principles, and applications of magnetism and electromagnetism.

Following a carefully designed instructional program, students will become familiar with all components of the board; and will be able to isolate, identify, and test a series of circuits.

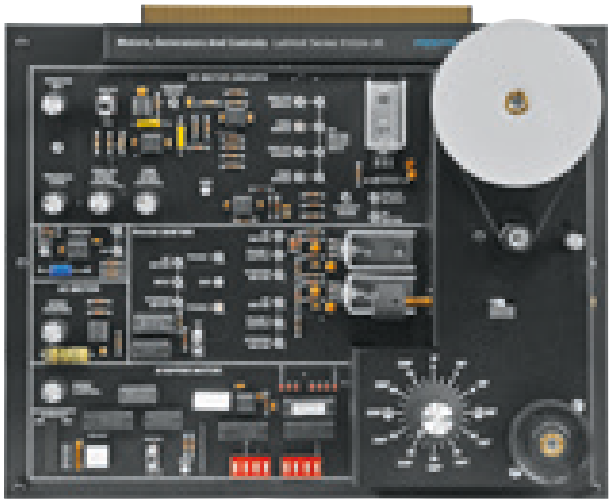
Topic Coverage
- What is Magnetism?
- Magnetic Fields
- Making a Magnet
- What is an Electromagnet?
- The Solenoid
- The Relay

Magnetism/Electromagnetism 91020 en	**581108**
Magnetism/Electromagnetism 91020 fr	**581109**
Magnetism/Electromagnetism 91020 es	**581110**

Workbooks, also order:

Student Manual, en	589705
Instructor Guide, en	580803

Motors, Generators, and Controls
Circuit Board 91024



The Motors, Generators, and Controls course provides comprehensive, hands-on instruction in the terminology, principles, and applications of the DC motor, AC synchronous motor, phase shifter, and stepper motor.

Following a carefully designed instructional program, students are able to perform troubleshooting exercises on analog and pulse-width modulated (PWM) DC motor positioning, analog and PWM DC motor speed control, variable frequency speed control of an AC synchronous motor, operation of a tachogenerator circuit, and speed and position control of a stepper motor with optional computer interface.

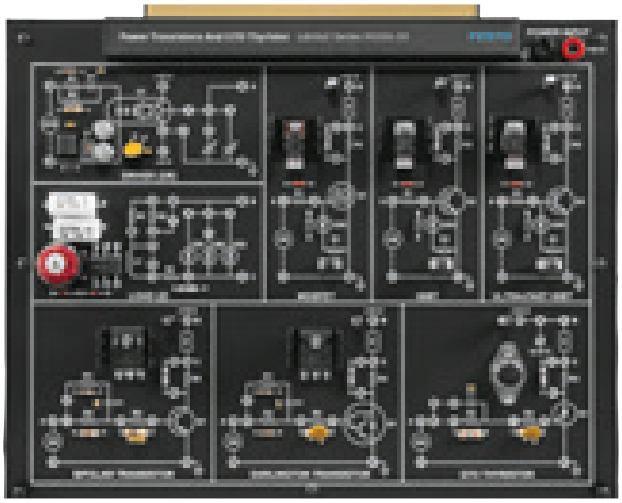
Topic Coverage
- DC Motor Circuits Familiarization
- Stepper Motor and AC Motor Circuits
- Analog DC Motor Positioning
- PWM DC Motor Positioning
- Analog and Pulsed Speed Control of a DC Motor
- Variable Frequency Control
- The Tachometer Generator
- The Stepper Motor
- The Stepper Motor Controller
- Troubleshooting
- Microprocessor Interface: This exercise and computer interface require the optional 32-Bit Microprocessor board (91017) plus accessories: 9 V Power Supply (91730), and Flat Ribbon Cable (91627).

Motors, Generators and Controls 91024 en	**581147**
Motors, Generators and Controls 91024 fr	**581148**
Motors, Generators and Controls 91024 es	**581149**

Workbooks, also order:

Student Manual, en	589708
Instructor Guide, en	580827

Power Transistors and GTO Thyristors
Circuit Board 91026



In the Power Transistors and GTO Thyristors course, students perform practical exercises that demonstrate the use of several power electronic, self-commutated switches. The course contains six types of switches that are implemented with a MOSFET, an isolated-gate bipolar transistor (IGBT), a fast IGBT, a bipolar resistor, a Darlington resistor, and a GTO thyristor. Learning of switches is expanded with a Driver section, consisting of an opto-isolator and driver for power thyristors; a Load section, consisting of resistive and inductive components; and general-purpose, fast, and ultra-fast free-wheeling diodes.

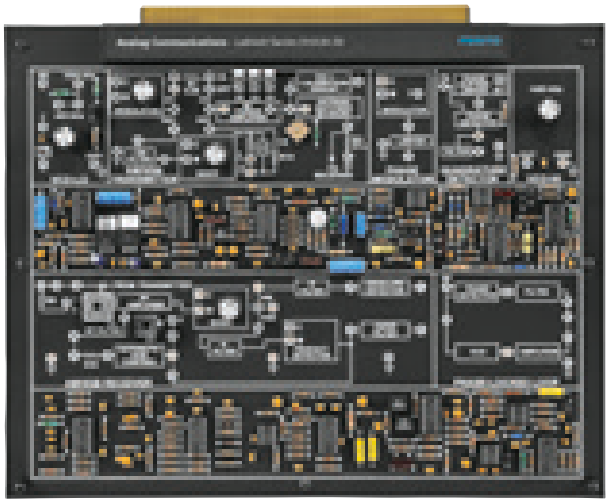
Topic Coverage
- Power Transistors and GTO Thyristor Identification
- Overview of the Circuit Blocks
- Familiarization with the Driver Circuit Block
- Familiarization with the Load Circuit Block
  Basic Operations of Power Bipolar Transistors
- Basic Operation of Power MOSFETs and IGBTs
- Basic Operation of GTO Thyristors
- Switching Time and Conduction Voltage Drop
- Switching Power in an Inductive Load
- Free-Wheeling Diode Recovery Time
- Losses in Electronic Power Switches
- The Bipolar Power Transistor
- The Darlington Power Transistor
- The GTO Thyristor
- The Power MOSFET
- The IGBT
- The Ultra-Fast IGBT

Power Transistors and GTO Thyristors 91026 en	**581171**
Power Transistors and GTO Thyristors 91026 fr	**581172**
Power Transistors and GTO Thyristors 91026 es	**581173**

Workbooks, also order:

Student Manual, en	580837
Instructor Guide, en	580847

Analog Communications
Circuit Board 91018



The Analog Communications course provides comprehensive, hands-on instruction in the terminology, principles, and applications of analog communications.

In this course, students receive hands-on circuit training and acquire skills to measure radio signals with an oscilloscope. Students also learn the functions of oscillators, filters, amplifiers, LC networks, modulators, limiters, mixers, and detectors in communication circuits.

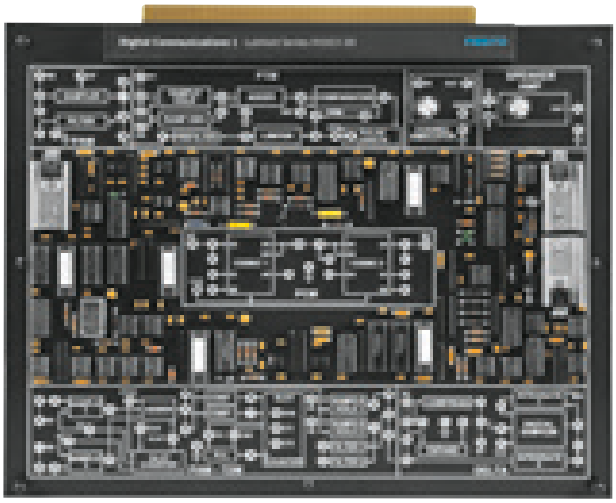
Topic Coverage
- Analog Communications Concepts
- Circuit Board Familiarization
- Amplitude Modulation (AM)
- RF Power Amplifier
- Balanced Modulator
- RF Stage
- Mixer, IF Filter, and Envelope Detector
- Balanced Modulator and LSB Filter
- Mixer and RF Power Amplifier
- RF Stage, Mixer, and IF Filter
- Product Detector and Automatic Gain Control
- Frequency Modulation (FM) and Phase Modulation (PM)
- Demodulation (Quadrature Detector)
- PLL (Phase-Locked Loop) Circuit and Operation
- FM Detection with a PLL
- Troubleshooting Basics
- Troubleshooting Analog Communications Circuits

Analog Communications 91018 en	**581084**
Analog Communications 91018 fr	**581085**
Analog Communications 91018 es	**581086**

Workbooks, also order:

Student Manual, en	589703
Instructor Guide, en	580787

Digital Communications 1
Circuit Board 91022



The Digital Communications 1 course provides comprehensive, hands-on instruction in the terminology, principles, and applications of digital circuits, including: Sampler, Sample/Hold, Adder, Ramp Generator, Comparator, Limiter, Filter, CODEC, PLL, Compressor, Expander, Integrator, Differentiator, Latched Comparator, Speaker Amplifier, and Channel Simulator.

Following a carefully designed instructional program, students will become familiar with all components of the board; will be able to isolate, identify, and test a series of circuits; and will perform troubleshooting exercises to demonstrate mastery of the course objectives.

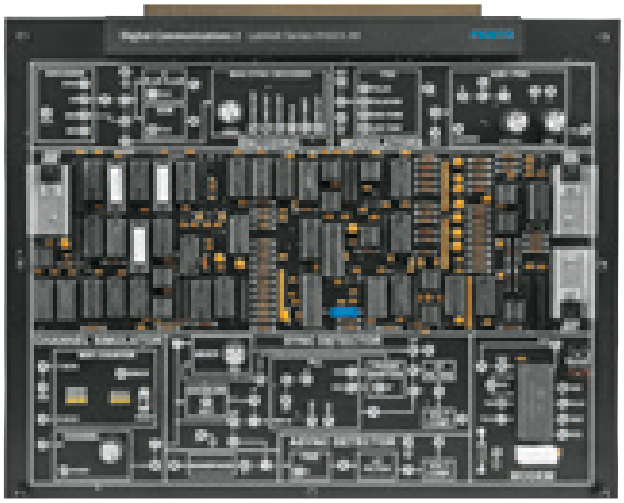
Topic Coverage
- Concepts of Digital Communications
- Circuit Board Familiarization
- Pulse Amplitude Modulation (PAM) Signal Generation
- PAM Signal Demodulation
- PAM Time-Division Multiplexing (TDM) Transmission
- PAM TDM Reception
- Pulse-Time Modulation (PTM) Signal Demodulation
- PTM Signal Generation
- Pulse-Code Modulation (PCM) Signal Generation and Demodulation
- PCM Signal TDM
- Delta Modulation (DM) Transmitter
- DM Receiver and Noise
- Channel Bandwidth
- Channel Noise
- Troubleshooting Basics
- Troubleshooting Digital Communications 1 Circuits

Digital Communications 1, 91022 en	**581123**
Digital Communications 1, 91022 fr	**581124**
Digital Communications 1, 91022 es	**581125**

Workbooks, also order:

Student Manual, en	589706
Instructor Guide, en	580811

Digital Communications 2
Circuit Board 91023



The Digital Communications 2 course provides further comprehensive, hands-on instruction in the terminology, principles, and applications of digital circuits, including: NRZ, RZ, Manchester Encoding and Decoding, Clock Synchronizer, Frequency-Shift Keying (FSK) Generation, FSK Asynchronous and Synchronous Detection, Phase-Shift Keying (PSK) Generation, PSK Synchronous Detection, Amplitude-Shift Keying (ASK) Generation, ASK Asynchronous and Synchronous Detection, Channel Effects, and FSK/DPSK (Differential Phase-Shift Keying) Modem.

Following a carefully designed instructional program, students will become familiar with all components of the board; will be able to isolate, identify, and test a series of circuits; and will perform troubleshooting exercises to demonstrate mastery of the course objectives.

Topic Coverage
- Circuit Board Familiarization
- Introduction to Digital Transmission
- Encoding and Decoding
- FSK Signal Generation
- FSK Asynchronous Detection
- FSK Synchronous Detection
- PSK Signal Generation
- PSK Synchronous Detection
- ASK Signal Generation
- ASK Asynchronous Detection
- The Channel Simulator
- Effects of Noise on ASK and PSK Signals
- Effects of Noise on Asynchronously and Synchronously Detected FSK Signals
- Operation of an FSK Modem
- Operation of a DPSK Modem
- Troubleshooting Basics
- Troubleshooting Digital Communications 2 Circuits

Digital Communications 2, 91023 en	**581135**
Digital Communications 2, 91023 fr	**581136**
Digital Communications 2, 91023 es	**581137**

Workbooks, also order:

Student Manual, en	589707
Instructor Guide, en	580819

Fiber Optic Communications
Circuit Board 91025

The Fiber Optic Communications course provides comprehensive, hands-on instruction in the theory and practice of fiber optic communications technology.

Following a carefully designed instructional program, students will become familiar with all components of the board; will be able to isolate, identify, and test a series of circuits; and will perform troubleshooting exercises to demonstrate mastery of the course objectives.

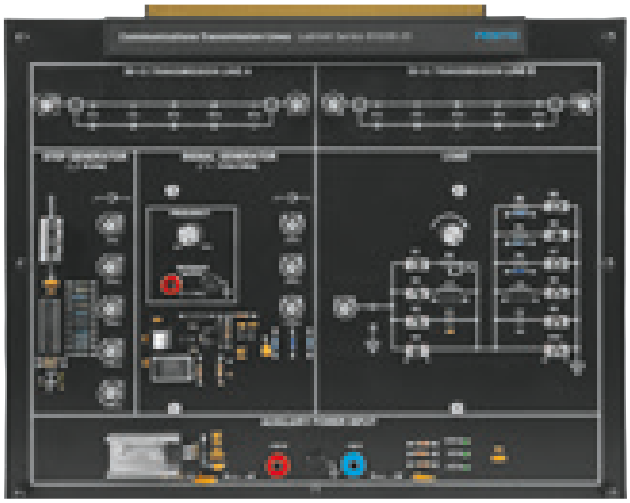
Topic Coverage
- Circuit Board Familiarization
- Introduction to Fiber Optic Communications
- Scattering and Absorption Losses
- Connectors and Polishing
- Numerical Aperture and Core Area
- Bending Loss and Modal Dispersion
- Light Source
- Driver Circuit
- Source-to-Fiber Connection
- Light Detector
- Output Circuit
- Fiber Optic Test Equipment
- Optical Power Budgets
- Analog Communications
- Digital Communications: This exercise and computer interface require the optional 32-Bit Microprocessor plus accessories: 9 V power supply, and Adapter. Additional option includes Polishing Kit
- Troubleshooting

Fiber Optic Communications 91025 en	**581159**
Fiber Optic Communications 91025 fr	**581160**
Fiber Optic Communications 91025 es	**581161**

Workbooks, also order:

Student Manual, en	589709
Instructor Guide, en	580835

Communications Transmission Lines
Circuit Board 91028



The Transmission Lines circuit board provides students with the theory and measurement skills required to implement and test communications transmission lines. Courseware covers the principles and operational characteristics of transmission lines, conducting transmission line measurements under transient (step testing) and sinusoidal steady-state conditions, and valuable foundational information on the theory and practice of time-domain reflectometry (TDR), as well as impedance matching and transformation.

The circuit board uses two 24-meter (78.7 feet) RG-174 coaxial cables which can be used separately or connected end-to-end. Each line has five probing points that permit observation and measurements of signals along the line, using an oscilloscope. Two generators are provided to study the transmission line behavior: a step generator that produces a 50-kHz square-wave voltage for transient behavior testing, and a signal generator that produces a sinusoidal voltage of variable frequency (5 kHz – 5 MHz) for steady-state behavior testing. Each generator has several BNC outputs providing different output impedances. A load section, consisting of a configurable network of resistors, inductors, and capacitors, permits connection of different load impedances to the receiving end of each line.

Topic Coverage
- Characteristics of Transmission Lines
- Transmission Line Measurements Under Transient (Step Testing) and Sinusoidal Steady-State Conditions

Communications Transmission Lines 91028 en	**581192**
Communications Transmission Lines 91028 fr	**581193**
Communications Transmission Lines 91028 es	**581194**

Workbooks, also order:

Student Manual, en	580353
Instructor Guide, en	580361

Accessories

Virtual Instrument Package

A powerful package
The Virtual Instrument Package, LabVolt Series 1250, replaces conventional desktop test equipment with a powerful, space-saving, virtual instrumentation package that gives students state-of-the-art tools to measure, analyze, observe, and display the results of electronic circuit tests.

Fully integrated with the FACET® Electronics Training program, the Virtual Instrument Package enables students to conduct all experiments of the FACET® curriculum.

Complete software suite
The complete Virtual Instrument Package consists of an interface unit for data acquisition connections, and a Windows-based software. The interface is connected to the computer via a USB connection.

The software displays the various instruments in separate windows and includes the following virtual instruments and signal source:
– Dual-Channel Oscilloscope
– Multimeter
– Spectrum Analyzer
– Waveform Generator

This package operates under any one of the following Microsoft Windows operating systems:
Windows 7, Windows 8,
and Windows 10.

It is also possible to interface the unit with MATLAB® and LabVIEW® software for advanced control and analysis.

The interface unit
The Virtual Instrument unit is a lightweight, compact interface module powered from a standard AC power wall outlet.

On the front panel of the Virtual Instrument unit, two BNC connectors and a pair of safety banana sockets provide access to the various virtual instruments. A third BNC connector provides the signal generator output. A BNC connector on the back panel of the Virtual Instrument unit is the access to the external trigger input of the virtual oscilloscope.

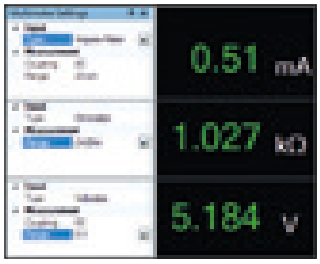
The Virtual Instrument unit samples the signals applied to its various inputs to provide raw signal data that is used by the virtual instrument software to measure, filter, and display the input signals. The high sampling rate of 1 GS/s provides the Virtual Instrument unit a 250 MHz bandwidth that is amply sufficient for the observation and analysis of the various signals in the FACET® Electronics Training program.

The Virtual Instrument unit also generates signal samples (data) that are converted to analog format to produce the output signal.

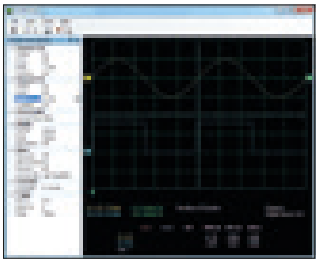
Data exchange between the Virtual Instrument unit and the host computer that runs the virtual instrument software is through a USB link (USB 1.1 and 2.0 compatible).

Virtual Instrument Package, Model 1250

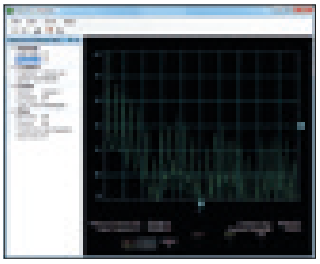
Order no.	**8098535**



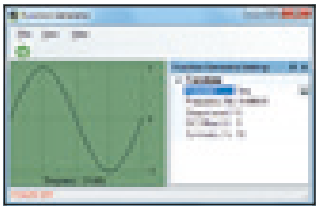
Multimeter
The Multimeter has one input channel sampled at a rate of 1 GS/s and can measure the AC and DC values of voltage and current as well as resistance, like any conventional multimeter.



Oscilloscope
The Oscilloscope has two input channels and an external trigger input. The maximum sampling rate is 1 GS/s when a single channel is used and 500 MS/s when both channels are used. Cursors are available to perform voltage, frequency, and phase measurements on the displayed signals. The Oscilloscope can perform continuous sampling or single-shot sampling of the input signals.



Spectrum Analyzer
The Spectrum Analyzer has two independent input channels, each channel being sampled at a rate of 1 GS/s. The Spectrum Analyzer converts the signal samples into frequency-domain information that is displayed as a graph of signal level as a function of frequency. The vertical scale can be either linear or logarithmic and has a fully-adjustable range. Cursors are available to measure the level and frequency of particular components in the displayed frequency spectra, frequency intervals, signal bandwidth, etc.
The Spectrum Analyzer can perform continuous sampling or single-shot sampling of the input signals.



Arbitrary Waveform Generator (AWG)
The Arbitrary Waveform Generator can produce sine-wave, triangle-wave, square-wave DC, and noise signals. It has a bandwidth of 20 MHz.
The AWG output has a maximum voltage range of -10 V – +10 V with 14-bit resolution and adjustable DC offset. The AWG output impedance is 50 Ω.

Accessories

Digital Multimeter/Function Generator, LabVolt Series 1247
The Digital Multimeter/Function Generator, designed as a general-purpose instrumentation module, provides the necessary test equipment (except oscilloscope) to perform the lessons in the FACET® program. This instrument consists of a sine/square/triangle waveshape function generator and an auto-ranging digital multimeter. The instrumentation shares a common power input and is housed in a portable enclosure. All components, switches, and terminals are mounted in a tamper-resistant manner. The system's design protects the instruments from inadvertent short circuits and overloads within the FACET® system.

with NEMA 5-15 cord line	
en	**580851**
es	**580852**
with CEE 7 cord line	
en	**580853**
es	**580854**
with AS-3112 cord line	
en	**580855**

Dual-Trace Digital Storage Oscilloscope, LabVolt Series 798
The Dual-Trace Digital Storage Oscilloscope is a low-cost oscilloscope that is ideally suited for general purpose use in any classroom laboratory. Two low-capacitance probes are included with the unit.

Features and Benefits:
– Color, 7-inch LCD
– Multilingual, on-display menu
– 40 MHz bandwidth
– 1 GSa/s maximum sampling rate
– USB and RS 232 ports
– Compact design

with NEMA 5-15 power cord	
en	**585695**
with CEE 7 cord line	
en	**585696**
with AS-3112 cord line	
en	**585694**

FACET® Storage Enclosure, LabVolt Series 1369
The FACET® Storage Enclosure is a portable and sturdy metal enclosure that can house up to ten boards of the FACET® program. The enclosure includes a locking cover and a carrying handle.

Order no.	**585728**

Accessory Kit, LabVolt Series 91052
The Accessory Kit is a replacement kit that contains the same accessories as those provided with any of the FACET® base units. The kit consists of miniature banana-jack jumpers and leads, alligator clips, and test point pins.

Order no.	**581215**

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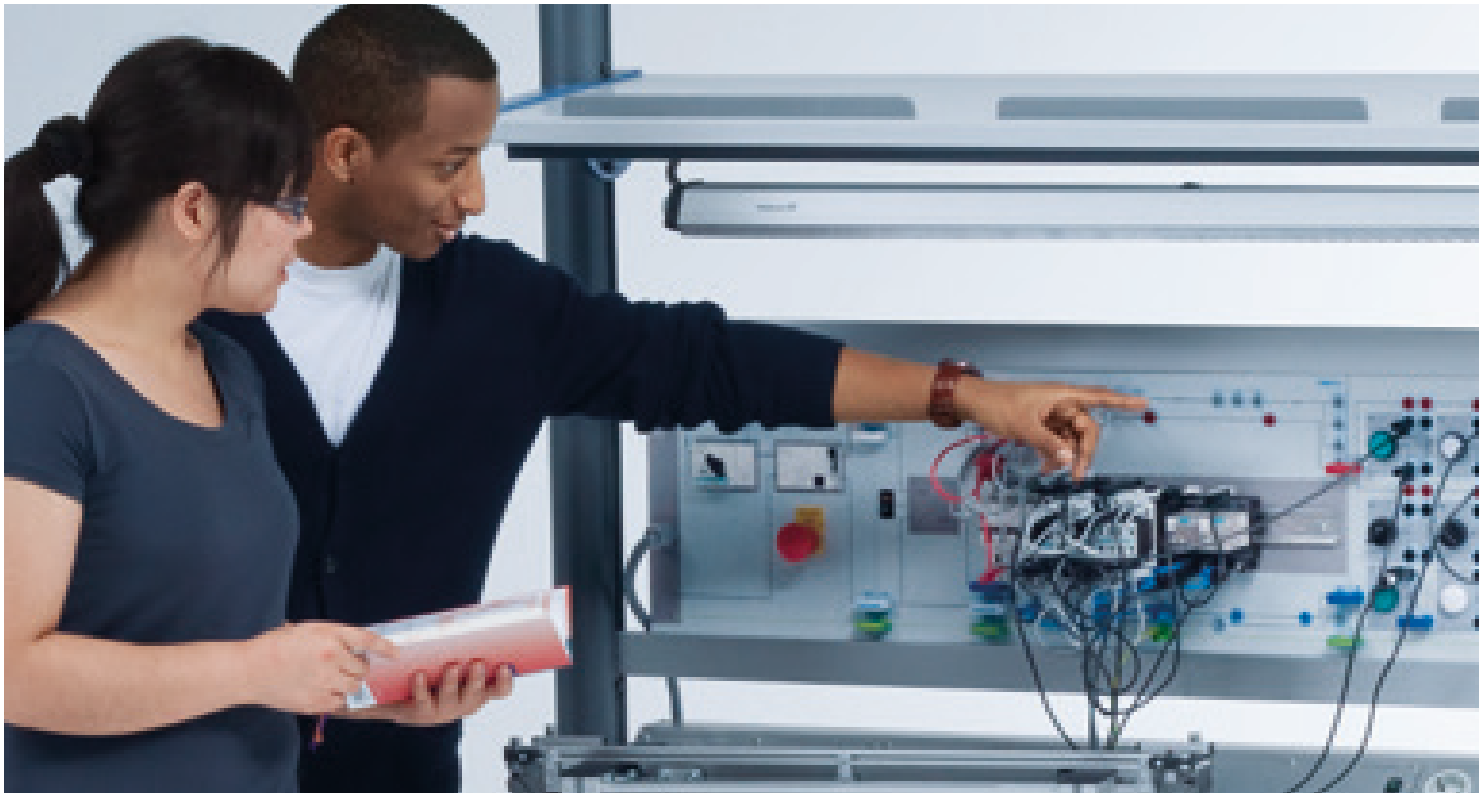

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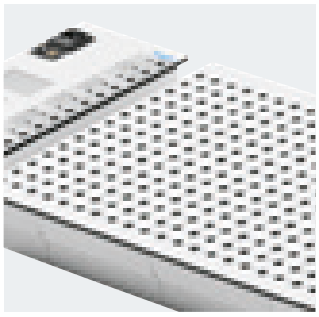
With learning systems from Festo Didactic, learning laboratories – be they modular, customized or complete – can be equipped for any application and budget, whether for industry or trades, for teaching basic principles, for building systems or control or drive technology.

Rapid transfer
Whether in initial professional training or more advanced courses: It is essential to be able to recall what has been learned and apply it immediately. This is easier to do if the worlds of learning and work are as similar as possible. That is why the training packages for electrical engineering only contain industrial components, and the exercises in the course documents come from a typical, professional environment.

Maximum compatibility
Electrical engineering and electronics are fundamental components of automation. These training packages can therefore be used where mechatronics or bus technology are involved.
- 4 mm safety sockets and SysLink guarantee “electrical compatibility”
- A new standard coupling ensures that motors and driven elements are universally compatible
- H-rails and housing dimensions allow components from other manufacturers to be used



Useful modularity
The training packages for electrical engineering and electronics are expandable. For example, they begin with electrical protective measures and a domestic connection. Later, they add the starter kit for sub-distribution and the topic of building automation. This modularity has a further benefit: each training device is smaller, more portable and can be housed in a cabinet more easily.

Proven training concept

Festo Didactic's proven and continuously upgraded teachware concept also underpins the training packages for electrical engineering.

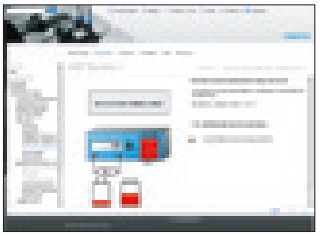
It is based on project-based exercises that increase in complexity from one exercise to the next. The knowledge learned is revisited, reinforced and consolidated in subsequent exercises.

Theoretical content can be illustrated and communicated more clearly with the help of the photos and videos on the enclosed multimedia CD-ROM to communicate it more clearly.

Teacher and student versions of documents are provided, with identical page numbering to make it easier to answer questions. Exercise sheets can simply be printed as required.

All projects include practical problems. Drawings, images and videos give a broad view of industrial reality.

Safe connection technology
When it comes to dealing with electricity, safety and protective measures are a key focus. Of course, all of our electrical connections are fitted with safety sockets or plugs.
– The plug-in modules of the equipment set for the basic principles of electrical engineering/electronics
– Power supply units and power supplies
– Back plates and EduTrainer®



Combination with self-study
Education in schools, companies or university cannot be successful without a willingness to do self-study. That is why the appropriate WBTs are available for all topics. Our range of digital training programs provides exciting learning scenarios and supplements the classroom-based parts of a course. The WBTs are particularly well suited for teaching the basic principles and thus provide the optimum supplement to practical experiments.

Mobile solution
Anyone who wants to design varied teaching and personal learning concepts requires flexible and modular training systems. That is why most of the equipment sets from Festo Didactic are compatible with the practical and mobile Systainers. This makes storage and transportation easier and supports flexible working.

product design award 2011

Focus Open Silver 2011

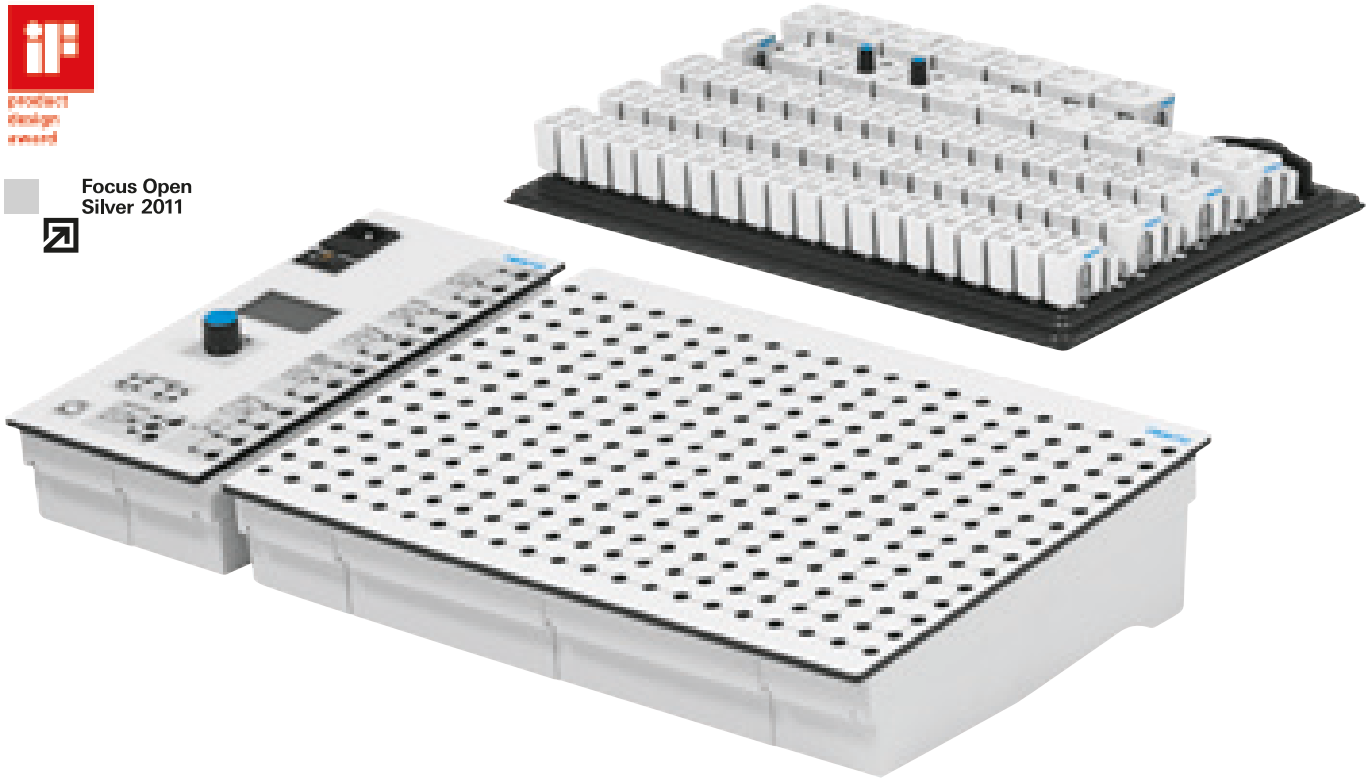
Winner
of the iF product design award 2011 and the Focus design award in Silver 2011:

Equipment set TP 1011
Basic principles of electrical engineering/electronics

Equipment Set TP 1011

Fundamentals of electrical engineering/electronics

Focus Open
Silver 2011



The basis of everything – Electrical engineering and electronics

The universal patch panel of this training package uses the proven 19 mm grid. The universal patch panel and basic power supply unit, which provides a function generator among other things, form the basis on which the digital and control technology component sets can be used.

With the component set, all basic tests of DC, AC and semiconductor technology can be performed and basic electronic circuits can be examined. The storage panel, with its clearly labelled slots, provides order and structure.

The equipment set variant TP 1011 M additionally contains a measuring module integrated in the power supply unit and the necessary measuring leads, adapters, and the PSURemote software.

Training content

- **Direct current**
  Voltage, current, resistance, conductance, Ohm's law, using measuring devices, energy and capacity, series and parallel connections, voltage dividers, non-linear resistors, bridge circuit, voltage source
- **Alternating current**
  Electric field, induction, capacitor and coil in DC and AC circuit, series and parallel circuits, active resistance, reactance and impedance, phase shift of current and voltage
- **Semiconductors**
  Semiconductor diode, Zener diode, LED, bipolar transistors, unipolar transistors, diac, triac, thyristor
- **Basic electronics circuits**
  Transistors and basic circuits, multi-level amplifiers, power amplification, differential and direct current amplifier, impulse and saw tooth generators, sine wave generators, power supply unit circuits

On the safe side!
The system is completely equipped with safety plugs and sockets based on state-of-the-art technology.

This applies to all electrical connections – whether on the components or devices. The equipment set is therefore ideal for use in any laboratory, even if there are high voltages present. Safety first!

Easy to connect!
Safety plugs at the bottom, safety sockets at the top – each component has double the connections.

As a result, measurements can be taken at any time without having to modify the circuit, and parallel connections are easy to establish.

Complete equipment set TP 1011	**571780**

The most important components at a glance:

1	1x	EduTrainer basic power supply unit without integr. measuring module	576624
2	1x	Universal patch panel EduTrainer	567322
3	1x	Component set for electrical engineering/electronics	567306
4	1x	Safety jumper plugs, 28 pieces, grey-black	571809

Complete equipment set TP 1011 M	**8029635**

The most important components at a glance:

1	1x	EduTrainer basic power supply unit with integrated measuring module	567321
2	1x	Universal patch panel EduTrainer	567322
3	1x	Component set for electrical engineering/electronics	567306
4	1x	Safety jumper plugs, 28 pieces, grey-black	571809
	4x	2 mm Safety laboratory cables, 500 mm, red	576295
	4x	2 mm Safety laboratory cables, 500 mm, blue	576296
	8x	4 mm – 2 mm safety measuring adapter	8023960
	1x	PSURemote Software, de/en ➔ Page 73	574179

Necessary accessories, also order:

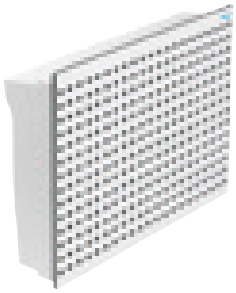
IEC power cable ➔ www.festo-didactic.com	
4 mm Safety laboratory cables ➔ Page 271	
2x Digital multimeter ➔ Page 275	
Digital storage oscilloscope ➔ Page 277	

Possibilities of expansion:

	Set of components for digital technology ➔ Page 74	
	Set of components for control technology ➔ Page 76	
	Equipment set TP 1023 Opto-electronics ➔ Page 70	
5	Operational amplifier	576621

1

2



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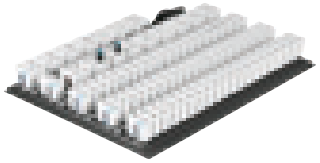


4

5

Also order:

Workbooks

The exercises contain concrete, realistic projects with problem descriptions, parameters and project tasks.

In addition to the basic principles of electrical engineering, the workbooks also thoroughly explain the function of the components, their characteristic values and the basic circuits typical for the components.

The workbooks contain:
– Sample solutions
– Educational instructions
– Multimedia CD-ROM with graphics
– Worksheets for learners

The worksheets support the learner in the information and planning phase as well as with execution, monitoring and documentation.

Fundamentals of direct current technology

Campus license:

de	**567207**
en	**567209**
es	**567211**
fr	**567213**

Fundamentals of alternating current technology

Campus license:

de	**567215**
en	**567217**
es	**567219**
fr	**567221**

Fundamentals of semiconductors

Campus license:

de	**567281**
en	**567283**
es	**567285**
fr	**567287**

Basic electronics circuits

Campus license:

de	**567289**
en	**567291**
es	**567293**
fr	**567295**

Fundamentals of analogue technology

Campus license:

de	**8023586**
en	**8023587**
es	**8023588**
fr	**8023589**

Operational amplifier

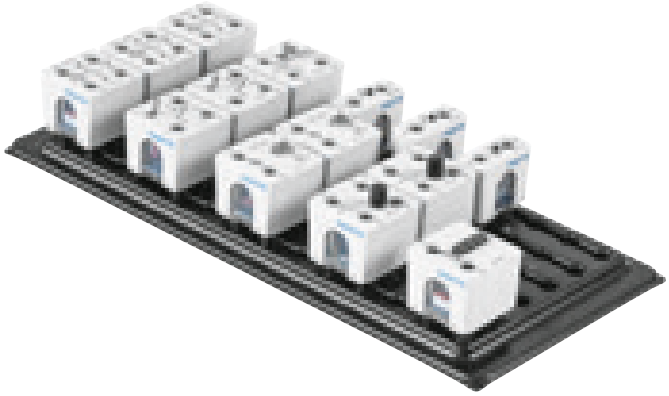
For constructing amplifier circuits.
– Supply voltage +/-15 V DC via 2 mm safety plug
– Output short circuit proof
– Offset compensation possible with potentiometer
– OP type LM741

Order no.	**576621**

Extension Component Sets for TP 1011

Installation and relay technology

New



Extension component set Installation and relay technology TP 1022

The plug-in components (including TP 1011 or TP 1011 M) are used for introducing students to electrical installation and industrial control technology.

Students work with practical learning scenarios in realistic projects. This includes planning, constructing and testing a variety of basic circuits.

The extension component set consists of plug-in components on a storage panel. The plug-in components fit on the EduTrainer® patch panel in a 19 mm grid.

Symbols and electrical values are printed on the top of each plug-in component. In the event of malfunctions, the plug-in components can be easily opened and repaired.

Training content
- Basic circuits for electrical installation (switching-off, series connection, two-way connection, cross connection)
- Control circuits for relay technology

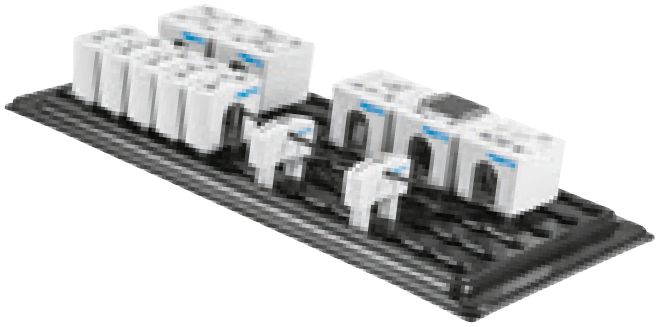
Components included
- 2x Relay, NO/NC
- 1x Relay, NO/NO
- 2x Toggle switch
- 1x Crossover switch
- 2x Pushbutton, two-pin, NO/NC
- 2x Pushbutton, single-pin, NO
- 1x Pushbutton, single pin, NC
- 2x Lamp, 12 V/3 W
- 1x Fuse, 1 A

To carry out the exercises, you will need components from:
- Equipment set TP 1011 or
- Equipment set TP 1011 M

➔ Page 69

Extension component set for installation and relay technology TP 1022	**8111819**

Optoelectronics



Extension component set Optoelectronics TP 1023

The training package Opto-electronics expands on TP 1011 or TP 1011 M to provide a comprehensive introduction to optical electronics. The kit enables students to explore the combined use of electronics and light. They will learn about optical semiconductor behavior, construction, and characteristics.

Using an EduTrainer patch panel and the components of TP 1011 or TP 1011 M, students easily build complete working circuits thanks to the flexibility and modularity of our training concept. They perform multiple project-oriented exercises and can also measure how they performed.

The plug-in components fit on the EduTrainer® patch panel in a 19 mm grid.

The equipment set ensures user safety, as it operates at low voltage and does not rely on laser technology. A convenient storage plate is included.

Training content
- Light-emitting diodes characteristic data and curves
- Infrared LED
- Control of LED (gate drive)
- Solar cell, Photodiode
- Phototransistor
- Optical signal transmission (with photodiode and phototransistor)
- Optocoupler
- Fiber optic cable

List of components
- 1x Photo transistor
- 1x Light diode (IR)
- 1x Photo diode (BPW 46)
- 1x Light diode (HLMP)
- 1x Light diode (BL)
- 1x Solar cell (AM 5610)
- 1x Lamp (12 V – 5 W)
- 1x LED lamp (15 V – 1 W5)
- 1x Isolation optocoupler (SFH618A)
- 1x Isolation optocoupler (MOC3051M)
- 1x Optical fiber

To carry out the exercises, you will need components from:
- Equipment set TP 1011 or
- Equipment set TP 1011 M

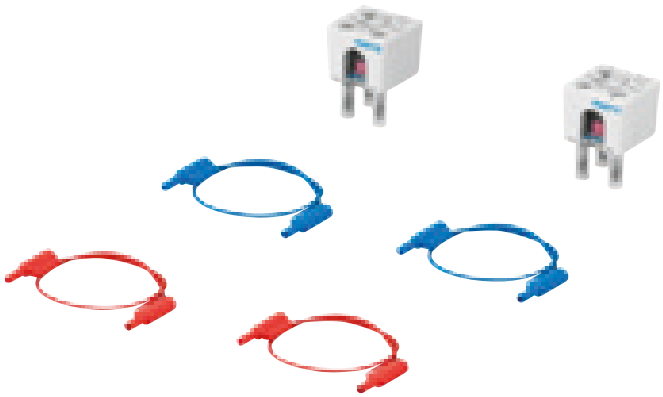
➔ Page 69

Also order:

Workbook
Fundamentals of Optoelectronics
➔ Page 33

Extension component set Optoelectronics TP 1023	**8077920**

Analog technology



Extension component set
Analog technology TP 1024

The analog technology set of components extends the equipment sets TP 1011 and TP 1011 M, basics of electrical engineering/electronics, by analog technology components. It provides information on the structure, function, and behavior of operational amplifiers and their application in different circuits.

The students set up complete, fully functional circuits by means of an EduTrainer® patch panel and the components from TP 1011 or TP 1011 M. This enables the students to acquire the skills required to recognize the properties and characteristics of operational amplifiers and use them in analog circuits.

Symbols and component values are printed on the top of the components. The housing of the set of components can be opened to renew the components in the event of a malfunction. The components are installed on a patch panel with a 19 mm grid.

Training content
- No load difference
- Output limits of the output voltage
- Use of the output current limiter of an OPA
- Limits of the usable input voltage common mode range
- Mode of operation of a warning for low operating voltage
- Mode of operation of a twilight switch
- Principle of a timer with RC element
- Structure and function of a window comparator
- Measurement of the slew rate of an operational amplifier
- Mode of operation and application of pulse-width modulation

Components included:
- 2x Operational amplifier
- 2x 2 mm safety laboratory cables, 300 mm, red
- 2x 2 mm safety laboratory cables, 300 mm, blue

To carry out the exercises, you will need components from:
- Equipment set TP 1011 or
- Equipment set TP 1011 M
➔ Page 69

Also order:

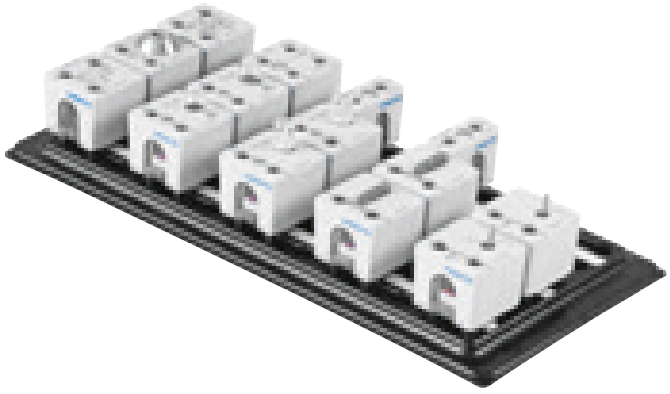
Workbook
Fundamentals of analog technology
➔ Page 33

FluidSIM®-Electrical engineering
➔ Page 28

Analog technology extension component set TP 1024	**8115716**

Motor vehicle mechatronics

New



Extension component set
Motor vehicle mechatronics TP 1025

The students set up simple motor vehicle-specific basic circuits.

The students set up simple motor vehicle-specific basic circuits using an EduTrainer® patch panel and the components from TP 1011 or TP 1011 M. Guided by action-oriented learning scenarios, they identify and eliminate malfunctions.

Symbols and component values are printed on the top of the components. The housing of the set of components can be opened to renew the components in the event of a malfunction. The components are installed on a patch panel with a 19 mm grid.

Built-in fault switches can be used to selectively manipulate components to enable realistic troubleshooting in the circuits.

All components are included in the electrical engineering library FluidSIM® 5. This library also contains extensive teaching material, adapted to the first year of training of automotive mechatronics technicians.

Training content
- Troubleshooting: rear fog light, reversing light, dashboard lighting, trailer lighting, low beam, tail and brake lights
- Diagnostics: instrument and dashboard lighting, fog lights, low beam, high beam and fog lights, right tail light, indicator system

Components included
- 1x 12 V Voltage regulator
- 2x Bulb, 12 V/20 mA
- 1x Key switch
- 1x Pulse oscillator
- 2x Lamp, 12 V/3 W
- 2x Lamp LED, 12 V
- 1x Normally open relay, 12 V
- 1x Fuse, 1 A
- 1x Fuse, 2 A
- 2x Switch

To carry out the exercises, you will need components from:
- Equipment set TP 1011or
- Equipment set TP 1011 M
➔ Page 69

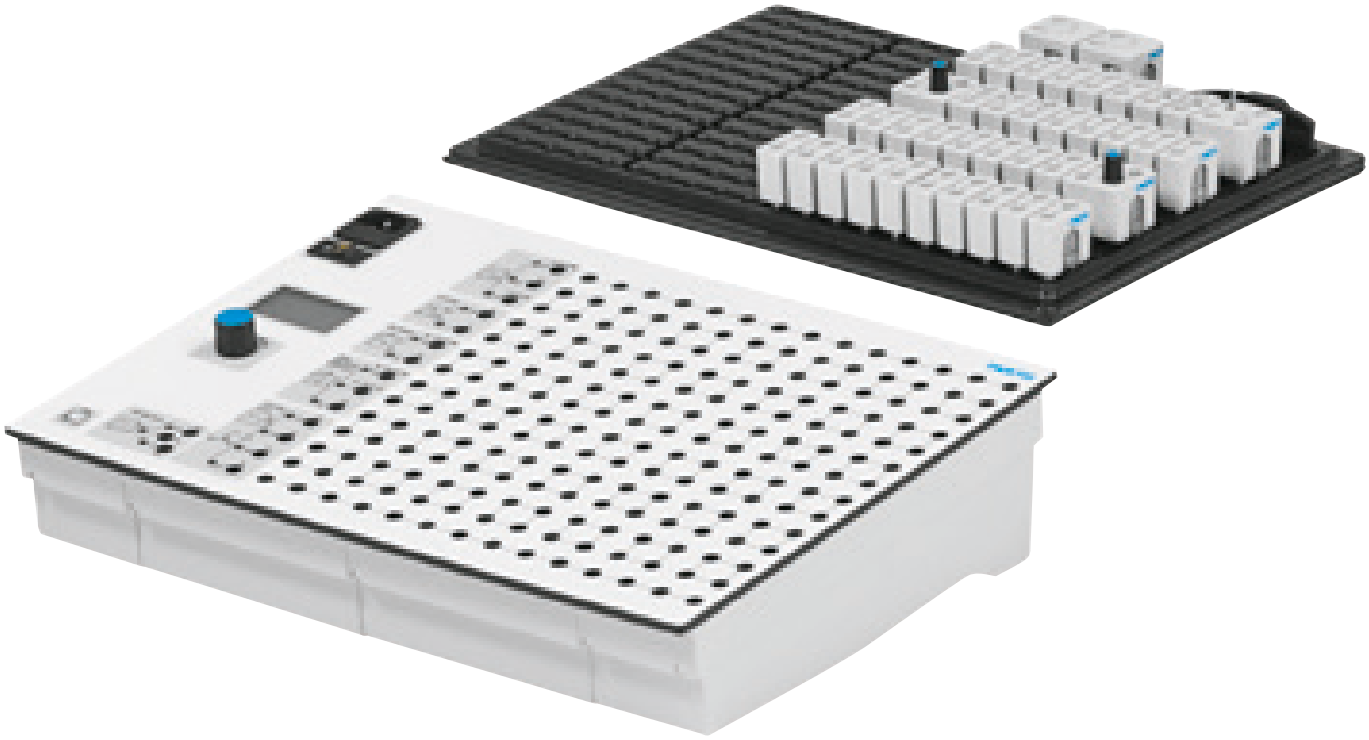
Also order:

FluidSIM®-Electrical engineering
➔ Page 28

Motor vehicle mechatronics extension component set TP 1025	**8106705**

Equipment Set TP 1010

Basic principles of electrical engineering for metalworking occupations



Basic principles of electrical engineering for metalworking occupations

Can you limit your training to DC and AC technology now and in the future? Then this equipment set, with the small Combiboard Fundamentals EduTrainer® and a reduced range of components, is an economical alternative to TP 1011.

A basic knowledge of circuits is becoming more important even in mechanical professions. It is important for understanding many functions and processes in complex systems.

The examples used by the training package Basic principles of electrical engineering for metalworking occupations to teach the basic principles are taken from this field. The learning objectives include the electrical variables and their relationships with each other. With the project-based exercises, the content can be clearly taught through theory and practical tests. Measurements illustrate relationships, and promote understanding and in-depth learning.

The component set contains all of the components for carrying out basic tests for DC and AC technology. The clearly labelled slots of the storage panel provide order and structure.

Training content

- **Direct current technology**
  Voltage, current, resistance, conductance, Ohm's law, using measuring devices, energy and capacity, series and parallel connections, voltage dividers, non-linear resistors, bridge circuit, voltage source
- **Alternating current technology**
  Electric field, induction, capacitor and coil in DC and AC circuit, series and parallel connection, active resistance, reactance and impedance, phase shift of current and voltage

On the safe side!
The system is completely equipped with safety plugs and sockets based on state-of-the-art technology.

This applies for all electrical connections - whether on the components or on the Combiboard. The equipment set is therefore ideal for use in any laboratory, even if there are high voltages present. Safety first!

Complete equipment set TP 1010	**8023958**

The most important components at a glance:

1	1x Combiboard Fundamentals EduTrainer	571810
2	1x Set of components for electrical engineering	8005374
3	1x Safety jumper plugs, 28 pieces, grey-black	571809

Necessary accessories, also order:

IEC power cable ➔ www.festo-didactic.com	
4 mm Safety laboratory cables ➔ Page 271	
2x Digital multimeter ➔ Page 275	
Digital storage oscilloscope ➔ Page 277	

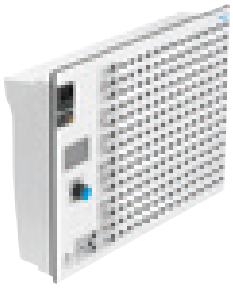
Possibilities of expansion:

Set of components for digital technology	574193

Recommended training media, also order:

Fundamentals of direct current technology: Workbook ➔ Page 32
Fundamentals of alternating current technology: Workbook ➔ Page 32

1



2

3

The setting and measurement software for TP 1010, TP 1011 and TP 1011 M

Also order:

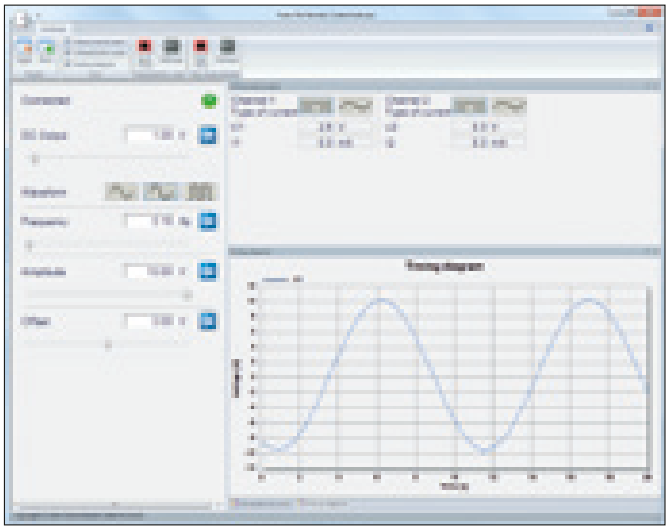
PSURemote Software

Software incl. USB cable for PC-supported setting and measurement with the basic power supply unit EduTrainer®.

Basic functions:
– Setting the variable DC output
– Setting the signal shape, frequency, amplitude and offset of the frequency generator
– Saving and recalling parameter sets

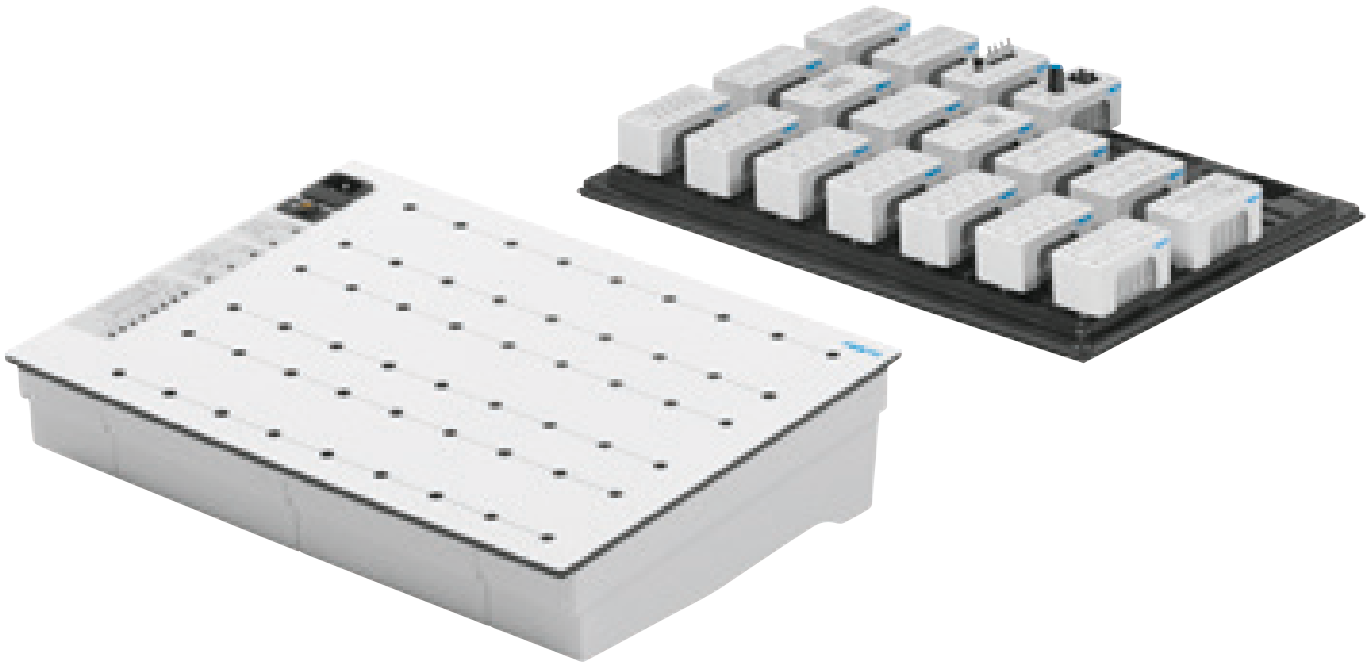
Also with the built-in measuring module on the power supply unit:
– Direct measured value indicator for voltage and current inputs
– Recording of measured values over time
– X-Y comparison of measured values
– Automatic curve recording with configurable DC voltage output

USB cable with angled USB plug on power supply side, length: 2 m



Equipment Set TP 1012

Basic principles of digital technology



The perfect introduction to digital technology

The training package Basic principles of digital technology provides the optimum introduction to the world of digital signal processing. Those who learn and understand digital technology can easily and quickly learn any automation programming language.

The basic principles of digital technology include logical operations, signal flow and data formats. The curriculum also includes structured procedures for problem solving.

Special characteristics
- The components of the training package are constructed with real logic gates. They permit realistic examinations of their behaviour.
- The ICs contained in the components have a base and can be exchanged in only a few steps.
- All parts of the equipment set are completely equipped with safety plug connections.
- The Combiboard Digital and Control Technology EduTrainer® included with this training package provides the required supply voltages for all tests and also contains a square-wave generator with 7 different output frequencies.
- This Combiboard EduTrainer® can also be used as a patch panel for the components of the control technology equipment set.

Components included
- 1 inverter
- 2 AND
- 2 OR
- 1 NAND
- 1 NOR
- 1 XOR
- 1 hex switch and analogue source 0 – 5 V
- 1 LED bar graph
- 1 counter
- 1 7-segment display
- 1 RS flip-flop
- 2 JK flip-flops
- 2 shift registers
- 1 full adder
- 1 signal input

Training content
- Elementary logic modules
- Important symbols
- Designing and optimising logical circuits
- Logic algebra
- Conjunctive and disjunctive standard format
- Switching matrix diagrams
- Schmitt trigger
- Hysteresis
- Types of trigger circuits
- Using flip-flops
- Counting circuits
- Converting and transferring data
- Shift register
- Data conversion
- Arithmetic circuits

Complete equipment set TP 1012	**8023961**

The most important components at a glance:

1	1x Combiboard Digital and control technology EduTrainer	8023962
2	1x Set of components for digital technology	574193

Necessary accessories, also order:

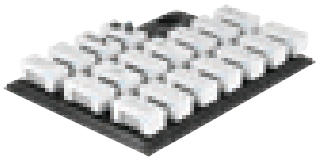
IEC power cable ➔ www.festo-didactic.com	
2 mm Safety laboratory cables ➔ Page 272	

Possibilities of expansion:

I/O level converter 5 V ‹–› 24 V	576622
I/O level converter 5 V ‹–› 24 V with Sub-D HD15	8042619
IC zero insertion force socket	576623
Set of components for control technology	8023963

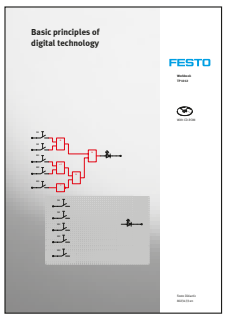
1

2



Also order:

Workbook



The exercises in the workbook contain concrete, realistic projects with problem descriptions, parameters and project tasks.

The workbook contains:
– Sample solutions
– Educational instructions
– Multimedia CD-ROM with graphics
– Worksheets for learners

The worksheets support the learner in the information and planning phase as well as with execution, monitoring and documentation.

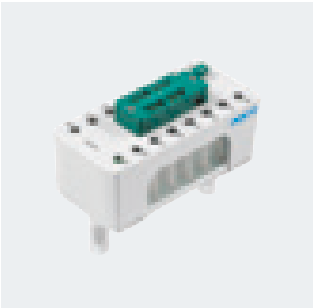
All exercises require independent performance, evaluation and documentation from the learner.

Campus license:

de	**8023432**
en	**8023433**
es	**8023434**
fr	**8023435**

I/O level converter 5 V ‹–› 24 V
I/O level converter for the implementation of digital inputs and outputs for digital technology or microcontrollers on functional models.
– Supply voltage DC/24 V via 4 mm safety plug
– 8 inputs 5 V via 2 mm safety plug, 8 outputs 5 V via 2 mm safety plug
– SysLink connection with 8 inputs and 8 outputs 24 V
– Acceptable current load per DC/24 V output 300 mA, protected against short circuits and overloads
– Sum of the output currents: max. 2 A

Order no. 576622

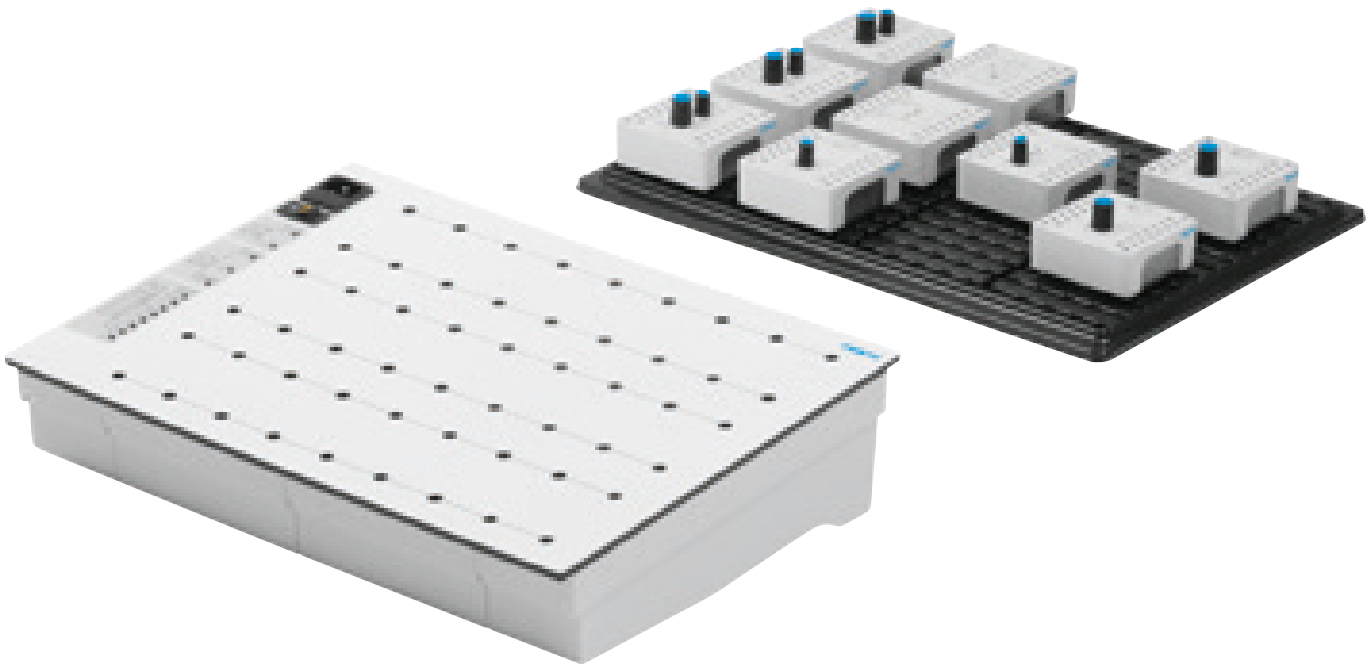


IC zero insertion force socket
High-quality IC socket for tool-free adaptation of ICs, compatible with digital technology.
– 16 pins in a 2.54 mm grid
– Tool-free assembly using clamping lever
– Contacting with 2 mm safety plug

Order no. 576623

Equipment Set TP 1013

Basic principles of control technology



Control technology explained simply and comprehensibly

The training package Basic principles of control technology provides a fast and easy-to-understand introduction to the topic of controllers and controlled systems.

The basic terminology of control technology, the behaviour of various controllers and the structured analysis of requirements for controlled systems are particularly important here.

Ways and means of analysing and solving control problems are shown and looked at in depth through experiments during the projects.

The equipment set permits fast and flexible construction of different controllers and thus allows simple inspections of behaviour based on the interaction with controlled systems of different types.

All parts of the equipment set are completely equipped with safety plug connections. The Combiboard Digital and Control Technology EduTrainer® contained in the equipment set provides the required supply voltages for all tests and also contains a square-wave generator with 7 different output frequencies. This Combiboard EduTrainer® is also used in the training package Digital technology.

Components included
- 1x 2 differential inputs with subtracter
- 1x P element
- 1x I element
- 1x D element
- 1x summer with adjustable offset
- 1x limiter with level adaptation of the output signals
- 1x comparator with hysteresis and switching output
- 2x controlled system

Training content
- Structure of a control circuit
- Spring response, dynamic behaviour
- Standardising physical variables
- Bode diagram
- Modelling a controlled system
- Positive and negative feedback
- Two and three-step action controller
- P, I and PID controllers
- Stable and unstable behaviour
- Controller gain
- Delay behaviour according to Ziegler and Nichols

Complete equipment set TP 1013	**8023964**

The most important components at a glance:

1	1x Combiboard Digital and control technology EduTrainer	8023962
2	1x Set of components for control technology	8023963

Necessary accessories, also order:

IEC power cable ➔ www.festo-didactic.com
2 mm Safety laboratory cables ➔ Page 272
Digital storage oscilloscope ➔ Page 277

Possibilities of expansion:

Set of components for digital technology	574193
Application Module Level Control	8133444
Application Module Speed Control	8152965
Application Module Linear Position Control	8133202
Application Module Light and Temperature Control	8155732

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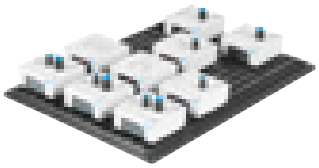
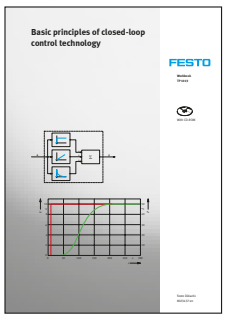


Also order:

Workbook



The exercises in the workbook contain concrete, realistic projects with problem descriptions, parameters and project tasks.

The workbook contains:
– Sample solutions
– Educational instructions
– Multimedia CD-ROM with graphics
– Worksheets for learners

The worksheets support the learner in the information and planning phase as well as with execution, monitoring and documentation.

All exercises require independent performance, evaluation and documentation from the learner.

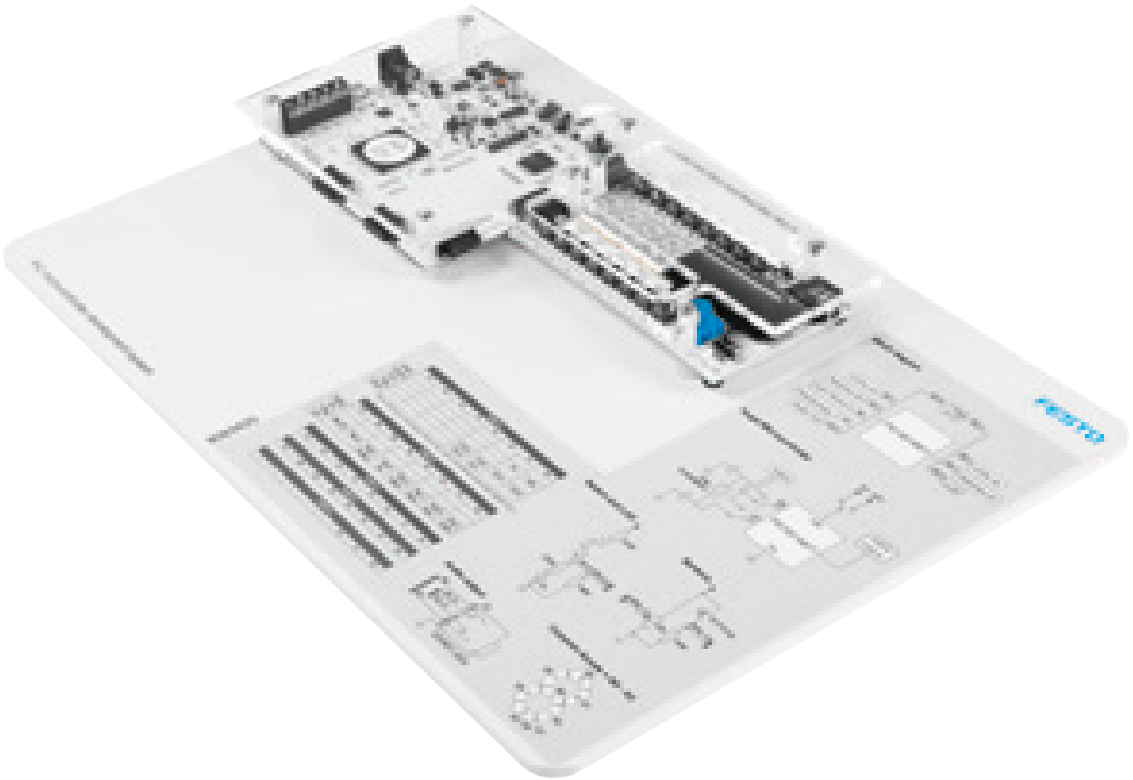
Campus license:

de	**8023436**
en	**8023437**
es	**8023438**
fr	**8023439**

Equipment Sets TP 1515/TP 1516

Microcontroller Development Systems (PIC/Arduino)

New



Flexibility through modularity

The equipment sets TP 1515/1516 offer an affordable introduction to microcontroller systems and programming. They are ideal for learning about embedded electronic systems, programmable electronics, and for rapid prototyping.

Each set consists of a mounting panel, with a choice of upstream programmer board technology – PIC or Arduino – and a standard downstream board.

The sets can be used by students in educational environments, up to engineers in the industrial world. The technology is real, up-to-date, and provides a great base for training the next generation of engineers and technicians.

Flexible expansion

A wide selection of optional expansion boards is available, allowing coverage of specific topics to perfectly match training needs: input/output boards, wired/ wireless boards, motors/actuators boards, sensor boards, prototype boards, and graphical displays.

Boards can be snapped together using the rugged Har-flex® connectors to form a wide variety of systems for teaching or learning and for the rapid prototyping of complex electronic systems.

Students develop, simulate, test, and debug a microcontroller program to control embedded systems or mechatronics applications. The optional MecLab Interface connects TP 1515 to any MecLab Station.

Rugged design for education

The boards fit together in a flat 2D layout manner allowing the entire system to be easily seen and understood.

The sets have been designed to be electrically and mechanically rugged to withstand the pressures of the lab: downstream board interfaces include damage protection resistors and cannot be damaged by programming errors. Plastic covers protect panel-based boards and prevent chips from being removed.

Non-programmer friendly

The equipment sets are supported by Flowcode – a graphical, advanced integrated development environment (IDE) for electronic and electromechanical system development. Flowcode allows students to design, simulate, and test a wide variety of microcontroller-based systems with ease.

A 2D and 3D graphical development interface allows students to construct a complete electronic system on-screen, develop a program based on standard flowcharts, simulate the system and then produce hex code for programming a range of devices.

1 Complete equipment set TP 1515	**8085562**

The package includes:
– 1x 8-bit PIC programmer board
– 1x Combo board
– 1x Mounting panel
– 1x Power supply
– 1x USB cable
– 1x Storage tray
– 1x Programming Microcontroller (student manual)

2 Complete equipment set TP 1516	**8085563**

The package includes:
– 1x Arduino programmer board
– 1x Combo board
– 1x Mounting panel
– 1x Power supply
– 1x USB cable
– 1x Storage tray
– 1x Programming Microcontroller (student manual)

Necessary accessory, please order:

Flowcode	see page 83

Possibilities of expansion

Expansion boards	see page 80
MecLab Interface	see page 81

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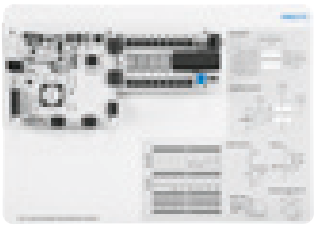

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Included with the equipment sets:

Workbook
Programming Microcontroller

Table of contents:
– Introduction
– Intro to microcontrollers
– Using E-blocks
– Flowcode – first program
– Flowcode – examples
– Programming exercises
– Arduino adjustments

The aim of this course is to introduce the concepts of developing electronic systems using microcontrollers. Students learn what a microcontroller is, how to construct circuits and systems based on microcontrollers, and how to program microcontrollers.

The course is suitable for BTEC National in Engineering unit 6, Microcontroller systems for engineers.

Author: Matrix Technology Solution Limited
Edition 06/2018
80 pages, in color, in folder

en	**8094009**

Introduce electronics students to the Internet of Things!

The Internet of Things, a network in which smart devices connect, communicate, and exchange data, is a key concept underlying the Industry 4.0. Several boards tackle communication technologies, such as Wi-Fi, Ethernet, and Bluetooth.

Equipment Sets TP 1515/TP 1516

Expansion boards and MecLab Interface

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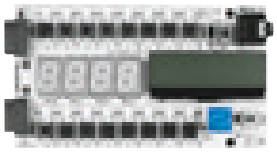

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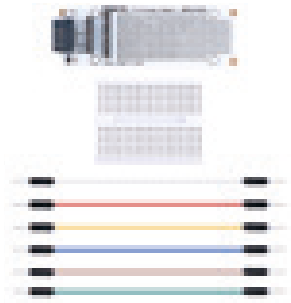

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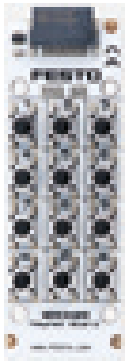

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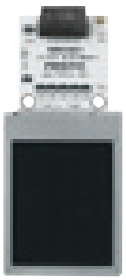

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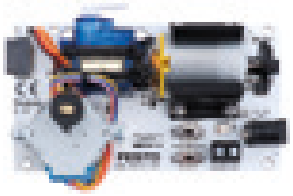

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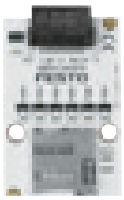

1 **Combo Board**
The Combo Board works with any upstream programmer board, allowing multiple technologies to be explored using a single downstream board. The board includes 16 individual LEDs, 16 individual switches, a quad 7-segment display, a 20 x 4-character alphanumeric LCD, on-boards sensors (light / potentiometer), and an audio output socket. . The graphical LCD is driven via an intelligent conversion module (macro) to allow it to be treated as a standard Alphanumeric HD44780 compatible device.

Order no. **8083412**

2 **Prototype Board**
The Prototype Board allows for easy addition of custom circuitry into the system. It connects the I/O lines of a port to an array of standard pitch holes. The board is supplied with a small a solderless breadboard and leads.

Order no. **8083406**

3 **Keypad 3x4 Board**
The Keypad Board allows for simple data entry using an array of switch inputs. Switches are push to make.

Order no. **8083408**

4 **Color Graphical LCD Board**
The Color Graphical LCD Board provides a 160 x 128 pixel TFT color graphical display capable of drawing text, displaying images and symbols in 16-bit color. Featuring a Flowcode compatible ILI9163C display driver IC the display can be programmed and fully simulated within the Flowcode environment. The board also features a dimmable backlight to provide maximum display visibility even in the dark.

Order no. **8089821**

5 **Actuators Board**
The Actuators Board includes a DC motor with both analogue and digital feedback, a servo motor and a stepper motor with gearbox, plus the circuitry to drive the motors. A DC socket allows the various drivers to be powered from a secondary power supply.

Order no. **8083413**

6 **LED Board**
The LED Board allows a bank of eight LED indicators to be added to the system. LEDs can be driven in a digital way using on or off output states or in an analogue way using pulse width modulation (PWM) techniques. Each LED is in the active high configuration.

Order no. **8083404**

7 **LCD Board**
The LCD Board provides a 20 x 4 character alphanumeric display compatible with the standard HD44780 type displays. An onboard microcontroller listens for HD44780 compatible commands and converts the incoming commands into SPI packets that drive the modern chip on glass (COG) graphical display.

Order no. **8083407**

8 **SD card Board**
The micro SD card Board allows a large amount of data storage to be added to the system. The board provides a means of reading and writing data to the SD card as well as providing level shifting to allow 5V and 3V3 systems to be compatible. The board also provides a means of detecting if the card is present via a switch built into the card socket.

Order no. **8083409**

1 **Grove Sensor Board***
The Grove sensor board allows for the addition of many peripherals and sensors from the Seeed Studio range of Grove modules (sold separately). The board can use up to four Grove sensors at a time.

Order no.	**8083414**

2 **Relay Board**
The Relay Board provides two electrically controllable relays which act as isolated switches. The external connections to the relays are screw terminals; normally open (NO) and normally closed (NC) connections allow for maximum flexibility. Each relay features a LED.

Order no.	**8083419**

3 **Bluetooth Board**
The Bluetooth Board contains a Microchip RN4677 module which provides certified Bluetooth 4.0 functionality to the system. The module allows for exploration of both Bluetooth classic (BR/EDR) and Low Energy (LE) protocols.

Order no.	**8089815**

4 **Wi-Fi Board**
The Wi-Fi Board allows connection and communication with an existing Wi-Fi network. It can also be used to create a data access point. It is provided with a fully certified and ruggedized ESP12F module.

Order no.	**8089816**

5 **MecLab Interface**
MecLab® Interface is a component that bridges a Microcontroller Development System TP 1515 with any MecLab® Station. It allows control of the station by the microcontroller located on TP 1515. Using the visual programming software Flowcode, students can quickly and easily code a microcontroller to perform a sequence of actions on the station. The program is uploaded to the microcontroller and test run on the station. Two variants are available, depending if your MecLab® Stations are equipped or not with the EasyPort Mini EasyKit with Power supply and Connecting cables.

Complete version	**8136430**
Add-on version	**8127367**

Additional expansion boards

Switch board	8083405
Terminals board	8083410
Servo motor board	8083411
Manual patch board	8083415
Splitter board	8083416
ZigBee board router	8083417
Upstream link board	8083418
ZigBee board coordinator	8084231
Ethernet board	8089822
Click board**	8089817
Mono gLCD board	8089818
CAN bus board	8089819
I/O expander board	8089820

*Compatible with Grove™ products
**Compatible with MikroElektronika products

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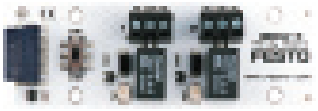

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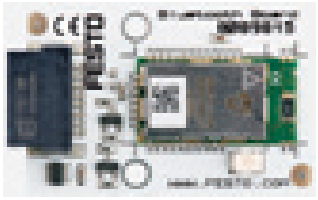

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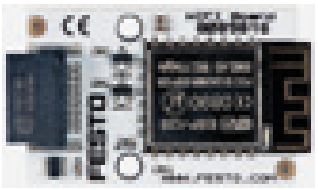

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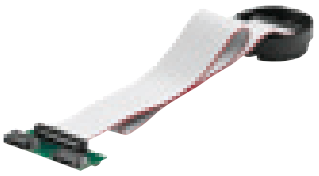
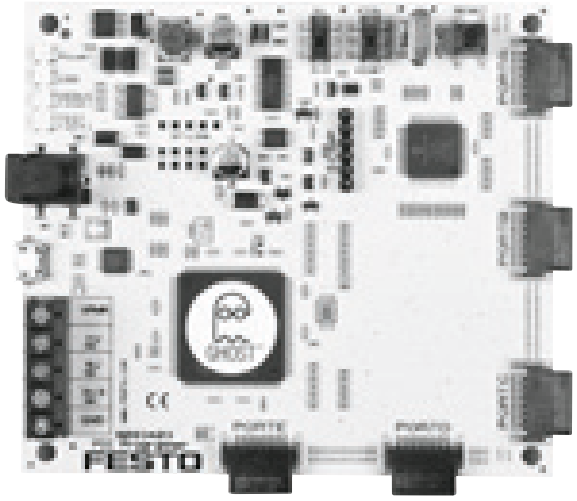


Equipment Sets TP 1515/TP 1516
Programmer boards



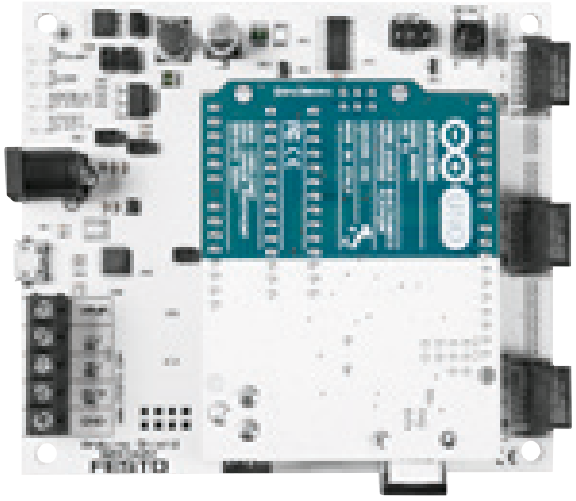
8-bit PIC Programmer Board

The 8-bit PIC Programmer Board is equipped with a powerful PIC16F18877 microcontroller.

This upstream board contains the microcontroller that drives the training system. It is loaded with firmware to drive the required embedded functionality. The board presents all I/O pins collected together as ports sockets. The boards take power from an external power supply or from the micro USB port.

It can be used with various programming languages including Assembly, C, and Flowcode. Using the board with Flowcode allows the use of the advanced Ghost debugging features including in circuit debugging, real time pin monitoring and bus decoding.

Characteristics:
- Voltage selector 5V/3.3V
- Powered via USB port or external supply
- Power output via screw terminal
- Adjustable clock frequencies
- Programmable via micro USB
- 5 ports; 35 I/O
- Reset button
- Chip features: 32 MHz, 56 kb flash memory



Arduino UNO Programmer Board

The Arduino UNO Programmer Board is equipped with the Arduino UNO R3 PDIP.

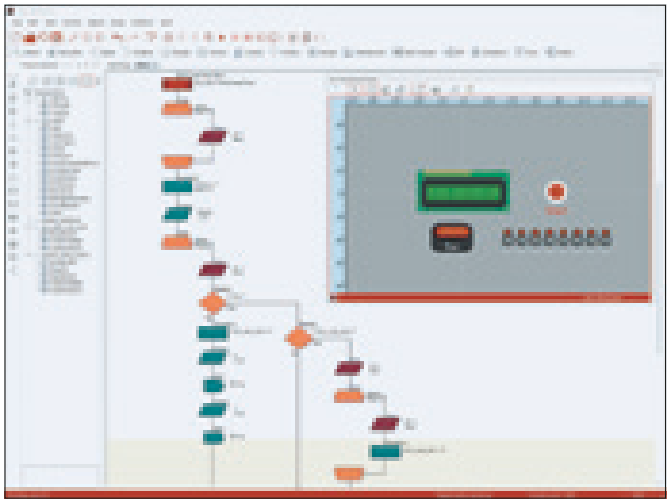
This upstream board contains the microcontroller that drives the training system. It is loaded with firmware to drive the required embedded functionality. The board presents all I/O pins collected together as ports sockets. The boards take power from an external power supply or from the micro USB port.

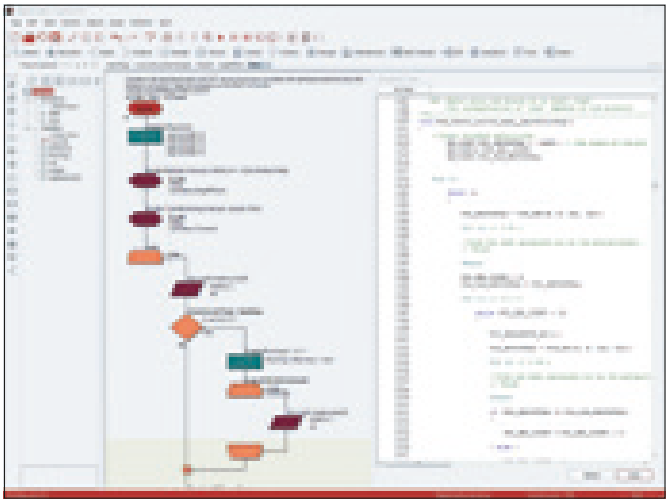
It can be used with various programming languages including Assembly, C, Arduino IDE, and Flowcode. Using the board with Flowcode allows the use of the advanced Ghost debugging features including in circuit debugging, real time pin monitoring and bus decoding.

Characteristics:
- Powered via USB port or external supply
- Power output via screw terminal
- Adjustable clock frequencies
- Programmable via micro USB
- 3 ports; 20 I/O
- Reset button
- Chip features: 16 MHz, 32 kb flash memory

Flowcode 9

A visual programming environment





Flowcode enables quick and easy development of complex electronic and electromechanical systems. The graphical programming tool allows those with little experience to develop systems in minutes.

Flowcode is an advanced integrated development environment (IDE) for electronic and electromechanical system development. Engineers — both professional and academic – use Flowcode to develop systems for control and measurement based on microcontrollers or on rugged industrial interfaces using Windows compatible personal computers.

Furthermore, Flowcode allows full simulation (including simulation of C code), with users also being able to convert C code to flowcharts and other programming languages.

Other features included the ability to Auto ID downstream boards that are connected, improved compatibility with Arduino hardware, to give a more streamlined and smooth approach to programming this popular family, and SCADA mode – meaning users can now control external hardware from their PC using this impressive feature.

Graphical programming
The graphical icons which are used to develop systems within Flowcode are easy-to-use. It enables first-time developers to pick up the fundamentals and run with their designs. Using graphical icons allows users to view and learn code side-by-side for easier learning.

For more advanced users with a good understanding of programming, Flowcode allows integration of pre-written codes.

Microcontroller flexibility
Flowcode gives you the ability to work with multiple chip variants in an easy and flexible way. When learning and developing designs using 8-bit PIC or Arduino microcontrollers, Flowcode is perfect for students and makes code-porting simple, meaning that users can switch target devices with ease.

Testing and debugging
Ghost Technology embedded on upstream boards provides a real-time log of the status of all the pins on the microcontroller whilst a Flowcode program is running on the device.

Built into Flowcode is a data recorder and oscilloscope which makes test and debugging procedures straightforward. Flowcode is also compatible with external hardware including oscilloscopes, power supplies, signal generators and more.

Component library
The library contains a vast collection of components that can be used to create systems, from simple switches and LED's to more complex communications modules.

Electronic communications
Communications developments form a large part of modern day electronic education and understanding. Communications including CAN bus, Bluetooth, USB, Ethernet and WIFI are available within the Flowcode environment.

Flowcode 9 licenses

Flowcode for PIC academic, single license	**585809**
Flowcode for PIC academic, 10 licenses	**585810**
Flowcode for PIC academic, 50 licenses	**585811**
Flowcode for Arduino academic, single license	**595168**
Flowcode for Arduino academic, 10 licenses	**595160**
Flowcode for Arduino academic, 50 licenses	**595164**

Contact us for more licensing options.

AC/DC Training System

Introduction to the basic principles of electrical circuits

LabVolt Series 3351

The AC/DC Training System is a state-of-the-art training system that is specifically designed to introduce students to the basic principles of electrical circuits, both in direct current (DC) and alternating current (AC). It provides a comprehensive, high-quality, and cost-effective solution to rapidly build student knowledge in electricity and electrical circuits.

The AC/DC Training System comprises the most common electrical components in modern electrical circuits, easy to access and safe for student experimentation. Two 24 V power supplies provide DC power and AC power. The training system itself can be powered from a standard AC wall outlet.

All the components come in a rugged carrying case for easy transportation. During experiments, the top lid of the case can be removed, allowing access to the components. The form of the case also enables multiple units of the training system to be conveniently and securely stacked one atop the other.

The curriculum is divided into two courses designed so that students learn progressively the different concepts important to the study of DC and AC circuits. The courses feature into exercises that each include all required theory, as well as hands-on experimentations.

Highlights
- Full introduction to important concepts in AC/DC circuits
- Comprises the most common electrical components
- Operates at a low voltage for student safety
- Built-in faults
- Comprehensive courseware
- Rugged transportation and storage case

Main components
- Fixed to the front panel: protected DC and AC power sources, resistors, an inductor, two capacitors, a transformer, switches (SPST, SPDT, DPDT, NO push button, NC push button, selector and knife switches, AC and DC relays, indicator lights, a potentiometer, a DC motor, a solenoid, a buzzer, a circuit breaker with test components, a fuse.
- Individual components that can be fixed to or stored in the case lid: two multimeters, a connection leads set, compass, an iron rod (for electromagnetism experiments)
- Six built-in faults can be individually inserted using a toggle switch. These faults are designed to test and improve the troubleshooting skills of students.

AC/DC Training System 120V/60Hz	**587589**
AC/DC Training System 220V/50Hz	**587590**

For other country voltage/frequency configurations, please contact your local sales representative.

Included manual:

DC Circuit Fundamentals

Student Manual, en	583852
Instructor Guide, en	583854

AC Circuit Fundamentals

Student Manual, en	583855
Instructor Guide, en	583856

Note: PDF version also available.

Topic coverage

– Basic concepts of electrical circuits, both in direct current (DC) and alternating current (AC)
– Ohm's law
– Kirchhoff's voltage and current laws
– Using measuring instruments (voltmeters, ammeters, ohmmeters, etc.)
– Solving series and parallel circuits
– Electromagnetism
– Electrical distribution
– Troubleshooting electrical circuits
– Exploration of the most common electrical components: power sources, resistors, inductors, capacitors, transformers, switches, relays, motors

Building System Technology

Building System Technology
Learning solutions

Introduction to building system technology
The learning solutions teach a broad range of the basic knowledge required for the various technologies and requirements.

The training packages provide an introduction to the topic of electrical protective measures. They explain where and why dangers arise and how to avoid them. An additional training package covers the basic principles of electrical installation. Building system technology: learning solutions

Energy-efficient lighting systems
The lighting system of a building consumes significant amounts of energy. As a result, energy-efficient solutions are increasingly important in this area.

The training packages for this topic focus mainly on energy-efficient lighting technology, fluorescent lamps, high-intensity discharge lamps and high-power LEDs.

Building automation
Modern buildings are characterized by intelligent solutions, especially when it comes to lighting and air-conditioning. Building system technology and bus systems play an important role here.

With the aid of learning solutions based on KNX/EIB technology, the students will learn about the switching and dimming of light, light scene control systems, timer circuits, heating and air conditioning control systems, blind and shutter controllers, and much more.

Modular learning systems
Step by step to success

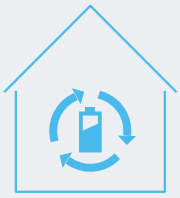
The digitization and networking of building control technology and the demand for reliable, energy-efficient and cross-system solutions present new challenges for teachers and students.

Different systems, such as for lighting, heating, renewable energy, blinds, alarm systems, etc., from different industries must communicate with each other and have to be operated by installers, technicians and users alike.

Building management systems
A complex control system is required for efficiently monitoring the climate of a building.

Our learning system provides the perfect foundations for teaching this knowledge and providing practical training using real-life components.

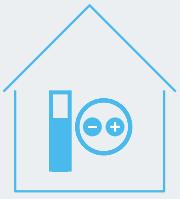
It covers components of the Direct Digital Control building automation system DDC-GA and provides an introduction to network architecture (BACnet MS/TP).



Renewable energy
These learning solutions provide practical experiments in the fields of photovoltaics and wind power, as well as grid supply and smart grid scenarios.

Several different training packages are available in order to cater to a variety of needs.

More information on this subject can be found in the Electric power technology section, which starts on ➔ Page 118.



Electric vehicles
The increasing number of electric vehicles is presenting new challenges for building installations.

Our charging station for electric vehicle enables instructors to teach essential content such as planning and installing a charging station, including connection/commissioning, initial test/proof test and troubleshooting.

Fundamental Electrical Protective Measures

Sensitizing people to dangers: the electrical protective measures

Protective measures protect people and the machine from harm.

Special rules must be followed when dealing with electrical energy, because electrical energy can be recognized only by its effects.

The three training packages provides an introduction to the topic of electrical protective measures. It explains where and why dangers arise and how to avoid them.

Fundamental electrical protective measures Edutrainer®
General functional explanation of protective measure, suitable for all professions and areas of activity.

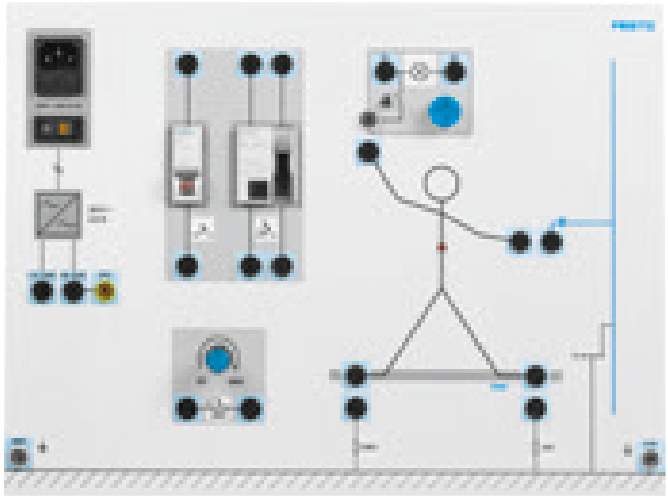
Electrical protective measures for metalworking occupations, equipment set TP 1110
Training package developed especially for metalworking occupations, which addresses the typical sources of danger for this occupation.

Power supply systems and protective measures, equipment set TP 1111
Training package for all occupations that require in-depth knowledge of protective measures and power supply systems

The numerous examples illustrate the particular issue of danger due to electrical energy and explain the necessary protective measures.

The exercises provide inspiration to examine the existing conditions and show the hazards resulting from a particular situation using concrete measurements.

The subsequent analysis and interpretation of the measurement results show the relationships and justify the protective measures taken.



A4 board for raising awareness and communicating the dangers of electric current. Hazards to human beings from electric current is in particular determined by the scale of the electric current that flows through the person. This device teaches the difference between circuit breakers for the protection of a system and residual current protection devices for the protection of persons.

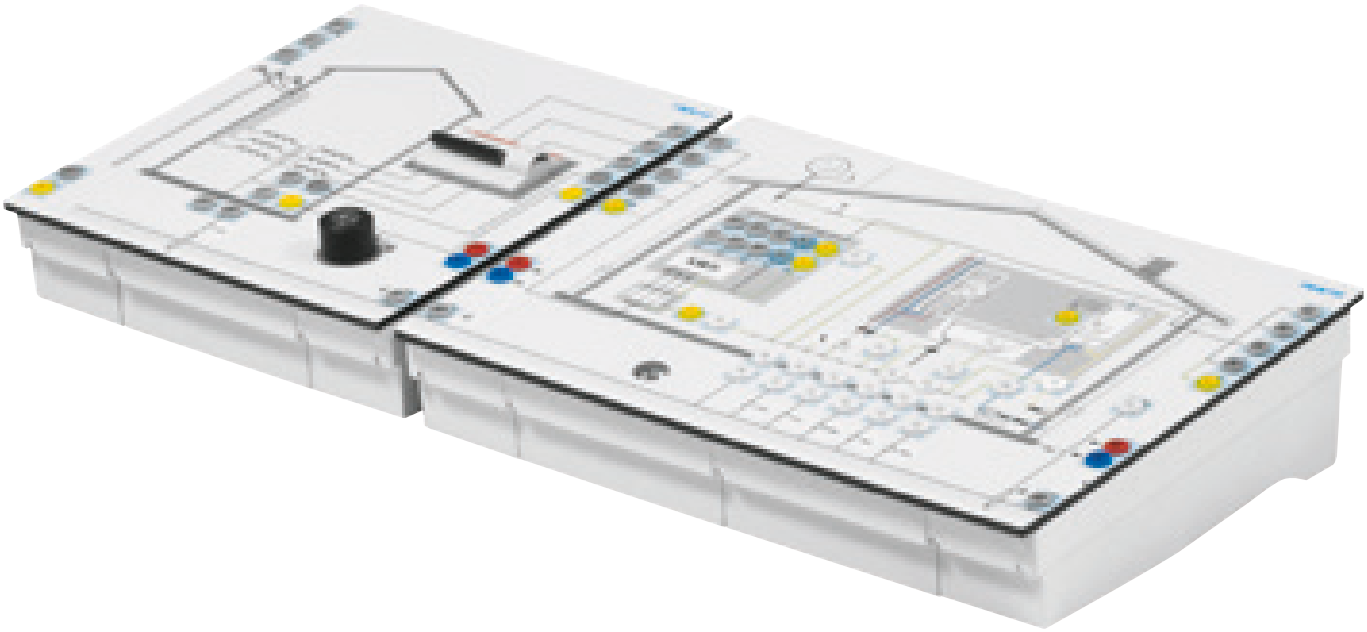
Due to the built-in transformer, all training content is explained at a non-hazardous voltage level of 24 V. The scope of delivery includes the corresponding workbook.

Technical data
- Input voltage: 1 AC/240 V cold device connection
- Output voltage: 1 AC/24 V
- Line circuit breaker: 1 A
- Fault current protective circuit: 30 mA
- Fault simulation via potentiometer and fixed resistances
- Equipment: LED lamp with toggle switch for simulating housing faults
- Front panel: 266 mm x 297 mm
- Console housing with rubber feet for use in an A4 frame or on a table
- Connection via 4 mm safety plug

Order no.	**8048616**

Electrical Safety Measures for Metalworking Occupations

Equipment set TP 1110



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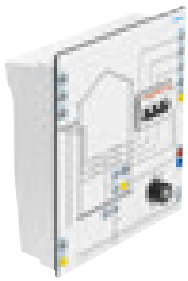

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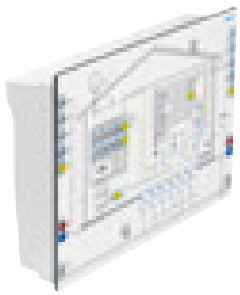

Complete Equipment set TP 1110	**8023971**

The most important components at a glance:

1	1x	EduTrainer net board	571825
2	1x	EduTrainer house installation	571826

Necessary accessories, also order:

- 4 mm safety laboratory cables ➔ Page 271
- Safety jumper plugs ➔ Page 272
- Installation tester for VDE 0100 ➔ Page 276

Recommended training media, also order:

- Electrical protective measures: eLearning course ➔ Page 22

Also order:

Workbook
Protective measures for metal occupations
➔ Page 34

The exercises in the workbook contain concrete, realistic projects with problem descriptions, parameters and project tasks.

Campus license (➔ Page 31):

de	**8023440**
en	**8023441**
es	**8023442**
fr	**8023443**

Training content:

Mains supply:
– Power supply systems (TN, TT, IT system)
– Safety measures in the different networks

Service connection:
– Components of a service connection system
– Additional designations in the TN system (TN-C, TN-S, TN-C-S)
– Selection of the safety measure and protective devices
– Safety measure measuring devices
– Initial tests acc. DIN VDE 0100-610 and repeat tests acc. DIN VDE 0105 and BGV A3

Power Supply Systems and Protective Measures

Equipment set TP 1111

Fundamentals of electrical protective measures

Protecting people plays an important role when using electrical energy, as it is not visible and is recognisable only by its effects. Possible risks must therefore be minimised through suitable safety measures.

Examples provide an introduction to the problems associated with electrical safety measures. Current conditions are examined and the risks resulting from the relevant situation are demonstrated by means of measurements. The subsequent analysis and interpretation of the measurement results show the relationships and identify measures

Training content

Power supply:
– Power supply systems (TN, TT, IT system)
– Protective measures in the different networks

Service connection:
– Components of a service connection system
– Additional designations in the TN system (TN-C, TN-S, TN-C-S)
– Selection of the protective measure and protective devices
– Protective measure measuring devices
– Planning and execution of initial tests in accordance with DIN VDE 0100-610 and repeat tests in accordance with DIN VDE 0105 and BGV A3
– Creating test reports
– Safety and availability advice for customers

Sub-distribution:
– Using protective measures and measuring devices
– Planning and execution of initial and repeat tests
– Evaluation of the measurement results
– Creating test reports
– Identifying, describing and measuring risks due to errors
– Systematic troubleshooting

General:
Conducting customer dialogues
– for system commissioning
– for repeat testing
– for errors/malfunctions in the electrical system
– following successful repair

Advantages

– Lockable error switches integrated in the housing facilitate realistic fault finding
– No additional power supply required
– For a practical explanation of the protective measures, measurements and tests are carried out using conventional test and measuring devices.
– The optionally available Systainer solution meets work, transport and storage requirements efficiently.

Complete equipment set TP 1111	**571824**

The most important components at a glance:

1	1x EduTrainer net board	571825
2	1x EduTrainer house installation	571826
3	1x EduTrainer subdistributor	571827

Necessary accessories, also order:

4 mm safety laboratory cables ➔ Page 271	
Safety jumper plugs ➔ Page 272	
Installation tester for VDE 0100 ➔ Page 276	

Possibilities of expansion:

Selective RCD EduTrainer ➔ Page 94	574173
RCD A/B EduTrainer ➔ Page 94	574174
IT network EduTrainer ➔ Page 95	574178

Recommended training media, also order:

Electrical protective measures: eLearning course ➔ Page 18	

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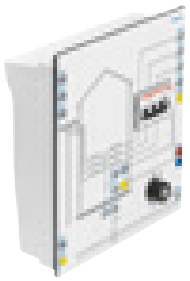

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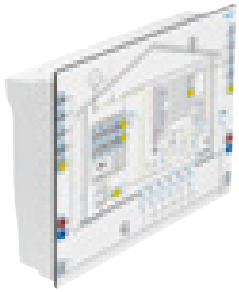

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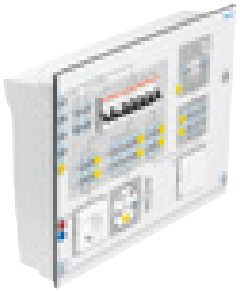
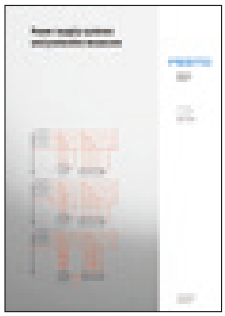


Also order:

Workbook
Power supply systems and protective measures ➔ Page 34



The exercises in the workbook contain concrete, realistic projects with problem descriptions, parameters and project tasks.

The workbook contains:
– Sample solutions
– Educational instructions
– Multimedia CD-ROM with graphics
– Worksheets for learners

The worksheets support the learner in the information and planning phase as well as with execution, monitoring and documentation.

All exercises require independent performance, evaluation and documentation from the learner.

Campus license (➔ Page31):

de	**567307**
en	**567309**
es	**567311**
fr	**567313**

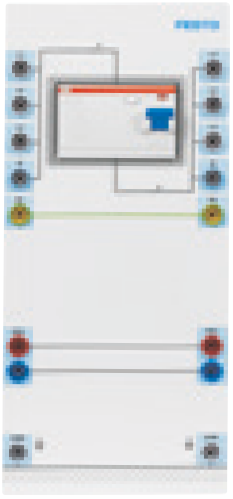
Recommended Tec2Screen® courses
➔ Pages 24 – 26

Direct Current Technology
– Ohm's Law, Power, Work, Energy
– Resistors, Consumers
– Voltage sources, Adaptations
– Capacitors, Parameter-dependent resistors, Measuring

Alternating Current Technology
– Three-Phase Systems
– Characteristics
– Capacitors
– Coils
– RC-Elements
– Electric Power

Possibilities of Expansion

for power supply systems and protective measures – TP 1111



Selective RCD EduTrainer®

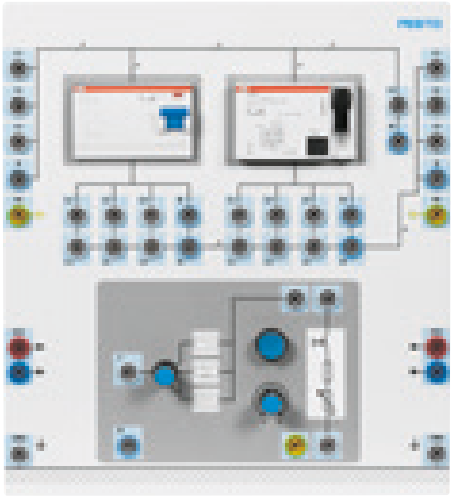
The Selective RCD EduTrainer® allows for treatment of the topic of selectivity for residual current circuit breakers in mains systems and protective measures. The selective RCCB ideally supplements the RCD A/B EduTrainer®, so that it can be easily integrated and its essential characteristics can be elaborated.

The locations of all connections are standardised and are laid out as safety sockets.

Technical data

- Input voltage: 3 x 400 V AC
- Output voltage: 3 x 400 V AC
- Front panel: 133 mm x 297 mm
- Console housing with rubber feet for use in an A4 frame or on a table
- Connection via 4 mm safety plugs

Order no. **574173**



RCD A/B EduTrainer®

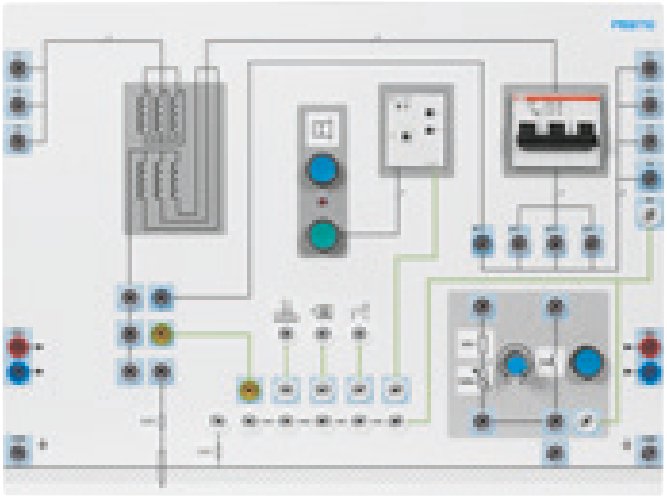
The RCD A/B EduTrainer® covers the topic of residual current circuit breakers in mains systems and protective measures. The two basic types of RCD, type A and type B, are compared with each other and their essential characteristics can be elaborated. The board is equipped with a fault simulator at which various types of voltage can be selected for the simulation of leakage current including alternating voltage, pulsed direct voltage and smoothed direct voltage. An additional voltage tap for expansion circuit breakers/RCCBs enables optimal integration into the equipment set for mains systems and protective measure.

The locations of all connections are standardised and are laid out as safety sockets.

Technical data

- Input voltage: 3 x 400 V AC (50 Hz)
- Output voltage: 3 x 400 V AC
- Tap for expansion circuit breakers/RCCBs
- Pushbutton and adjustment potentiometer for fault simulation
- Voltage type for leakage current can be set to alternating voltage, pulsed direct voltage or smoothed direct voltage
- Max. leakage current: approx. 40 mA, option for looping in an ammeter
- Front panel: 266 mm x 297 mm
- Console housing with rubber feet for use in an A4 frame or on a table
- Connection via 4 mm safety plugs

Order no. **574174**



IT network EduTrainer®

The IT network EduTrainer® expands the equipment set for mains systems and protective measures to include the topic of IT systems. The integrated fault simulator allows simulation of insulation faults which are detected and displayed by the insulation monitor. If the adjustable value is fallen short of, this is indicated by a lamp, as well as a buzzer which can be acknowledged.

The locations of all connections are standardised and are laid out as safety sockets.

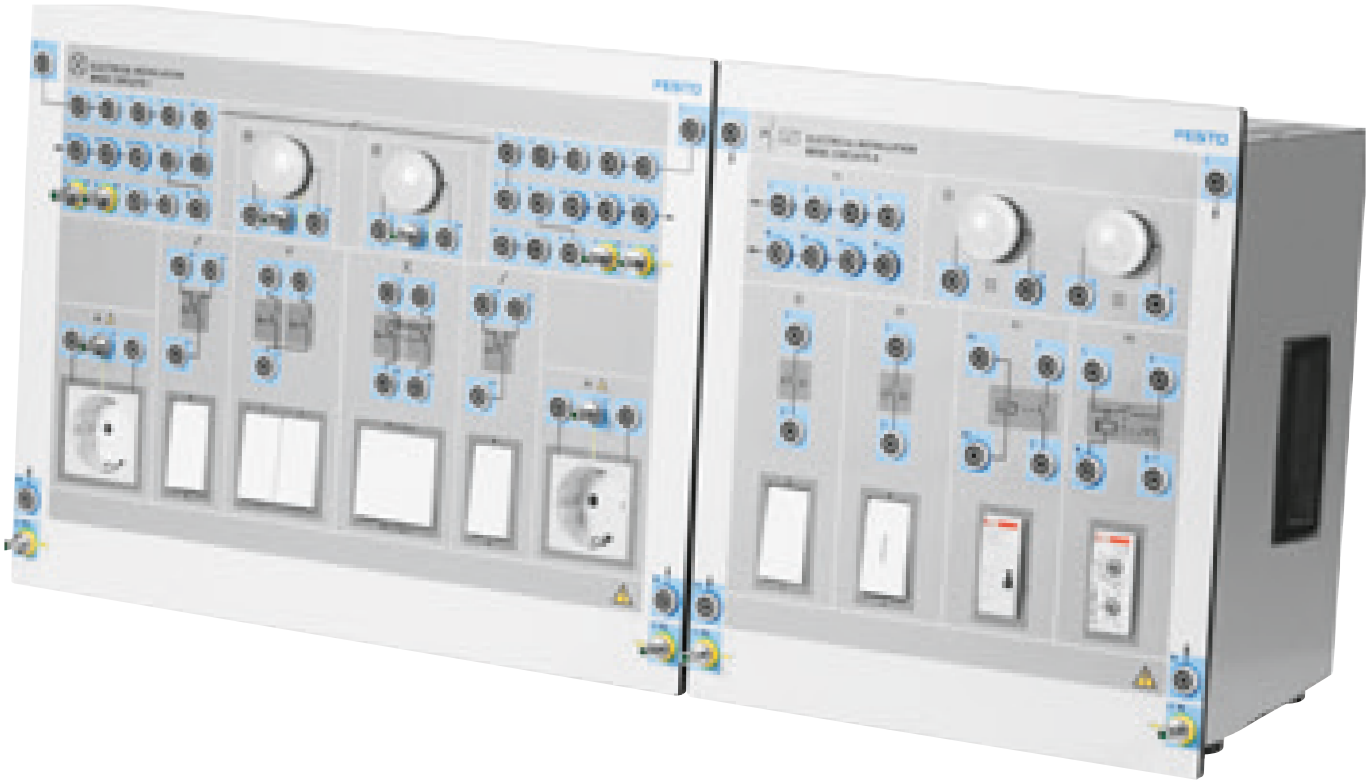
Technical data
- Input voltage: 3 x 400 V AC
- Output voltage: 3 x 400 V AC
- Output current: max. 1 A
- Front panel: 399 mm x 297 mm
- Console housing with rubber feet for use in an A4 frame or on a table
- Connection via 4 mm safety plugs

Order no.	**574178**

Basic Principles of Electrical Installation

Equipment set TP 1121

New



Basic principles of electrical installation

The equipment set provides an introduction to the planning and implementation of electrical installations. The following circuits can be built for a variety of scenarios:
– Switch-off circuit
– Crossover circuit
– Series circuit
– Power surge circuit
– Staircase lighting timer circuits
– Various two-way circuits

All with and without junction box and plug socket circuits.

Training content
– Planning and normative principles
– Circuit diagrams and circuit symbols
– Basic circuits
– Teaching through practical project tasks

Advantages
– Complete function range
– Easy, fast and reliable setup
– Work book with theoretical part and project tasks

Complete equipment set TP 1121	**8105156**

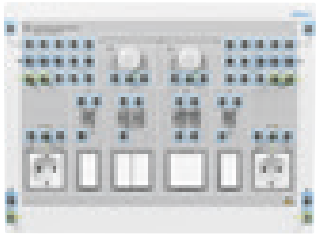
The most important components at a glance:

1	1x	Basic circuits in installation engineering I EduTrainer	8085468
2	1x	Basic circuits in installation engineering II EduTrainer	8085560

Necessary accessories, also order:

4 mm safety laboratory cables ➔ Page 271
Safety jumper plugs ➔ Page 272

1



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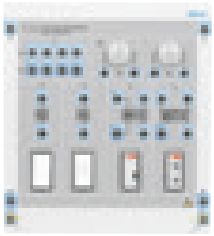

Basic circuits in installation engineering I EduTrainer®

Makes it possible to set up different basic circuits for electrical installation engineering.

Product features
– 2x Junction boxes with 7 multipole terminals
– 2x Lamps
– 2x Earth contact sockets
– 2x Toggle switch
– 1x Series switch
– 1x Crossover switch

Features
– Front panel with multicolored, scratch-resistant front print
– Graphics with division into didactic function blocks
– Rear hood for use in A4 frame or as upright table unit
– All connections are equipped with 4 mm or 2 mm safety sockets
– Removable adapter for PE conductor plug-in system which cannot be swapped over

Basic circuits in installation engineering II EduTrainer®
– Surge current and timer circuits (for stairwell lighting) with one or two actuation points and one or two lighting points
– Automatic stairwell lighting system with switch-off pre-warning
– The circuits can be set up with or without a junction box.

Product features
– 1x Junction box
– 2x Lamps
– 1x Pushbutton
– 1x Pushbutton, illuminated
– 1x Impulse relay
– 1x Automatic stairwell lighting system

Also order:

Workbook
Basic principles of electrical installation
➔ Page 35

The exercises in the workbook contain concrete, realistic projects with problem descriptions, parameters and project tasks.

The workbook contains:
– Sample solutions
– Educational instructions
– Multimedia CD-ROM with graphics
– Worksheets for learners

The worksheets support the learner in the information and planning phase as well as with execution, monitoring and documentation.

All exercises require independent performance, evaluation and documentation from the learner.

Campus license (➔ Page 31):

en	**8113396**

Energy-Efficient Lighting Engineering

Equipment set TP 1141

New

Light can be produced in a variety of efficient ways

The equipment set provides an introduction to lighting engineering. Particularly the mode of operation of the lamps and the light they produce as well as their comparison, industrial energy efficiency and consumption costs and/or amortization of the acquisition can be considered.

The dimming of lamps with conventional and electronic dimmers is also possible.

An 8-piece cable set for 2 mm connections and measurements is included with the equipment set.

Training content
- Method of operation of lamps
- Industrial energy efficiency of lamps
- Light and light temperature
- Dimming properties
- Taught using practical project exercises

Advantages
- Complete function range
- Easy, fast and reliable setup
- Work book with theoretical part and project tasks

Complete equipment set TP 1141	**8106863**

The most important components at a glance:

1	1x Room lighting EduTrainer	8064061

Necessary accessories, also order:

4 mm safety laboratory cables ➔ Page 271	
Safety jumper plugs ➔ Page 272	
Light meter	8064082
Color card set	8087222

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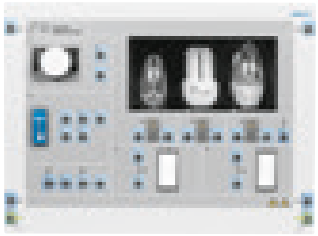


Also order:

Workbook
Energy-efficient
lighting engineering
➔ Page 35

The exercises in the workbook contain concrete, realistic projects with problem descriptions, parameters and project tasks.

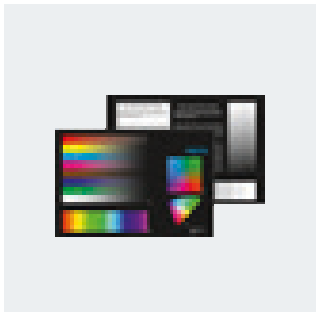
The workbook contains:
– Sample solutions
– Educational instructions
– Multimedia CD-ROM with graphics
– Worksheets for learners

The worksheets support the learner in the information and planning phase as well as with execution, monitoring and documentation.

All exercises require independent performance, evaluation and documentation from the learner.

Campus license (➔ Page 31):

en	**8113398**



Color card set
The color cards allow subjective assessment of color rendering and legibility under different light sources.
– Set of 12
– Delivery in the storage system
– Easy to use
– For the subjective evaluation of light sources of different types

Order no.	8087222

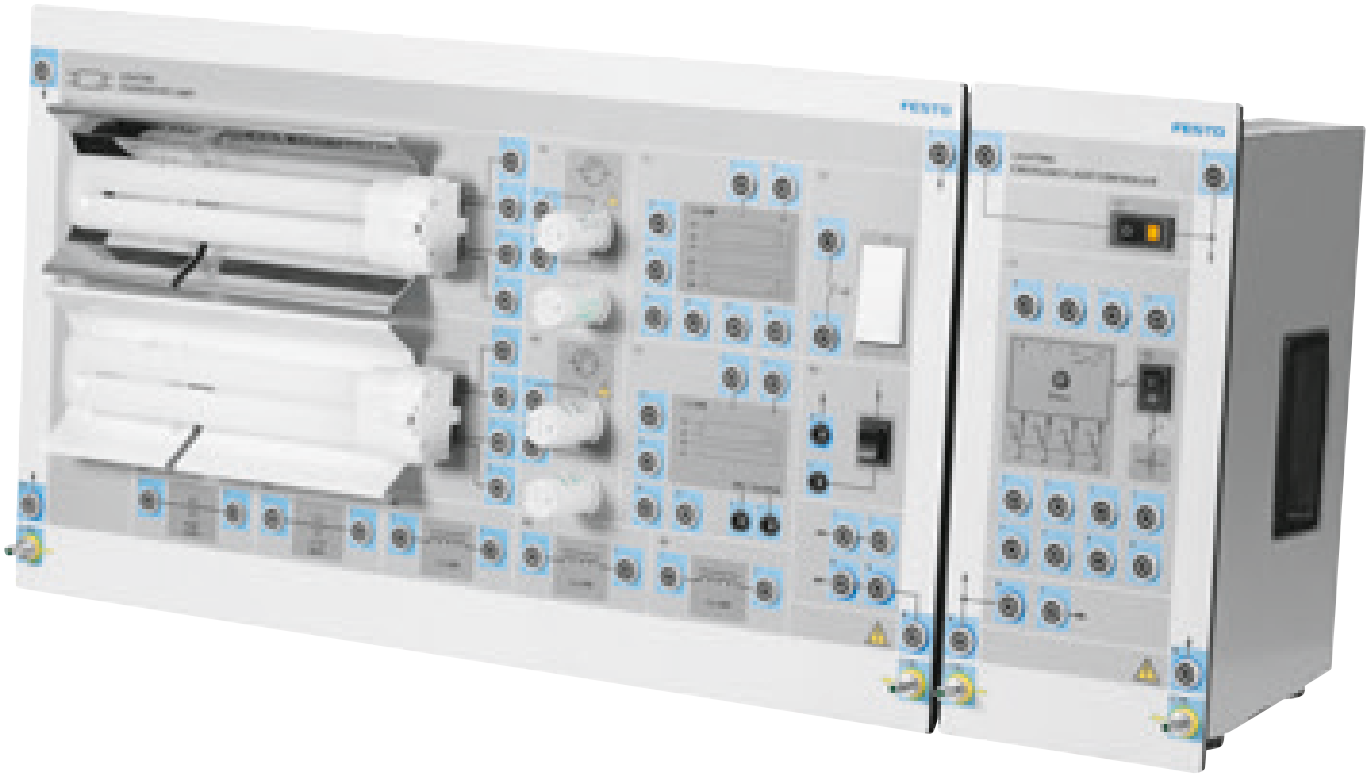
Light meter
The device is used to record technical light quantities during experiments on lighting technology.
– Compact handheld measuring device
– Easy to use
– Various measurements of photometric parameters

Order no.	8064082

Fluorescent Lamps

Equipment set TP 1142

New



Fluorescent lamps are used for a variety of purposes and are wired differently

The equipment set provides an introduction into fluorescent lamp circuits and emergency light modules. The setup of extremely diverse circuits with one or two fluorescent lamps using conventional wiring or electronic ballasts as well as technical light and energy investigations are possible.

As a special feature, circuits with an emergency light module can also be set up and investigated.

An 8-piece cable set for 2 mm connections and measurements is included with the equipment set.

Training content
- Mode of operation of fluorescent lamps
- Function of the components
- Circuits with fluorescent lamps
- Emergency light
- Taught using practical project exercises

Advantages
- Complete function range
- Easy, fast and reliable setup
- Work book with theoretical part and project tasks

Emergency light module EduTrainer®

The emergency light module can be used to study the emergency lighting scenarios in the event of a power failure. The integrated rechargeable battery allows a fluorescent lamp to be operated autonomously. The power failure can be simulated on the module. The charge check is used for conditioning.

Fluorescent lamps EduTrainer®

The module can be used to set up a wide range of different circuits. In addition to conventional circuits for one fluorescent lamp,tandem and duo circuits can also be made by using both lamps. Electronic ballasts are also provided. The range of functions is topped off by a variety of reflectors.

Complete equipment set TP 1142	**8106864**

The most important components at a glance:

1	1x Emergency light module EduTrainer	8064073
2	1x Fluorescent lamps EduTrainer	8064063

Necessary accessories, also order:

4 mm safety laboratory cables ➔ Page 271
Safety jumper plugs ➔ Page 272

Recommended accessories, also order:

Light meter	8064082
Color card set	8087222

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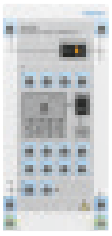

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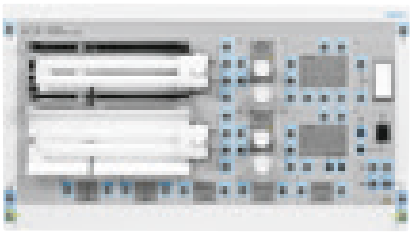

Product features emergency light module EduTrainer®
– Emergency light module
– Power failure simulation
– Charge check

Product features Fluorescent lamps EduTrainer®
– 2x Fluorescent lamps
– 2x Different reflectors
– 1x Electronic ballast with DALI interface
– 1x Duo electronic ballast
– 1x Switches
– 1x Pushbutton
– 2x Capacitors
– 3x Chokes
– 4x Starters

Features
– Front panel with multicolored, scratch-resistant front print
– Graphics with division into didactic function blocks
– Rear hood for use in A4 frame or as upright table unit
– All connections are equipped with 4 mm or 2 mm safety sockets
– Removable adapter for PE conductor plug-in system which cannot be swapped over

Also order:

Workbook
Fluorescent lamps
➔ Page 35

The exercises in the workbook contain concrete, realistic projects with problem descriptions, parameters and project tasks.

The workbook contains:
– Sample solutions
– Educational instructions
– Multimedia CD-ROM with graphics
– Worksheets for learners

The worksheets support the learner in the information and planning phase as well as with execution, monitoring and documentation.

All exercises require independent performance, evaluation and documentation from the learner.

Campus license (➔ Page 31):

en	**8113400**

High-Pressure Discharge Lamps

Equipment set TP 1143

New

Mainly used for street and industrial lighting as well as floodlighting systems

The high-pressure discharge lamps equipment set allows an introduction to sodium vapor lamps and metal halide lamps. It is possible to connect the lamps with electronic ballasts for operation in photometric and energy investigations.

An 8-piece cable set for 2 mm connections and measurements is included with the equipment set.

Training content
- Types of high-pressure discharge lamps
- Industrial energy efficiency of high-pressure discharge lamps
- Circuitry of high-pressure discharge lamps
- Application areas of high-pressure discharge lamps
- Taught using practical project exercises

Advantages
- Complete function range
- Easy, fast and reliable setup
- Work book with theoretical part and project tasks

Complete equipment set TP 1143	**8106865**

The most important components at a glance:

1	1x Metal halide lamp EduTrainer	8064065
2	1x Sodium vapor lamp EduTrainer	8064067

Necessary accessories, also order:

4 mm safety laboratory cables ➔ Page 271	
Safety jumper plugs ➔ Page 272	
Light meter	8064082
Color card set	8087222

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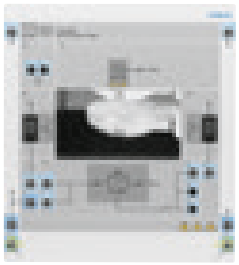

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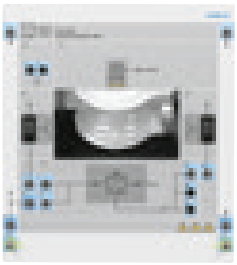


Product features
– 1x Metal halide lamp
– 1x Sodium vapour lamp
– 1x Ballast with DALI interface
– 1x Switches
– 1x Pushbutton
– 1x Temperature sensor

Features
– Front panel with multicolored, scratch-resistant front print
– Graphics with division into didactic function blocks
– Rear hood for use in A4 frame or as upright table unit
– All connections are equipped with 4 mm or 2 mm safety sockets
– Removable adapter for PE conductor plug-in system which cannot be swapped over

Also order:

Workbook
High-pressure discharge lamps
➔ Page 35

The exercises in the workbook contain concrete, realistic projects with problem descriptions, parameters and project tasks.

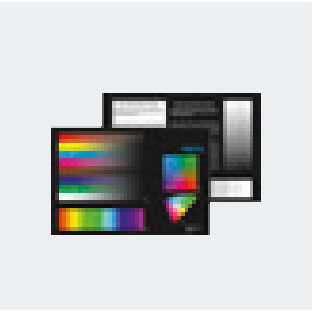
The workbook contains:
– Sample solutions
– Educational instructions
– Multimedia CD-ROM with graphics
– Worksheets for learners

The worksheets support the learner in the information and planning phase as well as with execution, monitoring and documentation.

All exercises require independent performance, evaluation and documentation from the learner.

Campus license (➔ Page 31):

en	**8111397**



Color card set
The color cards allow subjective assessment of color rendering and legibility under different light sources.
– Set of 12
– Delivery in the storage system
– Easy to use
– For the subjective evaluation of light sources of different types

Order no. 8087222

Light meter
The device is used to record technical light quantities during experiments on lighting technology.
– Compact handheld measuring device
– Easy to use
– Various measurements of photometric parameters

Order no. 8064082

High-Power LEDs

Equipment set TP 1144

New

The most modern and energy efficient way of lighting

Enables two different high-power LEDs to be connected in a circuit.

The high-power LED equipment set provides an introduction to high-power LEDs. It is possible to connect the lamps with LED driver for operation in photometric and energy investigations.

An 8-piece cable set for 2 mm connections and measurements is included with the equipment set.

Training content
- Method of operation of LEDs
- Industrial energy efficiency of LEDs
- Dimming LEDs
- Light and light temperature
- Taught using practical project exercises

Advantages
- Complete function range
- Easy, fast and reliable setup
- Work book with theoretical part and project tasks

Complete equipment set TP 1144	**8106866**

The most important components at a glance:

1	1x	High-power LED EduTrainer	8064069

Necessary accessories, also order:

4 mm safety laboratory cables ➔ Page 271	
Safety jumper plugs ➔ Page 272	
Light meter	8064082
Color card set	8087222

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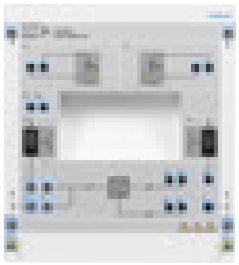
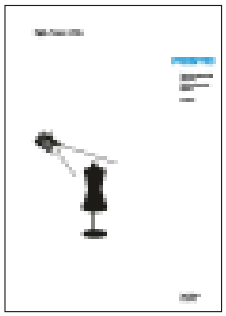


Product features
– 1x High-power LED warm white
– 1x High-power LED cold white
– 1x LED driver with DALI
– 1x Switches
– 1x Pushbutton

Features
– Front panel with multicolored, scratch-resistant front print
– Graphics with division into didactic function blocks
– Rear hood for use in A4 frame or as upright table unit
– All connections are equipped with 4 mm or 2 mm safety sockets
– Removable adapter for PE conductor plug-in system which cannot be swapped over

Also order:

Workbook
High-power LEDs
➔ Page 36



The exercises in the workbook contain concrete, realistic projects with problem descriptions, parameters and project tasks.

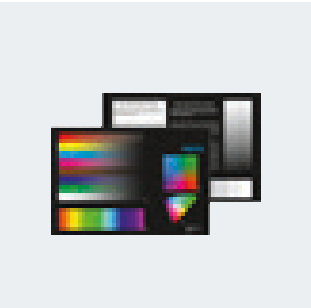
The workbook contains:
– Sample solutions
– Educational instructions
– Multimedia CD-ROM with graphics
– Worksheets for learners

The worksheets support the learner in the information and planning phase as well as with execution, monitoring and documentation.

All exercises require independent performance, evaluation and documentation from the learner.

Campus license (➔ Page 31):

en	**8111399**



Color card set
The color cards allow subjective assessment of color rendering and legibility under different light sources.
– Set of 12
– Delivery in the storage system
– Easy to use
– For the subjective evaluation of light sources of different types

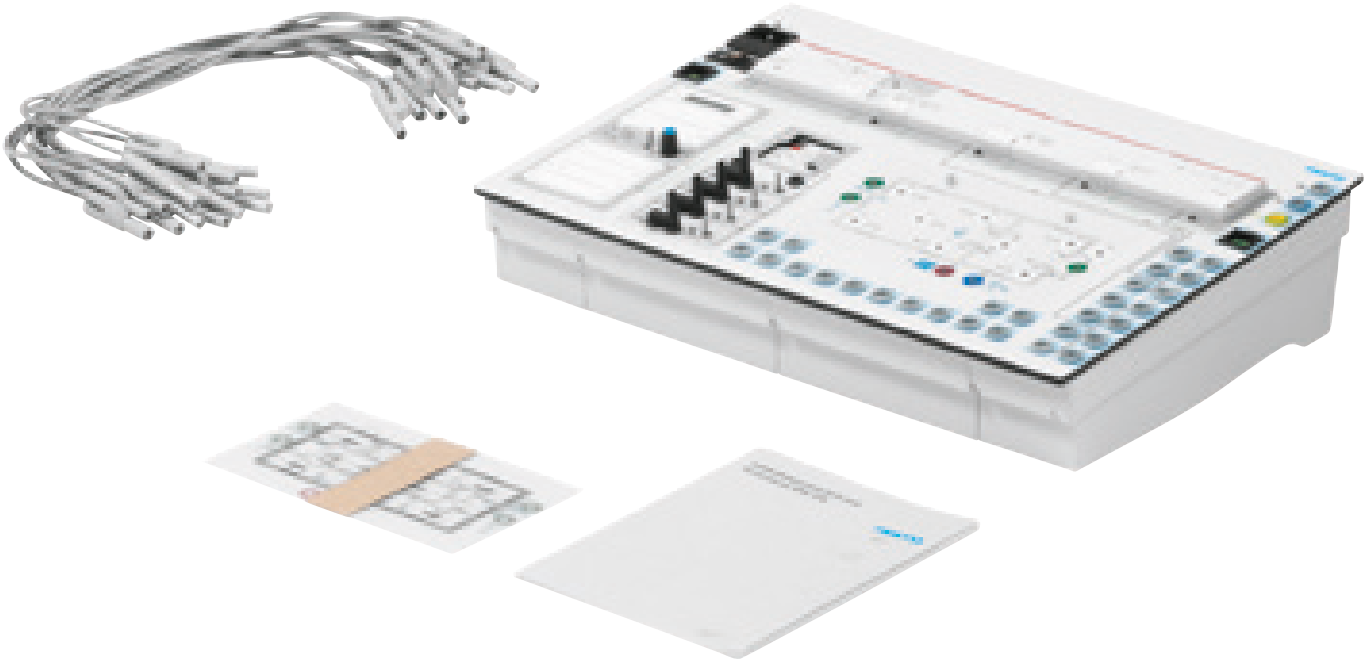
Order no.	8087222

Light meter
The device is used to record technical light quantities during experiments on lighting technology.
– Compact handheld measuring device
– Easy to use
– Various measurements of photometric parameters

Order no.	8064082

KNX/EIB Compact Board

Equipment set TP 1131



Intelligent solutions

Modern buildings are characterised by intelligent lighting and air-conditioning solutions. Building automation systems and bus systems play a key role here.

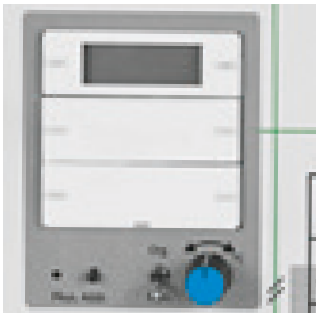
The KNX/EIB compact board EduTrainer® is used to explain use of this technology. Equipped with the latest generation of industrial components, it delivers state-of-the-art technology.

When selecting the devices used, efforts were made to ensure that the widest possible range of levels of complexity can be realised. Beginners are therefore not overwhelmed and can use the full range of functions to meet increasing requirements.

The optionally available Systainer solution meets work, transport and storage requirements efficiently, thus reducing the amount of work required before and after lessons.

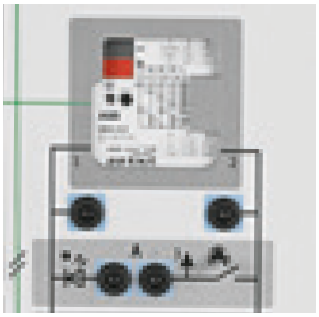
Training content

– KNX/EIB system fundamentals
– Using the system software ETS4
– Switching and dimming the light
– Two-way circuits
– Interval timers
– Staircase lighting timers
– Light scene control systems
– Different floor plans
– Heating and climate control
– Louvre and blind control systems
– Logic operation of signals



Functional

The pushbutton sensor elements can be used either as rockers or as independent buttons, the actual value of the integrated temperature controller can be specifed and further processed using an external potentiometer.



Universal

The channels of the 4-fold universal interface can be parameterised as both binary input and outputs. This means, for example, that the LEDs can be used to indicate a wide variety of states or solid state relays can be controlled for electrothermal heating valve drives.

Complete equipment set TP 1131	**571867**

Scope of delivery
– KNX/EIB compact board
– Overlay masks
– 14 laboratory safety cables

Necessary accessories, also order:

1 KNX cable set	8023965

Possibilities of expansion:

KNX EduTrainer heating actuator	574175
KNX EduTrainer line connector	574176
KNX EduTrainer louvre	574177
KNX EduTrainer universal experimental board	8023966
KNX IP/Wi-Fi function package	8111317
KNX logic/time function package	8023968
KNX room climate function package	8023969
KNX energy function package	8023970

Technical data
– Input voltage: 1 AC/230 V AC (50 Hz), short circuit and overload protection
– Phase display
– Output for the connection of additional KNX/EIB EduTrainer® modules
– Output voltage: 1 AC/230 V AC
– Integrated power supply unit 30 V DC 0.16 A
– USB interface
– 4/4-fold switching output/ binary input
– 2-fold louvre actuator
– 2-fold dimming actuator
– 4-fold universal binary I/O
– 4-fold multi-function pushbutton sensor with 8 pushbuttons
– 2-fold multi-function pushbutton sensor with 4 pushbuttons, room temperature controller including setpoint and actual value input and display
– Integrated simulation panel with 14 colour LEDs, some dimmable
– KNX system connector for bus connection
– Connection via 4 mm and 2 mm safety connectors
– Front plate: 399 mm x 297 mm
– Control console housing with rubber feet for use in A4 frame or on tabletop

Also order:

Workbook
Building automation with KNX
➔ Page 40

The exercises in the workbook contain concrete, realistic projects with problem descriptions, parameters and project tasks.

Particular emphasis is placed on independent execution, evaluation and documentation by the student.

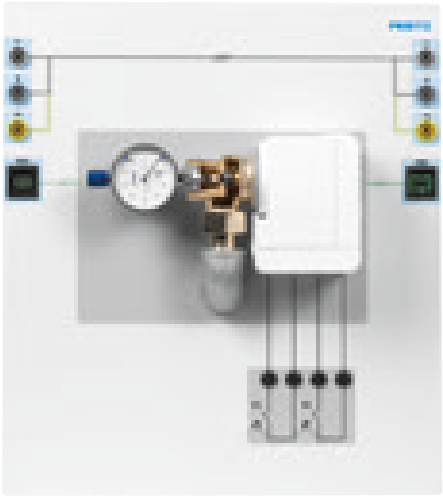
Worksheets support the students through the required stages of introduction, planning and execution of exercises up to the evaluation of results and documentation.

The workbook contains:
– Sample solutions
– Educational instructions
– Multimedia CD-ROM with graphic
– Worksheets for learners

Campus license (➔ Page 31):

de	**8023444**
en	**8023445**
es	**8023446**
fr	**8023447**

Expansions for KNX/EIB Compact Board – TP 1131



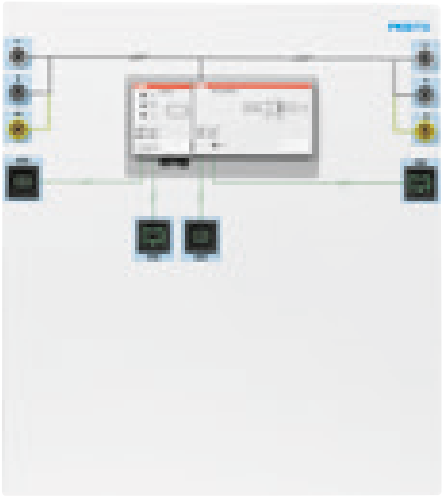
KNX EduTrainer® heating actuator

The heating actuator controls the heating water circuits in heating systems. The interior of the valve is visible, and an integrated gauge shows the stroke of the plunger. The valve is supplied entirely via the KNX bus. Two binary inputs are available as presence and/or window contacts and can be controlled via switches or external signals. The plate also contains the KNX system distributor for 230 V.

The locations of all connections are standardised and are routed to safety sockets or system plugs.

Technical data
- Input voltage: 1 x 230 V AC
- Output voltage: 1 x 230 V AC
- Electric motor functional principle, automatic limit stop connection, controller stroke 6 mm, run-time < 20 s/mm, control force > 120 N
- Display of valve stroke via LEDs
- Gauge triggering: 0.01 mm
- Front panel: 266 mm x 297 mm
- Console housing with rubber feet for use in an A4 frame or on a table
- Connection via 4 mm safety plugs
- Connections for KNX bus via KNX bus plug connectors

Order no. **574175**



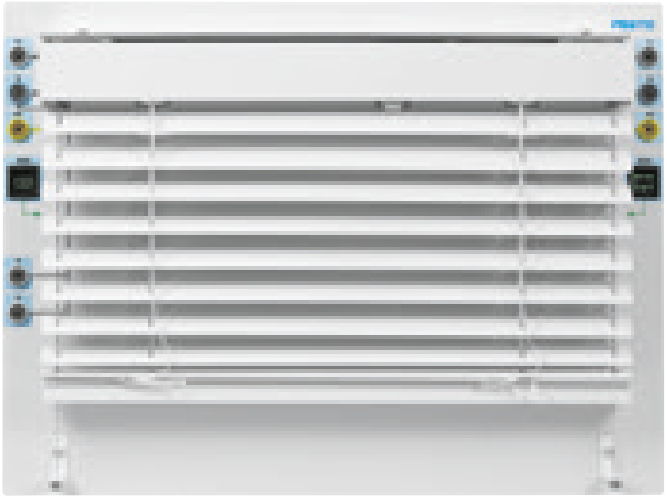
KNX EduTrainer® line connector

The line connector connects the main and secondary line in a KNX systems. This also permits targeted filtering of signals. The main line is also equipped with a power supply. The plate also contains the KNX system distributor for 230 V.

The locations of all connections are standardised and are routed to safety sockets or system plugs.

Technical data
- Input voltage: 1 x 230 V AC
- Output voltage: 1 x 230 V AC
- Power supply EIB: 30 V DC, 160 mA
- Front panel: 266 mm x 297 mm
- Console housing with rubber feet for use in an A4 frame or on a table
- Connection via 4 mm safety plugs
- Connections for KNX bus via KNX bus plug connectors

Order no. **574176**



KNX EduTrainer® louvre

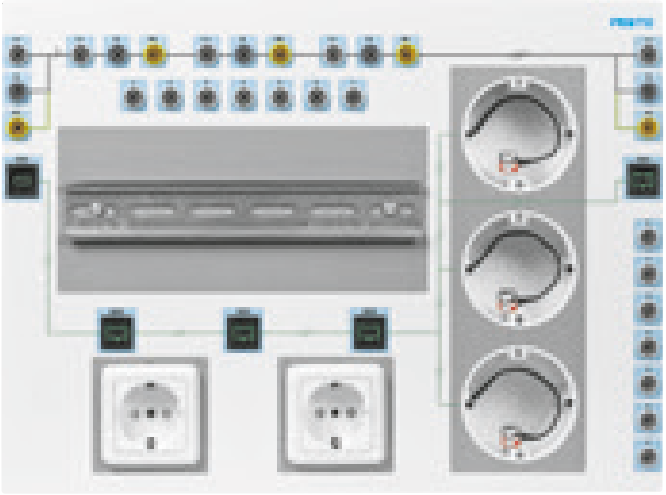
The louvre is used to emulate situations in building automation. For this purpose, the louvre can be raised or lowered and the slat position can be influenced. The connections for controlling “UP” and “DOWN” are routed to 4 mm safety sockets. The plate also contains the KNX system distributor for 230 V.

The locations of all connections are standardised and are routed to safety sockets or system plugs.

Technical data
- Input voltage: 1 x 230 V AC
- Output voltage: 1 x 230 V AC
- Louvre: Length 440 mm, stroke 160 mm
- Power consumption: 100 W, current max. 0.45 A
- Front panel: 399 mm x 297 mm
- Console housing with rubber feet for use in an A4 frame or on a table
- Connection via 4 mm safety plugs
- Through-feed for KNX bus via compact KNX bus plug connectors
- Connection option for the louvre control to the KNX compact board via jumper plugs

Order no.	**574177**

KNX Universal Experimental Board



The universal experimental board serves to integrate KNX bus devices of all kinds into the KNX learning system.

It makes it possible to integrate rail mounted devices and surface-mounted and flush-mounted devices. Both an operating voltage supply and bus connections are available for electrical connection of the equipment. The outputs are routed to positions suitable for the system. Two sockets make it possible to supply external equipment with voltage. In addition, the panel contains the KNX system distribution for 230 V.

The locations of all connections are standardised and are routed to safety sockets or system plugs.

Technical data
– Input voltage: 230 V AC
– Output voltage: 230 V AC
– 2 plug socket outlets for 230 V AC
– 7 output connections
– Front panel: 399 mm x 297 mm
– Console housing with rubber feet for use in an A4 frame or on a table
– Connection via 4 mm safety plugs
– Connections for KNX bus via KNX bus plug connectors

Theme-based KNX function packages:

KNX IP/Wi-Fi function package
– KNX IP-Router
– WLAN Access Point
KNX logic/time function package
– Logic module
KNX room climate function package
– Air quality sensor
KNX energy function package
– Energy actuator

Each function package consists of the KNX component and the necessary accessories.

Order no.	**8023966**

Themed function packages:

KNX IP/Wi-Fi function package	8111317
KNX logic/time function package	8023968
KNX room climate function package	8023969
KNX energy function package	8023970

KNX room climate function package
The KNX Air Quality Sensor is a combined sensor for CO_2, temperature and humidity measurement (relative humidity). Three independent thresholds can be set for the CO_2 concentration and the relative humidity in addition to a threshold for the temperature.

The communication object Ventilation can be used for speed control or as a position indicator for ventilation flaps. The connection to the KNX is established using the bus connection terminals on the interior of the device.

Order no.	**8023969**

KNX logic/time function package
The device contains logical function with the possibility of individual parameter parameterisation.

Function selection:
– Logic gates
– Gate
– Timer
– Multiplier
– Temperature comparison function
– Switch value
– Threshold sensing
– Format converter
– Scenes
– Counter
– Stairwell lighting

Order no.	**8023968**

KNX IP/Wi-Fi function package
KNX IP router and WLAN access point for extending the KNX compact board.

Insert on the KNX Universal Experimental Board forms the interface between KNX systems and IP networks and thus permits data exchange.

Product features
– IP router and access point
– Auxiliary power supply
– Connecting cables

Order no.	**8111317**

KNX energy function package
The device records the energy consumption of the connected consumers in the end power circuit. A range of electronic variables are monitored, and peak loads are limited by a simple load control device.

The energy actuator can switch resistive, inductive and capacitive loads.

In addition to this, the ETS application also provides simple load management functionality, which allows the user to interconnect up to ten energy actuators. The electrical consumers at the three potential-free switching outputs are switched manually via KNX or the device itself.

Order no.	**8023970**

EduTrainer® for Mini Control Systems

For a basic introduction to control and monitoring tasks

Basic trainer for mini control systems

Mini control systems are becoming increasingly common in industry and trade. They are used for numerous small control and monitoring tasks for which a PLC would be oversized. Mini control systems or programmable control relays control and operate conveyors, monitor doors and gates, control heating, and so on.

For training purposes, they represent the link between classic safety circuits and programmable logic controllers. Functions can be implemented quickly and easily based on the learned ladder diagram or function chart methodology using simple programming software.

Mini control systems are characterized by the large number of features that they provide. They are easy to program and to connect, are flexible and low-cost, and are therefore indispensable in basic training.

Another advantage of these small and compact devices, which are suitable for mounting in 35 mm H-rails, is that they implement many functions in a single device.

Mini control systems include:
– Controllers
– Indicators
– Diagnostic tools
– Text displays with operating buttons
– Interfaces to fieldbus systems
– Web servers
– and many more

Numerous extension modules expand the possible functions.

The **EduTrainer® for mini control systems** provides a broad basic platform for your project work. The board is designed to hold mini control systems and expansion modules, for example the Siemens LOGO! 8, the EATON Easy family or a Controllino.

Up to 12 inputs can be picked off on 4 mm safety sockets. Four of these inputs can also be connected directly on the device using a pushbutton/latched switch. Up to 8 relay outputs can be changed to digital outputs using a toggle switch. Up to 2 analog outputs can also be connected to 4 mm safety sockets.

The device also includes two controllable analog encoders, which can be used to bridge voltages from 0 to 10 V at two inputs. An RJ45 Ethernet socket can connect the controller to the programming unit or network switch.

Please request a quotation for your individual requirements.

EduTrainer® Universal Preferred Versions Laboratory

A4/A4 rack with SIMATIC S7-1500 and 19” simulation modules

1

1 S7-1512C-1PN	**8065595**
2 S7-1516-3PN/DP	**8042524**
3 S7-1516F-3PN/DP	**8034574**

Notes

Order no. 8065595, 8042524 and 8034574 are based on Siemens SCE Trainer Packages and each one contains one EduTrainer® including programming cable (Ethernet cable) and programming software STEP 7 TIA portal. When Siemens updates these Trainer Packages, the controllers are replaced by successor models. Subject to technical implementation.

Recommended accessories:

I/O data cable with SysLink connectors (IEEE 488), 2.5 m	34031
Analog cable, parallel, 2 m	529141
Safety laboratory cable, 3 m	571817
IEC power cable 90° ➔ Page 270	

Other accessories:

Analog cable, crossover, 2 m	533039

2

3

The ultimate in power and efficiency

The SIMATIC S7-1500 controller family represents the new controller generation in the TIA portal and a milestone in automation. It delivers maximum performance and user-friendliness for medium and high-end applications in machine and plant automation.

EduTrainer® Universal with:

CPU S7-1512C-1PN
- Main memory: 250 KB for program and 1 MB for data
- Memory card included
- Interface: PROFINET IRT with 2-port switch

Inputs/outputs:
- 32 digital inputs (24 V DC)
- 32 digital outputs (24 V DC/0.5A)
- 5x Analog inputs, 4x U/I, 1x R/RTD, 16-bit resolution
- 2x Analog outputs, 2x U/I, 16-bit resolution

CPU S7-1516-3PN/DP
- Main memory: 1 MB for program and 5 MB for data
- Memory card included
- Interface 1: PROFINET IRT with 2-port switch
- Interface 2: Ethernet
- Interface 3: PROFIBUS, 10 ns bit performance

Inputs/outputs:
- 32 digital inputs (24 V DC)
- 32 digital outputs (24 V DC/0.5A)
- 8x Analog inputs, 8x U/I/RTD/TC, 16-bit resolution
- 4x Analog outputs, 4x U/I, 16-bit resolution

CPU S7-1516F-3PN/DP
- Main memory: 1.5 MB for program and 5 MB for data
- Memory card included
- Interface 1: PROFINET IRT with 2 port switch
- Interface 2: Ethernet
- Interface 3: PROFIBUS, 10 ns bit performance

Inputs/outputs:
- 32 digital inputs (24 V DC)
- 32 digital outputs (24 V DC/0.5 A)
- 8x Analog inputs, 8x U/I/RTD/TC, 16-bit resolution
- 4x Analog outputs, 4x U/I, 16-bit resolution

The mounting system
- EduTrainer® Universal, size 1 (W x H) 305 x 300 mm
- Can be placed on a desk or in an MPS station
- Stable, powder-coated, sheet-steel mounting system
- Integrated power supply unit, AC 110/230 V/DC 24 V, 4 A
- 19” module 16DIN (12 HP), 16 digital inputs on 4 mm safety sockets and 16 switches/push buttons for signal simulation
- 19” module 16DOUT (12 HP), 16 digital outputs on 4 mm safety sockets
- 19” module 4AIN/2AOUT (12 HP), analog processing 4 analog inputs on 4 mm safety sockets can be switched to simulation via potentiometer and 2 analog outputs on 4 mm safety sockets
- 19” module 24 V/0 V (9 HP), 8 x 4 mm safety sockets, red for 24 V distribution, 8 x 4 mm safety sockets, blue for 0 V distribution
- 19” module simulation plate with 2x SysLink plug connector for MPS station and control panel, each with 8 digital inputs and 8 digital outputs and 1x Sub-D 15-pin plug connector with 4 analog inputs and 2 analog outputs; emergency stop jumper to connect a safety circuit for disconnecting 8 digital outputs.

Special license rules apply for schools and educational institutes in the commercial sector.

EduTrainer® Universal Preferred Versions MPS

A4 rack with SIMATIC S7-1500

The ultimate in power and efficiency

The controller family SIMATIC S7-1500 is a new controller generation in the TIA portal and a milestone in automation. It delivers maximum performance and user-friendliness for medium and high-end applications in machine and plant automation.

EduTrainer® Universal with:

CPU S7-1512C-1PN (MPS)
– Main memory: 250 KB for programs and 1 MB for data
– Memory card included
– Interface: PROFINET IRT with 2-port switch

Inputs/outputs:
– 32 digital inputs (24 V DC)
– 32 digital outputs (24 V DC/0.5A)
– 5x Analog inputs, 4x U/I, 1x R/RTD, 16-bit resolution
– 2x Analog outputs, 2x U/I, 16-bit resolution

CPU S7-1516-3PN/DP (MPS)
– Main memory: 1 MB for program and 5 MB for data
– Memory card included
– Interface 1: PROFINET IRT with 2-port switch
– Interface 2: Ethernet
– Interface 3: PROFIBUS, 10 ns bit performance

Inputs/outputs:
– 32 digital inputs (24 V DC)
– 32 digital outputs (24 V DC/0.5A)
– 8x Analog inputs, 8x U/I/RTD/TC, 16-bit resolution
– 4x Analog outputs, 4x U/I, 16-bit resolution

The mounting system
– EduTrainer® Universal, size 1 (W x H) 305 mm x 300 mm
– Can be placed on a desk or in an MPS station
– Stable, powder-coated, sheet-steel mounting system
– Integrated power supply unit, AC 110/230 V/DC 24 V, 4 A
– 19” module simulation plate with 2x SysLink plug connector for MPS station and control panel, each with 8 digital inputs and 8 digital outputs and 1x Sub-D 15-pin plug connection with 4 analog inputs and 2 analog outputs; emergency stop jumper to connect a safety circuit for disconnecting 8 digital outputs.

1

1 S7-1512C-1PN (MPS)	**8065452**
2 S7-1516-3PN/DP (MPS)	**8065594**

Notes

Order no. 8065452 and 8065594 are based on Siemens SCE Trainer Packages and each one contains one EduTrainer® including programming cable (Ethernet cable) and programming software STEP 7 TIA portal. When Siemens updates these Trainer Packages, the controllers are replaced by successor models. Subject to technical implementation.

Recommended accessories:

I/O data cable with SysLink connectors (IEEE 488), 2.5 m	34031
Analog cable, parallel, 2 m	529141
Safety laboratory cable, 3 m	571817
IEC power cable 90° → Page 270	

Other accessories:

Analog cable, crossover, 2 m	533039

2

Special license rules apply for schools and educational institutes in the commercial sector.

Building HVAC Controls

[X]

Building management systems in the digital age

Most modern commercial buildings have heating, ventilation and air conditioning (HVAC) systems that are controlled automatically. HVAC control systems control the temperature, airflow, humidity and carbon-dioxide content of rooms based on the temperatures inside and outside of the building in question. This keeps the climate in the rooms pleasant and the power consumption low.

Modern HVAC systems contain a wide range of technologies and complex control systems. In order to ensure smooth and efficient operation, installation and maintenance engineers must possess an in-depth understanding of how these systems work. Our learning system provides the perfect foundations for teaching this knowledge and providing practical training using real-life components.

Practical training
The Building management systems learning system is the ideal medium for teaching the basics of modern control systems to the level required for training in the field of HVAC. The system possesses industry-standard components provided by Johnson Controls, a world-renowned manufacturer.

Web-based supervisory controller
A built-in web server that acts as an HMI interface can be used to access all the system data in real time via LAN or WLAN. The graphic overview enables the students to keep an eye on the ventilation system and ventilation shafts at all times. Other special functions include time sequence control, forecast displays and alarm management.

Simulated signals, real control
The HVAC system plan module models a typical air conditioning system with simplified building ventilation shafts. This provides the foundation for the learning system. This module can be used to easily simulate change in temperature, pressure and carbon dioxide concentration. It also contains simulated flaps, cooling and heating equipment, fans and humidifiers.

The module's sensor and actuator simulations are connected to a real field controller. This gives the students practical experience of how an HVAC control system responds to changes in conditions. The field controller's control algorithm has been optimized to speed up the processes modeled in the system.

Topic coverage
- Structure of an HVAC system for a commercial building
- Components of the Direct Digital Control building automation system DDC-GA
- Introduction to network architecture (BACnet MS/TP)
- Field controllers
- Supervisory controller and HMI
- Temperature and humidity control of constant air volume systems (CAV)
- Pressure-dependent and pressure-independent variable air volume systems (VAV)

 [X] Picture contains accessories

Complete equipment set	**594538**

The most important components at a glance:

1	Building HVAC layout	594518
2	Supervisory controller	594519
3	2x Programmable controller	594516
4	Temperature network sensor	594517
5	Control transformer	594515
	Programmable controller software	588274
	Test lead kit	594520

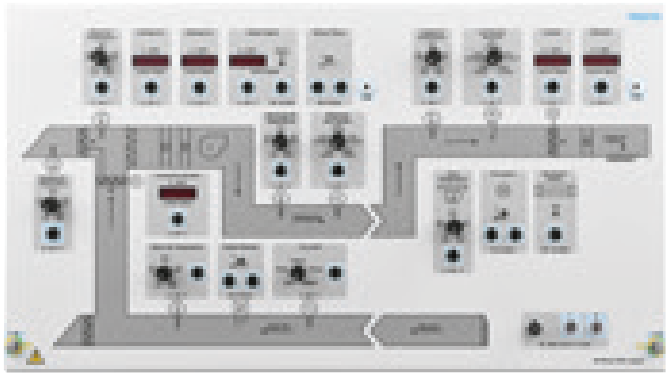
Necessary accessories, also order:

1x	Mobile Frameline, complete model without energy duct*	8075133
1x	Frameline mobile table*	8087149

* Or equivalent

Also required:
PC with DVD drive running on Windows

1



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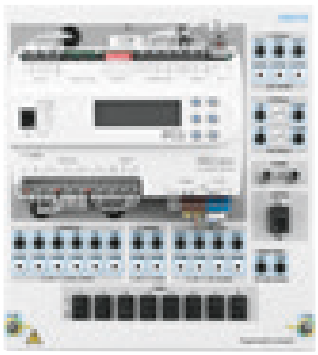

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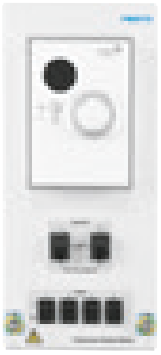

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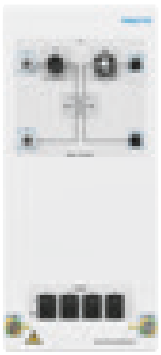
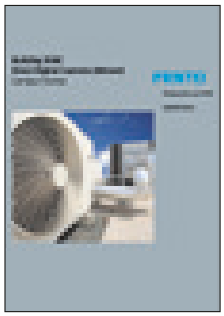


Also order:

Workbook
Building HVAC Controls (BACnet)
➔ Page 36



The exercises in the workbook contain concrete, realistic projects with problem descriptions, parameters and project tasks.

The workbook contains:
– Exercises and sample solutions
– Educational instructions
– Worksheets for learners

The worksheets support the learner in the information and planning phase as well as with execution, monitoring and documentation.

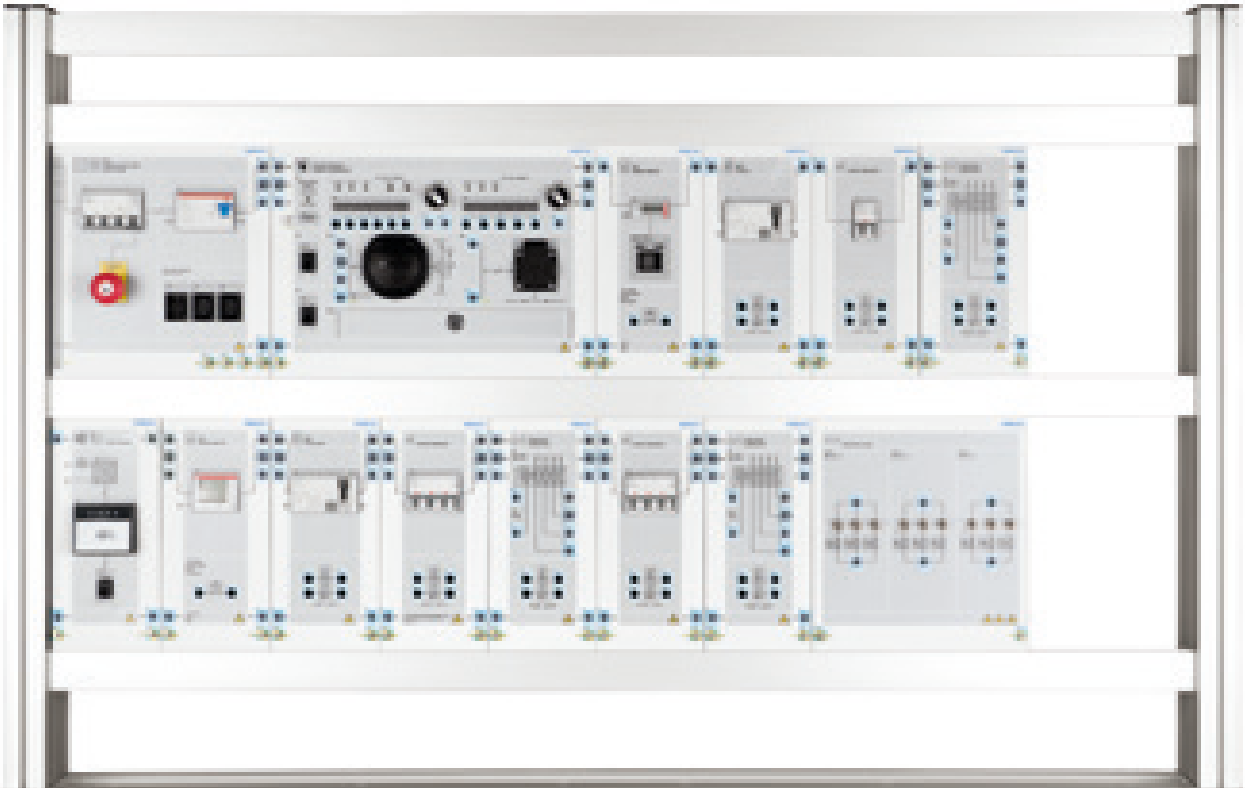
All exercises require independent performance, evaluation and documentation from the learner.

Campus license (➔ Page 31):

de	**793120**
en	**793119**
es	**793122**

Electric Vehicle Charging Station

Equipment set TP 8014



Learn everything about charging stations for electric vehicles

Like all permanently-wired electrical installations, charging stations are required to meet stringent regulations to ensure proper operation and user safety. There is, therefore, a growing need for competent, well-trained personnel to install, commission, and service charging stations.

The Electric Vehicle Charging Station of Festo Didactic is designed for hands-on training in the planning, installation, testing, and troubleshooting of a modern charging station. The flexible, modular design enables easy set-up of various charging station configurations, ranging from a simple, single-phase station to more advanced, multi-phase stations that can simultaneously charge two users.

The advanced stations include electrically commuted power circuits that automatically adapt to the capacity of the detected charging cable. Among further options for advanced stations are energy meters to measure consumption during a charge, and RFID-based user identification and charge control.

The modules that make up the system are designed to be mounted in a standard A4 workstation. Each module has front-panel connections for power and for sensing/control signals. In addition, commercially-available protective devices, such as circuit breakers and residual current devices, are included as system modules.

Features
- Covers two independent charging points in accordance with VDE 0100-722
- Modular design allows the combination of packages
- Flexible packages for specific training and budget needs
- Designed for A4 mounting frames
- New and safer inter-module grounding methods
- Possibility to link with commercial devices
- Hidden faults to develop troubleshooting skills
- Includes commercial energy meters, RFID reader, EV charge controller and EV simulator/tester

Training content
Students will follow the scope of the training curriculum from an initial understanding of electric vehicles, batteries, and charging stations to installing, operating, and commissioning such a charging station.

The following topics will be covered:
- Types of vehicles and the charging cycle
- Electric vehicle charging modes
- Electrical hazards and protective measures
- Communication with the EV
- Single and three-phase installations (IEC 62196-2 Type 2)
- Common Components
- Safety interlocks
- RFID for user identification
- Adapting an existing installation
- Energy management
- Commissioning and testing
- Troubleshooting and analysis

Complete equipment set TP 8014	**8108234**

The most important components at a glance:

1	1x Electric Vehicle Charge Controller	594525
2	1x 3 AC RCD Type B	594528
3	1x 1 AC RCD Type B	594530
4	1x 1 AC 16 A Circuit Breaker	594531
5	1x 3 AC 16 A Circuit Breaker	594529
	1x 3 AC 32 A Circuit Breaker	594903
6	3x Four-Pole Contactor	594527

Note

The equipment set covers single and three-phase installations. If you require only one of these configurations, consult your sales representative for a down-scaled equipment set.

Necessary accessories, also order:

1x	Connection Lead Set and Grounding Kit	594536
1x	Pocket Oscilloscope*	594535
1x	EV Simulator/Tester	8160048
1x	Mobile Frameline, complete model without energy duct**	8075133
1x	Frameline mobile table***	8087149
1x	Tabletop Workstation (DIN A4)	8153360
1x	Tabletop Double-Sided Workstation (DIN A4)	8158409
1x	3 AC Power Supply and Safety Unit****	594826

* The Pocket Oscilloscope can be replaced by a conventional oscilloscope.
** Or equivalent; a standard A4 workstation is required to hold the modules.
*** Or equivalent table.
**** Highly recommended accessory if your lab does not provide the suitable infrastructure. For safety regulations, the workstation shall be equipped with a safety unit with an emergency shutoff and a RCD to provide three-phase power to the system. Other units or energy panels could be used.

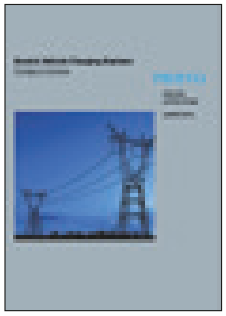
Optional accessories:

1x	Installation tester	8064024
1x	1 AC Energy Meter	594904
1x	3 AC Energy Meter	594532
1x	RFID Reader	594526
1x	Resistive Load*	594820

* Can be used in conjunction with Festo energy counters to simulate a load.

Also order:

Workbook
Electric Vehicle Charging Stations
➔ Page 36



The exercises in the workbook contain concrete, realistic projects with problem descriptions, parameters and project tasks.

The workbook contains:
– Exercises and sample solutions
– Didactic recommendations
– Multimedia CD-ROM with graphics
– Worksheets for learners

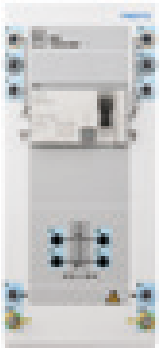
The exercises in the workbooks contain the theory and lab activities that cover the above training content.
Campus license (➔ Page 31):

de	**8096874**
en	**8096870**
fr	On request
es	On request

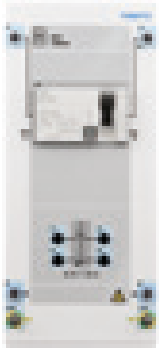
The Campus License includes teaching material for the TP 8014 Electric Vehicle Charging Station on both hard copy and CD-ROM. This also includes the reproduction rights for commercial and educational organizations.

1

2



3



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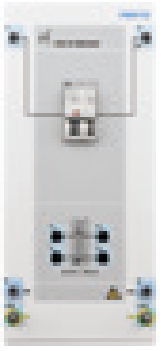
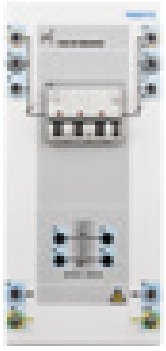
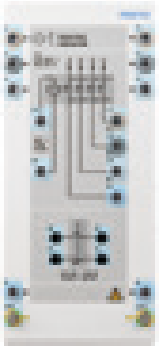


5



6



Electric Power Technology

Electric Power Technology Training Program and the EMS

Equipment Sets TP 8012 Electric Power Technology (EMS A4)

Training Systems

CE

Some training solutions included in this product guide do not have a CE mark and cannot be ordered for delivery to Europe.

If you are located in a country where this marking is required, please contact your Festo sales representative before placing an order.

Electric Power Technology Training Program and the EMS

A comprehensive platform, flexible enough to support electrical engineering programs, from beginning to end

Extensive program

The program starts with a variety of courses providing in-depth topic coverage of the fundamentals related to the field of electrical energy.

It then builds on the knowledge gained by the student through these basic courses to provide training in more advanced subjects.

Several different subjects in the field of electrical energy are covered, such as rotating machines, electrical power transmission, power electronics, home energy production from renewable resources (wind and sunlight), large-scale electricity production from hydropower and wind power, smart-grid technologies (SVC, STATCOM, HVDC transmission, etc.), storage of electrical energy in batteries, and drive systems for small electric vehicles and cars.

Modular design approach

The program is highly flexible and allows a multitude of different customized training solutions.

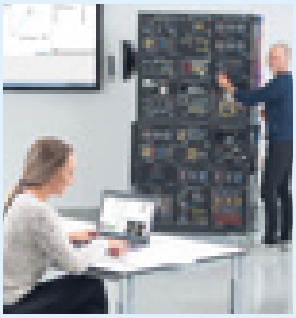
Modular hardware equipment and curriculum can be easily expanded to teach other subjects within the program. Instructors build their electrical-energy laboratory selecting what they need. This ensures that new courses and equipment can be added over time without unnecessary duplication, ensuring investment is cost-efficient.

Sturdy and safe

All workstations, modules, and components are very sturdy, ensuring a prolonged service life in a demanding training laboratory environment.

The systems are designed to ensure user safety. Modules are grounded using a railing system enclosed in the workstation. Safety jacks are used for connections to electric power circuits. Inputs and outputs are protected against improper connections and overvoltage or overcurrent conditions. Exercises cover safety procedures.

A flexible, complete training platform, based on a unique training program



The Electric Power Technology Training Program from Festo Didactic answers the increasingly diversified needs for training in the wide field of electrical energy.

The program combines hardware, software, and courseware content aimed at maximizing learning and experimentation. Workbooks and preset systems offer predefined learning paths, but modularity enables instructors to create a tailored solution that matches specific requirements.

This product family was added to the learning solutions portfolio through the acquisition of the US-Canadian company LabVolt. It is commonly referred to as the 8010 systems from the LabVolt Series.

Electric Power Technology Training Program

A complete, progressive learning path

Computerized tools made for learning and optimizing lab time

Computerized measuring instruments and control functions for power electronics and the dynamometer are available with selected hardware modules and software.

Students can measure, observe, analyze, and control electrical and mechanical parameters more easily.

These tools allow for better understanding, monitoring, and control in comparison to conventional tools. They also lower the cost of acquisition and replacement of accessories.

Pre-set training systems

The hardware and the program are totally customizable to specific needs. However, pre-set learning systems are also available to show popular configurations among customers.

Each pre-set system includes necessary modules and selected courses of the Electric Power Technology Training Program. These turnkey systems are also expandable to answer evolving needs or to cover more topics.

A sound training program offering tremendous flexibility

Courses part of the Electric Power Technology Training Program are the result of years of development and improvement.

Each course represents one workbook that includes one to ten full lab exercises (including necessary theory) to train the students on the covered topics.

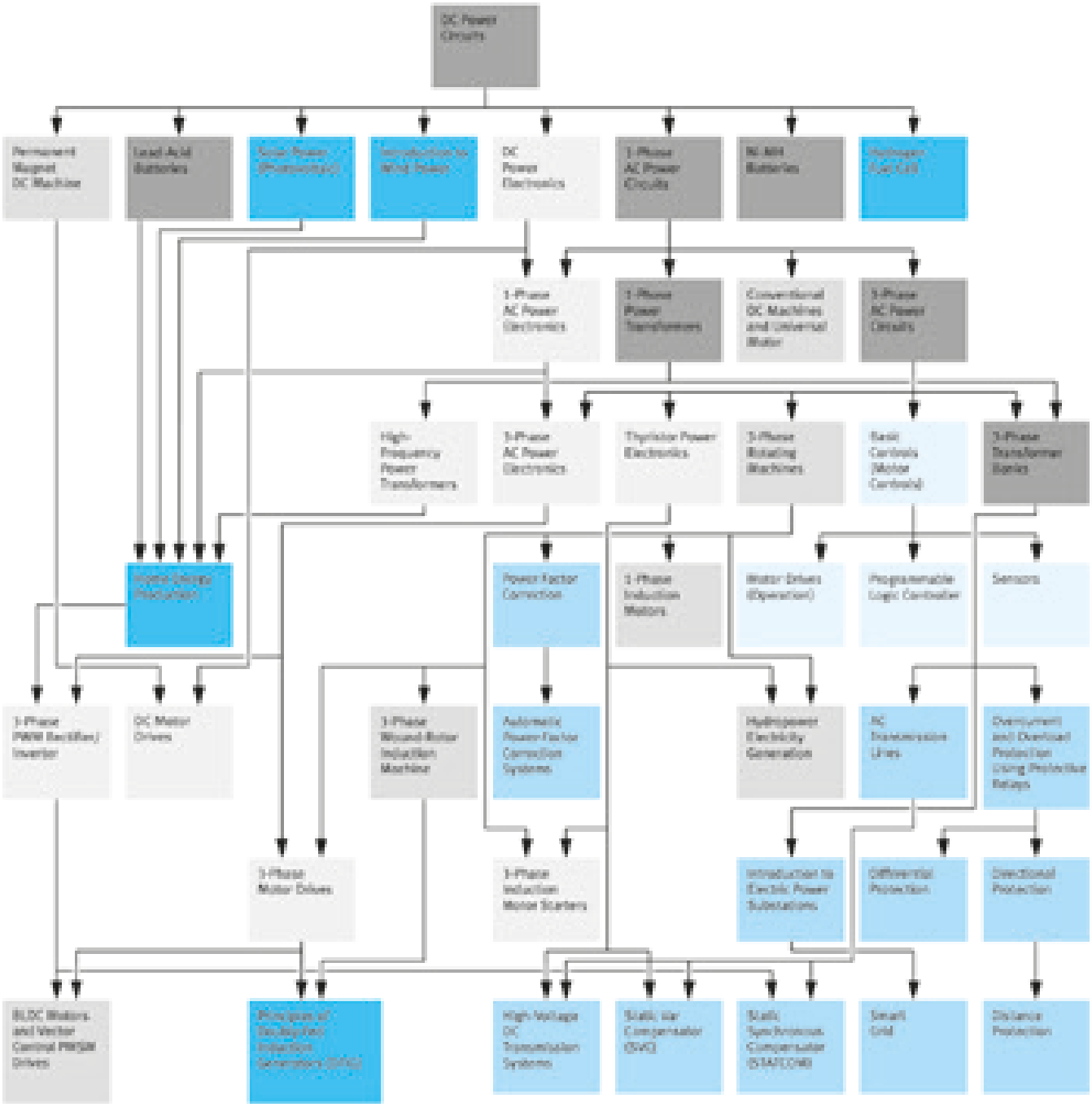
The modularity of the Electric Power Technology training platform enables instructors to select the desired courses or exercises and acquire only the hardware required by the courses.

The illustrated student manual providing all the theoretical matter required, guided lab-exercise procedures to be performed with the training equipment, and review questions that test the knowledge gained by the student. The instructor guide providing all lab results and answers to questions is also included with each course.

Contact your Festo sales representative to build your perfect training solution.

Note that the classic EMS is now available in A4 format, fully compliant with CE regulations. Please see page 156 for details.

Basic Electric Power	**Renewable Energies**
Rotating Machines	**Smart Grid**
Power Electronics	**Industrial Controls**


DC Power Circuits
Permanent Magnet DC Machine
Lead-Acid Batteries
Solar Power (Photovoltaic)
Introduction to Wind Power
DC Power Electronics
1-Phase AC Power Circuits
Ni-MH Batteries
Hydrogen Fuel Cell
1-Phase AC Power Electronics
1-Phase Power Transformers
Conventional DC Machines and Universal Motor
3-Phase AC Power Circuits
High-Frequency Power Transformers
3-Phase AC Power Electronics
Thyristor Power Electronics
3-Phase Rotating Machines
Basic Controls (Motor Controls)
3-Phase Transformer Banks
Power Factor Correction
1-Phase Induction Motors
Motor Drives (Operation)
Programmable Logic Controller
Sensors
1-Phase PWM Rectifier/ Inverter
DC Motor Drives
3-Phase Wound-Rotor Induction Machine
Automatic Power-Factor Correction Systems
Hydropower Electricity Generation
AC Transmission Lines
Overcurrent and Overload Protection Using Protective Relays
3-Phase Motor Drives
3-Phase Induction Motor Starters
Introduction to Electric Power Substations
Differential Protection
Directional Protection
BLDC Motors and Vector Control PWM Drives
High-Voltage DC Transmission Systems
Static Var Compensator (SVC)
Smart Grid
Distance Protection

Electric Power Technology Training Program

Courses overview

DC Power Circuits

Training content
- Voltages and currents in electrical circuits
- Ohm's and Kirchhoff's laws
- Concept of equivalent resistance
- Equivalent resistance of a combination of resistors
- Power dissipated in a DC circuit
- Solution of complex series and parallel circuits using fundamental laws

120–208V/60Hz	en	es
Student Manual	**579339**	**579340**
Instructor Guide	**579341**	**579342**
220–380V/50Hz		
Student Manual	**579339**	**579340**
Instructor Guide	**579341**	**579342**
240–415V/50Hz		
Student Manual	**579339**	
Instructor Guide	**579341**	
220–380V/60Hz		
Student Manual	**579339**	**579340**
Instructor Guide	**579341**	**579342**

Lead-Acid Batteries

Training content
- Fundamental principles of batteries
- Types and features of lead-acid batteries
- Charge and discharge characteristics
- Experiments with various methods for charging lead-acid batteries (constant-current, constant-voltage, modified constant-voltage, float charging, trickle)

120–208V/60Hz	en	es
Student Manual	**579343**	**579344**
Instructor Guide	**579345**	**579346**
220–380V/50Hz		
Student Manual	**579343**	**579344**
Instructor Guide	**579345**	**579346**
240–415V/50Hz		
Student Manual	**579343**	
Instructor Guide	**579345**	
220–380V/60Hz		
Student Manual	**579343**	**579344**
Instructor Guide	**579345**	**579346**

Ni-MH Batteries

Training content
- Reactions occurring during charge and discharge cycles
- Battery characteristics during discharge
- Calculation of energy released during a discharge cycle
- Effects of charge input, charge rate, and ambient temperature on the voltage and temperature profiles during a charge cycle
- Charging methods and charge-control techniques

120–208V/60Hz	en	es
Student Manual	**585178**	**585179**
Instructor Guide	**585180**	**585181**
220–380V/50Hz		
Student Manual	**585178**	**585179**
Instructor Guide	**585180**	**585181**
240–415V/50Hz		
Student Manual	**585178**	
Instructor Guide	**585180**	
220–380V/60Hz		
Student Manual	**585178**	**585179**
Instructor Guide	**585180**	**585181**

Single-Phase AC Power Circuits

Training content
- Voltage and current sine waves
- Power dissipated in a resistive load
- Inductive reactance and capacitive reactance
- Relationship between the source frequency and the reactance of an inductor or a capacitor
- Active, reactive, and apparent power
- Impedance calculation method and the power triangle method

120–208V/60Hz	en	es
Student Manual	**579366**	**579367**
Instructor Guide	**579368**	**579369**
220–380V/50Hz		
Student Manual	**579366**	**579367**
Instructor Guide	**579368**	**579369**
240–415V/50Hz		
Student Manual	**579366**	
Instructor Guide	**579368**	
220–380V/60Hz		
Student Manual	**579366**	**579367**
Instructor Guide	**579368**	**579369**

Single-Phase Power Transformer

Training content
- Turns, voltage, and current ratios
- Characteristics of step-up and step-down power transformers
- Polarity of power transformer windings
- Equivalent diagram of a power transformer.
- Voltage, current, and power ratings
- Effect of saturation on the magnetizing current and no-load power losses of a power transformer

120–208V/60Hz	en	es
Student Manual	**579437**	**579438**
Instructor Guide	**579439**	**579440**
220–380V/50Hz		
Student Manual	**579437**	**579438**
Instructor Guide	**579439**	**579440**
240–415V/50Hz		
Student Manual	**579437**	
Instructor Guide	**579439**	
220–380V/60Hz		
Student Manual	**579437**	**579438**
Instructor Guide	**579439**	**579440**

Three-Phase AC Power Circuits

Training content
- Difference between line and phase voltages and currents
- Active power dissipated in each phase of a three-phase circuit and the total active power dissipated
- Phase sequence and wye and delta circuit configuration
- Active, reactive, and apparent power in balanced, wye- or delta-connected, three-phase circuits

120–208V/60Hz	en	es
Student Manual	**579374**	**579376**
Instructor Guide	**579378**	**579379**
220–380V/50Hz		
Student Manual	**579374**	**579376**
Instructor Guide	**579381**	**594093**
240–415V/50Hz		
Student Manual	**579374**	
Instructor Guide	**579383**	
220–380V/60Hz		
Student Manual	**579374**	**579376**
Instructor Guide	**579384**	**594092**

Three-Phase Transformer Banks

Training content
- Operation of three-phase transformer banks
- Connection of the windings of 3-phase transformer banks in wye, delta, wye-wye, delta-delta, wye-delta, or delta-wye configuration
- Voltage, current, and phase relationships between the primary and secondary windings
- Uses of three-phase transformer banks in 3-phase AC power circuits

120–208V/60Hz	en	es
Student Manual	**579448**	**579449**
Instructor Guide	**579451**	**579452**
220–380V/50Hz		
Student Manual	**579448**	**579449**
Instructor Guide	**579454**	**579455**
240–415V/50Hz		
Student Manual	**579448**	
Instructor Guide	**579457**	
220–380V/60Hz		
Student Manual	**579448**	**579449**
Instructor Guide	**579458**	**579459**

Permanent Magnet DC Motor

Training content
- Prime mover and brake operation
- Basic functions of the 4-quadrant dynamometer/power supply
- Polarity of speed, torque, and mechanical power
- Construction of permanent magnet DC machines and their operation as generators
- Voltage-speed and torque-current characteristics of a permanent magnet DC machine operating as a generator or as a motor

120–208V/60Hz	en	es
Student Manual	**579362**	**579363**
Instructor Guide	**579364**	**579365**
220–380V/50Hz		
Student Manual	**579362**	**579363**
Instructor Guide	**579364**	**579365**
240–415V/50Hz		
Student Manual	**579362**	
Instructor Guide	**579364**	
220–380V/60Hz		
Student Manual	**579362**	**579363**
Instructor Guide	**579364**	**579365**

Electric Power Technology Training Program

Courses overview

Conventional DC Machines and Universal Motor

Training content
- Fundamentals of rotating machines
- Prime mover and brake operation
- DC motors and generators
- Series, shunt, compound, separately-excited motors
- Shunt, separately-excited, and compound DC generators
- Armature reaction and saturation effect
- Universal motor

120–208V/60Hz	en	es
Student Manual	**579469**	**588946**
Instructor Guide	**579470**	**588948**
220–380V/50Hz		
Student Manual	**579469**	**588946**
Instructor Guide	**579471**	**588949**
240–415V/50Hz		
Student Manual	**579469**	
Instructor Guide	**579472**	
220–380V/60Hz		
Student Manual	**579469**	**588946**
Instructor Guide	**579473**	**588947**

Three-Phase Rotating Machines

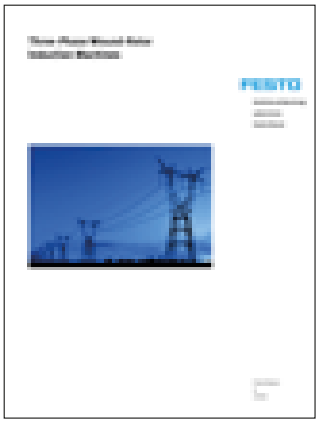
Training content
- Prime mover and brake operation
- Three-phase squirrel-cage induction machines
- Eddy-current braked and asynchronous generator
- Synchronous motor
- Synchronous generators (alternators)
- Voltage, torque
- Generator synchronization

120–208V/60Hz	en	es
Student Manual	**579407**	**579408**
Instructor Guide	**579409**	**579410**
220–380V/50Hz		
Student Manual	**579407**	**579408**
Instructor Guide	**579412**	**579413**
240–415V/50Hz		
Student Manual	**579407**	
Instructor Guide	**579414**	
220–380V/60Hz		
Student Manual	**579407**	**579408**
Instructor Guide	**579415**	**579416**

Single-Phase Induction Motors

Training content
- AC induction motors
- Operation and characteristics of single-phase induction motors

120–208V/60Hz	en	es
Student Manual	**579474**	**579475**
Instructor Guide	**579476**	**579477**
220–380V/50Hz		
Student Manual	**579474**	**579475**
Instructor Guide	**579478**	**579479**
240–415V/50Hz		
Student Manual	**579474**	
Instructor Guide	**579480**	
220–380V/60Hz		
Student Manual	**579474**	**579475**
Instructor Guide	**579481**	**579482**



Three-Phase Wound-Rotor Induction Machines

Training content
- Three-phase wound-rotor induction machine with a short-circuited rotor
- Three-phase wound-rotor induction machine with rotor resistance

120–208V/60Hz	en	es
Student Manual	**579421**	**585196**
Instructor Guide	**579422**	**585201**
220–380V/50Hz		
Student Manual	**579421**	**585196**
Instructor Guide	**579423**	**585202**
240–415V/50Hz		
Student Manual	**579421**	
Instructor Guide	**579424**	
220–380V/60Hz		
Student Manual	**579421**	**585196**
Instructor Guide	**579425**	**585200**

BLDC Motors and Vector Control PMSM Drives

Training content
- Permanent magnet synchronous machines
- PMSM control using a three-phase, six-step 120° modulation inverter
- BDLC motor
- Vector control PMSM drive

120–208V/60Hz	en	es
Student Manual	**585206**	**588942**
Instructor Guide	**585207**	**588943**
220–380V/50Hz		
Student Manual	**585206**	**588942**
Instructor Guide	**585207**	**588943**
240–415V/50Hz		
Student Manual	**585206**	
Instructor Guide	**585207**	
220–380V/60Hz		
Student Manual	**585206**	**588942**
Instructor Guide	**585207**	**588943**

Hydropower Electricity Generation

Training content
- Hydropower electricity generation
- Generator frequency and voltage control principles
- Generator synchronization using a synchro-check relay
- Generator operation with speed and voltage regulation
- Droop
- Generator parallel operation and load sharing

120–208V/60Hz	en	es
Student Manual	**579742**	**594109**
Instructor Guide	**579743**	**594111**
220–380V/50Hz		
Student Manual	**579742**	**594109**
Instructor Guide	**588941**	**594112**
240–415V/50Hz		
Student Manual	**579742**	
Instructor Guide	**588939**	
220–380V/60Hz		
Student Manual	**579742**	**594109**
Instructor Guide	**588940**	**594110**

DC Power Electronics

Training content
- Operation and characteristics of diodes and switching transistors
- Buck, boost, buck/boost, and four-quadrant choppers
- Concept of voltage-type and current-type circuits, and free-wheeling diodes
- Ripple phenomenon in a chopper
- Implement a lead-acid battery charger using a buck chopper with feedback loop

120–208V/60Hz	en	es
Student Manual	**579358**	**579359**
Instructor Guide	**579360**	**579361**
220–380V/50Hz		
Student Manual	**579358**	**579359**
Instructor Guide	**579360**	**579361**
240–415V/50Hz		
Student Manual	**579358**	
Instructor Guide	**579360**	
220–380V/60Hz		
Student Manual	**579358**	**579359**
Instructor Guide	**579360**	**579361**

Single-Phase AC Power Electronics

Training content
- Operation of power diode
- Single-phase rectifiers
- Half-wave and full-wave rectifier
- Average DC voltage
- Operation of the single-phase PWM inverter

120–208V/60Hz	en	es
Student Manual	**579370**	**579371**
Instructor Guide	**579372**	**579373**
220–380V/50Hz		
Student Manual	**579370**	**579371**
Instructor Guide	**579372**	**579373**
240–415V/50Hz		
Student Manual	**579370**	
Instructor Guide	**579372**	
220–380V/60Hz		
Student Manual	**579370**	**579371**
Instructor Guide	**579372**	**579373**

Electric Power Technology Training Program

Courses overview

Three-Phase AC Power Electronics

Training content
- Analysis of three-phase half-wave and full-wave rectifiers, as well as single- and three-phase PWM inverters
- Voltage and current waveforms
- Advantages of three-phase rectifiers over single-phase rectifiers
- Dual polarity DC power supply

120–208V/60Hz	en	es
Student Manual	**579393**	**579394**
Instructor Guide	**579395**	**579396**
220–380V/50Hz		
Student Manual	**579393**	**579394**
Instructor Guide	**579397**	**579398**
240–415V/50Hz		
Student Manual	**579393**	
Instructor Guide	**579399**	
220–380V/60Hz		
Student Manual	**579393**	**579394**
Instructor Guide	**579400**	**579401**

Thyristor Power Electronics

Training content
- Diodes
- Single-phase half-wave rectifier and single-phase full-wave (bridge) rectifier
- Voltage and current waveforms
- Thyristor in AC circuits with loads
- Thyristor three-phase rectifier/ inverter

120–208V/60Hz	en	es
Student Manual	**579402**	**594096**
Instructor Guide	**579403**	**594098**
220–380V/50Hz		
Student Manual	**579402**	**594096**
Instructor Guide	**579404**	**594099**
240–415V/50Hz		
Student Manual	**579402**	
Instructor Guide	**579405**	
220–380V/60Hz		
Student Manual	**579402**	**594096**
Instructor Guide	**579406**	**594097**

High-Frequency Power Transformers

Training content
- High-frequency power transformers and their uses
- Effect of frequency on the power rating of transformers
- Analysis of high-frequency power transformers in switched-mode power supplies and insulated DC-to-DC converters

120–208V/60Hz	en	es
Student Manual	**579441**	**579442**
Instructor Guide	**579443**	**579444**
220–380V/50Hz		
Student Manual	**579441**	**579442**
Instructor Guide	**579445**	**590153**
240–415V/50Hz		
Student Manual	**579441**	
Instructor Guide	**579446**	
220–380V/60Hz		
Student Manual	**579441**	**579442**
Instructor Guide	**579447**	**590154**

DC Motor Drives

Training content
- Basic PWM DC motor drives
- Bidirectional PWM DC motor drives with regenerative braking
- Speed feedback and current control in PWM DC motor drives

120–208V/60Hz	en	es
Student Manual	**579467**	**585296**
Instructor Guide	**579468**	**585298**
220–380V/50Hz		
Student Manual	**579467**	**585296**
Instructor Guide	**579468**	**585298**
240–415V/50Hz		
Student Manual	**579467**	
Instructor Guide	**579468**	
220–380V/60Hz		
Student Manual	**579467**	**585296**
Instructor Guide	**579468**	**585298**

Three-Phase Motor Drives

Training content
– Principles and operation of 3-phase variable-frequency induction motor drive
– three-phase variable-frequency induction motor drive with a constant Volt-per-Hertz (V/f) ratio

120–208V/60Hz	en	es
Student Manual	**579426**	**594105**
Instructor Guide	**579427**	**594107**
220–380V/50Hz		
Student Manual	**579426**	**594105**
Instructor Guide	**579428**	**594108**
240–415V/50Hz		
Student Manual	**579426**	
Instructor Guide	**579429**	
220–380V/60Hz		
Student Manual	**579426**	**594105**
Instructor Guide	**579430**	**594106**

Three-Phase Induction Motor Starters

Training content
– Induction motor starters
– DOL starters and soft starters
– Advanced features of soft starters

120–208V/60Hz	en	es
Student Manual	**579462**	**585271**
Instructor Guide	**579463**	**585273**
220–380V/50Hz		
Student Manual	**579462**	**585271**
Instructor Guide	**579464**	**585274**
240–415V/50Hz		
Student Manual	**579462**	
Instructor Guide	**579465**	
220–380V/60Hz		
Student Manual	**579462**	**585271**
Instructor Guide	**579466**	**585272**

Three-Phase PWM Rectifier/Inverter

Training content
– Three-phase PWM rectifier/inverter
– Block diagram
– Most common applications
– Active current and reactive current command variation
– Active and reactive power control

120–208V/60Hz	en	es
Student Manual	**585194**	
Instructor Guide	**585195**	
220–380V/50Hz		
Student Manual	**585194**	
Instructor Guide	**590147**	
240–415V/50Hz		
Student Manual	**585194**	
Instructor Guide	**590148**	
220–380V/60Hz		
Student Manual	**585194**	
Instructor Guide	**590149**	

Solar Power (Photovoltaic)

Training content
– Diode
– Solar panel
– Effect of temperature on solar panel performance
– Energy storage into lead-acid batteries
– Effect of shading on solar panel operation
– Solar panel orientation
– Insolation and performance

120–208V/60Hz	en	es
Student Manual	**579347**	**579348**
Instructor Guide	**579349**	**579350**
220–380V/50Hz		
Student Manual	**579347**	**579348**
Instructor Guide	**579349**	**579350**
240–415V/50Hz		
Student Manual	**579347**	
Instructor Guide	**579349**	
220–380V/60Hz		
Student Manual	**579347**	**579348**
Instructor Guide	**579349**	**579350**

Electric Power Technology Training Program

Courses overview

Hydrogen Fuel Cell

Training content
- The basic functions of the fuel cell system
- The characteristic curve
- Parameters influencing the characteristic curve
- Determination of the hydrogen current curve
- Efficiency of the fuel cell stack
- Set-up of a fuel cell power supply
- Efficiency of a fuel cell power supply

120–208V/60Hz	en	es
Student Manual	**579355**	
Instructor Guide	**579356**	
User Guide	**579357**	
220–380V/50Hz		
Student Manual	**579355**	
Instructor Guide	**579356**	
User Guide	**579357**	
240–415V/50Hz		
Student Manual	**579355**	
Instructor Guide	**579356**	
User Guide	**579357**	
220–380V/60Hz		
Student Manual	**579355**	
Instructor Guide	**579356**	
User Guide	**579357**	

AC Transmission Line

Training content
- Equivalent circuits and characteristics of AC transmission lines for resistive, inductive, and capacitive loads
- Voltage compensation
- Active power transmission
- Shunt-capacitor substations
- Control of the flow of active and reactive power

120–208V/60Hz	en	es
Student Manual	**580204**	
Instructor Guide	**580205**	
220–380V/50Hz		
Student Manual	**580204**	
Instructor Guide	**580206**	
240–415V/50Hz		
Student Manual	**580204**	
Instructor Guide	**580207**	
220–380V/60Hz		
Student Manual	**580204**	
Instructor Guide	**580208**	

Introduction to Wind Power

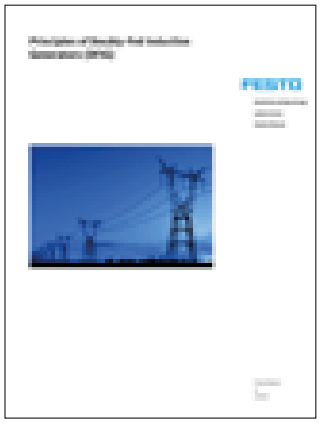
Training content
- Wind turbines and small-scale wind power
- Voltage-speed and torque-current characteristics of a wind turbine generator
- Wind power variation with wind speed
- Energy storage in batteries

120–208V/60Hz	en	es
Student Manual	**579351**	**579352**
Instructor Guide	**579353**	**579354**
220–380V/50Hz		
Student Manual	**579351**	**579352**
Instructor Guide	**579353**	**579354**
240–415V/50Hz		
Student Manual	**579351**	
Instructor Guide	**579353**	
220–380V/60Hz		
Student Manual	**579351**	**579352**
Instructor Guide	**579353**	**579354**

Home Energy Production

Training content
- Stand-Alone Home Energy Production
- Single-Phase Grid-Tied Inverter (PWM Rectifier/Inverter)
- Grid-Tied Home Energy Production Using a Solar or Wind Power Inverter without DC-to-DC converter
- Large-Scale Energy Storage: A step in the implementation of the Smart Grid

120–208V/60Hz	en	es
Student Manual	**579385**	**579386**
Instructor Guide	**579387**	**579389**
220–380V/50Hz		
Student Manual	**579385**	**579386**
Instructor Guide	**579390**	**590145**
240–415V/50Hz		
Student Manual	**579385**	
Instructor Guide	**579391**	
220–380V/60Hz		
Student Manual	**579385**	**579386**
Instructor Guide	**579392**	**590146**



Principle of Doubly-fed Induction Generators (DFIG)

Training content
- Three-phase wound-rotor induction machine used as a synchronous machine
- Doubly-fed induction motors and generators

120–208V/60Hz	en	es
Student Manual	**579435**	**594127**
Instructor Guide	**579436**	**594129**
220–380V/50Hz		
Student Manual	**579435**	**594127**
Instructor Guide	**589800**	**594130**
240–415V/50Hz		
Student Manual	**579435**	
Instructor Guide	**589801**	
220–380V/60Hz		
Student Manual	**579435**	**594127**
Instructor Guide	**589802**	**594128**

Power Factor Correction

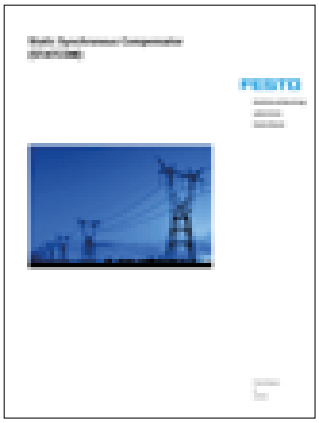
Training content
- Types of power corrections: plant-wide versus distributed
- Using banks of switched capacitors
- Correction in three-phase circuits

120–208V/60Hz	en	es
Student Manual	**579334**	**595121**
Instructor Guide	**579335**	**595122**
220–380V/50Hz		
Student Manual	**579334**	**595121**
Instructor Guide	**579336**	**595123**
240–415V/50Hz		
Student Manual	**579334**	
Instructor Guide	**579337**	
220–380V/60Hz		
Student Manual	**579334**	**595121**
Instructor Guide	**579338**	**595124**

High-Voltage DC Transmission Systems

Training content
- Voltage regulation and displacement power factor (DPF) in thyristor three-phase bridges
- Basic operation of HVDC transmission systems
- DC current regulation and power flow control in HVDC transmission systems
- Commutation failure at the inverter bridge
- Harmonic reduction using thyristor 12-pulse converters

120–208V/60Hz	en	es
Student Manual	**579460**	**594135**
Instructor Guide	**579461**	**594139**
220–380V/50Hz		
Student Manual	**579460**	**594135**
Instructor Guide	**594140**	**594141**
240–415V/50Hz		
Student Manual	**579460**	
Instructor Guide	**594136**	
220–380V/60Hz		
Student Manual	**579460**	**594135**
Instructor Guide	**594137**	**594138**



Static Synchronous Compensator (STATCOM)

Training content
- Voltage Compensation of AC transmission lines using a STATCOM
- Dynamic power factor correction using a STATCOM

120–208V/60Hz	en	es
Student Manual	**579433**	**594120**
Instructor Guide	**579434**	**594124**
220–380V/50Hz		
Student Manual	**579433**	**594120**
Instructor Guide	**594125**	**594126**
240–415V/50Hz		
Student Manual	**579433**	
Instructor Guide	**594121**	
220–380V/60Hz		
Student Manual	**579433**	**594120**
Instructor Guide	**594122**	**594123**

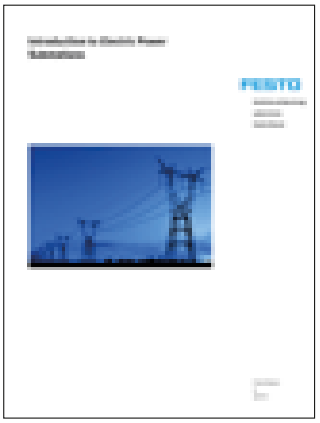
Electric Power Technology Training Program

Courses overview

Static Var Compensator (SVC)

Training content
- Main Components of a Static Var Compensator (SVC)
- Voltage Compensation of AC Transmission Lines Using an SVC
- Dynamic Power Factor Correction using an SVC

120–208V/60Hz	en	es
Student Manual	**579431**	**594113**
Instructor Guide	**579432**	**594117**
220–380V/50Hz		
Student Manual	**579431**	**594113**
Instructor Guide	**594118**	**594119**
240–415V/50Hz		
Student Manual	**579431**	
Instructor Guide	**594114**	
220–380V/60Hz		
Student Manual	**579431**	**594113**
Instructor Guide	**594115**	**594116**



Introduction to Electric Power Substations

Training content
- Electric power substations
- High-voltage disconnecting switches and circuit breakers
- Single-bus scheme
- Double-bus, single breaker scheme

120–208V/60Hz	en	es
Student Manual	**589173**	
Instructor Guide	**589174**	
220–380V/50Hz		
Student Manual	**589173**	
Instructor Guide	**589174**	
240–415V/50Hz		
Student Manual	**589173**	
Instructor Guide	**589174**	
220–380V/60Hz		
Student Manual	**589173**	
Instructor Guide	**589174**	

Differential Protection

Training content
- Fundamentals of differential protection
- Percentage restrained differential protection

120–208V/60Hz	en	es
Student Manual	**590085**	
Instructor Guide	**590086**	
220–380V/50Hz		
Student Manual	**590085**	
Instructor Guide	**590086**	
240–415V/50Hz		
Student Manual	**590085**	
Instructor Guide	**590086**	
220–380V/60Hz		
Student Manual	**590085**	
Instructor Guide	**590086**	

Distance Protection

Training content
- Introduction to distance protection
- Distance relay impedance characteristics
- Conventional time-stepped distance protection
- Distance protection using communication-assisted tripping schemes

120–208V/60Hz	en	es
Student Manual	**593880**	
Instructor Guide	**593881**	
220–380V/50Hz		
Student Manual	**593880**	
Instructor Guide	**593881**	
240–415V/50Hz		
Student Manual	**593880**	
Instructor Guide	**593881**	
220–380V/60Hz		
Student Manual	**593880**	
Instructor Guide	**593881**	

Overcurrent and overload protection using protective relays

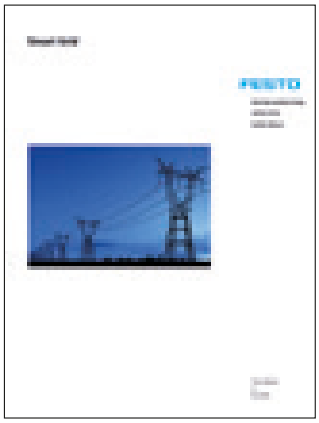
Training content
– Overcurrent protection
– Overcurrent and overload protection of AC machines, power transformers, radial feeders

120–208V/60Hz	en	es
Student Manual	**589887**	
Instructor Guide	**589888**	
220–380V/50Hz		
Student Manual	**589887**	
Instructor Guide	**589888**	
240–415V/50Hz		
Student Manual	**589887**	
Instructor Guide	**589888**	
220–380V/60Hz		
Student Manual	**589887**	
Instructor Guide	**589888**	

Directional protection

Training content
– Introduction to directional protection
– Directional overcurrent protection
– Directional comparison protection
– Directional power protection

120–208V/60Hz	en	es
Student Manual	**589889**	
Instructor Guide	**589890**	
220–380V/50Hz		
Student Manual	**589889**	
Instructor Guide	**589890**	
240–415V/50Hz		
Student Manual	**589889**	
Instructor Guide	**589890**	
220–380V/60Hz		
Student Manual	**589889**	
Instructor Guide	**589890**	



Smart Grid

Training content
– Smart grid fundamentals
– Reducing power losses in electric power substations
– Upgrading a substation for operation in the smart grid
– Operating a substation in the smart grid

120–208V/60Hz	en	es
Student Manual	**8107698**	
Instructor Guide	**8107696**	
220–380V/50Hz		
Student Manual	**8107698**	
Instructor Guide	**8112136**	
240–415V/50Hz		
Student Manual	**8107698**	
Instructor Guide	**8112138**	
220–380V/60Hz		
Student Manual	**8107698**	
Instructor Guide	**8112140**	

Motor drives (operation)

Training content
– AC drives
– Volts per Hertz characteristics
– Ramp and voltage boost
– Protection
– Braking and jogging
– Remote controls
– DC drives
– Current limiting and IR compensation

120–208V/60Hz	en	es
Student Manual	**593904**	
Instructor Guide	**593905**	
220–380V/50Hz		
Student Manual	**593904**	
Instructor Guide	**593905**	
240–415V/50Hz		
Student Manual	**593904**	
Instructor Guide	**593905**	
220–380V/60Hz		
Student Manual	**593904**	
Instructor Guide	**593905**	

Electric Power Technology Training Program

Courses overview

Basic controls

Training content
- Basic principles
- Circuit layouts and specifications
- Basic control circuits
- Jogging control circuits
- Reversing/manual reversing starters
- Reduced AC voltage starters
- Time relay circuits

120V/60Hz	en	es
Student Manual	**603855**	**603856**
Instructor Guide	**603857**	**603858**
220V/50Hz		
Student Manual	**603855**	**603856**
Instructor Guide	**603857**	**603858**
240V/50Hz		
Student Manual	**603855**	
Instructor Guide	**603857**	
220V/60Hz		
Student Manual	**603855**	**603856**
Instructor Guide	**603857**	**603858**

Programmable Logic Controllers

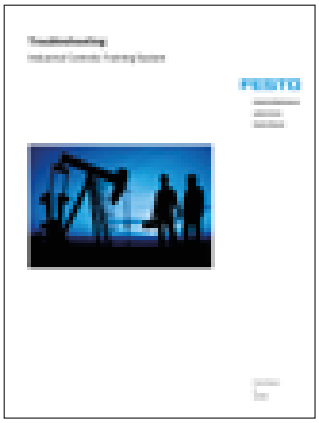
Training content
- PLC
- Control and timing relay functions
- Boolean logic and markers
- Counter and comparator functions
- PLC control circuits
- Interfacing voltages
- Motor and reversing motor starters with jogging

120–208V/60Hz	en	es
Student Manual	**580464**	**580465**
Instructor Guide	**580466**	**580467**
220–380V/50Hz		
Student Manual	**580464**	**580465**
Instructor Guide	**580466**	**580467**
240–415V/50Hz		
Student Manual	**580464**	
Instructor Guide	**580466**	
220–380V/60Hz		
Student Manual	**580464**	**580465**
Instructor Guide	**580466**	**580467**

Sensors

Training content
- Sensors
- Background suppression photoelectric switch
- Polarized retroreflective photo-electric switch
- Capacitive proximity, inductive proximity, and limit switches
- Motor-operated circuits using sensors
- PLC-controlled circuits using sensors

120–208V/60Hz	en	es
Student Manual	**580470**	**580471**
Instructor Guide	**580472**	**580473**
220–380V/50Hz		
Student Manual	**580470**	**580471**
Instructor Guide	**580472**	**580473**
240–415V/50Hz		
Student Manual	**580470**	
Instructor Guide	**580472**	
220–380V/60Hz		
Student Manual	**580470**	**580471**
Instructor Guide	**580472**	**580473**



Troubleshooting

Training content
- Troubleshooting: introduction and methods
- Troubleshooting basic motor control circuits (manual reversing starter circuit, motor starter with jogging circuit, plugging with time relay circuit)
- Troubleshooting PLC circuits (PLC circuit, PLC reversing motor starter with jogging circuit, PLC motor starter with jogging circuit)
- Troubleshooting AC and DC drive circuits (AC drive circuit, AC drive braking and jogging circuit, DC drive circuit)

120–208V/60Hz	en	es
Student Manual	**580480**	**580481**
Instructor Guide	**580482**	**580483**
220–380V/50Hz		
Student Manual	**580480**	**580481**
Instructor Guide	**580482**	**580483**
240–415V/50Hz		
Student Manual	**580480**	
Instructor Guide	**580482**	
220–380V/60Hz		
Student Manual	**580480**	**580481**
Instructor Guide	**580482**	**580483**

DC and AC Power Circuits
Training System

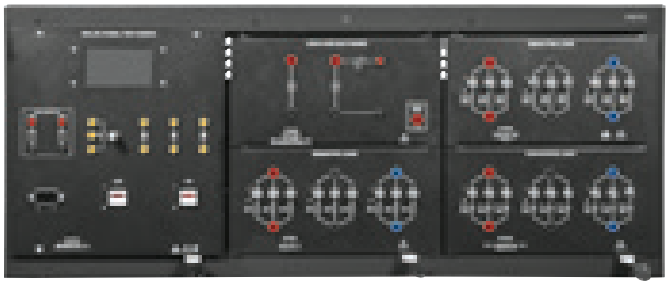
LabVolt Series 8010-1

The DC and AC Power Circuits Training System combines a modular design approach with computer-based data acquisition and control to introduce students to the fundamentals of electricity, such as direct current (DC), alternating current (AC), voltage, resistance, and Ohm's Law. The training system is designed to operate at a low voltage to ensure the safety of students beginning their training in electric power technology.

Topic coverage
– DC Power Circuits
– Single-Phase AC Power Circuits

	en	es	fr
120 V/60 Hz	**579281**		
220 V/50 Hz	**579282**		
240 V/50 Hz	**579283**		
220 V/60 Hz	**589056**		

Solar Power
Training System



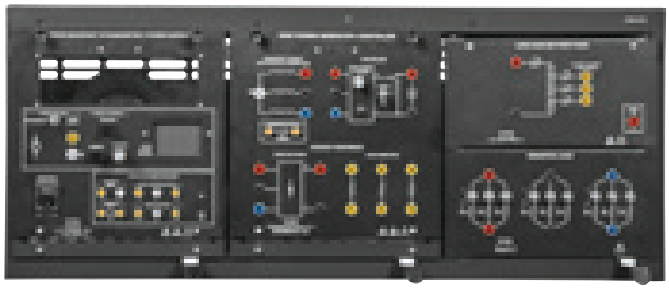
LabVolt Series 8010-2

The Solar Power Training System introduces students to the production of electrical energy from solar power, with emphasis on the use and operation of photovoltaic panels, as well as storage of electrical energy in batteries. The system consists of a solar panel test bench and a monocrystalline silicon solar panel. Students can conduct indoor or outdoor experiments on solar panel operation and performance.

Training content
– DC Power Circuits
– Solar Power (Photovoltaic)

	en	es	fr
120 V/60 Hz	**579284**		
220 V/50 Hz	**579285**		
240 V/50 Hz	**579286**		

Small-Scale Wind Power Electricity Generation Training System



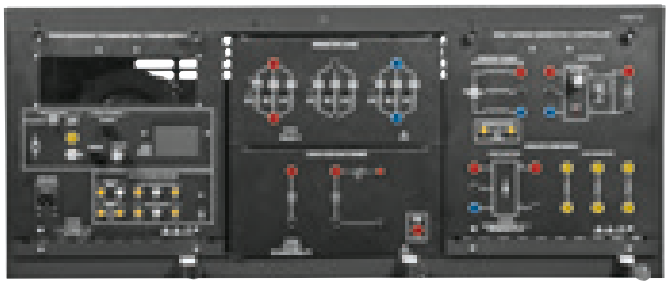
LabVolt Series 8010-3

The Small-Scale Wind Power Electricity Generation Training System enables students to study the complete process of wind power electricity generation directly in the classroom. Wind speed and air density are simulated using a user-friendly and configurable wind emulator. The learning system also covers the storage of electrical energy in batteries to ensure that it is available when there is no wind or during low wind periods.

Training content
– DC Power Circuits
– Lead-Acid Batteries
– Introduction to Wind Power

	en	es	fr
120 V/60 Hz	**579287**		
220 V/50 Hz	**579288**	**595187**	
240 V/50 Hz	**579289**		

Lead-Acid Batteries Training System



LabVolt Series 8010-4

The Lead-Acid Batteries Training System teaches the principles of lead-acid battery operation during both charge and discharge. It introduces students to the operation of lead-acid batteries and covers voltage regulation, internal resistance, capacity, depth of discharge, and cycle life of lead-acid batteries. Hands-on experiments cover the discharge characteristics and the most popular charging methods of lead-acid batteries.

Training content
– DC Power Circuits
– Lead-Acid Batteries

	en	es	fr
120 V/60 Hz	**579290**	**579291**	
220 V/50 Hz	**579292**		
240 V/50 Hz	**579293**		

Basic Renewable Energy
Training System

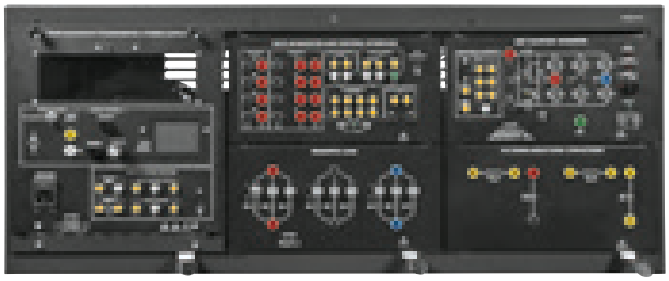
LabVolt Series 8010-5

The Basic Renewable Energy Training System provides in-depth coverage of foundational renewable energy systems. It provides an introduction to DC power circuits, and covers in detail the principles behind the production of electrical energy from both solar power and wind power. The students are then introduced to the storage of electrical energy produced from renewable resources into lead-acid batteries for future consumption.

Training content
– DC Power Circuits
– Lead-Acid Batteries
– Solar Power (Photovoltaic)
– Introduction to Wind Power

	en	es	fr
120 V/60 Hz	**579294**	**579295**	
220 V/50 Hz	**579296**	**594501**	
240 V/50 Hz	**579297**		

DC Power Electronics
Training System



LabVolt Series 8010-6

The DC Power Electronics Training System provides a comprehensive study of the diode and switching transistor, two semiconductor components that are widely used in power electronics circuits. The training system also provides in-depth coverage of various types of choppers, a power electronics device used in many DC power circuits. The operation of these modules is controlled via the LVDAC-EMS software, which also provides the instrumentation required to measure and record the experimental data.

Training content
– DC Power Circuits
– DC Power Electronics

	en	es	fr
120 V/60 Hz	**579298**		
220 V/50 Hz	**579299**		
240 V/50 Hz	**579300**		

Home Energy Production
Training System

LabVolt Series 8010-7

The Home Energy Production Training System is a comprehensive and flexible program related to home energy production systems including all the prerequisites in renewable energies and power electronics.

Training content
- DC power circuits
- Lead-acid batteries
- Solar power (Photovoltaic)
- Introduction to wind power
- Single-phase power power circuits
- Single-phase power transformers
- DC power electronics
- Single-phase AC power electronics
- High-frequency power transformers

	en	es	fr
120 V/60 Hz	**579301**	**579302**	
220 V/50 Hz	**579303**	**579304**	
240 V/50 Hz	**579305**		
220 V/60 Hz	**579306**	**588988**	

Hydrogen Fuel Cell
Training System

LabVolt Series 8010-8

The Hydrogen Fuel Cell Training System realistically demonstrates the basic functions of a 50 W hydrogen fuel cell system and is ideal for teaching the basic engineering principles of fuel cell systems. The modular design of the system enables flexibility in setup complexity — from simple experiments for teaching basic principles to complex experiments for experienced students. The course covers the structure and functioning principles of thermodynamics theory, and characteristics of a real fuel cell system.

Training content
- Basic functions of the fuel cell system
- Characteristic curve of a fuel cell
- Parameters influencing the characteristic curve
- Determination of the Hydrogen current curve
- Efficiency of the fuel cell stack
- Set-up of a fuel cell power supply
- Efficiency of a fuel cell power supply
- Application I: Remote traffic light
- Application II: Fuel cell car

	en	es	fr
Order no.	**579307**		

Electromechanical
Training System

LabVolt Series 8010-9

The Electromechanical Training System combines a modular design approach with computer-based data acquisition to provide unrivaled training in basic electric power technology. Training is oriented toward today's competency requirements.

Training content
- DC power circuits
- Permanent magnet DC motor
- Single-phase and three-phase AC power circuits
- Single-phase transformers
- Three-phase transformer banks
- Three-phase rotating machines
- Power factor correction

	en	es	fr
120 V/60 Hz	**579308**	**579309**	
220 V/50 Hz	**579310**	**594502**	
240 V/50 Hz	**579311**		
220 V/60 Hz	**579312**	**579313**	

Power Electronics
Training System

LabVolt Series 8010-A

The Power Electronics Training System is a comprehensive introduction to the most common power electronic components and devices used in numerous industrial applications today. It provides unrivaled training in power electronics to students already having a sound knowledge of basic electric power technology.

Training content
- DC power electronics
- Single-phase and three-phase AC power electronics
- Thyristor power electronics
- DC motor drives
- Three-phase motor drives
- Three-phase induction motor starters

	en	es	fr
120 V/60 Hz	**579314**	**579315**	
220 V/50 Hz	**579316**		
240 V/50 Hz	**579317**		
220 V/60 Hz	**579318**	**579319**	

AC Power Transmission
Training System

LabVolt Series 8010-B

The AC power transmission training system is a comprehensive introduction to the basic principles of AC power transmission lines. computerized controls provide better understanding, monitoring, and control compared to conventional measuring instruments. Optional courses may be added to provide students with the basic knowledge of electric power technology required to study AC power transmission systems.

Training content
- DC power circuits
- Single-phase AC power circuits
- Single-phase power transformers
- Three-phase power transformers

	en	es	fr
120 V/60 Hz	**579320**		
220 V/50 Hz	**579321**		
240 V/50 Hz	**579322**		
220 V/60 Hz	**579323**	**579324**	

Smart Grid Technologies
Training System

LabVolt Series 8010-C

The Smart Grid technologies training system provides a turn-key solution dealing with smart grid technologies. Real-world, complex applications, normally found in large power stations, can now be recreated within this training platform. Computerized controls provide better monitoring and control compared to conventional measuring instruments.

Training content
- Home energy production
- Static Var Compensator (SVC)
- Static Synchronous Compensator (STATCOM)
- High-voltage DC transmission systems

	en	es	fr
120 V/60 Hz	**579325**		
220 V/50 Hz	**579326**		
240 V/50 Hz	**579327**		
220 V/60 Hz	**589057**		

DFIG Principles
Training System

LabVolt Series 8010-D

The Doubly-Fed Induction Generators (DFIG) Training System combines a unique, modular design approach with computer-based data acquisition and control to provide unrivaled training in the basic principles of the doubly-fed induction generator (DFIG) to students that already have a sound knowledge of three-phase AC power circuits, rotating machines, and motor drives.

Training content
- Three-phase wound-rotor induction machine
- Principles of Doubly-Fed Induction Generators (DFIG)

	en	es	fr
120 V/60 Hz	**579328**		
220 V/50 Hz	**579329**		
240 V/50 Hz	**579330**		
220 V/60 Hz	**581466**		

Power Transmission Smart Grid Technologies
Training System

LabVolt Series 8010-E

The Power Transmission Smart Grid Technologies Training System provides a turn-key solution related to power transmission of smart grids. Students learn that SVCs and STATCOMs can be used in conjunction with HVDC transmission systems to greatly enhance the controllability and power transfer capability of a power network, and are thus essential tools to the implementation of a smart grid.

Training content
- AC transmission line
- Static Var Compensator (SVC)
- Static Synchronous Compensator (STATCOM)
- High-voltage DC transmission systems

	en	es	fr
120 V/60 Hz	**579331**		
220 V/50 Hz	**579332**		
240 V/50 Hz	**579333**		
220 V/60 Hz	**589058**		

Smart Grid
Training System

LabVolt Series 8010-F

The Smart Grid Training System introduces students to the concept of upgrading and operating an electric power substation in today's smart grid. To demonstrate this in a concrete way, the course shows how an aging distribution substation can be upgraded to improve its reliability, maintainability, flexibility of operation, and power efficiency. The course also shows that proper control of the operations in electric power substations is as important as upgrading the infrastructures.

Training content
- Reducing Power Losses in Electric Power Substations
- Upgrading a Substation for Operation in the Smart Grid
- Operating a Substation in the Smart Grid

	en	es	fr
120 V/60 Hz	**8117310**		
220 V/50 Hz	**8117311**		
240 V/50 Hz	**8117312**		

Hydropower Electricity Generation
Training System

LabVolt Series 8010-G

The Hydropower Electricity Generation Training System examines the large-scale production of electricity from hydro power using a synchronous generator. The students learn how to adjust the voltage and frequency of the synchronous generator in a hydropower plant, as well as how to synchronize the generator using a synchro-check relay. The system concludes with a study of the automatic speed (frequency) and voltage regulation systems used in a hydropower plant.

Training content
- Fundamentals of Hydropower Electricity Generation
- Generator Frequency and Voltage Control Principles
- Operation of a Synchro-Check Relay and Generator Synchronization
- Generator Operation with Speed and Voltage Regulation
- Droop
- Generator Parallel Operation and Load Sharing

	en	es	fr
120 V/60 Hz	**8108668**		
220 V/50 Hz	**8108669**		
240 V/50 Hz	**8108670**		

BLDC Motors and Vector Control PMSM Drives
Training System

LabVolt Series 8010-J

The BLDC Motor and Vector Control PMSM Drives Training System introduces students to the permanent magnet synchronous machine (PMSM). It covers the operation and characteristics of two types of motor that use PMSM technology: the brushless dc (BLDC) motor and the PMSM drive. It also deals with the most common types of modulation used to implement BLDC motors (six-step 120° modulation and six-step PWM) and PMSM drives (vector control).

Training content
- Fundamentals of Permanent Magnet Synchronous Machines
- PMSM Control Using a Three-Phase, Six-Step 120 Degrees Modulation Inverter
- The BLDC Motor
- The Vector Control PMSM Drive

	en	es	fr
120 V/60 Hz	**8108674**		
220 V/50 Hz	**8108675**		
240 V/50 Hz	**8108676**		

Electric Power Substations
Training System

LabVolt Series 8010-K

The Electric Power Substations Training System introduces students to the operation of electric power substations. It begins by covering the main components of substations. The system then fully describes and presents both advantages and disadvantages of two switching schemes commonly implemented in substations: the single-bus scheme and the double-bus, single-breaker scheme.

Training content
- Design Factor of Electric Power Substation
- High-Voltage Disconnecting Switches and Circuit Breakers
- Single-Bus Scheme
- Double Bus, Single Breaker Scheme

	en	es	fr
120 V/60 Hz	**8108677**		
220 V/50 Hz	**8108678**		
240 V/50 Hz	**8108679**		

Numerical Protective Relays
Training System

LabVolt Series 8010-L

The Numerical Protective Relays Training System covers the theoretical background, as well as practical application, of protective devices and their protection functions. The system uses power-utility-grade equipment, Siemens' newest generation the SIPROTEC 5 series. Example scenarios are created in the accompanying professional programming tool, DIGSI 5, which allows users to create different setups and simulate possible faults using the built-in relay testing unit. The response of the relay is then analyzed with the relay display and the fault record.

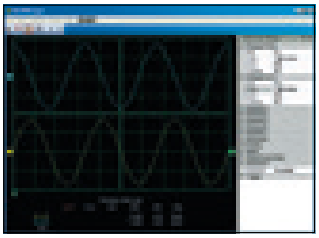
Training content
– Overcurrent/Overload Protection
– Directional Protection
– Differential Protection
– Distance Protection

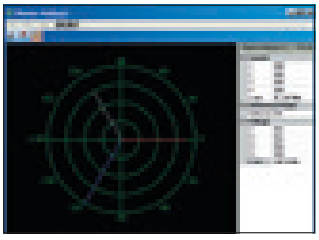
	en	es	fr
120 V/60 Hz	**8108680**		

LVDAC-EMS

Computer-assisted data acquisition

Computer-based instruments replace a multitude of actual data acquisition devices:
- The Metering window displays up to eighteen meters that can be configured to measure a multitude of parameters.
- The Oscilloscope displays up to eight waveforms simultaneously. Each waveform is of a different color for easy identification.
- The Phasor Analyzer displays the phasors related to measured voltages and currents instead of the values and waveforms related to these voltages and currents.
- The Harmonic Analyzer allows
- observation and analysis of the
- harmonic components in the
- measured voltages and currents.
- The recorded values of all meters and indicators in the Data Table can be saved to a file and used to plot graphs.
- Several sets of computer-based
- functions can be activated in the DACI and controlled directly in LVDAC-EMS.





The LVDAC-EMS software is a user-friendly tool that facilitates the use of the various functions which can be implemented with USB peripherals, such as the Data Acquisition and Control Interface (DACI) and the Four-Quadrant Dynamometer/Power Supply.

Together, the DACI and LVDAC EMS provide a complete set of modern computer-based instruments to measure, observe, analyze, and control electrical and mechanical parameters. The provided instruments include voltmeters, ammeters, power meters, frequency meters, efficiency meters, impedance meters, power factor meters, energy meters, torque and speed meters, an oscilloscope, a phasor analyzer, a harmonic analyzer, and a spectrum analyzer.

The DACI and LVDAC-EMS also allow manual and timed data recording. The recorded data can be saved to files in any specified location, graphically represented with the provided graph plotting tool, and exported into a spreadsheet application.

The DACI and LVDAC-EMS can also be used with the Four-Quadrant Dynamometer/Power Supply, Model 8960, to implement a variety of control functions for advanced training in various fields of electricity and new energy, including electric power technology, ac/dc rotating machines, renewable energy, transmission lines, and power electronics.

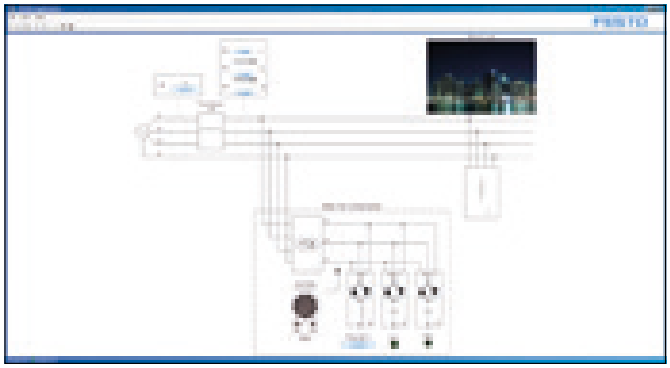
The LVDAC-EMS software and the Data Acquisition and Control Interface allow complex power system applications such as hydropower generators, large-scale wind turbines (PMSG and DFIG), high-voltage direct current (HVDC) transmission systems, static var compensators (SVCs), and static synchronous compensators (STATCOMs) to be implemented. SCADA windows are available in the LVDAC-EMS software for these complex applications to ease system control and monitoring, as well as to allow students to quickly understand what is going on in these applications.

Highlights
- Affordable compared to conventional equipment, as virtual tools lower the cost of acquisition and replacement of accessories
- Several instrumentation functions and control function sets available
- SCADA windows available for several applications
- Software development kit (SDK) for customization
- Free software and updates

Download the LVDAC-EMS free of charge
➔ www.festo-didactic.com

SCADA for LVDAC-EMS

Supervisory control and data acquisition (SCADA)



SCADA for LVDAC-EMS is a software program designed to run in combination with LVDAC-EMS. It transforms LVDAC-EMS software and the workstation's computer into a local workstation that can be monitored and controlled over a local network from a supervisory computer.

Using the OPC Server protocols, SCADA-EMS enables users to design their own interfaces by calling the different applications running on the local workstations.

SCADA-EMS enhances LVDAC-EMS by adding several new features:
- Collect data from local workstations.
- Observe and control one or multiple stations from one or multiple supervisory stations.
- Remotely control several applications in a lab.
- Use a workstation in a different room to present actual demonstrations over the network in your classroom without having to bring a workstation to class.
- Introduce students to the fundamentals of SCADA in a grid context.
- Recreate a complete grid with several different applications running.

A locked version of the SCADA-EMS software program can be downloaded from our website and can be unlocked by a USB dongle.
A dongle unlocks five workstations; order as many dongles as required.
LVDAC-EMS is required to run SCADA-EMS.

Order no.	**8094377**

LVSIM-EMS

Simulation software

Electromechanical Systems Simulation Software (LVSIM®-EMS) is a simulation software that enables students to perform actual experiments using virtual equipment

It covers the same courseware as the following systems: the computer-assisted 0.2 kW electromechanical training system, the DC and AC power circuits training system, the electromechanical training system, and the AC power transmission training system.

LVSIM-EMS is a web-browser based application available in three different configurations. The simulation software can either be installed locally on a Windows® personal computer (local version), on a Windows® server (network version), or accessed directly online through our website.

Highlights
- Replicates the electromechanical training system
- Students prepare for laboratories in advance using virtual equipment, thereby decreasing the time they require to perform the exercises using actual equipment
- Decreases the quantity of actual equipment required per student
- Allows students to practice with EMS equipment operation and connection at home on a personal computer

LVSIM-EMS
Local installation,
single license

en	**586920**
es	**586922**
fr	**586921**

Note: Several license options are available

Electric Power Technology Training Modules

Data acquisition and control interface (DACI)

Most popular packages

DACI with Computer-Based Instrumentation

	en	es	fr
Order no.	**579680**	**579682**	**579681**

DACI with Computer-Based Instrumentation and Chopper/Inverter Control

	en	es	fr
Order no.	**579683**	**579685**	**579684**

Note: For reference numbers of other variants DACI control functions or specific packages based on your needs, please contact your Festo sales representative.

LabVolt Series 9063

Measuring, observing, analyzing, and controlling electrical and mechanical parameters in electric power systems and power electronics circuits represent an important part of the training in various areas, such as electric power technology, AC/DC machines, renewable energy, and power electronics.

For these purposes, the Data Acquisition and Control Interface (DACI) is a versatile USB peripheral that features a set of computer-based instruments and instrumentation tools, which can be accessed through Data Acquisition and Control for Electromechanical Systems (LVDAC-EMS) software.

The DACI and the LVDAC-EMS software are standard features in the Electric Power Technology Training Systems and in the Computer-Assisted 0.2-kW Electromechanical Training System.

Highlights

- Computer-based tools increase student knowledge and understanding of electric power systems and power electronics circuits
- Customizable DACI with several control functions available to fit specific training needs
- Pre-built SCADA interface facilitates an understanding of the process taking place
- Several inputs/outputs for easy connection with other modules
- Optically isolated inputs
- Includes free software (LVDAC-EMS)
- Software Development Kit for third-party programming tools
- Short set-up time
- Safe and affordable

Control function sets

Several sets of computer-based functions allowing control of power electronics modules can be activated in the DACI. Instructors can select and combine the functions they need.

- Computer-Based Instrumentation
- Chopper/Inverter Control
- Thyristor Control
- Home Energy Production Control
- Three-Phase PWM Rectifier/ Inverter Control
- BLDC Motor/PMSM Control
- High-Voltage DC (HVDC) Transmission System Control
- Static Var Compensator (SVC) Control
- 9063 Software Development Kit
- Synchronous Generator Control
- Static Synchronous Compensator (STATCOM) Control
- Synchroscope
- SCADA

Electric Power Technology Training Modules

Four-quadrant dynamometer/power supply

LabVolt Series 8960

The Four-Quadrant Dynamometer/power Supply is a highly versatile USB peripheral designed to be used in the Electric Power Technology Training Systems. Two operating modes are available: Dynamometer and Power Supply. A wide variety of user-selectable functions is available in each operating mode.

In the Dynamometer mode, the unit becomes a four-quadrant dynamometer that can act as either a fully configurable brake or a fully configurable prime mover. In the power supply mode, the unit becomes a four-quadrant power supply that can act as a DC voltage source, DC current source, ac power source, etc.

In each operating mode, key parameters related to the selected function are displayed and can be monitored using the computer-based instruments in the software LVDAC-EMS. Speed, torque, mechanical power, and energy are displayed in the Dynamometer mode while voltage, current, electrical power, and energy are displayed in the Power Supply mode. Optional functions, such as a small wind-turbine emulator, a hydraulic turbine emulator, a solar panel emulator, battery chargers, an SDK (Software Development Kit) etc., can be added to the standard functions to further enhance the training possibilities of the Four-Quadrant Dynamometer/Power Supply.

Highlights
- Multipurpose device combining power supply, prime mover, dynamometer, metering, and emulator properties
- Manual or computer-based control mode
- Green device: it returns the power produced directly on the grid
- Emulation of multiple load types
- Optional functions can be added to the standard functions to further the training possibilities

Topic coverage
- Speed and Torque
- Voltage and Current
- Mechanical and Electrical Power
- Energy

Function sets
- Standard Functions (Manual Control)
- Standard Functions (Computer-Based Control)
- Turbine Emulator
- Lead-Acid Battery Charger
- Ni-MH Battery Chargers
- Solar Panel Emulator
- LabVolt Series 8960 Software Development Kit

Most popular packages

Four-quadrant dynamometer/power supply with manual and computer-based control

	en	es	fr
120 V/60 Hz	**579648**	**579650**	**579649**
220 V/50 Hz	**579651**	**579653**	**579652**
240 V/50 Hz	**579654**		

Note: For reference numbers of other variants Dynamometer/Power Supply control functions or specific packages based on your needs, please contact your Festo sales representative:

Electric Power Technology Training Modules

Loads, filters

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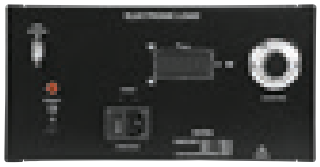

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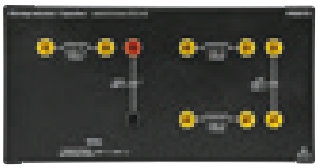

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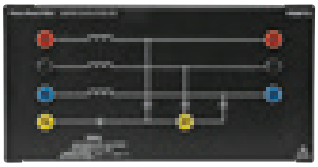

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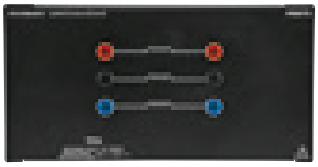

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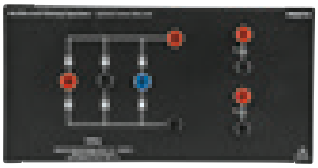

1 **Inductive Load**
Nine iron-core power inductors arranged in three identical banks.

	en	es	fr
120–208V/60Hz	**763362**	**763363**	**579516**
220–380V/50Hz	**579517**	**579519**	**579518**
240–415V/50Hz	**579520**		
220–380V/60Hz	**579521**	**579522**	

2 **Capacitive Load**
Nine capacitors arranged in three identical banks.

	en	es	fr
120–208V/60Hz	**763366**	**763367**	**579544**
220–380V/50Hz	**579545**	**579547**	**579546**
240–415V/50Hz	**579548**		
220–380V/60Hz	**579549**	**579550**	

3 **Resistive Load**
Nine wire-wound power resistors arranged in three identical banks.

	en	es	fr
120–208V/60Hz	**763359**	**763360**	**579511**
220–380V/50Hz	**579512**	**579514**	**579513**
240–415V/50Hz	**579515**		

4 **Electronic Load**
Provides manual or computer-assisted adjustment of constant rated currents that can be used to record the characteristic curves of a fuel cell system.

	en	es	fr
120–208V/60Hz	**579575**	**579575**	**579575**

5 **Filtering Inductors/Capacitors**
Two separate filters (low- and high-frequency) enclosed in a half-size EMS module.

	en	es	fr
120–208V/60Hz	**579523**	**579525**	**579524**
220–380V/50Hz	**579526**	**579528**	**579527**

6 **Three-Phase Filter**
Three inductors and four capacitors enclosed in a half-size EMS module.

	en	es	fr
120–208V/60Hz	**579529**	**579530**	**586454**

7 **Line Inductors**
Three separate inductors enclosed in a half-size EMS module to be connected in series in a three-phase circuit.

	en	es	fr
120–208 V/60Hz	**763364**	**594487**	**586455**

8 **Rectifier and Filtering Capacitors**
Three-phase bridge rectifier and two separate capacitors enclosed in a half-size EMS module.

	en	es	fr
120–208V/60Hz	**579630**	**579632**	**579631**
220–380V/50Hz	**579633**	**579635**	**579634**
240–415V/50Hz	**579636**		

Batteries, renewable energy sources

1 **Traffic Lights**
Simulates a real-world traffic light application that can be used as a load for a fuel cell system.

	en	es	fr
120–208V/60Hz			
	579574	**579574**	**579574**

2 **Lead-Acid Batteries**
Two 12 V valve-regulated, lead-acid (VRLA) batteries enclosed in a half-size EMS module. Batteries can be connected in series or parallel.

	en	es	fr
120–208V/60Hz			
	763374	**763375**	**579590**

3 **Solar Panel Test Bench**
Full-size EMS module in which a Solar Panel can be installed.

	en	es	fr
120–208V/60Hz			
	579594	**579596**	**579595**
220–380V/50Hz			
	579597	**579598**	
240–415V/50Hz			
	579599		

4 **Smart meter**
Compact device designed for basic metering and energy monitoring and featuring a SENTRON PAC3200 from Siemens.

	en	es	fr
120V/60Hz			
	8093902		

5 **Lead-Acid Battery Pack**
Half-size EMS module housing four 12 V lead-acid batteries connected in series.

	en	es	fr
120–208V/60Hz			
	579591	**579592**	

6 **Ni-MH Batteries**
Two 12 V packs of nickel-metal hydride (Ni-MH) batteries enclosed in a half-size EMS module.

	en	es	fr
120–208V/60Hz			
	586799	**586800**	

7 **Hydrogen Fuel Cell**
A fuel cell stack comprising a fuel cell controller, a hydrogen flow meter, a dc-to-dc converter, an air supply, and seven LED displays for visualizing all essential system parameters.

	en	es	fr
120–208V/60Hz			
	579593	**579593**	**579593**

8 **Monocrystalline Silicon Solar Panel**
Two independent photovoltaic modules mounted on a common metal chassis that can be installed in the Solar Panel Test Bench or on a tripod.

	en	es	fr
120–208V/60Hz			
	579600	**579602**	**579601**

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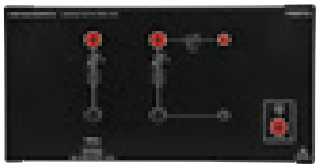

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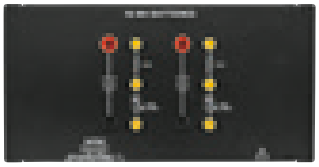

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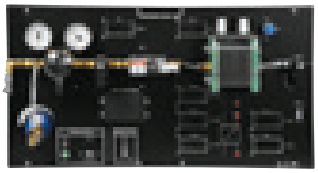

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Electric Power Technology Training Modules

Transformers, power transmission

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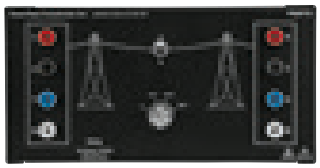

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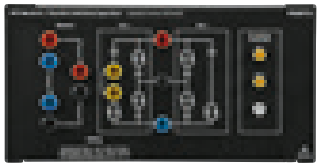

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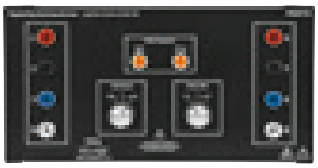

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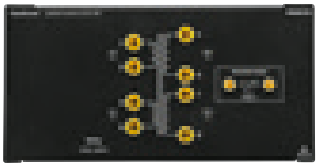

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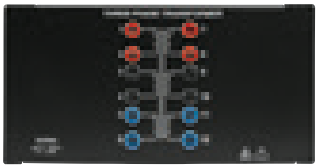

1 **Three-Phase Transmission Line**
Three iron-core inductors enclose in a half-size EMS module.
The inductors are specifically designed to simulate a high-voltage ac transmission line.

	en	es	fr
120–208V/60Hz			
	579535	**579537**	**579536**
220–380V/50Hz			
	579538	**579540**	**579539**
240–415V/50Hz			
	579541		
220/380 V — 60 Hz			
	579542	**579543**	

2 **SVC Reactors/Thyristor Switched Capacitors**
Module consisting of a set of three identical inductors to implement thyristor-controlled reactors (TCRs) using the Power Thyristors.

	en	es	fr
120–208V/60Hz			
	763368		
220–380V/50Hz			
	579556		
240–415V/50Hz			
	579557		
220/380 V — 60 Hz			
	579558	**594488**	

3 **Three-Phase Transformer Bank**
Three independent power transformers enclosed in a module.

	en	es	fr
120–208V/60Hz			
	579559	**579561**	**579560**
220–380V/50Hz			
	579562	**579564**	**579563**
240–415V/50Hz			
	579565		

4 **Regulating Autotransformer**
Three-phase autotransformer enclosed in a half-size EMS module.

	en	es	fr
120–208V/60Hz			
	763369	**763370**	**579566**
220–380V/50Hz			
	579567	**579569**	**579568**
240–415V/50Hz			
	579570		

5 **Transformer**
Power transformer enclosed in a module. Both the primary and secondary sides are made of two identical separate windings.

	en	es	fr
120–208V/60Hz			
	763371	**763372**	**579571**

6 **Three-Phase Transformer**
Three-phase power transformer, made up of a single magnetic core with three branches, enclosed in a half-size EMS module.

	en	es	fr
120–208V/60Hz			
	763373	**592542**	**586468**
220–380V/50Hz			
	579572	**594489**	
240–415V/50Hz			
	579573		

Motors, generators

1 **DC Motor/Generator**
DC machine mounted in a full-size EMS module, that can operate independently as a DC motor or a DC generator.

	en	es	fr
120–208V/60Hz			
	579759	**579761**	**579760**
220–380V/50Hz			
	579762	**579764**	**579763**
240–415V/50Hz			
	579765		

2 **Permanent Magnet DC Motor**
High-speed, brushed DC motor mounted in a full-size EMS module.

	en	es	fr
120–208V/60Hz			
	579485	**579486**	

3 **Wind Turbine Demonstrator**
Actual small-scale wind turbine modified to display the main internal components. The wind turbine has a fixed-pitch, three blade rotor that is directly coupled to the generator.

	en	es	fr
120–208V/60Hz			
	579766	**579766**	**579766**

4 **Wind Turbine Generator/ Controller**
Three-phase permanent-magnet synchronous and a controller (converts the 3-phase power into DC power) of an actual small-scale wind turbine, mounted in a full-size EMS module.

	en	es	fr
120–208V/60Hz			
	579487	**579489**	

5 **Four-Pole Squirrel Cage Motor**
A squirrel-cage induction machine mounted in a full-size EMS module. The machine stator windings allow connection in either wye or delta configuration.

	en	es	fr
120–208V/60Hz			
	586267	**586268**	
220–380V/50Hz			
	586269	**586270**	
240–415V/50Hz			
	586266		

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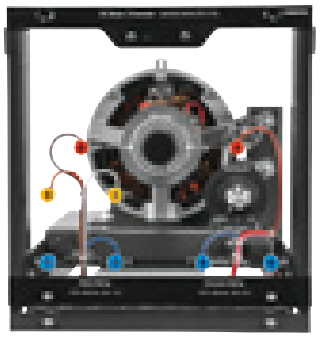

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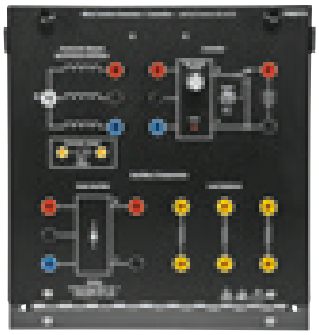

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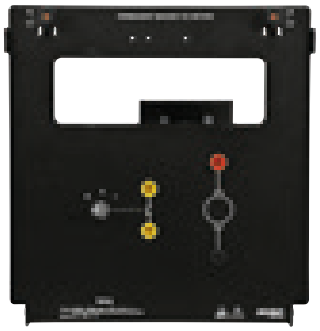

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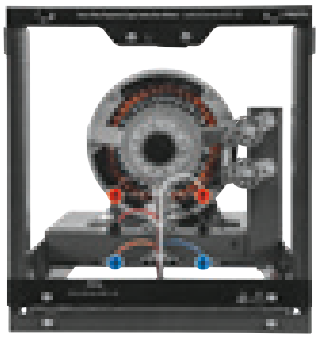

3

Electric Power Technology Training Modules

Motors, generators

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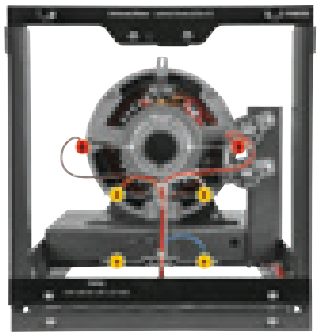

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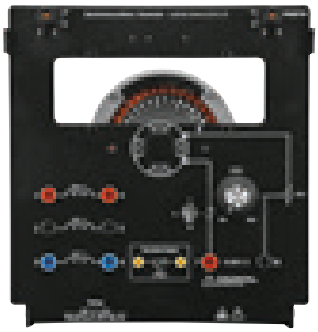

1 **Universal Motor**
Universal machine mounted in a full-size EMS module.

	en	es	fr
120–208V/60Hz			
	579774	**579776**	**579775**
220–380V/50Hz			
	579777	**579779**	**579778**
240–415V/50Hz			
	579780		

2 **Three-Phase Wound Rotor Induction Machine**
Induction machine with a wound rotor mounted in a full-size EMS module.

	en	es	fr
120–208V/60Hz			
	579497	**592532**	**579498**
220–380V/50Hz			
	579499	**594484**	
240–415V/50Hz			
	579500		
220–380V/60Hz			
	579501	**594483**	

3 **Three-Phase Synchronous Motor/ Generator**
0.2 kW three-phase synchronous machine mounted in a full-size EMS module that can be operated either as a three-phase motor or a three-phase generator.

	en	es	fr
120–208V/60Hz			
	579502	**579504**	**579503**
220–380V/50Hz			
	579505	**579507**	**579506**
240–415V/50Hz			
	579508		
220–380V/60Hz			
	579509	**579510**	

4 **Permanent Magnet Synchronous Machine**
Permanent magnet synchronous machine encased in a full-size module. The stator windings of the machine are connected in a wye configuration.

	en	es	fr
120–208V/60Hz			
	586378	**594485**	

5 **Capacitor-Start Motor**
Capacitor-start machine mounted in a full-size EMS module. The centrifugal switch and contact points of the machine are mounted externally.

	en	es	fr
120–208V/60Hz			
	579767	**579769**	**579768**
220–380V/50Hz			
	579770	**579772**	**579771**
240–415V/50Hz			
	579773		
220–380V/60Hz			
	581389	**581390**	

Switching devices, power electronics

1 **Insulated DC-to-DC Converter**
Used to convert a low-voltage DC source, such as the Battery Pack, into a high-voltage DC output suitable for AC conversion.

	en	es	fr
120–208V/60Hz			
	579618	**579620**	**579619**
220–380V/50Hz			
	579621	**579622**	

2 **IGBT Chopper/Inverter**
Consists of seven insulated-gate bipolar transistors (IGBT) mounted in a half-size EMS module. Six IGBTs are used to implement choppers and inverters. The seventh IGBT and a dumping resistor allow smooth dissipation of excess energy at the DC bus.

	en	es	fr
120–208V/60Hz			
	579623	**579625**	**579624**
220–380V/50Hz			
	579626	**579628**	**579627**
240–415V/50Hz			
	579629		

3 **Power Thyristors**
Six power thyristors (SCRs) mounted in a half-size EMS enclosure. A firing control section allows six 0-5 V pulse signals from either the Data Acquisition and Control Interface, Model 9063, the Thyristor Firing Unit, Model 9030, or any compatible 0-5 V control unit, to be applied to the gating circuits of the thyristors.

	en	es	fr
120–208V/60Hz			
	763376	**763378**	**763377**
220–380V/50Hz			
	763379	**763381**	**763380**
240–415V/50Hz			
	763382		

4 **Synchronizing Module/ Three-Phase Contactor**
Half-size EMS module used to control various electric devices, or synchronize two ac power sources like a synchronous generator with an AC power network. It consists of a three-phase contactor whose coil can be energized either manually with a toggle switch, or automatically with a thyristor.

	en	es	fr
120–208V/60Hz			
	579576	**579577**	
220–380V/50Hz			
	579578	**579579**	
240–415V/50Hz			
	579580		

5 **Fault Module**
Consists of a three-phase normally open contactor enclosed in a half-size EMS module. Each phase of the contactor can be used to insert different types of faults in an electric power circuit, such as ground faults and phase-to-phase faults.

	en	es	fr
120–208V/60Hz			
	588972		
220–380V/50Hz			
	589055		
240–415V/50Hz			
	589054		

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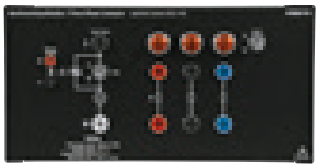

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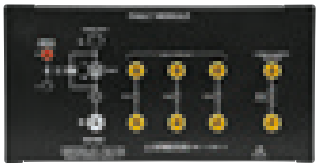

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Electric Power Technology Training Modules

Protective relaying, workstations

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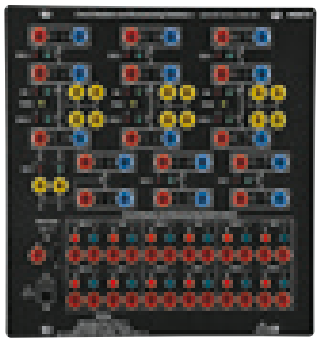

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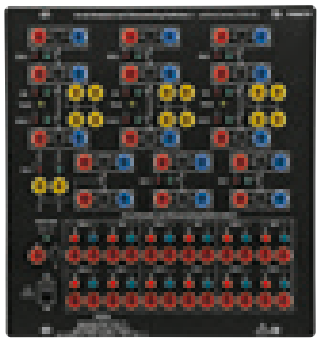

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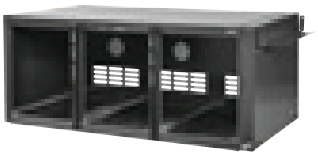

4

5

1 **Circuit Breakers and Disconnecting Switches 1**
Module that can be operated independently using dedicated I/O (open/close) switches or open/close control inputs on the front panel. An Ethernet port on the module front panel allows all circuit breakers and disconnecting switches to be controlled independently using a SCADA system.

	en	es	fr
120–208V/60Hz			
	588952		

2 **Circuit Breakers and Disconnecting Switches 2**
Consists of 3 three-phase circuit breakers and 9 three-phase disconnecting switches, enclosed in a full-size EMS module, that can be used to implement electric power substations with different switching schemes. An Ethernet port on the module front panel allows all circuit breakers and disconnecting switches to be controlled independently using a SCADA system.

	en	es	fr
120–208V/60Hz			
	588953		

Numerical Distance Relay
See page 216

Numerical Directional Overcurrent Relay
See page 216

Numerical Differential Protective Relay
See page 216

3 **Three-Module Workstation**
Workstation consisting of a single row of three full-height compartments that can accommodate up to three full-size EMS modules or six half-size EMS modules. Intended for use on a bench (not supplied) and is fitted with wooden feet to protect the bench top.

	en	es	fr
Order no.			
	579483	**579483**	**579483**

4 **Workstation**
Workstation intended for use on a bench (not supplied) and is fitted with rubber feet to protect the bench top. Three rows of compartments are designed to house EMS modules. Two of these rows have full-height compartments while the other row has half-height compartments.

	en	es	fr
Order no			
	579484	**579484**	**579484**

5 **Mobile Workstation**
Workstation mounted on a Mobile Storage Cabinet. Swivel casters allow easy movement. Immediately above the storage cabinet is a pullout work surface. The upper portion of the workstation consists of three rows of compartments designed to house EMS modules.

	en	es	fr
Order no.			
	579755	**579755**	**579755**

Accessories, power supplies

1 **Storage Shelves**
Module with five shelves, each of which can accommodate four full-size EMS modules or eight half-size EMS modules.

	en	es	fr
Order no.	**579756**	**579756**	**579756**

2 **AC power Network Interface**
Module used to interface the ac power network with EMS modules. It consists of an AC Power Inlet section comprising a C14 power cord inlet with 4 mm color-coded safety sockets for each terminal (line, neutral, and ground).

	en	es	fr
120–208V/60Hz	**579581**	**579583**	**579582**
220–380V/50Hz	**579584**	**579586**	**579585**
240–415V/50Hz	**579587**		
220–380V/60Hz	**579588**	**579589**	

24V AC Power Supply
Enclosed in a full-size EMS module, it provides DC power and AC power, both fixed and variable, single-phase and three-phase.

	en	es	fr
120–208V/60Hz	**579696**	**579696**	**579696**
220–380V/50Hz	**579697**	**579697**	**579697**
240–415V/50Hz	**579698**		
220–380V/60Hz	**579697**	**579697**	

3 **Three-Phase Power Supply**
Consists of a fixed-voltage three-phase ac power source and a fixed-voltage DC power source enclosed in a half-size EMS module.

	en	es	fr
120–208V/60Hz	**579612**	**579613**	
220–380V/50Hz	**579614**	**594495**	
240–415V/50Hz	**579615**		
220–380V/60Hz	**579616**	**579617**	

4 **Power Supply/Ethernet Switch**
consists of a 120 V DC power supply and an industrial-grade, five-port Ethernet switch enclosed in a half-size EMS module. The 120 V DC power supply is designed to power Circuit Breakers and Disconnect Switches modules.

	en	es	fr
120–208V/60Hz	**588954**		

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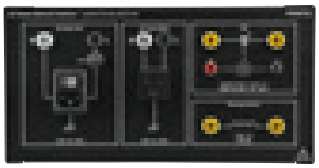

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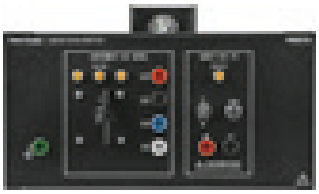

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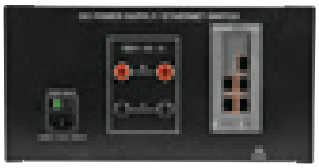


Electric Power Technology Training Modules
Accessories

Hydrogen Generator
HG 30 Heliocentris hydrogen generator that produces high-purity hydrogen (99.9999% vol) for laboratory and research use. It is ideal both for the direct operation of fuel cell systems and for filling low-pressure metal hydride canisters.

Order no **579781**

Hydrogen Canister
Order no **579699**

Hydrogen connection kit from 200 Bar
Order no **780548**

Timing Belt
The Timing Belt is a high-quality industrial synchro-cog timing belt made of rubber whose teeth exactly mesh with the geared pulley fitted on the shaft of all 0.2 kW EMS machines. The Timing Belt is supplied in a fixed length appropriate for coupling two adjacent EMS machines together without slippage between them.
Order no **579637**

Multimeter
An Amprobe AM-510 Tool Kit Digital Multimeter with Battery Test, ideal to perform voltage, current, and resistance measurements in exercises.
Order no **579782**

Heavy-Duty Tripod
Compact, heavy-duty unit that is perfectly suited to hold a solar panel when performing outdoor exercises.
Order no **583216**

Pyranometer
The Pyranometer is a high-quality instrument for measuring solar irradiance. The thermopile sensor construction measures the solar energy that is received from the total solar spectrum and the whole hemisphere (180° field of view). The output signal of the Pyranometer is a voltage proportional to the measured solar irradiance, expressed in Watts/m². The Pyranometer is a useful instrument when measuring the performance of solar panels versus .
Order no **579784**

Connection Leads
Extra-flexible leads terminated with stacking 4 mm safety banana plugs. The leads are supplied in different lengths and are color-coded according to length.
– 16x red, 600 mm
– 8x blue, 900 mm
– 16x yellow, 300 mm
Order no **586891**

Connection Leads
Extra-flexible leads terminated with stacking 4 mm safety banana plugs. In addition, the set includes stacking 2 mm banana plug leads of the same length and color.
– 4x red, 600 mm (2 mm plug)
– 10x red, 600 mm (4 mm plug)
– 4x blue, 900 mm (4 mm plug)
– 20x yellow, 300 mm (4 mm plug)
Order no **579638**

Connection Leads
Extra-flexible leads terminated with stacking 4 mm safety banana plugs. The leads are supplied in different lengths and are color-coded according to length. The set also includes three-phase leads, which are made of three color-coded leads bundled together along their length to simplify the connection of three-phase circuits.
– 4x 3-phase cable, 600 mm
– 8x red, 600 mm
– 4x blue, 900 mm
– 14x yellow, 300 mm
Order no **579639**

Connection Leads (Shielded)
Set consisting of two three-phase shielded cables terminated with stacking 4 mm safety banana plugs as well as two shielded cables terminated with 2 mm banana plugs.
Order no **586897**

Equipment Sets TP 8012
Electric Power Technology (EMS A4)

Raising qualification levels for a critical industry sector

The production of energy using renewable natural resources has gained much importance in recent years. The need for innovative technologies to make the grid smarter has recently emerged as a major trend, as the worldwide increase in electrical power demand makes it harder for the actual grid in many countries to keep up.

These trends have a direct impact on the training requirements of future workers.

New equipment sets based on a world-renowned platform

The electric power technology equipment sets constitute a unique, modular pedagogical concept – a combination of turnkey courseware, practical software, and rugged hardware designed for instructional purposes – that methodically and efficiently builds student knowledge and skills in electric power technology.

The concept is based on the proven Electromechanical training system (EMS), Model 8010 from the US-Canadian company Lab-Volt (acquired by Festo Didactic in 2014), which has successfully supported hands-on learning for several decades.

Thousands of technical schools, universities, and industrial companies from around the world rely on this comprehensive platform to build skills and knowledge in electrical engineering.

Equipment sets TP 8012 Electric Power Technology were derived from this platform to serve the needs of European training organizations. Hardware is now fully compliant with European Union regulations regarding health and safety (CE marking) and offered in A4 format – hence the platform name “EMS A4”.

Highlights
- Modular design enables equipment set combinations to meet specific training and budget needs
- New and safer grounding methods between the modules
- Unparalleled data acquisition and control interface designed specifically for learning purposes
- Ability to display multiple, high-power electrical signals with student-proof measuring instruments
- One oscilloscope monitors up to four high-voltage and four high-current inputs
- Live observation of the electrical vectors with the Phasor Analyzer
- Measure, calculate, and display electrical values quickly and easily with LVDAC-EMS software

An evolving educational approach for electrical engineering training

The modular design of the training packages allows instructors to build a learning solution customized to their training requirements and budget, while still compatible with future expansion options.

This tremendous flexibility enables the equipment sets to be expanded gradually, over time, while the hardware itself is durable enough to withstand the rigors of hands-on training. Computer-based tools also eliminate the need for purchasing and replacing actual equipment, the overall achievement being a cost-efficient, high return on investment.

Festo Didactic regularly releases new hardware and workbooks, ensuring that the EMS remains an evolving, state-of-the-art learning platform, and the benchmark for electrical engineering education.

Topics currently covered:

Wind and Solar Power

Training content
Configuring Photovoltaic Panels, Effects of Temperature and Shading in Power Production, Storing Energy in Batteries, Sun's Orientation, Wind Turbines, PWM and MPPT Chargers, Stand-Alone and Grid-Tied Inverters, Powering AC and DC Loads, etc.

AC/DC Power Circuits and Power Transformers

Training content
Ohm's Law, Series and Parallel Circuits, Electrical Loads (RLC), Impedance, Active Power, Reactive Power, Apparent Power, Power Factor, Solving AC and DC Circuits, Single-Phase and Three-Phase Transformers, Efficiency, Configurations, etc.

Available soon:

Electric Motors and Generators

Training content
Single and Three-Phase AC Motors and Generators (Asynchronous, Synchronous, Wound Rotor Induction, Capacitor-Start), DC Motors and Generators (Shunt, Series, Compound, Permanent Magnet, Universal), Speed-Torque Characteristics, Power Factor Correction, Generator Synchronization, etc.

Power Electronics

Training content
Rectifiers (AC to DC), Choppers (DC to DC), Inverters (DC to AC), DC Power Electronics, Single-Phase and Three-Phase Power Electronics, Diodes, Thyristor, IGBT, Voltage Control, DC Motor Drives, Variable Frequency Drives, Starters, Regenerative Braking, etc.

Equipment Sets TP 8012

Computer-based tools specialized for learning

A safe working environment

Festo Didactic provides a wide array of equipment to perform the practical exercises. Equipment sets suggest a learning path linking hardware and courseware, yet the modularity allows instructors to create divergent paths for customized solutions.

A variety of electrical loads, power supplies, motors and generators, inverters, power electronics components, transformers, mechanical loads, and other devices are available to ensure that student training builds the relevant skills for the future.

The hardware provides a new, innovative, and safer grounding method, which protects devices against reverse polarity and short circuits, and an electrical mechanism that prevents driving motors without the protective guard. All these features meet the highest safety levels in the educational market, while ensuring student safety and protecting the long-term investment value.

Computerized tools optimize learning and lab sessions

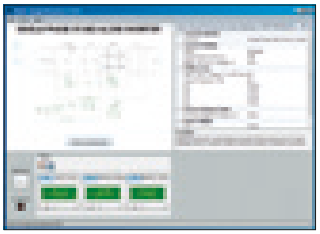
Once students have the foundational skills for using standard measuring tools, they can use computer-based tools to accelerate understanding, enabling more lab time to deepen comprehension.

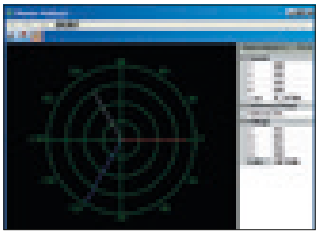
These tools are meant not only to measure and calculate, but also to control and emulate a variety of real-world applications. If new controllers are needed, the proper firmware can be activated in the relevant hardware, eliminating the need for multiple controllers, and firmware functions can easily be upgraded over time.

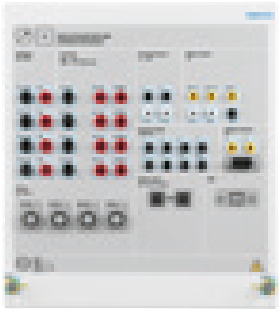
Courseware

Workbooks are available for each equipment set. Each workbook includes up to ten full lab exercises (including required theory) to train students on the specific topics. Workbooks can be ordered separately or bundled in a campus license.

The illustrated student manuals provide all the required theory, guided lab exercises for equipment set procedures, and review questions that test student knowledge. The instructor guide provides all lab results and answers to questions.







Data Acquisition and Control Interface (DACI)

Festo Didactic provides state-of-the-art data acquisition tools for quick, easy and safe measurements to help accelerate lab set-up, and reduce the downtime of using standard measuring instruments.

The Data Acquisition and Control Interface (DACI) is a versatile module used for measuring, observing, and analyzing electrical and mechanical parameters in electric power systems and power electronics circuits.

A set of computer-based instruments, as well as a variety of control functions, are available for the DACI and are quickly accessed through the LVDAC-EMS software.

This module is the main pillar of the learning concept and can later be easily and cost-efficiently upgraded to also perform numerous power electronics control applications (choppers, inverters, drives, etc.)

See page 170 for information.

Four-Quadrant Power Supply and Dynamometer Controller

Emulating the right loads is a challenge that Festo Didactic takes seriously, and one that is met with the second pillar of the learning concept: the 4-Quadrant Dynamometer and Power Supply.

Depending on lab requirements, this module can easily be configured as a prime mover/brake with several options, a fully flexible AC/DC power supply, or an emulator of specific loads (from simple mechanical loads to more complex applications like wind turbine, hydraulic turbine, or solar panel). These control function sets can be accessed through the LVDAC-EMS software.

See page 170 for information.

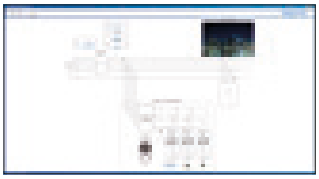
LVDAC-EMS

To control and monitor the Data Acquisition and Control Interface and the Four-Quadrant Dynamometer/ Power Supply, which connect to a PC via USB, students can rely on LVDAC-EMS, a complete software package with a wide range of capabilities for measuring, calculating, and controlling the different parameters and applications.

The software is used to configure the various software tools, save configurations, monitor and export data, and control the application, while keeping set-up to a minimum. Specifically designed and optimized for learning purposes, the software also includes an oscilloscope, a phasor analyzer, a data table, and a graph.

LVDAC-EMS software and upgrades are available free on our website.

See page 146 for information.



SCADA for LVDAC-EMS

SCADA for LVDAC-EMS is a software program designed to run concurrently with LVDAC-EMS. It introduces students to the fundamentals of SCADA in a smart grid context, recreating a complete grid with several different applications running.

SCADA-EMS transforms LVDAC-EMS and the workstation computer into a local workstation that can be monitored and controlled from a supervisory computer over a local network.

Using the OPC Server protocol, SCADA-EMS enables users to design their own interfaces by calling the different applications running on the local workstations.

See page 147 for information.

Equipment Sets TP 8012

AC/DC power circuits and power transformers

The ideal starting point for training in electric power technology

Providing students with comprehensive and realistic training in the fundamental principles of electricity is the solid foundation on which all further studies in this area are built.

As part of its continuously-growing portfolio in electrical engineering, Festo offers a series of learning packages for teaching the basics of continuous and alternating current power circuits, as well as power transformers, from fundamentals to three-phase circuit configurations.

Our learning solutions in this field are fully modular to meet student- and lab-specific needs, and can be combined with other equipment sets to create perfectly customized labs.

Highlights

– Unrivaled data acquisition and control interface specifically designed for learning purposes
– Ability to demonstrate multiple, high-power electrical signals with student-proof measuring instruments

Workbooks

The equipment sets are supported by five workbooks with a combined total of 24 full lab exercises. Students begin with fundamentals, such as Ohm's Law and series vs. parallel in DC, and continue to AC fundamentals, including the principles of phase angle, active/reactive/apparent power, impedance, and solving different single-phase AC circuits, and finally to understanding three-phase circuits.

Students then progress to electromagnetism principles and transformers operation, examining all the necessary facets of these important electrical circuit components, including three-phase configurations.

Equipment Set TP 8012-6 AC/DC Power Circuits	**8093319**

TP 8012-6 covers DC, and AC single- and three-phase power circuits.

The most important components at a glance:

1x Resistive Load	594820
1x Inductive Load	594821
1x Capacitive Load	594822
1x 3AC 400 V DC 230V Power Supply	594825
1x AC 24V Power Supply	772050
1x AC 230V DC 325V Variable Power Supply	* 8089266
1x Data Acquisition and Control Interface	594499
(with the Computer-Based Instrumentation function activated)	

Also order the following workbooks:
DC Power Circuits, Single-Phase AC Power Circuits, and Three-Phase AC Power Circuits

Equipment Set TP 8012-7 Power Transformers	**8093320**

TP 8012-7 covers single- and three-phase power transformers.

The most important components at a glance:

1x Resistive Load	594820
1x 3AC Transformer Bank	594823
1x 1AC Transformer	594824
1x 3AC 400 V DC 230V Power Supply	594825
1x AC 24V Power Supply	772050
1x AC 230V DC 325V Variable Power Supply	* 8089266
1x Data Acquisition and Control Interface	594499
(with the Computer-Based Instrumentation function activated)	

Also order the following workbooks:
Single-Phase Power Transformer, Three-Phase Transformer Banks

Equipment Set TP 8012-8 AC/DC Power Circuits and Transformers	**8093321**

TP 8012-8 combines TP 8012-6 and TP 8012-7 without duplication of hardware components.
Also order the following workbooks: DC Power Circuits, Single-Phase AC Power Circuits and Three-Phase AC Power Circuits, Single-Phase Power Transformer, Three-Phase Transformer Banks.

Required accessories for all equipment sets, also order:

2x Digital Multimeter	579782
1x Connection Lead Set and Grounding Kit	595916
1x 3AC Power Supply and Safety Unit	594826
1x Mobile Frameline, complete model without energy duct	8075133
1x Tabletop Workstation (DIN A4)	8153360
1x Tabletop Double-Sided Workstation	8158409

*This item can be replaced by 4-Quadrant Power Supply and Dynamometer Controller
➔ see page 170
Note: A computer with a Windows 7/8/10 operating system is required for all equipment sets.

Workbooks

DC Power Circuits
The workbook provides all the theory and details required to perform the following hands-on exercises:
– Voltage, Current, Ohm's Law
– Equivalent Resistance
– Power in DC Circuits
– Series and Parallel Circuits

Student Manual, en	**594086**
Instructor Guide, en	**594087**

Single-Phase AC Power Circuits
The workbook provides all the theory and details required to perform the following hands-on exercises:
– The Sine Wave
– Phase Angle and Phase Shift
– Instantaneous and Average Power
– Inductive Reactance
– Capacitive Reactance
– Impedance
– Active and Reactive Power
– Apparent Power and the Power Triangle
– Solving Simple AC Circuits using Circuit Impedance Calculation
– Solving AC Circuits using the Power Triangle Method

Student Manual, en	**594088**
Instructor Guide, en	**594089**

Three-Phase AC Power Circuits
The workbook provides all the theory and details required to perform the following hands-on exercises:
– Three-Phase Circuits
– Three-Phase Power Measurement
– Phase Sequence

Student Manual, en	**594090**
Instructor Guide, en	**594091**

Single-Phase Power Transformers
The workbook provides all the theory and details required to perform the following hands-on exercises:
– Voltage and Current Ratios
– Transformer Winding Polarity and Interconnection
– Transformer Losses, Efficiency, and Regulation
– Transformer Rating
– Effect of Frequency on Transformer Rating
– The Autotransformer

Student Manual, en	**594131**
Instructor Guide, en	**594132**

Three-Phase Power Transformers
The workbook provides all the theory and details required to perform the following hands-on exercise:
– Three-Phase Transformer Configurations

Student Manual, en	**594133**
Instructor Guide, en	**594134**

Campus license
This campus license includes the workbooks "Single-Phase Power Transformers" and "Three-Phase Power Transformers". Details about campus licenses on page „Campus license“ auf Seite 31.

en	**8093410**

For other languages, please contact your local sales representative for availability.

Equipment Sets TP 8012
Solar power

Solar power production training: from basic to industrial

Solar power has become commonplace in recent years, making it more affordable for residential use, which is increasing worldwide. As a result, there is an urgent need to train and qualify technicians to understand and maintain these systems.

Our modular, solar power learning solutions meet your training needs, from the fundamentals and functions of photovoltaic panels to actual operation of stand-alone or grid-tied photovoltaic energy production systems.

Features
- Solar Panel Emulator, for experiments requiring additional power
- PWM and MPPT inverters
- State-of-the-art data acquisition and control interface designed specifically for learning purposes

Workbooks
The two workbooks contain foundational information and theory required to perform the lab experiments. The first workbook is focused on actual photovoltaic panels, including their construction and operation under varying conditions. The second workbook provides hands-on experimentation with production scenarios in stand-alone (off-grid) or grid-tied (parallel) mode.

Equipment Set TP 8012-3 Solar Power Basic Package	**596086**

A cost-effective package covering the fundamentals of solar power.

The most important components at a glance:

1x 12 V Lead-Acid Batteries*	595060
1x Solar Panel Test Bench	595057
1x Monocrystalline Silicon Solar Panel	595058

Also order the following workbook: Solar Power

*A 12 V DC battery charger is required for this module. Users can use their own charger with 4 mm safety plugs or order the 4-Quadrant Power Supply and Dynamometer Controller, including manual and computer-based control (order no. 595028).

Required accessories for TP 8012-3, also order:

2x Digital Multimeter	579782
1x Connection Lead Set and Grounding Kit	595916

Equipment Set TP 8012-4 Photovoltaic Systems	**596087**

Covers the concepts of solar power production in stand-alone and also grid-tied scenarios

The most important components at a glance:

1x DC 48 V Lamps	595055
1x AC 230 V Lamps	595056
2x 1 AC Energy Meter	594904
1x 48 V Lead-Acid Battery Pack	595059
1x DC 48 V PWM Charge Controller	595051
1x DC 48 V MPPT Charge Controller	595050
1x AC 230 V Power Supply	595930
1x AC 24 V Power Supply	772050
1x 1 AC 230 V Stand-Alone Inverter	595052
1x 1 AC 230 V Grid-Tied Inverter	595053
1x 4-Quadrant Power Supply and Dynamometer Controller (including Manual and Computer-Based Control)	595028
1x Firmware Function (4Q Power Supply/Dynamometer) Solar Panel Emulator	581440
1x Data Acquisition and Control Interface (including computer-based instrumentation for 2x current inputs and 2x voltage inputs)	595912

Also order the following workbook: Photovoltaic Systems

Required accessories for TP 8012-4, also order:

1x Communications Gateway*	595054
1x Connection Lead Set and Grounding Kit	595916
1x Mobile Frameline, complete model without energy duct	8075133

* Only one per lab is necessary

Equipment Set TP 8012-5 Solar Power (Complete)	**596088**

TP 8012-5 combines TP 8012-3 and TP 8012-4 without duplication of hardware components

Required accessories for TP 8012-5, also order:

2x Digital Multimeter	579782
1x Communications Gateway*	595054
1x Connection Lead Set and Grounding Kit	595916
1x Mobile Frameline, complete model without energy duct	8075133
1x Tabletop Workstation (DIN A4)	8153360
1x Tabletop Double-Sided Workstation (DIN A4)	8158409

* Only one per lab is necessary

Also order the following workbooks: Solar Power and Photovoltaic Systems

Optional accessories (for outdoor experiments):

1x Tripod	583216
1x Pyranometer	579784

Workbooks

Solar Power

The workbook provides all the theory and details required to perform the following hands-on exercises:

– The Diode
– The Solar Panel (Photovoltaic Panel)
– Effect of Temperature on Solar Panel Performance
– Storing Energy from Solar Panels into Batteries (optional)
– Effect of Shading on Solar Panel Operation
– Solar Panel Orientation
– Solar Panel Performance versus Insolation

Student Manual, en	**603887**
Instructor Guide, en	**603890**

Photovoltaic Systems

The workbook provides all the theory and details required to perform the following hands-on exercises:

– Stand-Alone PV Systems for DC Loads
– Use of an MPPT Charge Controller in Stand-Alone PV Systems
– Stand-Alone PV Systems for AC Loads
– Grid-Tied PV Systems

Student Manual, en	**593985**
Instructor Guide, en	**593987**

Campus license

This campus license includes the workbooks “Solar Power” and “Photovoltaic Systems”. Details about campus licenses on page „Campus license“ auf Seite 31.

en	**596125**

Equipment Sets TP 8012
Wind power

Residential wind power production training

Wind power, like solar power, has become more commonplace and affordable. The increasing use of small wind turbines has created numerous, decentralized production nodes that must be considered in the context of today's industrial electrical networks.

Our modular wind power learning solutions can be used for stand-alone training or combined with other learning solutions. The equipment sets begin with an introduction to wind power, a hands-on experience that uses real-world wind turbine components adapted for a safe working environment. Our dynamometer recreates realistic wind conditions, as well as real power-torque curves. Once students have mastered the basics, the training progresses to energy production that supplies power to AC and DC loads.

Features
- Wind turbine emulator embedded in a flexible dynamometer
- Real-world wind turbine components adapted for a safe working environment
- State-of-the-art data acquisition and control interface designed specifically for learning purposes

Workbooks
The two workbooks contain foundational information and theory required to perform the lab experiments. The first workbook introduces wind power production and how it is used to charge batteries and power simple loads. The second workbook provides hands-on experimentation in setting up stand-alone applications that produce power for use with DC loads, or with AC loads in combination with an inverter.

Equipment Set TP 8012-0 Introduction to Wind Power	**596083**

A cost-effective package covering wind power fundamentals.

The most important components at a glance:

1x	Wind Turbine Generator/Controller	595061
1x	Wind Turbine Load Resistors	594819
1x	Resistive Load	594820
1x	48 V Lead-Acid Battery Pack	595059
1x	4-Quadrant Power Supply and Dynamometer Controller (including Manual and Computer-Based Control, Pb-Acid Battery Charger, Turbine Emulator)	596127
1x	4-Quadrant Dynamometer Motor	595062
1x	AC 24 V Power Supply	772050
1x	Timing Belt	793141
1x	Protective Guard – Side-by-side	794195

Also order the following workbook: Introduction to Wind Power

Required accessories for TP 8012-0, also order:

2x	Digital Multimeter	579782
1x	Connection Lead Set and Grounding Kit	595916

Equipment Set TP 8012-1 Wind Power Systems	**596084**

Covers power production for use with AC and DC loads

The most important components at a glance:

1x	Wind Turbine Generator/Controller	595061
1x	DC 48 V Lamps	595055
1x	AC 230 V Lamps	595056
1x	48 V Lead-Acid Battery Pack	595059
1x	AC 24 V Power Supply	772050
1x	1 AC 230 V Stand-Alone Inverter	595052
1x	4-Quadrant Power Supply and Dynamometer Controller (including Manual and Computer-Based Control, Pb-Acid Battery Charger, Turbine Emulator)	596127
1x	4-Quadrant Dynamometer Motor	595062
1x	Data Acquisition and Control Interface (including computer-based instrumentation for 2x current inputs and 2x voltage inputs)	595912
1x	Timing Belt	793141
1x	Protective Guard – Side-by-side	794195

Also order the following workbook: Wind Power Systems

Required accessory for TP 8012-1, also order:

1x	Connection Lead Set and Grounding Kit	595916

Equipment Set TP 8012-2 Wind Power (Complete)	**596085**

TP 8012-2 combines TP 8012-0 and TP 8012-1 without duplication of hardware components

Necessary accessories forTP 8012-2

2x	Digital Multimeter	579782
1x	Connection Lead Set and Grounding Kit	595916
1x	Mobile Frameline, Complete Model without energy duct	8075133
1x	Frameline table on wheels	8087149
1x	Tabletop Workstation (DIN A4)	8153360
1x	Tabletop Double-Sided Workstation (DIN A4)	8158409

Also order the following workbooks: Introduction to Wind Power and Wind Power Systems

Workbooks

Introduction to Wind Power

The workbook provides all the theory and details required to perform the following hands-on exercises:
– Voltage-Speed Characteristic of a Wind Turbine Generator
– Torque-Current Characteristic of a Wind Turbine Generator
– Power vs. Wind Speed
– Storing Energy from a Wind Turbine into Batteries

Student Manual, en	**603893**
Instructor Guide, en	**603896**

Wind Power Systems

The workbook provides all the theory and details required to perform the following hands-on exercises:
– Stand-Alone Wind Power Systems for DC Loads
– Stand-Alone Wind Power Systems for AC Loads

Student Manual, en	**593989**
Instructor Guide, en	**593991**

Campus license

This campus license includes the workbooks “Introduction to Wind Power” and “Wind Power Systems”. Details about campus licenses on page „Campus license“ auf Seite 31.

en	**596126**

Modules

DACI, dynamometer, power supplies

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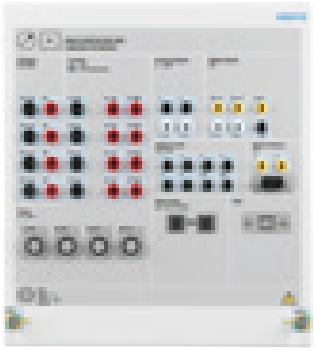

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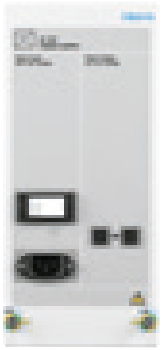

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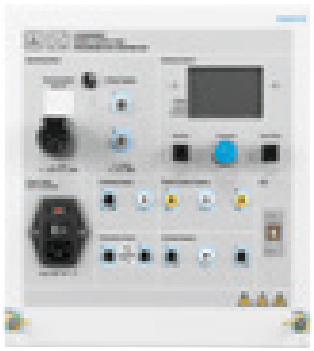

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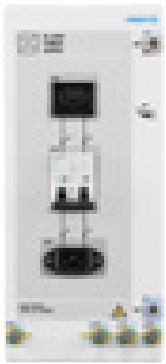

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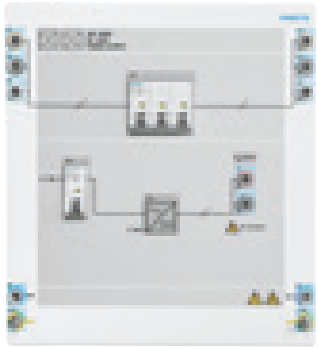

1 **Data Acquisition and Control Interface**
The Data Acquisition and Control Interface (DACI) is a versatile and complete device in an A4 module used for measuring, observing, and analyzing electrical and mechanical parameters in electric power systems and power electronics circuits.
Order no. **595912**

2 **4-Quadrant Power Supply and Dynamometer Controller**
The 4-Quadrant Power Supply and Dynamometer Controller is an A4 module that offers two main operating modes: Power supply and dynamometer. For the dynamometer, a dynamometer motor is also required. In the power supply mode, the unit acts as a versatile four-quadrant voltage or current source. In the dynamometer mode, the unit acts as a fully configurable mechanical brake or prime mover.
Order no. **596127**

3 **4-Quadrant Dynamometer Motor**
The 4-Quadrant Dynamometer Motor consists of a tabletop motor that is used as a complete 4-Quadrant dynamometer in conjunction with the 4-Quadrant Power Supply and Dynamometer Controller. This dynamometer can then act as a prime mover, a brake, or a motor test bench, and can also emulate various types of predefined or custom loads.
Order no. **595062**

4 **3 AC 400 V DC 230V Power Supply**
The 3 AC 400 V DC 230 V Power Supply is an A4 module that provides electrical supplies for a wide range of experiments on a workstation.
Order no. **594825**

5 **AC 24V Power Supply**
The AC 24 V power supply is an A4 module that provides auxiliary power for various system components.
Order no. **772050**

6 **AC 230V DC 325V Variable Power Supply**
The AC 230 V/DC 325 V Variable Power Supply provides two source outputs: one variable from 0 to 230 V AC single-phase and the other from 0 – 325 V DC.
Order no. **8089266**

7 **AC 230 V Power Supply**
The AC 230 V Power Supply consists of a single-phase power supply which, connected to the AC line voltage, supplies the necessary power for single-phase experiments. This power supply is mounted in an A4 module.
Order no. **595930**

Modules

Renewable energies

1 **Wind Turbine Generator/ Controller**
The Wind Turbine Generator/ Controller is a tabletop module that provides a wind turbine for experimentation. It can be coupled to a dynamometer motor to be externally driven.
Order no. **595061**

2 **Wind Turbine Load Resistors**
The Wind Turbine Resistive Load is an A4 module that provides a resistive electrical load for wind turbine experiments.
Order no. **594819**

3 **Solar Panel Test Bench**
The Solar Panel Test Bench is a tabletop module that houses the solar panel (sold separately) so that it can be illuminated, and experiments can be conducted.
Order no. **595057**

4 **Monocrystalline Silicon Solar Panel**
The Monocrystalline Silicon Solar Panel is mounted on a common metal chassis that can be installed in the Solar Panel Test Bench, when performing exercises indoors, or on a tripod when performing exercises outdoors.
Order no. **595058**

5 **DC 48 V Lamps**
The DC 48 V Lamps is a half-size A4 module that houses two lamps: ne LED and one incandescent.
Order no. **595055**

6 **AC 230 V Lamps**
The AC 230 V Lamps is a half-size A4 modules that houses three lamps: one incandescent, one CFL, and one LED.
Order no. **595056**

7 **Pyranometer**
The Pyranometer is a high-quality instrument for measuring solar irradiance.
Order no. **579784**

8 **1 AC Energy Meter**
The 1 AC Energy Meter is an A4 module that includes a single-phase energy meter.
Order no. **594904**

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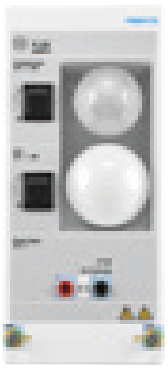

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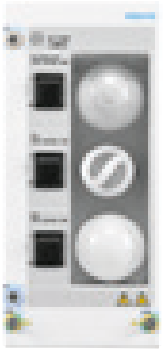

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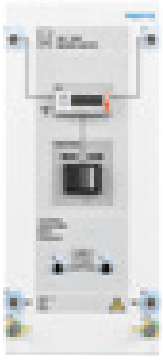

Modules

Loads, batteries, transformers, inverters, controllers

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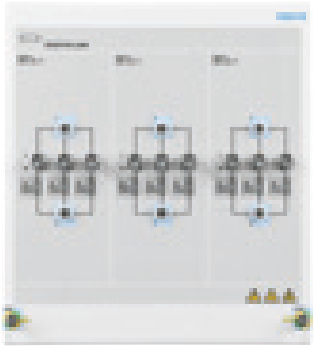

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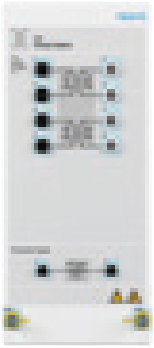

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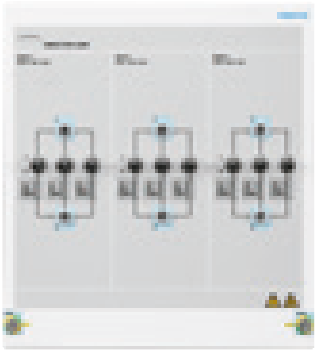

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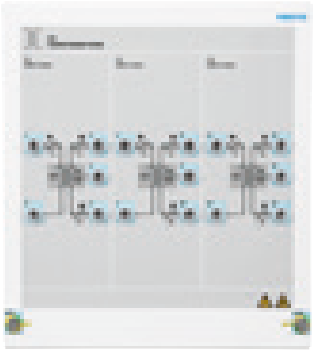

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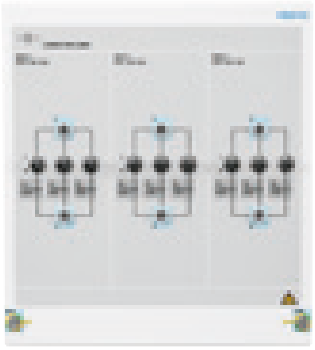

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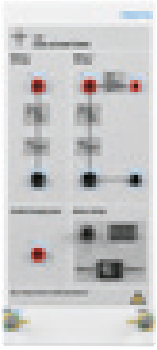

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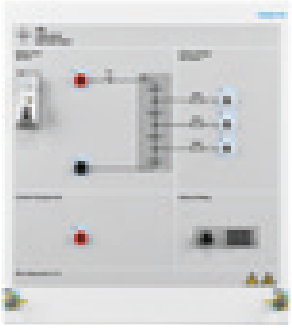


1 **Resistive Load**
The Resistive Load is an A4 module that provides a universal resistive electrical load for a wide range of experiments.
Order no. **594820**

2 **Inductive Load**
The Inductive Load is an A4 module that provides a universal inductive electrical load for a wide range of experiments.
Order no. **594821**

3 **Capacitive Load**
The Capacitive Load is an A4 module that provides a universal capacitive electrical load for a wide range of experiments.
Order no. **594822**

4 **1AC Transformer**
The 1 AC Transformer is an A4 module that includes a single-phase transformer with both primary and secondary sides made of two identical, separate windings.
Order no. **594824**

5 **3AC Transformer Bank**
The 3 AC transformer bank is an A4 module that includes three independent power transformers.
Order no. **594823**

6 **12 V Lead-Acid Batteries**
The 12 V Lead-Acid Batteries is a half-size A4 module that contains two VRLA batteries.
Order no. **595060**

7 **48 V Lead-Acid Battery Pack**
The 48 V Lead-Acid Battery Pack is an A4 module that contains four 12V lead-acid batteries.
Order no. **595059**

1 **DC 48 V PWM Charge Controller**
The DC 48 V PWM Charge Controller is an A4 module used to perform charge-controlling experiments with batteries and DC energy sources, such as solar.
Order no. **595051**

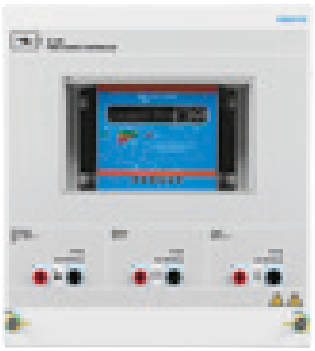
2 **DC 48 V MPPT Charge Controller**
The DC 48 V MPPT Charge Controller is an A4 module that is used to control the charge of batteries with DC energy sources, such as solar panels. It uses MPPT technology, which adjusts its input voltage and finds the maximum power operating point from the solar array, transferring this power to the battery and load.
Order no. **595050**

3 **1 AC 230 V Stand-Alone Inverter**
The 1 AC 230 V Stand-Alone Inverter converts a DC power source, such as batteries, into an AC power source for “off-the-grid” applications.
Order no. **595052**

4 **1AC 230 V Grid-Tied Inverter**
The 1 AC 230 V Grid-Tied Inverter is used to return power from a DC power source such as batteries directly to the grid and it is mounted in an A4 module.
Order no. **595053**

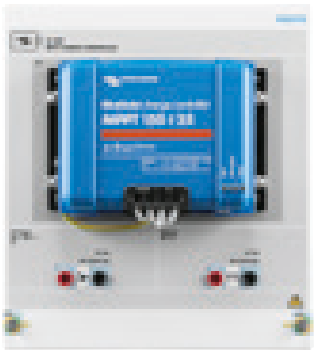
5 **Communications Gateway**
The Communications Gateway is anA4 module that is used to communicate and set grid-tied inverters over the AC line voltage directly.
Order no. 595054

1



4

2



5

3

Dissectible Machines Training System

Construction and operation of rotating machines

120V/60Hz	en	es	fr
Dissectible machines	**581467**	**581469**	**581468**
220V/50Hz			
Dissectible machines	**581470**	**581472**	**581471**
240V/50Hz			
Dissectible machines	**581473**		
220V/60Hz			
Dissectible machines	**592561**	**588989**	

Manual included: Dissectible Machines (Student Manual)

120V/60Hz	580223	580224
220V/50Hz and 240V/50Hz	580225	580226
220V/60Hz	589729	589730

Note: PDF version also available.

The most important components, at a glance:
- 1x Work bench for the Dissectible Machines Training System
- 2x Assembly housing modules
- 1x Dissectible machine parts
- 1x Timing belt

LabVolt Series 8020-2

The Dissectible Machines Training System is an electromechanical training system that provides hands-on training in the construction and operation of rotating machines. The system fulfills educational requirements that include industrial applications of electric power technology and employs training equipment that has characteristics similar to industrial equipment.

The dissectible machines are assembled with the use of tools from a complete set of components, including stators, rotors, armatures, rheostats, and capacitors. Once assembled, they can be mounted on basic modules that lock into place on any EMS workstation. The components allow students to construct two different machines at the same time. Fourteen different machines can be constructed with these components.

Machine windings are connected to the faceplate of the module with polarized plugs, allowing for the correct interconnection of different types of machines. Schematic connections are silkscreened on the interchangeable face on the basic module. Once assembled, machines can be inserted into an EMS workstation and operated just like any preassembled machine. The workstation and equipment required to operate the assembled rotating machines are optional equipment.

All machines that can be built with the Dissectible Machines Training System can be ordered separately as fully assembled machines that can be disassembled and re-assembled by students.

Highlights
- Rugged, high-quality components designed for hands-on training purposes
- Complete assembly drawing (exploded view) for each machine
- No tools required for machine assembly
- Two machines can be assembled at the same time
- Fourteen different machines can be constructed

Topic coverage

Assembly of the included rotating machines:
- DC Motor/Generator
- Four-Pole Squirrel-Cage Induction Motor
- Dahlander Two-Speed Constant Power Induction Motor
- Dahlander Two-Speed Variable Torque Induction Motor
- Dahlander Two-Speed Constant Torque Induction Motor
- Three-Phase Wound-Rotor Induction Motor
- Two-Phase Wound-Rotor Induction Motor
- Three-Phase Synchronous Motor/Generator
- Three-Phase Synchronous Reluctance Motor
- Capacitor-Start Motor
- Capacitor-Run Motor
- Universal Motor
- Two-Value Capacitor Motor
- Triple-Rate Motor

The rotating machines assembled using the Dissectible Machines Training System can be operated just like any preassembled machine. To do so, optional equipment is necessary, such as:
- Workstation or mobile workstation
- Resistive Load
- Power Supply
- Connection Leads
- Four-Quadrant Dynamometer/Power Supply
- Data Acquisition and Control Interface

Please contact your sales representative for details.

Motor Winding Kit

Construction techniques for electrical machines

LabVolt Series 8022

The Motor Winding Kit offers a new approach to teaching construction techniques for electrical machines. Starting with basic components such as laminations, motor ends, and magnet wire, the Motor Winding Kit allows the assembly of a squirrel-cage induction motor, a wound-rotor induction motor, a three-phase synchronous machine, and a split-phase capacitor-start motor. All parts necessary for assembly of the four machines are included in the kit. Two types of stator laminations are included for winding a three-phase stator and a single-phase stator.

Three types of rotors are included in the kit: a squirrel-cage rotor (fully assembled), a rotor with open slot laminations allowing the winding of a wound rotor, and a rotor with cruciform laminations and a damper assembly, allowing the winding of a four-pole synchronous machine rotor. The rotors are made of a double ended stainless-steel shaft on which the ball bearings and laminations are permanently assembled.

There is enough material supplied with the kit to wind each type of machine at least five times. All the necessary materials – lacing cord, slot insulators, insulating material, wooden wedges, and insulated magnet wire – are included. A hand-operated coil winder fitted with an adjustable mandrel and a turn counter facilitates the assembly of the different windings according to the specifications described in the instruction manual. All tools, such as the plastic mallet, scissors, wire stripper, soldering iron, and compass, are included in the kit.

Highlights
- High-quality components designed for hands-on training purposes
- Complete assembly kit that can be reused many times
- Nominal rating and the winding schematics are silk-screened on the overlay to facilitate learning
- Complete curriculum with instructions

Topic coverage
- Split-phase capacitor-start motor
- Three-phase squirrel cage induction motor
- Three-phase wound-rotor induction motor
- Synchronous machine

The rotating machines assembled using the Motor Winding Kit can be operated just like any preassembled machine. To do so, optional equipment is necessary, such as:
- Mobile workstation
- Workstation
- Resistive load
- Power supply
- Connection lead set
- Four-quadrant dynamometer/ power supply
- Data acquisition and control interface

Please contact your sales representative for details.

120V/60Hz	en	es	fr
Motor Winding Kit	**587332**	**587334**	**587333**
220V/50Hz			
Motor Winding Kit	**587335**	**587337**	**587336**
240V/50Hz			
Motor Winding Kit	**587338**		
220V/60Hz			
Motor Winding Kit	**589232**	**588990**	

Manual included: Winding Kit (Student Manual)

120V/60Hz	580228	580229	
220V/50Hz and 240V/50Hz	580230		580231
220V/60Hz	589734	589735	

Note: PDF version also available.

The most important components, at a glance:
- 1x Work bench for the Motor Winding Kit
- 1x Assembly housing module
- 1x Manual coil winder
- 1x Motor winding kit parts

MagTran® Training Systems

Magnetic circuit principles applied to basic transformers

120V/60Hz	en	es	fr
Complete system	**581481**	**581483**	**581482**
220V/50Hz			
Complete system	**581484**	**581486**	**581485**
240V/50Hz			
Complete system	**581487**		
220V/60Hz			
Complete system	**581488**		

Manual included: Magnetic Circuits and Transformers (Student Manual)

120V/60Hz	580275	580277	580276
220V/50Hz	580278	583983	
240V/50Hz	580279		
220V/60Hz	593866		

Note: PDF version also available.

The most important components, at a glance:
- 1x Three-Module Workstation
- 1x Resistive load
- 1x Inductive load
- 1x Capacitive load
- 1x Fully protected transformer
- 1x MagTran parts
- 1x DC voltmeter/ammeter
- 1x AC ammeter
- 1x AC voltmeter
- 1x Flux meter
- 1x Power supply
- 1x Connection lead set

LabVolt Series 8024

The MagTran® Training System is designed to teach magnetic circuit principles and the application of these principles to basic transformers. It is suitable for a broad range of teaching programs – from vocational schools to universities.

It consists of a set of laminated iron bars, a vise-type non-magnetic base that holds the bars in place, coils, and other related components that can be assembled in many ways. Correlated courseware contains an extensive set of laboratory experiments that illustrate basic principles of magnetism and electromagnetic induction.

The MagTran® Training System is designed to operate at a power 0.2 kW using standard EMS instrumentation. The training system includes all the equipment required to perform the exercises contained in the courseware, except for an oscilloscope. The equipment is packaged in a rugged carrying case.

Topic coverage
- Faraday's Law
- Principles of ac induction and magnetic coupling
- Resistance, reactance, and inductance of a coil
- Saturation curve and voltage ratio of a transformer
- Impedance transformation
- Current ratio and impedance of a transformer
- Regulation curves of a transformer
- Polarity of a transformer
- Autotransformer
- Eddy currents and laminated cores
- Properties of a permanent magnet
- Choke
- Magnetic amplifier
- Measurement of flux and leakage flux
- Hysteresis loop and core losses
- Peaking transformer
- Self-inductance, mutual Inductance, and coupling factor
- The three-phase transformer
- Principle of a shaded-pole magnet

Two versions of MagTran® are available: a complete (stand-alone) system or an add-on to 0.2 kW Electromechanical training systems.

Highlights
- Enables students to build single- and three-phase transformers.
- An incandescent lamp enables the observation and study of magnetic coupling.
- Students can rearrange magnetic circuits to learn about inductance and transformer ratios.
- Enables measurement of magnetic fluxes as low as 10 µWb to demonstrate leakage flux, saturation, and magnetic shunts.
- A low-cost flux meter with a special built-in circuit enables the observation of hysteresis loops on an oscilloscope (not included).
- Exploration of the shaded-pole principle magnetic amplifiers, and permanent magnet properties

LabVolt Series 8024-1
This product is an add-on to the MagTran® Training System, LabVolt Series 8024, that allows users to operate the training system in conjunction with the 0.2 kW Electromechanical Training Systems (LabVolt Series 8001, see page 178).

120V/60Hz	en	es	fr
Add-on (to LabVolt Series 8001)	**581489**	**581491**	**581490**
220V/50Hz			
Add-on (to LabVolt Series 8001	**581492**	**581494**	**581493**
240V/50Hz			
Add-on (to LabVolt Series 8001	**581495**		
220V/60Hz			
Add-on (to LabVolt Series 8001)	**581496**	**581497**	

Manual included: Magnetic Circuits and Transformers (Student Manual)

120V/60Hz	580275	580277	580276
220V/50Hz	580278	583983	
240V/50Hz	580279		
220V/60Hz	593866		

Note: PDF version also available.

The most important components, at a glance:
- 1x MagTran parts
- 1x Flux meter

2-kW Electromechanical Training Systems (EMS)

Simulation of high-power machines

LabVolt Series 8013

The 2-kW Electromechanical Training Systems deal with the different techniques associated with the generation and use of electrical energy.

The training systems simulate large power machines, yet are very safe for student experimentation. They incorporate heavy-duty components and machines that can be combined to create different configurations tailored to technical or university courses.

The systems satisfy educational requirements for industrial applications of electric power technology, using industrial-like equipment to provide easy-to-understand laboratory results and easily observed data values.

Highlights
- Modular design
- Extreme ease-of-use, safety, and durability
- The rotating machines have a specifically high inertia to simulate large-power machines
- Machine Motor frames equipped with transparent, shatter-proof shields for inspection of the interior
- Protection of vulnerable meter components without fuses
- Metering modules cover the complete range of measurements required with a minimum number of meters
- Machines may be joined with a hard rubber coupling device and patented locking fastener designed to eliminate vibrations
- Several combinations of machines can be studied simultaneously

Simulation of high-power machines
The rotating machines have a specifically high inertia to simulate high-power machines. In addition, all machines are equipped with search coils through which the magnetic flux distribution at various locations in the machine can be observed using an oscilloscope. Each 2-kW rotating machine in the training systems is permanently mounted on a mobile cart, and includes a double-extension shaft terminated with geared-type flanges. Different machines may be joined with a hard rubber coupling device and patented locking fastener designed to eliminate vibrations. Any combination of machines may be studied simultaneously.

Comprehensive courseware
The courseware consists of student manuals that guide students through the experiments and provide the necessary theoretical background to successfully complete the educational objectives. The instructor can select the experiments that will satisfy the objectives of technical courses or university programs. The flexibility of this system allows students to act on their own initiative during laboratory sessions.

Optional modules
In addition to the included hardware with the systems, optional modules and devices are available to expand learning possibilities:
- 2-kW Four-Quadrant Dynamometer
- 2-kW IGBT Chopper/Inverter
- 2-kW Power Thyristors
- Data Acquisition and Control Interface

2-kW Four-Quadrant Dynamometer

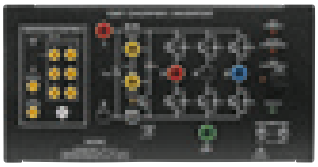
LabVolt Series 8540

This device can act as a prime mover or as a dynamometer, depending on user preference, and it can easily be coupled to any motor and generator from the 2-kW product line.

The Four-Quadrant Dynamometer consists of a squirrel-cage induction motor with an encoder feedback. The motor is driven by a closed-loop vector drive which is coupled to a touch-screen Human-Machine Interface (HMI). This interface enables the user to select the mode of operation (speed or torque) and to set either the speed (r/min) and direction or the output torque (N·m or lb·ft) of the machine. The interface displays the main parameters of operation in real-time (voltage, current, torque, speed, and frequency). Open-source software drivers are available to integrate it in specific research setups.

Electrical connections between the vector drive and the motor are made through jumpers on the front panel. This makes the separation of both components simple and allows the motor or the vector drive to be used independently in other experimentations.

	en	es	fr
120V/60Hz			
	586731	**586732**	
220V/50Hz			
	586733		
240V/50Hz			
	586734		

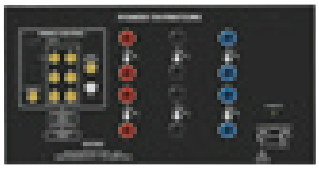


2-kW IGBT Chopper/Inverter

LabVolt Series 8857-1

This module consists of 7 insulated-gate bipolar transistors (IGBT) mounted in a half-size EMS module. Six IGBTs are used to implement choppers and inverters. These IGBTs are protected against a variety of severe operating conditions, such as short-circuits, overvoltage, overcurrent, and overheat. The seventh IGBT and an external dumping resistor allow smooth dissipation of excess energy at the DC bus. The module switching control section allows 0/5 V pulse signals from either the Data Acquisition and Control Interface, LabVolt Series 9063, the Chopper / Inverter Control Unit, LabVolt Series 9029, or any compatible 0/5 V control unit, to be applied to the gating circuits of the IGBTs.

	en	es	fr
120V/60Hz			
	586829	**586831**	**586830**
220V/50Hz			
	586832		
240V/50Hz			
	586828		



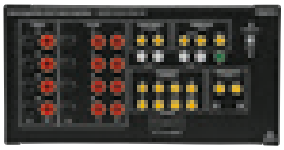
2-kW Power Thyristors

LabVolt Series 8861

This module consists of six power thyristors (SCRs) mounted in a half-size EMS enclosure. Each individual thyristor is protected against overcurrents and short-circuits. All the anodes and cathodes of the thyristors are terminated on the front panel by color-coded, 4 mm safety banana jacks. To reduce the number of external connections, the most typical thyristor configurations can be achieved using two toggle switches on the front panel.

A firing control section allows six 0-5 V pulse signals from either the Data Acquisition and Control Interface, LabVolt Series 9063, the Thyristor Firing Unit, LabVolt Series 9030, or any compatible 0-5 V control unit, to be applied to the gating circuits of the thyristors.

	en	es	fr
120V/60Hz			
	586833	**586834**	
220V/50Hz			
	586835		
240V/50Hz			
	586836		



Data Acquisition and Control Interface

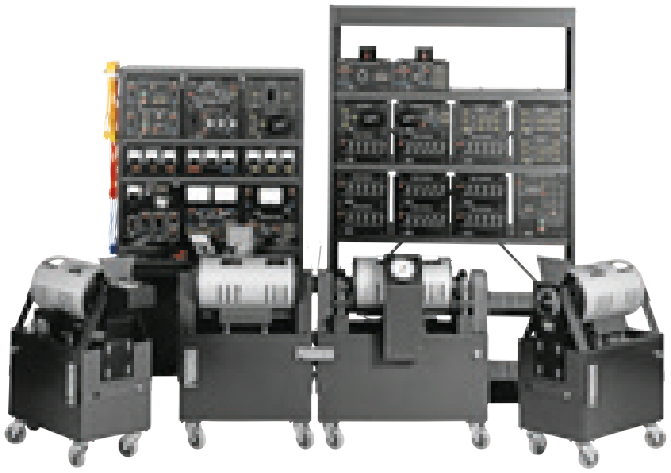
LabVolt Series 9063

The Data Acquisition and Control Interface (DACI) is a versatile USB peripheral used for measuring, observing, analyzing, and controlling electrical and mechanical parameters in electric power systems and power electronics circuits. For these purposes, a set of computer-based instruments as well as a variety of control functions are available for the DACI. These instruments and control functions are accessed through the LVDAC-EMS software.

Together, the DACI and the LVDAC-EMS software allow training in various areas such as electric power technology, ac/dc machines, renewable energy, transmission lines, and power electronics using modern and versatile measuring instruments and control functions. LVDAC-EMS also offers the possibility to use pre-built SCADA interfaces for several applications to ease the view and understanding of the process taking place.

See page 144 for more details.

2-kW EMS – Modularized



LabVolt Series 8013-1

Complete training system that covers the principles of power circuits, DC machines, and Transformers and AC machines.

Hardware included:
– 1x Mobile workstation
– 1x Storage Shelves
– 1x AC Voltmeter
– 1x DC Motor/Generator
– 1x Wiring Module for DC Motor/ Generator
– 1x Four-Pole Squirrel-Cage Induction Motor, 2 kW
– 1x Wiring Module for Squirrel-Cage Induction Motor
– 1x Three-Phase Wound-Rotor Induction Motor, 2 kW
– 1x Wiring Module for Wound-Rotor Induction Motor
– 1x Synchronous Motor/Generator
– 1x Wiring Module for Synchronous Motor/Generator
– 3x Resistive Load, 2 kW
– 3x Inductive Load, 2 kW
– 3x Capacitive Load, 2 kW
– 3x Single-Phase Transformer, 2 kW
– 1x DC Voltmeter/Ammeter
– 1x AC Ammeter Module, 2 kW
– 1x Wattmeter/Varmeter
– 1x DC Breaker, 2 kW
– 1x Synchronizing Module, 2 kW
– 1x Manual DC Motor Starter
– 1x Synchronous Motor Starter, 2 kW
– 1x Three-Phase Full-Voltage Starter, 2 kW
– 1x Three-Phase Rheostat, 2kW
– 1x Three-Phase Power-Factor Meter, 2kW
– 2x Field Rheostat, 2 kW
– 1x Variable Power Supply
– 1x Automatic DC Motor Starter
– 1x Digital Tachometer
– 1x Speed Sensor/Tachometer
– 2x Couplers
– 1x Digital Multimeter
– 1x Connection lead set

Included student manuals:
– Power Circuits
– DC Machines
– Transformers and AC Machines

Refer to the following systems for more details regarding the content of each workbook.

	en	es	fr
120V/60Hz	**587305**	**587307**	**587306**
220V/50Hz	**587308**	**587310**	**587309**
240V/50Hz	**587304**		

2-kW EMS – Power Circuits

LabVolt Series 8013-2

Training system that covers the principles of power circuits.

Hardware included:
– 1x Mobile workstation
– 1x Storage Shelves
– 1x AC Voltmeter
– 3x Resistive Load, 2 kW
– 3x Inductive Load, 2 kW
– 3x Capacitive Load, 2 kW
– 1x DC Voltmeter/Ammeter
– 1x AC Ammeter Module, 2 kW
– 1x Wattmeter / Varmeter
– 1x Synchronizing Module, 2 kW
– 1x Variable Power Supply
– 1x Digital Multimeter
– 1x Connection lead set

Included with this system:

Workbook – Power Circuits
The exercises in the workbooks contain the theory and lab exercises covering the following topic coverage:
– Series and Parallel Equivalent Resistances
– Resistances in Parallel
– Resistances in Series and in Series-Parallel
– Safety and the Power Supply
– Ohm's Law
– Circuit Solution
– Power in DC Circuits
– The Transmission Line
– AC Voltage and Current Measurement
– The Wattmeter
– Phase Angle, Real and Apparent Power Capacitive Reactance
– Inductive Reactance
– Watt, Var, Volt-Ampere and Power Factor
– Vectors and Phasors – Series Circuits
– Vectors and Phasors – Parallel Circuits
– Impedance
– Three-Phase Circuits
– Active, Reactive and Apparent Power in Three-Phase Circuits
– Three-Phase Power Measurement
– Phase Sequence

	en	es	fr
120V/60Hz	**587312**	**587314**	**587313**
220V/50Hz	**587315**	**587317**	**587316**
240V/50Hz	**587311**		

Power Circuits (Student Manual)

	en	es	fr
120V/60Hz	**583932**	**583933**	
220–240V/50Hz	**583934**		**583935**

2-kW EMS – DC Machines

LabVolt Series 8013-3

Training system that covers the principles of DC machines.

Hardware included:
– 1 x Mobile workstation
– 1 x Storage Shelves
– 1 x AC Voltmeter
– 1 x DC Motor/Generator
– 1 x Wiring Module for DC Motor/ Generator
– 1 x Synchronous Motor/Generator
– 1 x Wiring Module for Synchronous Motor/Generator
– 3 x Resistive Load, 2 kW
– 1 x DC Voltmeter/Ammeter
– 1 x AC Ammeter Module, 2 kW
– 1 x Manual DC Motor Starter
– 1 x Synchronous Motor Starter, 2 kW
– 2 x Field Rheostat, 2 kW
– 1 x Variable Power Supply
– 1 x Coupler
– 1 x Connection lead set

Included with this system:

Workbook – DC Machines
The exercises in the workbooks contain the theory and lab exercises covering the following topic coverage:
– Prime Mover Torque Measurement
– The Direct Current Motor
– The DC Shunt Motor
– The DC Series Motor
– The DC Compound Motor
– The Separately-Excited DC Shunt Generator
– The Self-Excited DC Shunt Generator
– The DC Compound Generator
– DC Motor Starter

DC Machines (Student Manual)

	en	es	fr
120V/60Hz			
	583937	**583938**	
220–240V/50Hz			
	583939		**583940**

	en	es	fr
120V/60Hz	**587319**	**587321**	**587320**
220V/50Hz	**587322**	**587324**	**587323**
240V/50Hz	**587318**		

2-kW EMS – Transformers and AC Machines

LabVolt Series 8013-4

Training system that covers the principles of transformers and AC machines

Hardware included:
Please refer to the list of hardware included with the 2-kW EMS – Modularized.

Included with this system:

Workbook – Transformers and AC Machines
The exercises in the workbooks contain the theory and lab exercises covering the following topic coverage:
– The Single-Phase Transformer
– Transformer Polarity
– Transformer Regulation
– The Autotransformer
– Transformers in Parallel
– The Distribution Transformer
– Three-Phase Transformer Connections
– Prime Mover and Torque Measurement
– The Wound-Rotor Induction Motor
– The Squirrel Cage Induction Motor
– The Synchronous Motor
– The Three-Phase Alternator
– The Alternator Under Load
– Alternator Synchronization
– Alternator Power
– Three-Phase Motor Starters
– Frequency Conversion
– Reactance and Frequency
– Selsyn Control

Transformers and AC Machines (Student Manual)

	en	es	fr
120V/60Hz			
	583941		
220–240V/50Hz			
	583942		**583943**

	en	es	fr
120V/60Hz	**587326**	**587328**	**587327**
220V/50Hz	**587329**	**587331**	**587330**
240V/50Hz	**587325**		

0.2-kW Electromechanical Training Systems (EMS)

Electric power technology through laboratory observations using analog meters

LabVolt Series 8001

The 0.2-kW Electromechanical Training System (EMS) is based on an approach to teaching electric power technology through laboratory observations. The program, presented in four subsystems, deals with the different techniques associated with the generation and use of electrical energy. The subsystems cover the common machines, and each subsystem is offered with its courseware presented in a student manual.

Each subsystem is available as a package that consists of the equipment necessary to perform the laboratory exercises presented in the correlated student manual.

Highlights

- Cutaway bell housings to permit visual inspection of the internal construction and observation of the machine during operation
- The shaft of each machine has a concave and slotted end to facilitate the use of tachometers, holding brakes, plugging switches, or inertia wheels
- Metering modules are designed to cover the complete range of required measurements with a minimum number of meters
- System conception and load components simplify calculations required in the learning process
- Safe: all live parts of the plugs are concealed and insulated

Carefully designed

The systems give instructors complete versatility. They were developed by educators to satisfy educational requirements that include industrial applications of electric power technology. The design objective was to develop a low-power (0.2 kW or ¼ hp) educational system with equipment that operates like industrial equipment.

Through careful attention to engineering detail, the systems provide laboratory results that are easy to understand, with data values that are easily observed. The data, when applied to formulas, provides results that verify electrical laws rather than deny them because of large operational tolerance errors.

Comprehensive courseware

Laboratory manuals guide students step-by-step through the experiments and provide the necessary theoretical background to allow students to successfully complete the educational objectives. These manuals contain experiments that correlate with the training equipment for hands-on involvement with the subject matter.

The instructor can select the experiments that will satisfy the objectives of technical courses or university programs. The flexibility of the training systems allows students to use their own initiative during the laboratory sessions. Under the direction of an instructor, students can gain the required competencies for successful employment.

0.2-kW EMS – Modular

LabVolt Series 8001-1

The 0.2 kW EMS – Modular Training System is complete and supported by student manuals for all four subsystems. The subsystems – Power Circuits, DC Machines, Single-Phase Transformer and AC Machines, and Three-Phase Transformer and AC Machines – cover the common machines, and are offered with corresponding courseware.

Hardware included:
– 1x Mobile Workstation
– 1x Storage Shelves
– 1x DC Motor/Generator
– 1x Four-Pole Squirrel-Cage Induction Motor
– 1x Three-Phase Wound-Rotor Induction Machine
– 1x Synchronous Motor/Generator
– 1x Capacitor-Start Motor
– 1x Capacitor-Run Motor
– 1x Universal Motor
– 1x Resistive Load
– 1x Inductive Load
– 1x Capacitive Load
– 3x Fully Protected Transformer
– 1x DC Voltmeter/Ammeter
– 1x AC Ammeter
– 1x AC Voltmeter
– 1x Single-Phase Wattmeter
– 1x Three-Phase Wattmeter
– 1x Synchronizing Module
– 1x Manual DC Motor Starter
– 1x Synchronous Motor Starter
– 1x Three-Phase Full-Voltage Starter
– 1x Three-Phase Rheostat
– 1x Power Supply
– 1x Electrodynamometer, Imperial Units
– 1x Digital Tachometer
– 1x Timing Belt
– 1x Digital Multimeter
– 1x Connection Lead Set
– 1x Thyristor Speed Controller

Manuals included:
– Power Circuits
– DC Machines
– Single-Phase Transformers and AC Machines
– Three-Phase Transformers and AC Machines
– See the next pages for order numbers.

	en	es	fr
120V/60Hz	**587243**	**587245**	**587244**
220V/50Hz	**587246**	**587248**	**587247**
240V/50Hz	**587242**		

0.2-kW EMS – Power Circuits

LabVolt Series 8001-2

Training system that covers the principles of power circuits.

Hardware included
– 1x Mobile Workstation
– 1x Storage Shelves
– 1x Resistive Load
– 1x Inductive Load
– 1x Capacitive Load
– 1x DC Voltmeter/Ammeter
– 1x AC Ammeter
– 1x AC Voltmeter
– 1x Single-Phase Wattmeter
– 1x Three-Phase Wattmeter
– 1x Synchronizing Module
– 1x Power Supply
– 1x Digital Multimeter
– 1x Connection Lead Set

Included with this system:

Workbook — Power Circuits
The exercises in the workbooks contain the theory and lab exercises covering the following topic coverage:
– Series and Parallel Equivalent
– Resistances
– Resistances in Parallel
– Resistances in Series and in Series-Parallel
– Safety and the Power Supply
– Ohm's Law
– Circuit Solution
– Power in DC Circuits
– The Transmission Line
– AC Voltage and Current
– The Wattmeter
– Phase Angle, Active, and Apparent Power
– Capacitive Reactance
– Inductive Reactance
– Watt, Var, Volt-Ampere, and Power Factor
– Vectors and Phasors – Series Circuit
– Vectors and Phasors – Parallel Circuits
– Impedance
– Three-Phase Circuits
– Three-Phase Watts, Vars, and Volt-Amperes
– Three-Phase Power Measurement
– Phase Sequence

Power Circuits (Student Manual)

	en	es	fr
120V/60Hz			
	583899	**583900**	
220V/50Hz			
	583901		
240V/50Hz			
	583906		

	en	es	fr
120V/60Hz	**587250**	**587252**	**587251**
220V/50Hz	**587253**	**587255**	**587254**
240V/50Hz	**587249**		

0.2-kW EMS – DC Machines

LabVolt Series 8001-3

Partial training system that covers the principles of DC machines.

Hardware included
– 1x Mobile Workstation
– 1x Storage Shelves
– 1x DC Motor/Generator
– 1x Synchronous Motor/Generator
– 1x Resistive Load
– 1x DC Voltmeter/Ammeter
– 1x AC Ammeter
– 1x AC Voltmeter
– 1x Manual DC Motor Starter
– 1x Power Supply
– 1x Electrodynamometer, Imperial Units
– 1x Digital Tachometer
– 1x Timing Belt
– 1x Connection Lead Set
– 1x Thyristor Speed Controller

Included with this system:

Workbook — DC Machines
The exercises in the workbooks contain the theory and lab exercises covering the following topic coverage:
– Safety and the Power Supply
– Prime Mover and Torque Measurement
– The Direct Current Motor
– The DC Shunt
– The DC Series Motor
– The DC Compound Motor
– The DC Separately Excited Shunt Generator
– The DC Self Excited Shunt Generator
– The DC Compound Generator
– DC Motor Starter
– Thyristor Speed Controller
– Thyristor Speed Controller with Regulation

DC Machines (Student Manual)

	en	es	fr
120V/60Hz	**583909**	**583910**	
220V/50Hz	**583911**		
240V/50Hz	**583912**		

	en	es	fr
120V/60Hz	**587257**	**587259**	**587258**
220V/50Hz	**587260**	**587262**	**587261**
240V/50Hz	**587256**		

0.2-kW EMS – Single-Phase Transformers and AC Machines

LabVolt Series 8001-4

Training system that covers the principles of transformers and AC machines

Hardware included:
– 1x Mobile Workstation
– 1x Storage Shelves
– 1x Capacitor-Start Motor
– 1x Capacitor-Run Motor
– 1x Universal Motor
– 1x Resistive Load
– 1x Inductive Load
– 1x Capacitive Load
– 2x Fully Protected Transformer
– 1x DC Voltmeter/Ammeter
– 1x AC Ammeter
– 1x AC Voltmeter
– 1x Single-Phase Wattmeter
– 1x Power Supply
– 1x Electrodynamometer, Imperial Units
– 1x Digital Tachometer
– 1x Timing Belt
– 1x Digital Multimeter
– 1x Connection Lead Set

Included with this system:

Workbook — Single-Phase Transformers and AC Machines
The exercises in the workbooks contain the theory and lab exercises covering the following topic coverage:
– Safety and the Power Supply
– The Single-Phase Transformer
– Transformer Polarity
– Transformer Regulation
– The Autotransformer
– Transformers in Parallel
– The Distribution Transformer
– Prime Mover and Torque Measurement
– The Split-Phase Inductor Motor
– The Capacitor-Start Motor
– The Capacitor-Run Motor
– The Universal Motor

Single-Phase Transformers and AC Machines (Student Manual)

	en	es	fr
120V/60Hz	**583913**	**583914**	
220V/50Hz	**583915**		
240V/50Hz	**583916**		

	en	es	fr
120V/60 Hz	**587264**	**587266**	**587265**
220V/50 Hz	**587267**	**587269**	**587268**
240V/50 Hz	**587263**		

0.2-kW EMS – Three-Phase Transformers and AC Machines

LabVolt Series 8001-5

Training system that covers the principles of transformers and AC machines:

Hardware included
– 1x Mobile Workstation
– 1x Storage Shelves
– 1x DC Motor/Generator
– 1x Four-Pole Squirrel-Cage Induction Motor
– 1x Three-Phase Wound-Rotor Induction Machine
– 1x Synchronous Motor/Generator
– 1x Resistive Load
– 1x Inductive Load
– 1x Capacitive Load
– 3x Fully Protected Transformer
– 1x DC Voltmeter/Ammeter
– 1x AC Ammeter
– 1x AC Voltmeter
– 1x Three-Phase Wattmeter
– 1x Synchronizing Module
– 1x Synchronous Motor Starter
– 1x Three-Phase Full-Voltage Starter
– 1x Three-Phase Rheostat
– 1x Power Supply
– 1x Electrodynamometer, Imperial Units
– 1x Digital Tachometer
– 1x Timing Belt
– 1x Connection Lead Set

Included with this system:

Workbook — Three-Phase Transformers and AC Machines
The exercises in the workbooks contain the theory and lab exercises covering the following topic coverage:
– Safety and the Power Supply
– Three-Phase Transformer Connections
– Prime Mover and Torque Measurement
– The Wound-Rotor Induction Motor
– The Squirrel-Cage Induction Motor
– The Synchronous Motor
– The Three-Phase Alternator
– The Alternator Under Load
– Alternator Synchronization
– Alternator Power
– Three-Phase Motor Starter
– Frequency Conversion
– Reactance and Frequency
– Selsyn Control

Three-Phase Transformers and AC Machines
Student Manual

	en	es	fr
120V/60Hz			
	583917	**583918**	
220V/50Hz			
	583919		
240V/50Hz			
	583920		

	en	es	fr
120V/60Hz	**587271**	**587273**	**587272**
220V/50Hz	**587274**	**587276**	**587275**
240V/50Hz	**587270**		

0.2-kW EMS – Electro-mechanical Training System

LabVolt Series 8001-6

Modular instructional program designed to teach electric power technology through laboratory observations.

Hardware included:
– 1x Mobile Workstation
– 1x Storage Shelves
– 1x DC Motor/Generator
– 1x Four-Pole Squirrel-Cage Induction Motor
– 1x Three-Phase Wound-Rotor Induction Machine
– 1x Synchronous Motor/Generator
– 1x Capacitor-Start Motor
– 1x Capacitor-Run Motor
– 1x Universal Motor
– 2x Resistive Load
– 1x Inductive Load
– 2x Capacitive Load
– 3x Fully Protected Transformer
– 1x DC Voltmeter/Ammeter
– 1x AC Ammeter
– 1x AC Voltmeter
– 1x Single-Phase Wattmeter
– 1x Three-Phase Wattmeter
– 1x Synchronizing Module
– 1x Three-Phase Rheostat
– 1x Power Supply
– 1x Electrodynamometer, Imperial Units
– 1x Digital Tachometer
– 1x Timing Belt
– 1x Connection Lead Set
– 1x Thyristor Speed Controller

Included with this system:

Workbook — Investigation in Electric Power Technology
This 65-experiment laboratory manual includes exercises such as:
– Resistances in Parallel, in Series, and in Series-Parallel
– Power in DC Circuits
– The Transmission Line
– Prime Mover and Torque Measurement
– DC Shunt Motor, DC Series Motor and DC Compound Motor
– DC Separately Excited Shunt Generator and DC Self-Excited Shunt Generator
– And many more

Investigation in Electric Power Technology
Student Manual

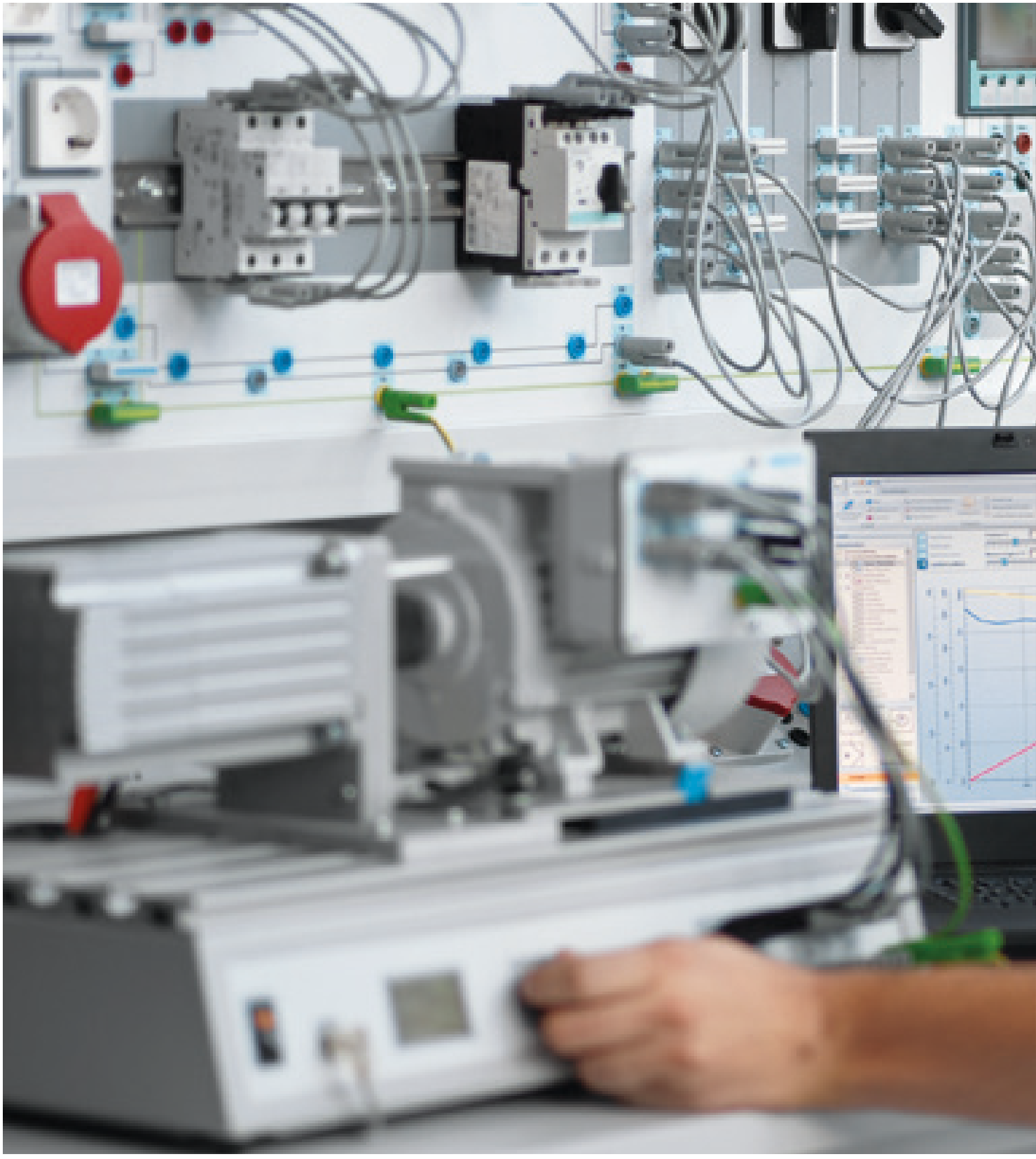
	en	es	fr
120 V/60Hz			
	583758	**583760**	**583880**
220 V/50Hz			
	583881	**583883**	**583885**
240 V/50Hz			
	583762		

Instructor Guide

	en	es	fr
120 V/60Hz			
	583759	**583761**	
220 V/50Hz			
	583882	**583884**	**583764**
240 V/50Hz			
	583763		

	en	es	fr
120V/60Hz	**587278**	**587280**	**587279**
220V/50Hz	**587281**	**587283**	**587282**
240V/50Hz	**587277**		

Industrial Motor Controls



Training Systems

Equipment Sets

CE

Some training solutions included in this product guide do not have a CE mark and cannot be ordered for delivery to Europe.

If you are located in a country where this marking is required, please contact your Festo sales representative before placing an order.

Industrial Controls Training Systems

Theory and techniques of electric motor controllers

LabVolt Series 8036

The Industrial Controls Training Systems are designed to teach the theory and techniques of electric motor controllers. They allow students to select and mount control devices to form typical control circuits, and to troubleshoot them once a fault is inserted. The modularity of the systems offers unique controls training possibilities.

The Industrial Controls Training Systems comprise four basic systems, each covering a specific topic that deals with various aspects of industrial controls equipment operation.

- Basic Controls (8036-1) provides students with a complete basic training in motor controls.
- Programmable Logic Controller (8036-2) introduces students to PLCs for motor operation control.
- Motor Drives (8036-3) introduces students to dc and ac drives.
- Sensors (8036-4) introduces students to photoelectric and proximity switches.

The control devices and motors in the 8036 Series are of standard industrial quality. Device designations can be added to each module with magnetic labels. Each module is equipped with up to four faults that can be inserted by the instructor using switches hidden behind the faceplate. Typical faults include open coils and contacts, dirty contacts, shorted connection, and crossed wires.

Courseware

The Industrial Controls Training Systems courseware consists of student manuals and instructor guides. The student manuals are divided into several units, each consisting of a series of hands-on exercises dealing with a particular topic of industrial controls. Each exercise provides a clearly stated objective, a discussion, an exercise procedure, a summary, and a set of review questions.

An additional ten-question test at the end of each unit allows the student to verify what was learned in the unit. The instructor guides contain the practical results and the answers for each hands-on exercise in the student manuals. They also contain the answers to the unit test questions

Integration into Electromechanical Training Systems

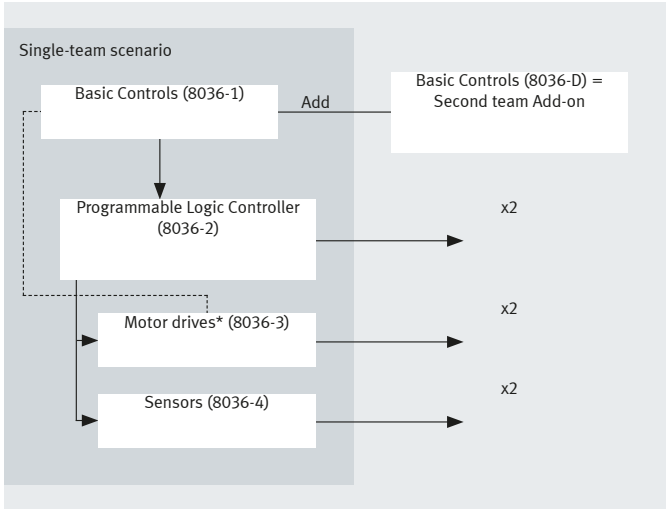
The Industrial Controls Training Systems can be integrated into the 0.2-kW Electromechanical Training Systems (LabVolt Series 8001 and 8006, see www.labvolt.festo.com), using the workstation and power supply provided with these systems.

Highlights
- Extensive array of modules makes it possible to create setups filling many training needs
- Wide variety of modules representative of control components found in the industry
- Electrical connections between the modules mirror real-life connections
- Comprehensive curriculum
- Safety features such as a lockable cut-out switch, a tagout device, and banana plug leads
- Insertion of faults to teach troubleshooting
- Sturdy, mobile, two-sided workstation
- Simulation software available

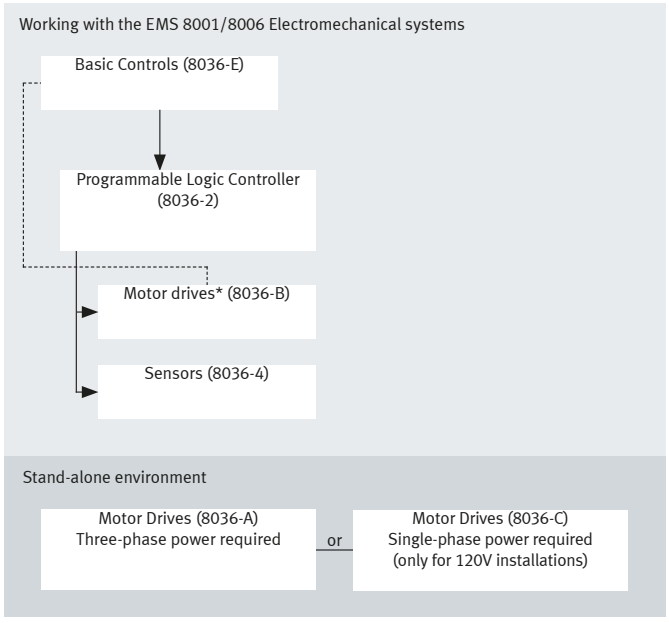
General training content
- Electric Motor Controls
- Circuit Layout and Specifications
- Basic Control Circuits
- Jogging Control Circuits
- Reduced AC Voltage Starters
- Controls with Electronic Devices
- AC and DC Drive Controls
- Programmable Logic Controllers
- Sensors
- Troubleshooting

Different learning scenarios
The modularity of the Industrial Controls Training Systems allows instructors to build a customized solution. The flowcharts describe different possible learning scenarios and how they supplement each other for one or two teams of students, with several options.

Two-team scenario (standard environment)



Other possible scenarios



* Note: Please check with your sales representative if you want to use Motor Drives as a direct add-on to Basic Controls, or if you want to order a system independent of its prerequisite system(s).

Basic Systems

Basic Industrial Controls Training System

1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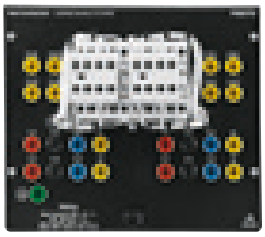

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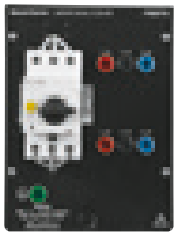

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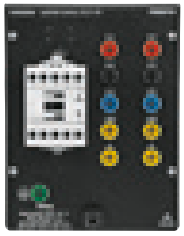

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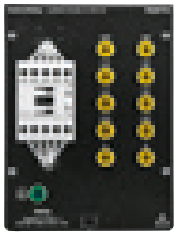

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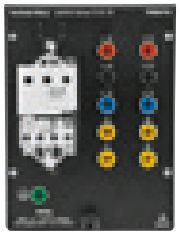

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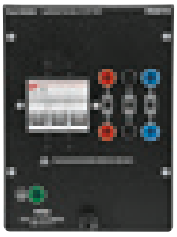

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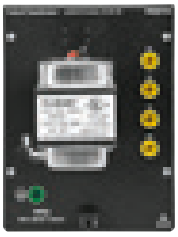

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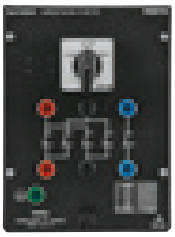

11


12


LabVolt Series 8036-1

Training content

– Basic Principles of Electric Motor Control (Lockout/tagout, control devices, starters, relays and contactors, protection)
– Circuit Layout and Specifications
– Basic Control Circuits (Two- and three-wire control, manual starter, reversing starters, multiple push buttons)
– Jogging Control Circuits
– Reduced AC Voltage Starters (Starting resistors, soft starters)
– Time Relay Circuits (Time relays, plugging circuits, starting resistors)
– Troubleshooting

	en	es	fr
120V/60Hz	**581502**	**581503**	
220V/50Hz	**581504**		**581505**
240V/50Hz	**581506**		
220V/60Hz	**581507**	**581508**	

If your country's voltage/frequency configuration, does not appear here, please contact your sales representative to check if available.

Main components at a glance:*	en	es	fr
1x Industrial Controls Mobile Workstation	581240	581240	
2x Push Buttons	581244	581246	
1x Selector Switches	581247	581249	
1x Emergency Button	581252	581254	
1 2x Pilot Lights	581255	581257	
2 1x Dual Contactors	581263	581265	
1x Lockout Module	581267	581269	
3 1x Three-Phase Manual Starter	581271	581273	
4 1x Contactor	581278	581280	
5 1x Control Relay	581289	581291	
6 1x Overload Relay	581295	581297	
7 1x Time-Delay Relay	595976	595978	
8 1x Three-Pole Fuse Holder	581305	581307	
9 1x Control Transformer	581309	581311	
10 1x Cam Switch	581320	581322	
1x Inertia Wheel	581327	581327	
11 1x Starting Resistors	581329	581331	
12 1x Brake Motor	581341	581341	
1x Soft Starter	581361	581363	
1x AC Power Supply	581365	581367	
1x Connection Lead and Accessory Set	581429	581429	
1x Fuses	582126	582126	
1x Magnetic Labels	582140	582140	

*Note: Order numbers provided for 120V/60Hz. For other configurations, please contact us.

Manuals included

Basic Controls	en	es	fr
1x Student Manual	603859	603860	
1x Instructor Guide	603861	603861	
Troubleshooting			
1x Student Manual	580480	580481	
1x Instructor Guide	580482	580483	

Note: PDF version also available.

Required equipment

1x Digital tachometer	581427
1x Stopwatch	781371
1x Multimeter	579782

Optional equipment

1x Basic Controls Training System, Second Team, Add-On (8036-D)	see page 191

Programmable Logic Controller Training System

LabVolt Series 8036-2

Training content

– Programmable Logic Controller – PLC
  Control relay functions, boolean logic, timing relays, counter, comparator)
– PLC Control Circuits
  (Interfacing voltages, motor starters with jogging, reversing starters)
– Troubleshooting

	en	es	fr
Order no.	**581509**	**581510**	

For all country voltage/frequency configurations

Main components at a glance:*	en	es	fr
1 2x Switches	581250	581251	
2 1x Pilot Lights 24 V DC	581261	581262	
3 1x Programmable Logic Controller	581285	581286	
4 1x Interposing Relays	581287	581288	
5 1x DC Power Supply	581318	581319	
1x Connection Lead Set	581430	581430	581430

Note: Order numbers provided for 120V/60Hz. For other configurations, please contact us.

Manuals included

Programmable Logic Controller	en	es	fr
1x Student Manual	580464	580465	
1x Instructor Guide	580466	580467	
Troubleshooting			
1x Student Manual	580480	580481	
1x Instructor Guide	580482	580483	

Note: PDF version also available.

Required equipment

Refer to flowchart on page 185 for prerequisites depending on the working environment

1


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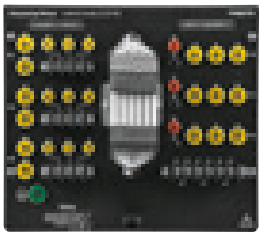

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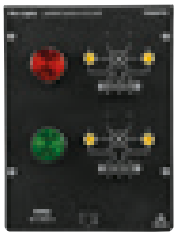


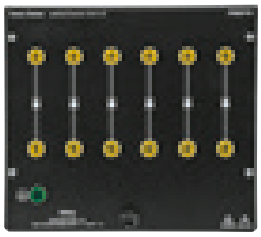
5


3


Basic Systems

Motor Drives Training System

1



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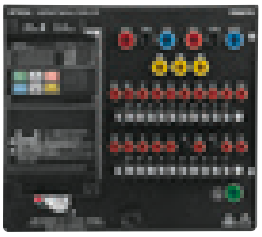

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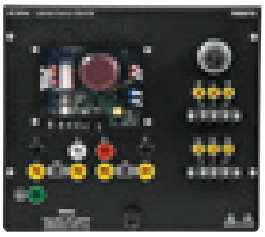


LabVolt Series 8036-3

Training content

– AC Drive
(overview, Volts per Hertz characteristics, ramp and torque boost, protection, braking, jogging, remote controls)
– DC Drive
(overview, speed control, current limiting, IR compensation)
– Troubleshooting

	en	es	fr
120V/60Hz	**581511**	**581512**	
220V/50–60Hz	**581513**	**581514**	
240V/50Hz	**581515**		

Main components at a glance:		en	es	fr
1	1x Power Diodes	581337	581339	
2	1x DC Motor (for 120V/60Hz networks)	581346	581346	
	1x DC Motor (for 220–240V/50-60Hz networks)	581347	581347	
3	1x AC Drive (for 120V/60Hz networks)	592522		
	1x AC Drive (for 220–230V/50–60Hz networks)	592523	581347	
4	1x DC Drive (for 120V/60Hz networks)	581356	581347	
	1x AC Drive (for 240V/50Hz networks)		592524	

Manuals included

Motor Drives	en	es	fr
1x Student Manual	593906		
1x Instructor Guide	593907		
Troubleshooting			
1x Student Manual	580480	580481	
1x Instructor Guide	580482	580483	

Note: PDF version also available.

Required equipment

Refer to flowchart on page 185 for prerequisites depending on the working environment

Sensors Training System

LabVolt Series 8036-4

Training content
– Photoelectric Sensors
(Background supression, polarize retroreflective)
– Proximity Switches
(Capacitive and inductive)
– Mechanical Limit Switches

	en	es	fr
Order no.	**581516**	**581517**	

For all country voltage/frequency configurations

Main components at a glance:

1	1x Limit Switch	581328
2	1x Background Suppression Photoelectric Switch	582361
3	1x Polarized Retroreflective Photoelectric Switch	582362
4	1x Inductive Proximity Switch	582363
5	1x Capacitive Proximity Switch	582364
	1x Reflective Block	582366
	1x Plastic Bottle	764073
	1x Tool Rotating Knob	582164

Manual included

Sensors	en	es	fr
1x Student Manual	580470	580471	
1x Instructor Guide	580472	580473	

Note: PDF version also available.

Required equipment
Refer to flowchart on page 185 for prerequisites depending on the working environment

1


4


2


5


3


Variants of Basic Systems

Motor Drives Training System Stand-Alone

LabVolt Series 8036- A

The Motor Drives Training System is a complete stand-alone system that allows students to perform the same exercises as in the Motor Drives Training System. The system is designed to be used directly on a tabletop.

	en	es	fr
120V/60Hz	**581518**	**592562**	
220V/50Hz	**581519**		
220V/60Hz	**581521**		
240V/60Hz	**581520**		

Main components at a glance:
- 1x Industrial Controls Tabletop Workstation
- 2x Switches
- 1x Emergency Button
- 1x Pilot Lights 24 V dc
- 1x Three-Phase Manual Starter
- 1x Control Relay
- 1x Control Transformer
- 1x Cam Switch
- 1x Inertia Wheel
- 1x Starting Resistors
- 1x Power Diodes
- 1x Machine Mounting Plate
- 1x Brake Motor
- 1x DC Motor
- 1x AC Drive
- 1x DC Drive
- 1x AC Power Supply
- 1x Connection Lead and Accessory Set
- 1x Magnetic Labels

Manual included

Motor Drives	en	es	fr
1x Student Manual	593902		
1x Instructor Guide	593903		

Note: PDF version also available.

Motor Drives Training System Second Team Add-On

LabVolt Series 8036-B

The Motor Drives Training System is an add-on to the Electromechanical Training System, LabVolt Series 8001 or 8006, that allows students to perform the same exercises as in the Motor Drives Training System (8036-3).

	en	es	fr
120V/60Hz	**581522**		
220V/50-60Hz	**581523**	**581524**	
240V/50Hz	**581525**		

Main components at a glance:
- 1x Industrial Controls Single-Rail Workstation
- 1x Switches
- 1x Pilot Lights 24 V dc
- 1x AC Drive
- 1x DC Drive
- 1x Connection Lead Set
- 1x Magnetic Labels

Manual included

Motor Drives	en	es	fr
1x Student Manual	593904		
1x Instructor Guide	593905		

Note: PDF version also available.

Motor Drives Training System Stand-Alone

LabVolt Series 8036-C

The Motor Drives Training System is an alternative version of the Motor Drives Training System (8036-A) that is designed to operate at a voltage and frequency of 120 V and 60 Hz. Both the DC and the AC drives are connected directly to a wall outlet. This system is only available for 120V/60 Hz networks.

	en	es	fr
120V/60Hz	**581526**	**587370**	

Main components at a glance:
- 1x Industrial Controls Tabletop Workstation
- 2x Switches
- 1x Emergency Button
- 1x Pilot Lights 24 V DC
- 1x Three-Phase Manual Starter
- 1x Control Relay
- 1x Control Transformer
- 1x Cam Switch
- 1x Inertia Wheel
- 1x Starting Resistors
- 1x Power Diodes
- 1x Machine Mounting Plate
- 1x Brake Motor
- 1x DC Motor
- 1x AC Drive
- 1x DC Drive
- 1x Connection Lead and Accessory Set
- 1x Magnetic Labels
- 2x Power Cord

Manual included

Motor Drives	en	es	fr
1x Student Manual	593902	595134	
1x Instructor Guide	593903	595135	

Note: PDF version also available.

Required equipment

Refer to flowchart on page 185 for prerequisites depending on the working environment

Motor Drives Training System Second Team Add-On

LabVolt Series 8036-D

The Basic Controls Training System is designed to be used with the Industrial Controls Mobile Workstation. It contains all the equipment necessary for a second team to perform the exercises in the Basic Controls Training System, without unnecessary duplication of the equipment that can be shared by the first team.

	en	es	fr
120V/60Hz	**581527**		
220V/50Hz	**581528**		
240V/50Hz	**587371**		
220V/60Hz	**581529**		

Main components at a glance:
- 2x Push Buttons
- 1x Selector Switches
- 1x Emergency Button
- 2x Pilot Lights
- 1x Dual Contactors
- 1x Lockout Module
- 1x Three-Phase Manual Starter
- 1x Contactor
- 1x Control Relay
- 1x Overload Relay
- 1x Time-Delay Relay
- 1x Three-Pole Fuse Holder
- 1x Control Transformer
- 1x Cam Switch
- 1x Inertia Wheel
- 1x Starting Resistors
- 1x Brake Motor
- 1x Soft Starter
- 1x Connection Lead and Accessory Set
- 1x Fuses
- 1x Magnetic Labels

Manuals included

Basic Controls	en	es	fr
1x Student Manual	603859	603861	
1x Instructor Guide	603861	603862	
Troubleshooting			
1x Student Manual	580480	580481	
1x Instructor Guide	580482	580483	

Note: PDF version also available.

Variants of Basic Systems

Basic Controls Training System Add-On

LabVolt Series 8036-E

The Basic Controls Training System is an add-on to systems 8001 or 8006 that allows students to perform the same exercises in the Basic Controls Training System (8036-1) using the power supply, motors, and additional equipment provided with systems 8001 or 8006.

	en	es	fr
120V/60Hz	**581530**	**592563**	
220V/50Hz	**581531**	**581532**	
240V/50Hz	**581533**		
220V/60Hz	**581534**		

Main components at a glance:
- 1x Industrial Controls Double-Rail Workstation
- 2x Push Buttons
- 1x Selector Switches
- 1x Emergency Button
- 2x Pilot Lights
- 1x Dual Contactors
- 1x Lockout Module
- 1x Three-Phase Manual Starter
- 1x Contactor
- 1x Control Relay
- 1x Overload Relay
- 1x Time-Delay Relay
- 1x Three-Pole Fuse Holder
- 1x Control Transformer
- 1x Cam Switch
- 1x Starting Resistors
- 1x Brake Motor (EMS version)
- 1x Soft Starter
- 1x Connection Lead Set
- 1x Zero Friction Machine
- 1x Inertia Wheel

Manuals included

Basic Controls	en	es	fr
1x Student Manual	603855	603856	
1x Instructor Guide	603857	603858	
Troubleshooting			
1x Student Manual	580480	580481	
1x Instructor Guide	580482	580483	

Note: PDF version also available.

Workstations, Software

1 **Industrial Controls Mobile Workstation**

The Industrial Controls Mobile Workstation is a double-sided, mobile workstation on casters. It has an A-frame configuration, is constructed of steel, and can accommodate two student groups simultaneously. Four pairs of mounting rails hold the control modules firmly in place. Additional mounting rails underneath the work surface increase the workstation storage capability. The work surface and storage shelf are protected against scratches by a rubber carpet. Safety bars are attached to each rail of the Industrial Controls Mobile Workstation. These bars prevent students from removing modules during laboratory exercises. Padlocks are provided to lock the safety bars in place once all modules are inserted in the workstation.

Order no.	**581240**

2 **Industrial Controls Tabletop Workstation**

This Industrial Controls Tabletop Workstation consists of an inclined mounting rail designed to be placed on top of a regular table. One pair of mounting rails holds the control modules firmly in place. A safety bar is attached to the rail of the Industrial Controls Tabletop Workstation. This bar prevents students from removing modules during laboratory exercises. A padlock is provided to lock the safety bar in place once all modules are inserted in the workstation.

Order no.	**581242**

3 **Industrial Controls Single- or Double-rail Workstation**

The Industrial Controls Single- or Double-Rail Workstation consists of one or two mounting rails designed to be installed on top of the Workstation or the Mobile Workstation to facilitate interconnection between the Industrial Controls Training Systems and the Electric Power Technology Training Systems. A safety bar is attached to the rail of the Industrial Controls Single Rail Workstation. This bar prevents students from removing modules during laboratory exercises. A padlock is provided to lock the safety bar in place once all modules are inserted in the workstation.

Single rail	**581243**
Double rail	**585964**

4 **Industrial Controls Simulation Software**

The Industrial Controls Simulation Software features simulations of the components of the Industrial Controls Training Systems. The simulations allow students to complete all the exercises in the training system courseware on a computer without the need for any actual equipment. Note that the simulation software is specially designed to perform the exercises found in the courseware, and cannot be used to perform customized exercises.

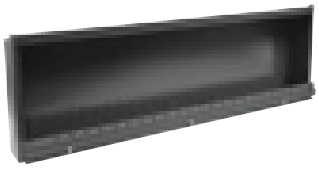
Site license (unlimited number of users)

	en	**es**
Order no.	**586017**	**586018**

1

2

3



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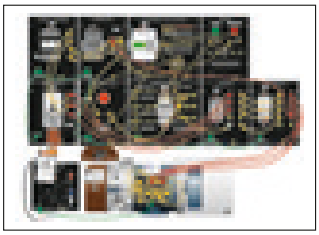


Variable-Frequency Drive Training System

Basic principles of VFDs and their motor applications

120V/60Hz	**592614**

Note: For other country voltage/frequency configurations, please contact your local sales representative for availability.

Manual included

Motor Control Using Variable-Frequency Drives

Student Manual, en	593895
Instructor Guide, en	593897

Note: PDF version also available.

LabVolt Series 3356

The Variable-Frequency Drive Training System is a state-of-the-art training system specifically designed to introduce students to the basic principles of variable-frequency drives (VFDs). It provides a comprehensive, high-quality, and cost-effective solution to rapidly build student knowledge in VFDs and their motor applications. It is designed for portability and powered using a standard single-phase AC outlet.

The Variable-Frequency Drive Training System comprises an advanced modern variable-frequency drive (Allen-Bradley PowerFlex 525), as well as an industrial low-power three-phase induction motor. All electrical and rotating components are easy to access and safe for student experimentation. A DC power supply provides power to the 24 V DC control components.

Courseware

Seven exercises progressively introduce students to variable-frequency drives and their more advanced functions. These experimentations reinforce the theoretical concepts and help students develop the skills necessary to work in the field of electricity. An exercise also introduces students to troubleshooting variable-frequency drives and their circuits.

Carrying case

The Variable-Frequency Drive Training System is contained in a sturdy, easy-to-transport carrying case. The carrying case is designed for maximal protection of the system components while still allowing easy transportation. The lid of the carrying case is fixed into place with durable plastic locks, but can be removed easily.

Highlights

- Introduction to all the important concepts of VFDs and three-phase induction motors
- Allen-Bradley PowerFlex 525 drive
- Easy access to components
- Built-in faults
- Rugged transportation and storage case

Main components

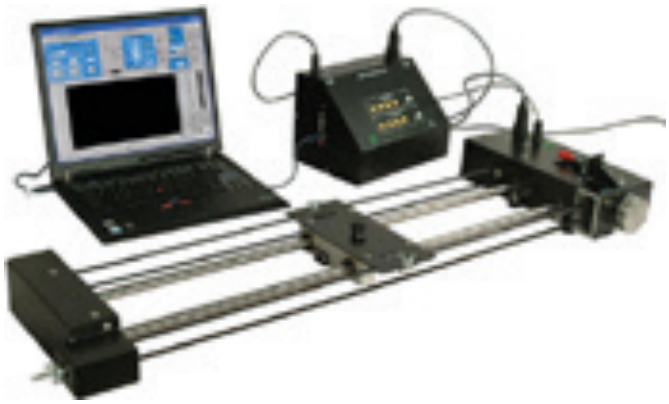
- Mounted on the front panel: variable-frequency drive (Allen-Bradley Powerflex 525), 14 inputs/outputs for the variable-frequency drive, AC induction motor, padlockable circuit breaker controlling main supply, 24 V DC power source, load pulley/brake disk, optical incremental encoder, magnetic brake, emergency stop and reset switch, four push-button switches, two selector switches, two indicator lights, variable DC signal source, Ethernet/IP coupler.
- Individual components that can be fixed to or stored in the case lid: connection leads set, tachometer, timing belt, digital multimeter, padlock and hasp, and tools.
- Six built-in faults that each can be individually inserted in the system using a toggle switch. These faults are designed to test and improve the troubleshooting skills of students

Training content

- Motor drives
- Three-phase induction motor characteristics and operation
- VFD characteristics and operation
- VFD control circuits and advanced functions, such as acceleration and deceleration, motor braking, jogging, and protection
- VFD load types/control methods
- VFD installation, maintenance, and troubleshooting
- Optional exercise about VFD operation with programmable logic controllers (PLCs) and human-machine interfaces (HMIs)

Digital Servo Training System

Fundamentals of digital servo motion control



LabVolt Series 8063

The Digital Servo Training System consists of a compact trainer designed to familiarize students with the fundamentals of digital servo motion control. The training system features a single-axis belt driven positioning system, a digital servo controller, and powerful software tools.

Motor control can be achieved in several ways: by using the included hardware controller, LABVIEW or MATLAB/SIMULINK, or an optional analog controller.

Open-source firmware and software controls are provided to allow the user to create his own control strategies by modifying the existing ones or by developing new ones.

Main features
- Servo controller and linear axis
- Position and speed control, friction break, belt tensioning and backsplash, dual encoders, transferable inertia load
- Observation and control can be performed simultaneously
- State-of-the-art 32-bit microcontroller coupled to a power amplifier
- Straps can be easily disengaged from the motor shaft to study the motor

Training content
- Open loop servo motor static characteristics
- Open loop servo motor transient characteristics
- Servo closed loop speed control – steady state characteristics
- Servo closed loop speed control – transient characteristics and disturbances
- Motor shaft angular position control
- Linear position sensing and Control
- Following error in a linear position control system

	en	es	fr
120V/60Hz			
	581535	**581536**	

Manual included

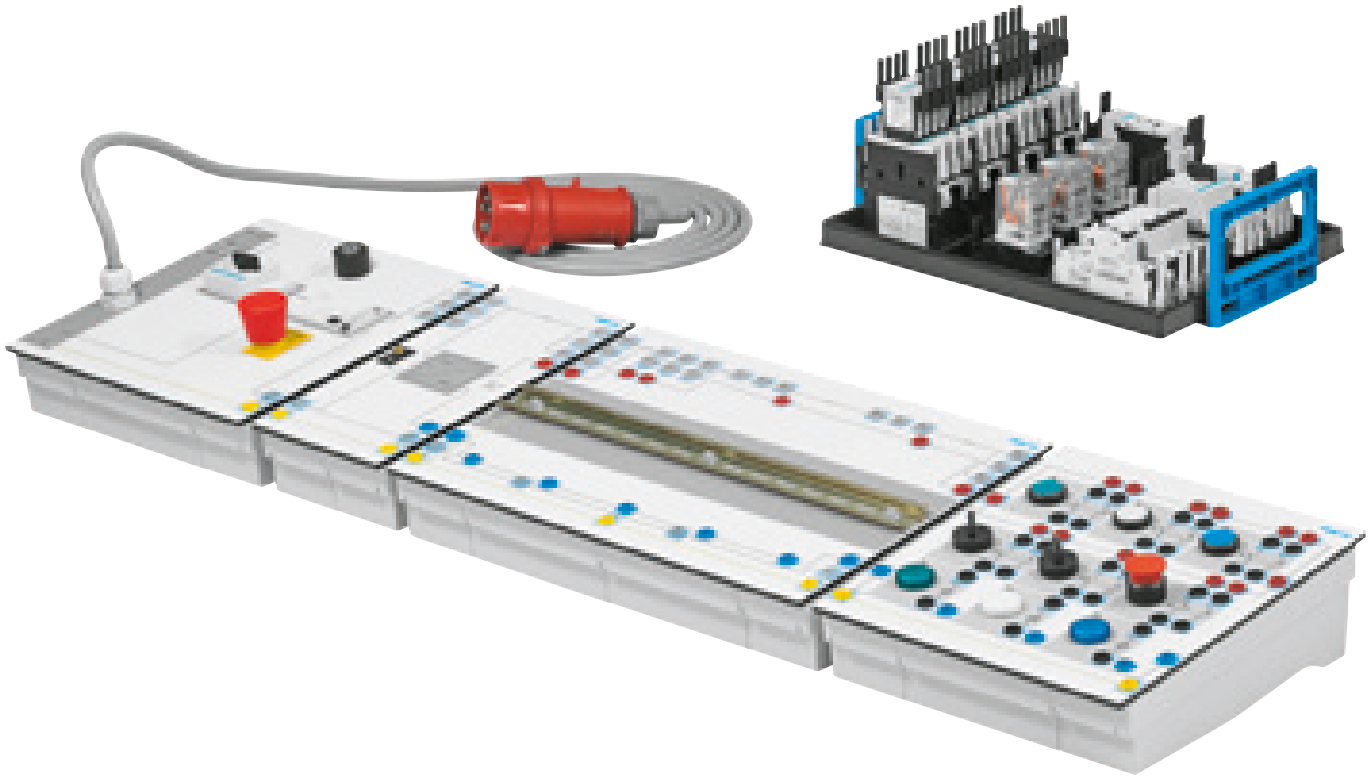
Digital Servo Motor Control

	en	es	fr
Student Manual			
	580535	**589797**	
Instructor Guide			
	580536	**589798**	

Note: PDF version also available.

Equipment Set TP 1211

Basic principles of circuits with contacts



Basic principles of control technology

Basic control circuits also have their place in modern automation technology, as simple automation tasks are still set up with low-cost safety circuits.

Realistic projects are executed using the equipment set and practical exercises. The design, function and areas of application of the components are explained along with their use.

Selecting the correct switching elements and equipment is just as important as the correct use and adjustment of protective devices.

The general operating principles are explained using examples and the basic knowledge of the control technology with contacts is explained comprehensively.

Training content
- Pushbuttons and switches
- N/O and N/C contacts
- Jog mode
- Self-latching loop
- Pushbutton lock
- Multiple control points
- Messages
- Design and function of a contactor
- Electronic time relays
- Overcurrent trigger and motor protection switch
- Equipment designations
- Connecting and testing a three-phase socket
- Main and control circuit
- Protective interlocking
- Reversing contactor circuit
- Star-delta starting up
- Reversing contactor circuit with automatic star-delta starting up

Advantages
- The three-phase AC supply guarantees the electrical safety of the workplace
- Extremely compact equipment
- Flexible thanks to the use of industrial components
- Easily expandable
- Jumper plugs for connecting the boards improve clarity
- Maximum effectiveness in combination with MPS® transfer line or electric machines
- Stable angled screw-in sockets for contacting
- The optional Systainer solution combines work, transport and storage requirements perfectly, thus reducing the amount of work required before and after lessons

Complete equipment set TP 1211	**571811**

The most important components at a glance:

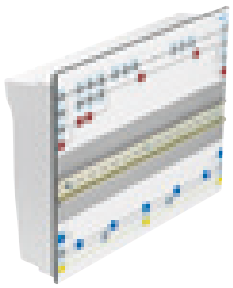
1	1x EduTrainer contactor board	571814
2	1x EduTrainer operator and signalling unit	571815
3	1x Motor technology contactor set	571816

Recommended accessories, also order:

Soft starter	8126037
3 AC Power supply and safety unit	594826
Protective conductor connecting cables with special socket, 14 pieces	8067503
Motor protection switch ➔ Page 205	
4 mm Safety laboratory cables, 106 pieces, red, blue and black	8092668
4 mm Safety laboratory cables, 58 pieces, brown, black, gray, and blue, with gray plugs	8092669
Safety jumper plugs ➔ Page„Safety jumper plugs“ auf Seite 272272	
Electric machines ➔ Page 204	
EduTrainer 24 V power supply unit	571813
Amprobe PRM-6-EUR phase sequence indicator	8081205

Note: This training package comes disassembled.
The safety connectors have to be assembled by the end user.

1



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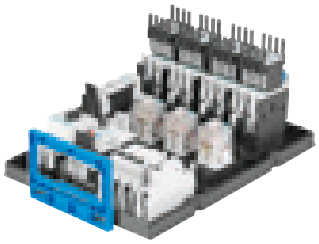


Also order:

Workbook

The exercises in the workbook contain concrete, realistic projects with problem descriptions, parameters and project tasks.

The workbook contains:
– Sample solutions
– Educational instructions
– Multimedia CD-ROM with graphics
– Worksheets for learners

The worksheets support the learner in the information and planning phase as well as with execution, monitoring and documentation.

All exercises require independent performance, evaluation and documentation from the learner.

Campus license:

de	**570901**
en	**567315**
es	**567317**
fr	**567319**

Equipment Set TP 1410

Servo brake and drive system

Electric drive technology

Modern drives are characterised by the bringing together of electrical and mechanical components to create complete systems.

With rotating electric machines in particular, the basic principles of the individual components along with the system approach and practicality play a crucial role.

Enclosed in a compact housing, this equipment set incorporates a complete, flexible and convenient load and drive system, which is used to analyse the systems to be examined in different load situations.

The unique didactic concept makes a clear distinction between the unit under test and the load. The practical quick-change system makes it easy to set up and change the machines to be examined. The unit under test circuits are created using reliable and flexible A4 EduTrainer® modules.

Simple tests such as the recording of a characteristic curve can be performed manually with the brake system, with no need for a PC and software. Measured values, characteristics and function mode are shown on the integrated display.

The convenient **DriveLab** software provides a wide range of options.

With the electric teaching machines, virtually all electric circuits and drives that exist in industry, in trade and in the home can be explained practically and effectively.

The range of drives includes systems of varying degrees of complexity, including single-phase and three-phase drives, DC drives and modern servo drives.

Training content
- Electric drive technology components
- DC drives
- AC drives
- Three-phase drives
- Special purpose machines
- Actuation with contact
- Frequency converters
- Communication technology

Technical data
- Input voltage: 1 AC/110 – 230 V, 50 – 60 Hz
- Control console housing with rubber feet for use in the desk
- Connection via 4 mm safety connector
- Integrated EMC filter
- Integrated braking resistor

Scope of delivery
- Servo brake and drive system
- Transparent shaft cover
- Coupling sleeve
- DriveLab software
- USB connecting cable

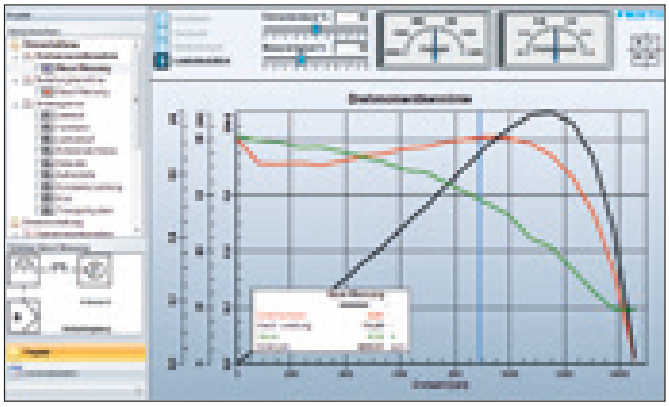
Complete equipment set TP 1410	**571870**

Possibilities of expansion:

EduTrainer three-phase current supply	571812
EduTrainer 24 V power supply unit	571813
EduTrainer contactor board	571814
Motor technology contactor set	571816
EduTrainer operator and signalling unit	571815
Electric machines ➔ Page 204	
Motor protection switch ➔ Page 205	
EduTrainer AC measurement board	576616
Sinamics G120 EduTrainer ➔ Page 208	
EduTrainer variable transformer	8037127
EduTrainer field rheostat	8036772
EduTrainer load resistance	8037136
EduTrainer motor switches	576309

Recommended training media, also order:

Electric drives 1: WBT ➔ www.festo-didactic.com	
Electric drives 2: WBT ➔ www.festo-didactic.com	



The convenient and intuitive **DriveLab** software supports the automatic recording of machine characteristic curves, the parameterisation of a static load and the simulation of load models for the examination of drives under realistic conditions. The comparison and optimisation of different drive concepts can be carried out in the form of project exercises. Sample configurations provide a quick and easy-to-understand introduction.

Different load models
– Inert load
– Pump/fan
– Hoist drive
– Calendar
– Winder drive
– Lathe
– Traversing drive

Also order:

Workbooks

The exercises in the workbooks contain concrete, realistic projects with problem descriptions, parameters and project tasks.

The workbooks contain:
– Sample solutions
– Educational instructions
– Multimedia CD-ROM with graphics
– Worksheets for learners

The worksheets support the learner in the information and planning phase as well as with execution, monitoring and documentation.

All the exercises require the learner to complete, evaluate and document them independently.

Fundamentals of DC machines

Campus license:

de	**571781**
en	**571783**
es	**571785**

Fundamentals of AC machines

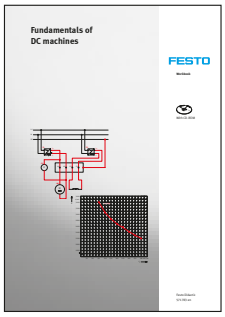
Campus license:

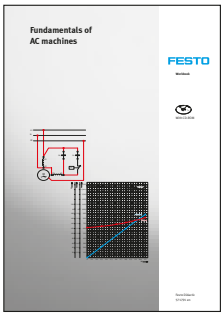
de	**571789**
en	**571791**
es	**571793**

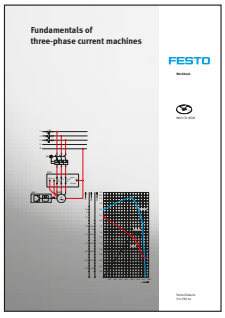
Fundamentals of three-phase current machines

Campus license:

de	**571797**
en	**571799**
es	**571801**
fr	**571803**







Electric Machines

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11


1	DC shunt machine	**571868**
2	DC series machine	**571869**
3	Universal motor	**571871**
4	Capacitor motor	**571872**
5	Three-phase current asynchronous motor 230/400 V	**571874**
6	Three-phase current asynchronous motor 400/690 V	**571875**
7	Synchronous machine	**572095**
	DC compound machine	**8023977**
	Three-phase AC multifunction machine	**8023978**
	Dahlander	**8023979**
11	Slip ring rotor	**8023980**
Three-phase current asynchronous motor 230/400 V IE3		**8147501**
Three-phase current asynchronous motor 400/690 V IE3		**8147502**

– Sturdy special design for training purposes
– Neutral rating plate
– Overtemperature protection (NC contact) in the winding
– Fully assembled and aligned on support plate
– One shaft end, equipped with coupling piece suitable for the servo brake and drive system
– Support plate with clamping slot and quick action mounting system for profile plate
– All connections on safety sockets
– Painted in RAL 7035

1 **DC shunt machine**
– Power rating: 0.3 kW
– Speed: 2,000 rpm
– Armature: 220 V/1.8 A
– Field: 220 V/0.3 A

2 **DC series machine**
– Power rating: 0.3 kW
– Speed: 2,000 rpm
– 220 V/1.9 A

3 **Universal motor**
– Power rating: 0.2 kW
– Speed: 3,000 rpm
– AC 230 V/3.0 A
– DC 140 V/2.5 A

4 **Capacitor motor**
– Power rating: 0.25 kW
– Speed: 1,400 rpm
– cos φ: 0.99
– AC 230 V/1.86 A
– Running/starting capacitor: 25 µF/10 µF

5 **Three-phase current asynchronous motor 230/400 V**
– Power rating: 0.25 kW
– Speed: 1,350 rpm
– cos φ: 0.79
– Star circuit: 400 V/0.76 A
– Delta circuit: 230 V/1.32 A

6 **Three-phase current asynchronous motor 400/690 V**
– Power rating: 0.25 k
– Speed: 1,350 rpm
– cos φ: 0.78
– Star circuit: 690 V/0.45 A
– Delta circuit: 400 V/0.77 A

7 **Synchronous machine**
– Power rating: 0.3 kW
– Speed: 1,500 rpm
– cos φ: 0,97
– Exciter: 150 V/0.95 A
– Star circuit: 400 V/0.66 A
– Delta circuit: 230 V/1.14 A

DC compound machine
– Output: 0.3 kW
– Speed: 2000 r.p.m
– Armature: 220 V/1.8 A
– Field: 205 V/0.25 A

Three-phase AC multifunction machine (AC slip ring rotor, can be synchronised)
– Output: 0.27 kW
– Speed: 1360/1500 r.p.m. 50 Hz
– cos φ: 0.7/1.0
– Star connection: 400 V/0.83 A
– Delta connection: 230 V/1.44 A
– U2: AC 107 V/1.7 A; DC 20 V/4.0 A

Dahlander
– Output: 0.3/0.43 kW
– Speed: 1390/2800 r.p.m 50 Hz
– cos φ: 0.73/0.8
– Double star circuit: 400 V/1.2 A
– Delta connection: 440 V/0.89 A

11 **Slip ring rotor**
– Output: 0.27 kW
– Speed: 1360 r.p.m 50 Hz
– cos φ: 0.72
– Star connection: 400 V/1.16 A
– Delta connection: 230 V/2 A
– U2: 95V

Three-phase current asynchronous motor 230/400 V IE3
– Power rating: 0.25 kW
– Speed: 1,395 rpm
– cos φ: 0,72
– Star circuit: 400 V/0,68 A
– Delta circuit: 230 V/1,19 A

Three-phase current asynchronous motor 400/690 V IE3
– Power rating: 0.25 kW
– Speed: 1,395 rpm
– cos φ: 0,72
– Star circuit: 690 V/0,40 A
– Delta circuit: 400 V/0,68 A

Other machines are available on request.

Motor Protection Switch

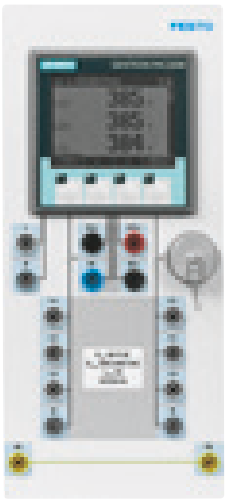
High-quality, industrial switching device from Siemens with 4 mm safety elbow adapters for professional protection of rotating electric machines.

Technical data
– Mounting on 35 mm H-rail
– Auxiliary contacts
  1 N/O contact + 1 N/C contact

Available with the following values:
0.35 – 0.5 A
0.55 – 0.8 A
1.1 – 1.6 A
1.8 – 2.5 A
2.2 – 3.2 A

0.35 – 0.5 A	**576284**
0.55 – 0.8 A	**573266**
1.1 – 1.6 A	**573267**
1.8 – 2.5 A	**573268**
2.2 – 3.2 A	**573269**

EduTrainer® AC Measurement Board



The measurement board is designed for measuring the electrical variables of voltage, current, apparent, real and reactive power, power factor and frequency of one- and three-phase loads. Other functions include min-max values, real and reactive energy, dual tariff recording, average power demand MIN/MAX, hours-run meter and energy meter.

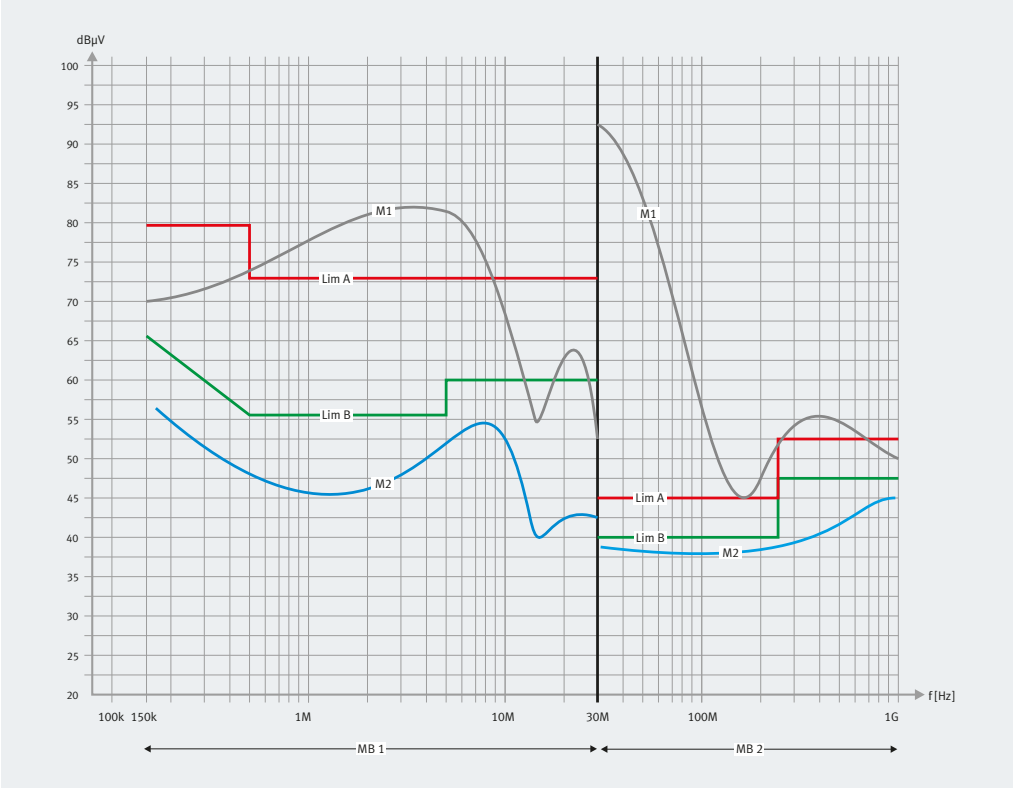
The locations of all connections are standardised and are routed to safety sockets or system plugs.

Ethernet port for integration in higher-level systems.

Technical data
– Supply voltage: 1 AC/95 – 240 V
– Measured voltage:
  1 AC/40 – 400 V, 3 AC/40 – 690 V
– Measured current max. 5 A
– Front panel: 133 x 297 mm
– Console housing with rubber feet for use in an A4 frame or on a table
– Connection via 4 mm safety plugs
– Floating switching output and meter input
– Cover cap for Ethernet connection

Order no.	**576616**

EMC-Resistant Drive Systems
Information and backgrounds



Key to illustration:
- MB1 (measuring range 1): 150 kHz – 30 MHz, measurement of the conducted emission
- MB2 (measuring range 2): 30 MHz – 1 GHz, measurement of the radiated emission
- Lim A: Limit curve per DIN EN 55011, Class A (industrial devices)
- Lim B: Limit curve per DIN EN 55011, Class B (domestic and small commercial devices)
- M1: Interference emission without EMC measures
- M2: Interference emission with EMC measures

The graph shows the two areas of application. The red line shows the limit value for Class A devices, the green line the limit value for Class B devices.

The black curve shows the interference emission for a frequency converter without a housing. The blue curve shows how the interference emission can be significantly reduced with additional measures like filtering, screening, enclosed metal housings and appropriate component arrangements.

Areas of application
The EMC standards define two areas of application: use in “industrial environments” and in “residential/small company” applications. The industrial environment is characterised by separation of the internal low-voltage grid from the public medium or high-voltage grid via a dedicated transformer. The limits for emitted interference of these industrial devices (Class A devices) are higher than the limits for residential devices (Class B devices) where many independent users are connected to the same low-voltage grid.

What is EMC?
Modern systems and plants are becoming increasingly technically-demanding, and in particular their electrical components are increasingly complex. In particular the growing amount of power electronics and microelectronics makes ever stricter demands of the components to guarantee trouble free and reliable operation.

EMC stands for “electromagnetic compatibility” and refers to “the ability of an equipment of system to function satisfactorily in its electromagnetic environment without introducing intolerable electromagnetic disturbances to other equipment in that environment”.

Resistance to interference and interference emission
In general, a device is examined for both of these phenomena. When testing the resistance to interference, the device is operated and subjected to various defined disturbance variables. These tests include typical electrical phenomena, such as static discharge or surge voltage (lightning strikes) and test for immunity against external interference sources.

By contrast, the emitted interference is tested by operating the device in a condition in which the maximum interference emission is to be expected. The emissions must not exceed a limit specified in the standards.

CE marking
EU directives define minimum standards for various product groups which products are required to comply with. The characteristics are entirely different depending on the product group.

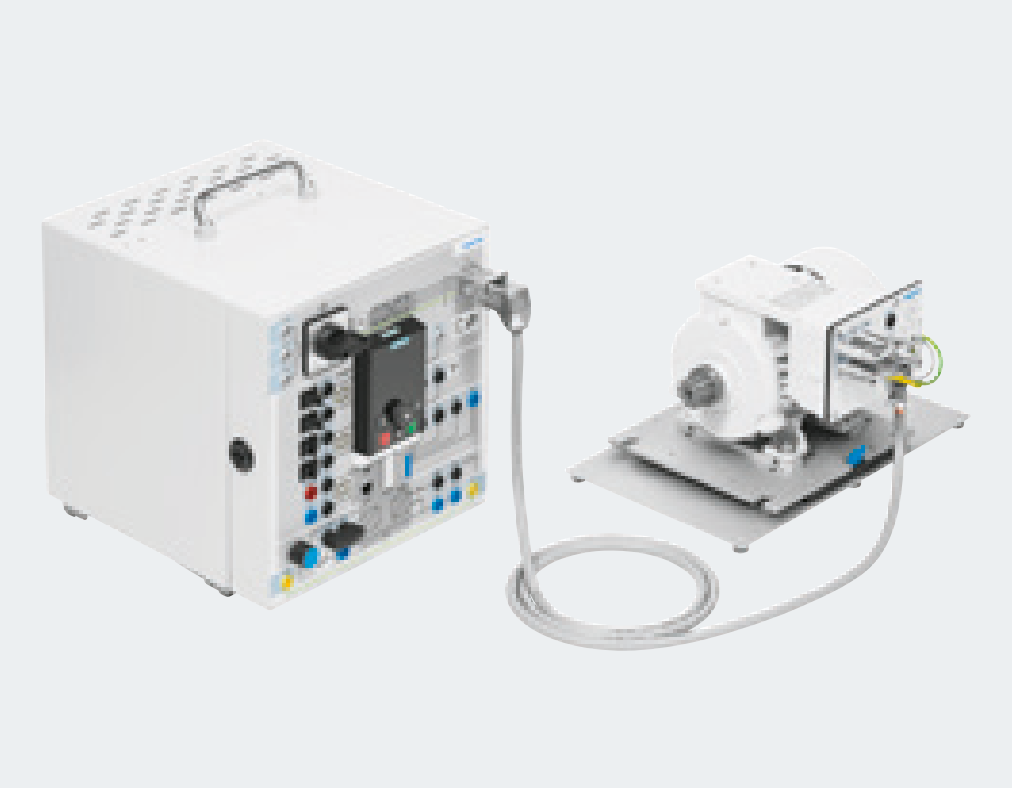
Manufacturers use the CE marking to confirm that the device complies with all relevant EU directives. This is confirmed by applying corresponding standards. Devices which do not fulfil the required directives may not bear the CE marking. The market supervisory authority can prohibit sales.

The following EU directives are relevant for CE marking of frequency converters:
– Low Voltage Directive (2006/95/EC)
– EMC (2014/30/EU)
– RoHS (2011/65/EU)

The low voltage directive requires that products do not cause electric hazards.

The EMC directive requires that electric devices must only influence one another to a limited extent.

The RoHS directive requires a limit to hazardous substances such as lead, mercury, cadmium or chrome.



On the safe side with Festo
In close cooperation with test laboratories, Festo Didactic has developed the optimal solution for operating frequency converters in training: The EMC-compliant frequency converters are designe to manufacturer's specifications, compact and safe to use.

The new design of the frequency converter fulfils all directives, as is confirmed by the CE marking. That means that the device can be operated safely in all laboratory environments without further measures.

Your advantages
Depending on the type of drive tasks, whether simple or complex, a range of frequency converters with suitable motors are available in various designs. The accessories for parameterisation and configuration are also available, as is a test system for measurements and loading the drive systems.

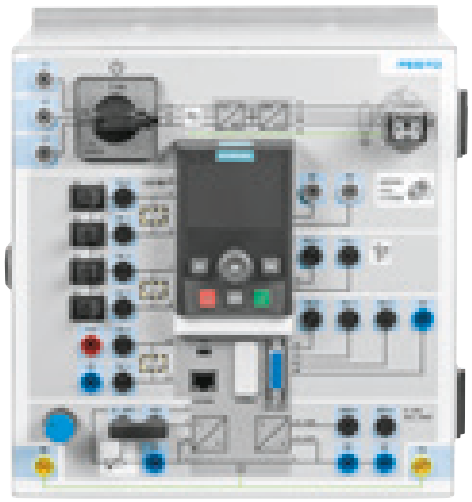
All relevant device interfaces are clearly arranged on a front panel. The control section of the frequency converter can be used there and replaced if necessary.

The motor is connected via a special EMC-compatible cable. The industry plug connector on the cabinet and the shielded clamp on the motor ensure EMC-compatible design of the drive system. The 4 mm safety plug on the motor side also focuses on the didactic aspect.

The interior structure and the consistent shielding concept clearly shows how EMC must be implemented practically. As a result the solution adds didactic value, as important training content on EMC-compliant design is taught.

The devices can be used both in the A4 mounting frame and as table-top devices. Furniture and storage systems for optimal classroom use are also available.

Sinamics G120 EduTrainer®



The next generation of the Sinamics G120 frequency converter – Optimised even further for training. Now in a completely new housing and EMC-compliant for use in laboratories without heeding installation instructions – just like that!

The G120 is well-suited as a beginner device, however its comprehensive functions offer plenty of potential for advanced users who want to implement complex drive tasks. Various bus systems, advanced safety functions and an optional encoder input permit perfect adjustment to the requirements and integration in control systems. All relevant ports are accessible on the front of the device and installed in 4 mm safety sockets or system connectors.

The motor is connected via the fully pre-assembled cable sold separately which permits EMC-compliant operation. The devices can be used flexibly – suspended in an A4 frame or on a table, and are equipped with an EMC filter with low leakage current. The corresponding control panels (BOP-2, IOP) are available as accessories.

Special characteristics
– Simple parametrisation via STARTER and the BOP-2 or IOP control panels
– Versatile, programmable inputs/outputs voltage/frequency characteristic curves for constant, square torque
– Encoder-free vector regulation brake functions (resistance, DC, motor holding, compound brake)
– Integrated protection/overload functions

Technical data
– 6 digital inputs, depending on the variant, 2 of which can be parameterised as failsafe inputs
– 3 digital outputs
– 1 analogue input
– 2 analogue outputs
– 3-m USB cable included
– Connections for temperature sensor and for external braking resistor
– Dimensions (H x W x D)
297 x 266 x 340 – 360 mm, depending on the variant
– Input:
1x 200-240 V AC (# 8105137)
3x 380-480 V AC (# 8037819 and # 8105421)
– Output:
3x 400 V AC, 0.55 kW (# 8037819) or 0.75 kW (# 8105421 and # 8105137)

Sinamics G120 DP	**8037819**
Sinamics G120 PN with encoder port (1 AC input)	**8105137**
Sinamics G120 PN with encoder port (3 AC input)	**8105421**

Possibilities of expansion and accessories for frequency converters

Intelligent Operator Panel (IOP-2)
Powerful operator panel with large plain text display and menu navigation. The application wizard guides you through the startup procedure for important applications. The general startup procedure is performed with quick-startup wizards. Up to two percentages can be displayed graphically or numerically. Contains de, en, fr, it and es language packages. Updatable and extendable via USB interface.

Order no.	**8022476**

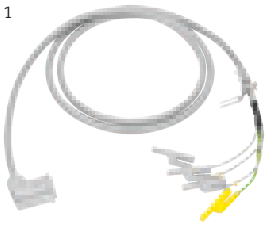
Basic Operator Panel (BOP-2)
Operator panel with 2-line display and basic startup menu navigation. Two percentages can be numerically displayed at the same time for frequency converter diagnostics.

Order no.	**8022475**

1 **EMC motor cable**
Pre-assembled cable, prepared to connect the asynchronous machine and frequency converter with one another with EMC compliance. The shielded cable has a system plug for connecting to the converter; on the motor side, it is equipped with a shielded terminal and individual 4 mm safety plugs. Set including shield connection adapter for motor. Length 2 m.

Order no.	**8038849**

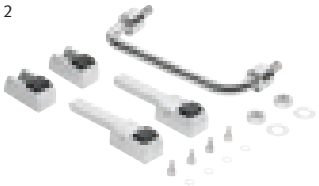
1



2 **Set of feet and device handle**
Using the frequency converter on the table-top is even more convenient with the optional conversion set. The set comprises 2 fixed and 2 fold-out device feet, a folding device handle and the required mounting material. Suitable for all EMC-compliant frequency converters.

Order no.	**8036788**

2

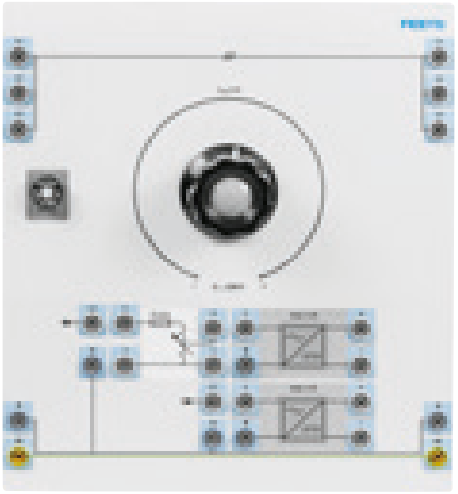


3 **Startdrive software**
Software program for parametrisation, startup, optimisation, diagnostics and control

order no.	**8105776**

3

EduTrainer®
Variable Transformer



Single-phase variable transformer for providing a variable alternating current.

Alternatively, the device can be used via the integrated rectifier as an unsmoothed direct current source with a variable and a fixed output, e.g. for supplying electrical machinery.

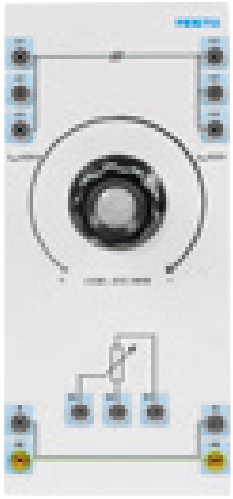
The integrated device circuit breaker deactivates the variable output voltage in the event of an overload or short circuit.

The locations of all connections are standardised and are routed to safety sockets or system plugs.

Technical data
– Input voltage: 1 x 230 V AC
– Output voltage: 1 AC/0 – 230 V, short-circuit and overload protected
– Max. output current: 4 A
– Rectifier load capacity: 4 A
– Front panel 266 x 297 mm
– For use in an A4 frame
– Connection via 4 mm safety plugs
– Through-feed for 3 x 400 V AC

Order no. **8037127**

EduTrainer®
Field Rheostat



The field rheostat allows the field voltage of motors and generators to be reduced if a set direct voltage is used. By connecting a variable resistor upstream, an exciter field can be set.

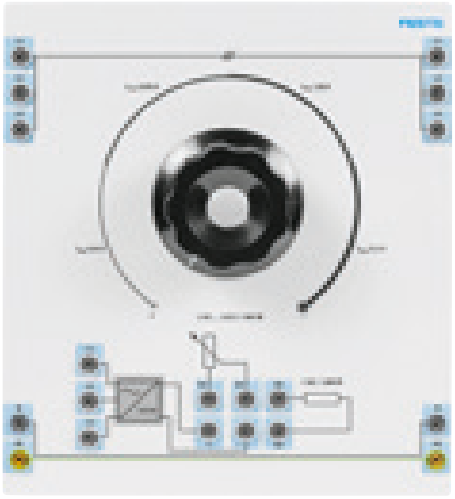
The resistor is infinitely adjustable.

All connection locations are standardised and are laid out as safety sockets.

Technical data
– Maximum input voltage: 230 V DC
– Maximum load capacity: 100 W
– Setting range 0 – 1.5 kΩ
– Maximum current:
  0 – 450 Ω, 0.5 A
  450 – 1.5k Ω, 0.25 A
– Front panel: 133 x 297 mm
– For use in an A4 frame
– Connection via 4 mm safety plugs
– Through-feed for 3 x 400 V AC

Order no. **8036772**

EduTrainer®
Load Resistance



The load resistance is used to load electrical machinery for use as generators or as starting resistors for slip ring rotors.

It consists of a rheostat with an upstream protecting resistor. An additional fixed resistor can extend the load range.

The rheostat is infinitely adjustable; the multi-level winding allows different maximum peak currents to be set as loads.

The 3-phase rectifier allows the load resistance to be used as a load for alternating and 3-phase current sources.

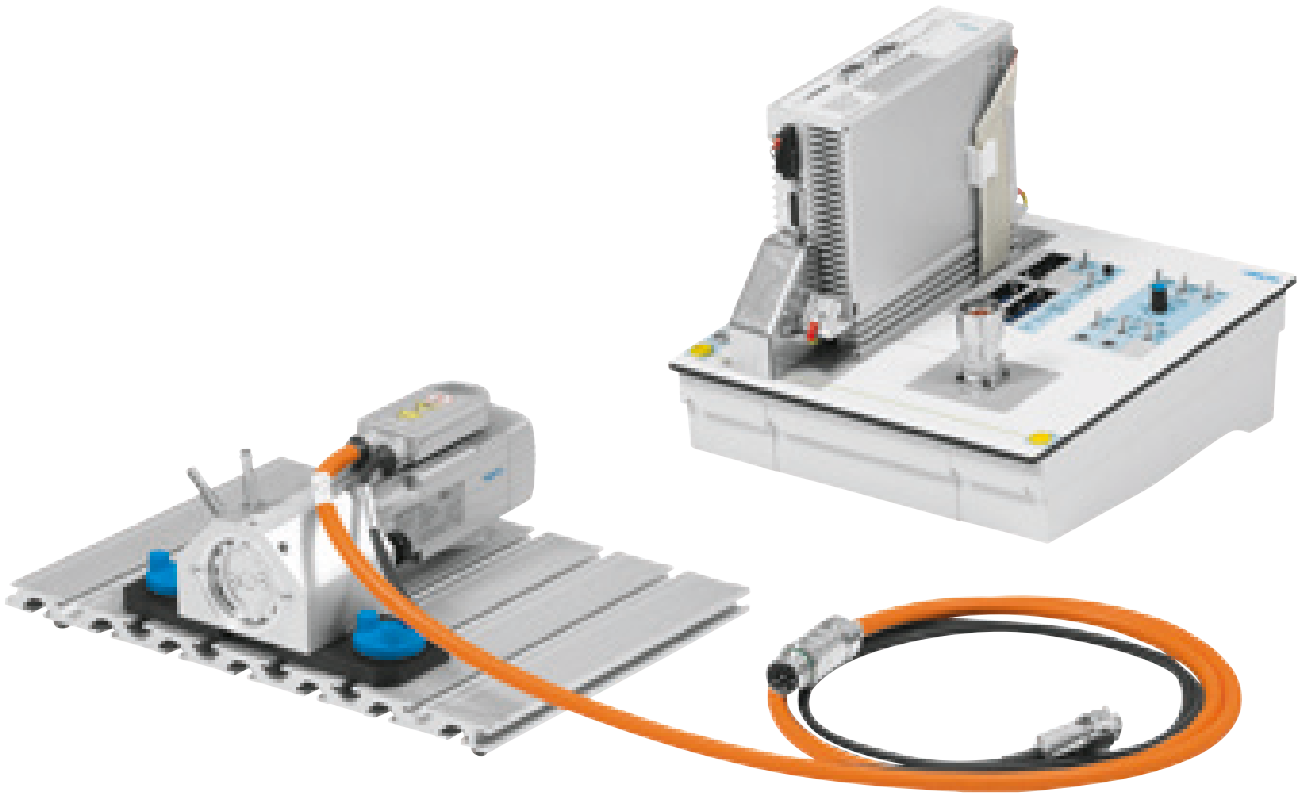
All connection locations are standardised and are laid out as safety sockets.

Technical data
– Maximum input voltage:
  230 V DC, 3x 400 V AC
– Load capacity: 500 W
– Setting range: 1.8 – 1 kΩ
– Maximum current:
  1.8 – 30 Ω, 3.1 A
  30 – 56 Ω, 1.8 A
  56 – 140 Ω, 0.95 A
  140 – 1 kΩ, 0.6 A
– Protecting resistance: 1.8 Ω
– Extension resistance: 1 kΩ/180 W
– Front panel: 266 x 297 mm
– For use in an A4 frame
– Connection via 4 mm safety plugs
– Through-feed for 3 x 400 V AC

Order no.	**8037136**

Equipment Set TP 1421

Servo motor drive technology



Drives with servo motors

Modern servo drives have become indispensable for a wide variety of automation tasks thanks to their combination of high precision, dynamic response and torque. Basic knowledge of the areas of application and the components of modern servo drives is therefore essential.

The use of the latest generation of Festo controllers and motors guarantees that this equipment set is up-to-date, while the supplied PC software facilitates project engineering.

Reliable and flexible

The rotary disk guarantees simple and reliable handling of the system throughout all stages of the introductory course. The integrated limit switches support the simulation of an axis on a range of rotation of approx. 340°. Metering can be implemented for extended training content.

Advantages

– Drive components from Festo
– Integrated SysLink interfaces
– Integrated test box for all important I/Os
– Standardised concept from basic principles to application
– The component set contains all of the components for carrying out basic experiments and provides clear assignment thanks to its printed storage panel.

Training content

– Components of a drive system
– Design
– Commissioning
– RPM regulation
– Regulating torque
– Homing
– Positions
– Ramps

Complete equipment set TP 1421	**571849**

The most important components at a glance:

1	1x EduTrainer servo motor controller	On request
2	1x Servo motor drive unit	On request
3	1x Null modem cable	On request

Possibilities of expansion:

EGC linear axis 600 mm including mounting kit	571873
MPS Handling station, electrical	567203

Recommended accessories, also order:

RS232 USB adapter	540699
Electric drives 1: WBT ➔ www.festo-didactic.com	
Electric drives 2: WBT ➔ www.festo-didactic.com	

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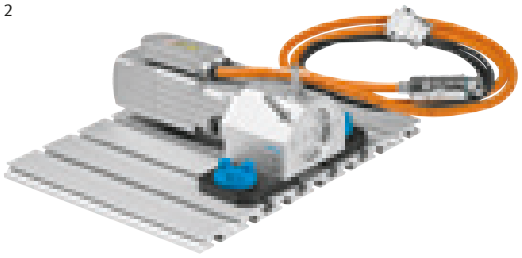
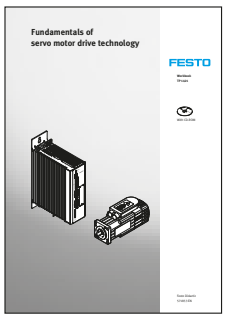


Also order:

Workbook



The basic principles of servo motor drive technology are explained using real project engineering.

Worksheets support the students through the required stages of introduction, planning and execution of exercises, evaluation of results and documentation.

Articular emphasis is placed on independent execution by the student.

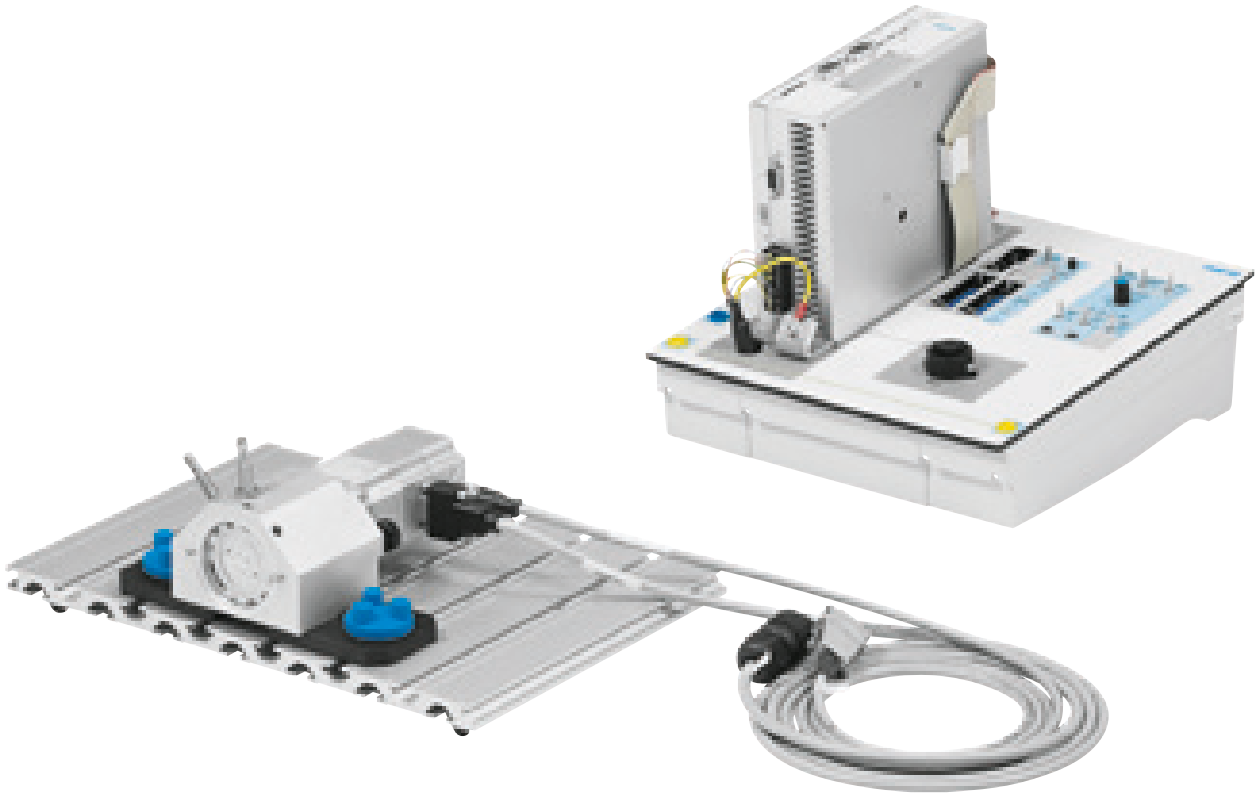
The workbook contains:
– Solutions
– Didactic notes
– Multimedia CD-ROM with graphics
– Worksheets for the student

Campus license:

de	**571851**
en	**571853**
es	**571855**
fr	**571857**

Equipment Set TP 1422

Stepper motor drive technology



Drives with stepper motors

One of the main reasons why drive tasks are implemented with stepper motor drives in modern systems is the cost benefit. However, the weaknesses associated with their design mean that basic knowledge of the components and areas of application is essential.

The current components in the equipment set and the supplied PC software provide a useful introduction to this topic.

Convenient and open

The integrated simulation box allows the connection of the required inputs and displays the states of all important outputs. This allows convenient operation without any additional hardware. The analogue and digital SysLink interfaces make it easy to integrate the drives in complete systems for explaining additional content.

Advantages

- The latest generation of modern drive components from Festo
- Integrated SysLink interfaces
- Integrated test box for all important I/Os
- Standardised concept from basic principles to application
- The component set contains all of the components for carrying out basic experiments and provides clear assignment thanks to its printed storage panel.

Training content

- Components of a drive system
- Design
- Commissioning
- RPM regulation
- Homing
- Positions
- Ramps

Complete equipment set TP 1422	**571850**

The most important components at a glance:

1	1x EduTrainer stepper motor controller	On request
2	1x Stepper motor drive unit	On request
3	1x Null modem cable	On request

Possibilities of expansion:

EGC linear axis 600 mm including mounting kit	571873
MPS Handling station, electrical	567203

Recommended accessories, also order:

RS232 USB adapter	540699
Electric drives 1: WBT ➔ www.festo-didactic.com	
Electric drives 2: WBT ➔ www.festo-didactic.com	

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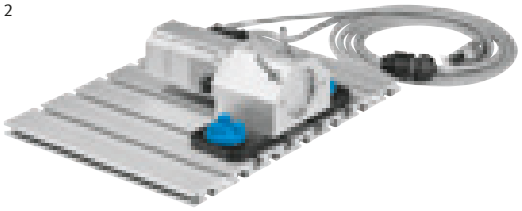
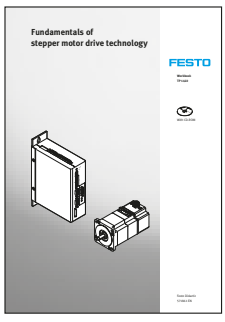


Also order:

Workbook



The basic principles of stepper motor drive technology are explained using real project engineering.

Worksheets support the students through the required stages of introduction, planning and execution of exercises, evaluation of results and documentation.

Articular emphasis is placed on independent execution by the student.

The workbook contains:
– Solutions
– Didactic notes
– Multimedia CD-ROM with graphics
– Worksheets for the student

Campus license:

de	**571859**
en	**571861**
es	**571863**

EGC Linear Axis 600 mm Including Mounting Kit

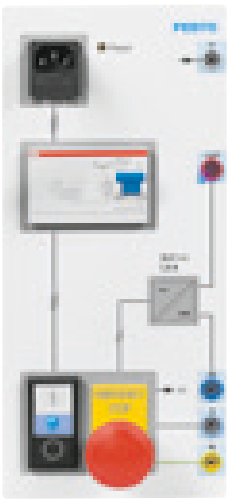
Linear axis for work on additional teaching content together with the basic training packages for servo or stepper motor drive technology.

Advantages:
– The latest generation of modern drive components from Festo
– Built-in quick coupling for connection to basic training drive packages
– Complete with Quick-Fix holder for slotted assembly board
– Limit switches included in scope of delivery

Technical data
– 600 mm working stroke
– Maximum speed 3 m/s
– Maximum acceleration 50 m/s²
– Feed force maximum 50 N
– Dimensions: 600 x 60 x 50 mm (H x W x D)

Order no. **571873**

EduTrainer® Supply Unit



The supply unit ensures safe operation of single-phase servo controllers or frequency converters at workstations where there is no corresponding infrastructure. It is connected to the mains supply via a non-heating device cable and makes it possible to provide an electrically safe workstation even in places where there is no separate fuse protection or type B RCD protection available.

The unit offers the following functions:
– Short circuit protection
– RCD protection, type B
– Emergency stop for the workstation
– Safety when restarting after voltage recovery
– Switching the workstation power supply on and off

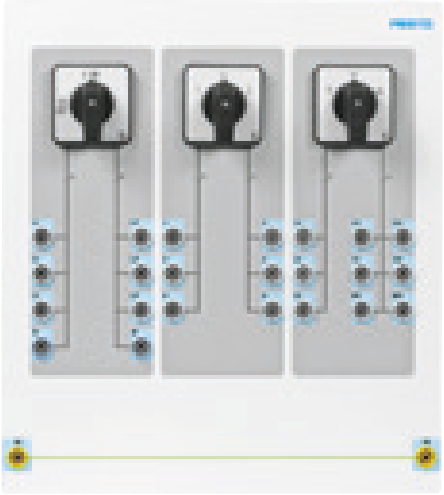
It also provides the 24 V DC voltage necessary for operation.

The locations of all connections are standardised and are laid out as safety sockets.

Technical data
– Supply voltage: 1 AC/230 V (50 Hz)
– Output voltage: 1 AC 230 V with type B RCD protection 30 mA, output current max. 6 A
– DC 24 V, 2 A
– Outputs are protected against short circuits and overload
– Front panel: 133 x 297 mm
– Console housing with rubber feet for use in an A4 frame or on a table
– Power supply via non-heating device connection
– Outputs for 4 mm safety plugs

Order no. **8023973**

EduTrainer® Motor Switches



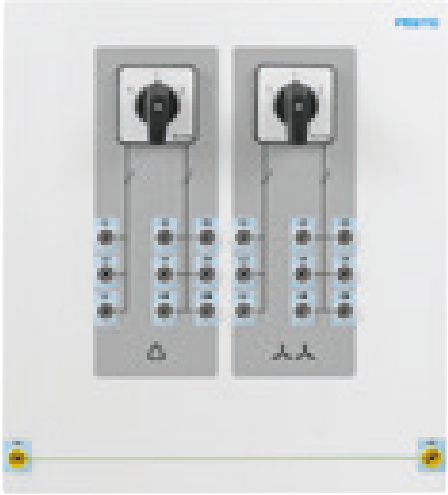
The motor switches are designed for direct switch activation of electric machines. Equipped with on/off switch, polarity reversal switch and star/delta switch.

The locations of all connections are standardised and are routed to safety sockets or system plugs.

Technical data
– Input voltage: 3 x 400 V AC
– Output voltage: 3 x 400 V AC
– Load rating: maximum 16 A
– Front panel: 266 x 297 mm
– Console housing with rubber feet for use in an A4 frame or on a table
– Connection via 4 mm safety plugs

Order no. **576309**

EduTrainer® Dahlander Switch



The motor switches are designed for direct switch activation of electric machines. Fitted with a Dahlander switch and switches for asynchronous motors with separate windings.

The locations of all connections are standardised and are routed to safety sockets or system plugs.

Technical data
– Input voltage: 3x 400 V AC
– Output voltage: 3x 400 V AC
– Load rating: maximum 16 A
– Front panel: 266 x 297 mm
– Console housing with rubber feet for use in an A4 frame or on a table
– Connection via 4 mm safety plugs

Order no. **8040011**

Power Transmission and Distribution

CE

Some training solutions included in this product guide do not have a CE mark and cannot be ordered for delivery to Europe.

If you are located in a country where this marking is required, please contact your Festo sales representative before placing an order.

Protective Relaying

Based on the SIPROTEC 5 series from Siemens

Modern, time-efficient, and interactive hands-on training

Protective relaying provides detection of abnormal operating conditions in electrical systems and is needed in order to act quickly to protect circuits, equipment, and the general public.

The theoretical background, as well as practical application, of these protective devices and their protection functions are an important part of the education of power systems for electrical engineers.

Power-utility-grade equipment, Siemens' newest generation the SIPROTEC 5 series, is used in this innovative teaching approach.

State-of-the-art hardware

Three different relays are available and must be selected in accordance with the desired learning path. Each features a display that can provide information about the relay protection functions, indicate numerous currently measured values such as the line voltages, line currents, phase power, three-phase power, and power factor, and show information about trip events that have been recorded. A keypad, also on the front panel of the relay, allows users to select the information displayed. The front panel of the relay also features a set of 16 LEDs that allows quick monitoring of the status of various relay functions.

Relay programming

Relay programming (e.g., protection function selection, function settings) is achieved via the Siemens DIGSI 5 software via a USB connection (both the software and USB are included with each relay and the software license is free for educational purposes). Relay function settings can also be performed using the keypad and display located on the front panel of the relay. Once programmed, the relays can be tested using a built-in relay testing unit to ensure it is programmed to operate as expected. This eliminates the need for users to purchase a costly external relay tester to perform relay testing. Access to the voltage and current inputs of the Numerical Distance Relay is through a removable panel located at the back of the relay enclosure.

Access to the relay Ethernet port, binary inputs, and binary outputs (e.g., trip contacts) is also through this removable panel. Each relay is powered via an ac power inlet mounted on the front of the relay enclosure. A variant of each relay with safety jacks and connectors mounted on the front panel to provide access to all relay inputs, outputs, and ports is also available.

Comprehensive courseware

Theoretical knowledge and hands-on training exercises teach students the basic and advanced relay protection functions. The available range of relays and manuals provide coverage of these topics:

Also order:
Workbooks

Overcurrent/Overload Protection
– Evolution of protective relays
– Overcurrent protection
– Overcurrent and overload protection of AC machines and power transformers
– Overcurrent protection of radial feeders

Student Manual, en	589887
Instructor Guide, en	589888

Directional Protection
– Protection of parallel power lines using overcurrent relays
– Directional overcurrent protection
– Directional comparison protection
– Directional power protection

Student Manual, en	589889
Instructor Guide, en	589890

Differential Protection
– Effect of the current measuring error on the sensitivity of current differential protection
– Percentage restrained differential protection
– Application of differential protection

Student Manual, en	590085
Instructor Guide, en	590086

Distance Protection
– Simplified diagram of a power system
– Conventional time-stepped distance protection
– Distance relay impedance characteristic
– Fault impedance vs. load impedance
– Line protection
– Generator loss-of-excitation protection
– Distance protection using communication-assisted tripping schemes

Student Manual, en	593880
Instructor Guide, en	593881

Note: PDF version also available.

Siemens DIGSI 5 software
License for non-educational user only

Order no.	779959

Numerical Directional Overcurrent Relay
– Directional phase overcurrent (67)
– Directional ground overcurrent (67N)
– Directional power (32)
– Instantaneous phase overcurrent (50)
– Instantaneous ground overcurrent (50N)
– Phase overcurrent (51)
– Ground overcurrent (51N)
– Other possible functions (ANSI 27, 37, 38, 46, 59, 74, 81, 86, and 87N)

Standard Version

Order no.	**589061**

Variant with external connection jacks

Order no.	**589110**

Numerical Distance Relay
– Phase distance (21)
– Ground distance (21N)
– Directional phase overcurrent (67)
– Directional ground overcurrent (67N)
– Directional power (32)
– Instantaneous phase overcurrent (50)
– Instantaneous ground overcurrent (50N)
– Phase overcurrent (51)
– Ground overcurrent (51N)
– Other possible functions (ANSI 27, 37, 38, 46, 59, 68, 74, 81, 86, and 87N)

Standard Version

Order no.	**589062**

Variant with external connection jacks

Order no.	**589111**

Numerical Differential Protective Relay
– Transformer differential (87T)
– Instantaneous phase overcurrent (50)
– Instantaneous ground overcurrent (50N)
– Phase overcurrent (51)
– Ground overcurrent (51N)
– Other possible functions (ANSI 37, 38, 46, 74, 86, 87N, and 87M)

Standard Version

Order no.	**589891**

Variant with external connection jacks

Order no.	**592529**

Notes
– The numbers in parenthesis are the corresponding ANSI/IEE protection functions.
– Required accessory for the three relays: IEC Power Cable see page 110

Protective Relay	**Workbooks**			
	Overcurrent/ Overload Protection	Directional Protection	Differential Protection	Distance Protection
Numerical Overcurrent Relay	x	x		
Numerical Distance Relay	x	x		x
Numerical Differential Relay	x		x	

0.2-kW Protective Relaying Training System

A complete program that extends training in protective relaying

LabVolt Series 8007

The 0.2-kW Protective Relaying Training System is a complete program that extends training in protective relaying beyond the operation and calibrations of individual relays into broader circuit applications.

The program provides hands-on training at the system level in generator protection, transformer protection, and induction motor protection.

The 0.2-kW Protective Relaying Training System consists of several modules, which can be divided into five groups: common electrical modules, power system modules, protective relaying control station, protective relays, and additional and optional equipment.

The prerequisites include: completion of a course in relay operation and calibration, and completion of a course in electric power technology that covers electric power generation, power transformers, and induction motors.

The modular structure of the 0.2-kW Protective Relaying Training System, together with the subdivision of student manuals into topical units, enables instructors to choose equipment that matches their budgets while progressively enhancing their systems over time.

For power utility users, it is possible to combine their own protective relays with a selection of modules from the 0.2-kW Protective Relaying Training System to obtain equipment setups that correspond to existing one-line and three-line diagrams.

Highlights

- Modular approach allowing selection of areas of interest for study, and tailoring to special training needs equipment selection to match budgets setup of complete power systems/generators feeding various devices such as transformers, transmission lines, and others progressive system enhancement with no replication of equipment
- Use of many modules from other well-known Electromechanical System (EMS)
- Wide range of protective relays
- Fault insertion capability for troubleshooting at the system level
- Very safe operation and experimentation
- Comprehensive curriculum with detailed lab procedures, exercises, theory, tests, etc.

0.2-kW Protective Relaying Training System

LabVolt Series 8007

Most important components
- 1x Source Impedance
- 1x Current Transformers
- 1x Voltage Transformers
- 1x Faultable Transformers
- 1x Transmission Grid 'A'
- 1x Interconnection Module
- 1x Universal Fault Module
- 1x Protective Relaying Control Station
- 1x Three-Phase Over Current Relay
- 1x AC/DC Current Sensitive Relay
- 1x Three-Phase Under/ Over Voltage Relay
- 1x AC/DC Voltage Sensitive Relay
- 1x Synchro-Check Relay
- 1x Under/Over Frequency Relay
- 1x Phase Balance/Sequence Relay
- 1x Reverse Power Relay
- 1x Motor Power-Factor Relay
- 1x Mobile Workstation
- 1x Three-Module Workstation
- 1x Storage Shelves
- 1x Four-Pole Squirrel-Cage Induction Motor
- 1x Synchronous Motor/Generator
- 2x Resistive Load
- 1x DC Voltmeter/Ammeter
- 1x AC Ammeter
- 1x AC Voltmeter
- 1x Wattmeter / Varmeter
- 1x Synchronizing Module
- 1x Power Supply
- 1x Power Diodes
- 1x Timing Belt
- 1x Connection Lead Set
- 1x Four-Quadrant Dynamometer/ Power Supply
- 1x Inertia Wheel

	en	es	fr
120V/60Hz			
	587292	**587293**	
220V/50Hz			
	587294		
240V/50Hz			
	587299		

Manuals included

Introduction to Protective Relaying

	en	es	fr
Student Manual			
	584217	**584218**	
Instructor Guide			
	584222		

Note: PDF version also available.

Protective Relaying Training System Add-On

LabVolt Series 8007-A

This equipment is an add-on to the 0.2 kW Electromechanical Training System (see page 139) which supplements the necessary components to teach Protective Relaying in conjunction with the standard EMS platform.

	en	es	fr
120V/60Hz			
	587296	**587297**	
220V/50Hz			
	587298		
240V/50Hz			
	587295		

Training content
- Differential protection
- Reverse power protection
- Rotor earth fault protection
- Loss-of-excitation protection
- Overvoltage protection
- Overspeed protection
- Overcurrent protection
- Generator synchronization
- Synchronous generator protection scheme
- Transformer magnetizing inrush
- Differential protection
- Restricted earth fault protection
- Overcurrent protection
- Three-phase power transformer protection scheme
- Stator-winding fault protection
- Overcurrent protection
- Phase reversal protection
- Phase unbalance and undervoltage protection
- Stall protection
- Mechanical overload/underload protection

Additional required equipment for both systems:

- 1 x Dual-Trace Digital Storage Oscilloscope (see page 277)
- 1 x Digital Multimeter (see page 275)

2-kW Electric Power Transmission Training Systems

Hands-on experimentation with power transmission

LabVolt Series 8059

The 2-kW Electric Power Transmission Training Systems are designed to teach through hands-on exercises the principles of transmission of electric power – a subject which is usually taught in a strictly theoretical manner.

The exercises show how changes in the source, the load, and the transmission line affect the overall performance of the system. They illustrate the meaning of active and reactive power, how the voltage at the end of a line can be lowered or raised, how power can be forced to flow over one transmission line instead of another, and how a system behaves when subjected to disturbances.

The tests relating to switching transients, sudden overloads, and momentary short-circuits dramatically demonstrate the mechanical swing of generator poles and the concurrent surges of power over the transmission line. More than any amount of theory could show, these exercises convey the meaning of power stability and the limits to power flow.

Alternator, motor, capacitors, reactors, resistors, regulating autotransformer, series compensator, and transmission lines are employed. Despite their small size, these components are designed to act in the same way under steady-state and transient conditions, as their larger counterparts in industry. This practical, hands-on course is presented in a way that is readily understandable by anyone who has foundational knowledge of electricity.

Three exclusive modules:
– Three-Phase Transmission Line
– Power Line Series Compensator
– Three-Phase Regulating Autotransformer

220V/50Hz

Complete System with Analog Meters	**587414**
Add-on to 8013 2-kW Electromechanical System with Analog Meters	**587415**
Complete System with Data Acquisition Interface	**587416**
Add-on to 8013 2-kW Electromechanical System with Data Acquisition Interface	**587417**

Included manual

2-kW Electric Power Transmission System

Student Manual	585094
Instructor Guide	585095

Training content
- Power measurements
- Voltage regulation and power transmission capability of a transmission line
- Shunt capacitors and phase angle between sender and receiver
- Parameters affecting active and reactive power flow
- Power-handling capability and parallel lines
- Effects of series compensation on the power transfer capability and system stability
- Effect of series compensation on the voltage regulation and power factor
- The alternator
- The synchronous motor
- The synchronous compensator and long high voltage lines
- Transmission line networks and the three-phase regulating autotransformer
- The synchronous motor under load
- Hunting and system oscillation
- Power system transients

Courseware

The 2-kW Electric Power Trans mission Training System courseware consists of a Student Manual and Instructor Guide. The Student Manual contains exercises designed to present the subject matter in convenient instructional segments. In each exercise, principles and concepts are presented first, followed by a step-by-step, hands-on procedure to complete the learning process.

The exercises in the Student Manual are written to be performed using the Data Acquisition Interface module. However, for those who are using a system with analog meters, the connection diagrams are included in the Appendix. The Instructor Guide contains the practical results and the answers for each hands-on exercise and review question.

2-kW Electric Power Transmission Training System – Analog Meters
LabVolt Series 8059-2

The-2 kW Electric Power Transmission Training System – Analog Meters is a complete system that uses analog meters to perform electrical measurements.

Most important components
- 1x Mobile Workstation
- 1x Three-Module Workstation
- 2x Three-Phase Transmission Line
- 1x Three-Phase Regulating Autotransformer
- 1x Power Line Series Compensator
- 1x AC Voltmeter, 1x Phase Meter
- 1x DC Motor/Generator
- 1x Wiring Module for DC Motor/Generator
- 1x Three-Phase Synchronous Motor/Generator
- 1x Wiring Module for Synchronous Motor/Generator
- 3x Resistive Load
- 3x Inductive Load
- 3x Capacitive Load
- 1x DC Voltmeter/Ammeter
- 1x AC Ammeter
- 2x Three-Phase Wattmeter/Varmeter
- 2x Field Rheostat
- 1x Power Supply
- 1x Phase-Shift Indicator
- 1x Stroboscope
- 1x Coupler
- 1x Connection Leads

2-kW Electric Power Transmission Training System – Add-on to LabVolt Series 8013 with Analog Meters
LabVolt Series 8059-3

The 2-kW Electric Power Transmission Training System – Add-On to LabVolt Series 8013 with Analog Meters is an add-on to the 2-kW Electromechanical Training System, LabVolt Series 8013. It provides the equipment required to perform the exercises using LabVolt Series 8013 and analog meters.

2-kW Electric Power Transmission Training System – with Data Acquisition Interface
LabVolt Series 8059-4

The 2-kW Electric Power Transmission Training System – With Data Acquisition Interface is a complete system that uses a Data Acquisition Interface, LabVolt Series 9063, to perform electrical measurements.

2-kW Electric Power Transmission Training System – Add-on to LabVolt Series 8013 with Data acquisition interface
LabVolt Series 8059-5

The 2-kW Electric Power Transmission Training System – Add-On to LabVolt Series 8013 with Data Acquisition Interface is an add-on system to the 2-kW Electromechanical Training System, LabVolt Series 8013 (see page 174). It provides the equipment required to perform the exercises using LabVolt Series 8013 and a Data Acquisition Interface, LabVolt Series 9063.

Power Line Series Compensation Demonstrator

Principles of series compensation for transmission lines

LabVolt Series 8362

The Power Line Series Compensation Demonstrator is specifically designed for hands-on training in the principles of series compensation for electric power transmission lines. All equipment is provided in a single, integrated mobile console.

The unit is powered from a standard single-phase ac wall outlet. It simulates two high-voltage (735 kV) three-phase transmission lines: one uncompensated, the other compensated to 17%, 25%, or 34%. Line voltage, current, active power, and reactive power are measured at the inputs and outputs of the lines. The module is also available at 220 V 50 Hz but it demonstrates the functionality of North American power line at 60 Hz.

The Power Line Series Compensation Demonstrator includes all the test equipment necessary to perform the lab exercises. Input and output metering, dual transmission lines and various loads are all available from the front panel of this self-contained unit. Mounted on casters, the trainer can be easily moved. A student manual is also included.

Topic coverage

- Power transfer capability of a transmission line
- Effects of series compensation on power transfer capability and system stability
- Effect of series compensation on regulation of the receiver voltage
- Reduction of transmission losses on parallel lines using series compensation

120V/60Hz	en	es	fr
	586474	**586475**	
240V/50Hz			
	586478		
220V/50Hz			
	586476		

Included manual:			
Student Manual	584247	584247	

Note: PDF version also available.

Distribution Transformer Trainer

Connect single- and three-phase transformers

LabVolt Series 8361

The Distribution Transformer Trainer is a portable, hands-on trainer designed to allow students to develop the skills required to connect single- and three-phase transformers similar to those found in North American ac power networks.

The trainer contains two sets of three single-phase transformers to demonstrate three-phase transformer bank configurations such as wye-wye, delta-delta, closed delta-wye, closed wye-delta, open-wye, open-delta, etc. Each individual transformer winding is protected by a thermal-magnetic circuit breaker and designed to accept multiple faults.

The trainer is faultable to develop sound techniques for troubleshooting single-phase and three-phase transformer banks. Eight trainer faults are available.

The trainer is complete with a student laboratory manual written in a skill-building, performance-based format, allowing easy set-up of all laboratory exercises.

Targeted skills

The trainer allows students to:
- Identify different types of transformers
- Identify faulted transformers
- Test for proper no-load voltage
- Show how a three-phase transformer produces correct and incorrect motor rotation
- Show how the ratio of the transformer windings affects the secondary output voltage
- Show how to simulate parallel single-phase and three-phase transformers
- Simulate a burned-out transformer in a three-phase bank, as well as the connection of the remaining transformers in open-wye and open-delta configurations to produce the correct voltage

Topic coverage
- Distribution Transformer Trainer
- Transformer Polarity and Terminal Markings
- Single-Phase Transformers Supplying Single-Phase Loads
- Single-Phase Paralleling
- Three-Phase Banking of Single-Phase Transformers

120V/60Hz	en	es	fr
	586459	**586470**	
220V/50Hz			
	586471	**586472**	
240V/50Hz			
	587299		

Included manual: Distribution Transformer Trainer

Student Manual	584073
Instructor Guide	584076

Note: PDF version also available.

Necessary accessories, also order:

Connection Lead Set	586903
Multimeter	780874

Communications and Radar Technology

CE

Some training solutions included in this product guide do not have a CE mark and cannot be ordered for delivery to Europe.

If you are located in a country where this marking is required, please contact your Festo sales representative before placing an order.

Communications and Radar Technology

Training in leading-edge technologies

Classroom training for high-tech communication technologies

Communications play a crucial role in today's connected world. This high-tech sector is directly impacted by evolving technologies, which make systems more complex, while broadening their scope of applications across various industries.

The demand for specialized workers in the design, development, and maintenance of such systems is increasing, requiring focused and applicable training. Hands-on practice is key to successful training. Therefore, Festo Didactic has developed affordable, safe learning solutions that reproduce radar and communications technologies in the classroom.

High realism and educational value

Realistic training systems specially designed for education purposes, deliver clear benefits through their similarity to industrial equipment, measurement capabilities, and behaviors (frequencies, bit rates, connectors, protocols...), allowing students to relate the experiments to real-world situations. Access to test points, fault-insertion capability, as well as additional settings and access to signals usually unavailable in industrial equipment, ensure better and faster learning.

Innovative features

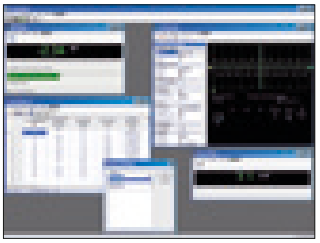
- FPGA-based radar processing allows for teaching pulse compression, otherwise impossible using traditional methods.
- A single reconfigurable training module (RTM) can be used for several technologies without duplicating equipment.
- A single power supply allows modules to be stacked on the power supply, thus optimizing space.

Turnkey courseware

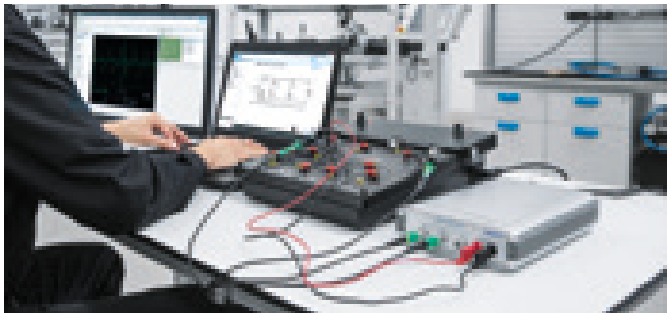
Festo Didactic first develops learning objectives and content, then develops the supporting hardware. The focus on pedagogical resources results in high quality, well-structured solutions adaptable to several teaching settings. Extensive student manuals – featuring theory, detailed lab experiments, and review questions– and instructor guides are available for each training system.

Communications and radar training systems from Festo Didactic incorporate hands-on experience with the principles and operations of electronic communications and radar systems.

Through computer-assisted curriculum or simulation software, trainees can progress from intermediate to advanced levels of study in the following communications-related technologies:
– Radar
– Satellite communication
– Antenna
– Microwave
– Telephony



Computer-based tools
Virtual tools complement courseware to stimulate students and support the learning process. Computer instrumentation reduces overall costs and optimizes time spent in the laboratory. Software programs enhance the modularity and flexibility of the system and allow multiple configurations.



Build knowledge in electronics
Electronics and communication technologies are closely connected. A sound understanding of electronics for communications can be conveyed with FACET, a completely integrated learning system for electronics. A unique combination of hardware (a base unit and circuit boards) and software (E-Learning courses and virtual instrumentation) provides a complete learning solution.

Circuit boards for communications technologies:
– Digital communications
– QPSK/OQPSK/DPSK
– Analog communications
– Fiber optic communications
– Communications transmission lines
– Digital signal processor
– and more

Radar Training Systems

The only real radar trainer that operates safely inside a classroom or a lab

LabVolt Series 8097

The Radar Training Systems provide students with real — not simulated — hands-on experience in the use of radar to detect and track passive targets at very short range in the presence of noise and clutter.

After more than 25 years, it is still the only real radar trainer that operates safely inside a classroom or lab. The level of technical advancement achieved by this system has been unequalled since. Affordable price, a fraction of real equipment.

The upgrade through the addition of computer-based control of the radar's processing and display functions ensure it will continue to be a leading-edge pedagogical product for many years.

High pedagogical value and interactivity

The Radar Training System is unique since it presents the realism of a real-world system while using the power of modern computer technologies. This realism makes the system very motivating to use by students and encourages their experimentation with the system.

The system is not a simulator: its operation is totally real. All outside world signals entering the system can be monitored and measured using the built-in virtual instruments. Conversely, several signals generated by the system, and made available on the Radar Training System's connectors and external test points can be measured with hardware instruments such as conventional oscilloscopes. This ensures that the system is perceived as real by the students.

Highlights

- Innovative design combining real-world radar with the power of modern surveillance technology
- Computer-based control of the radar's processing and display functions
- Comprehensive courseware and system level training with lab exercises
- Fault-insertion capability for the teaching of troubleshooting
- Turnkey, cost-effective training solution including instrumentation
- Powerful DSP, FPGA, and Data Acquisition System for Digital Analysis
- Realistic, high-gain parabolic antenna for high azimuth (angular) resolution
- Several subsystems allow delving into specific topics to expand knowledge and skills
- Can expand and complete existing telecommunication programs (satellite, antenna, microwave, etc.)

Training content

- Principles of radar systems
- Analog MTI processing
- Digital MTD processing
- Tracking radar
- Radar in an active target environment
- The phased array antenna
- RCS, SAR and ISAR measurements
- Radar Pulse Compression

Please note that some of the radar equipment is subject to export control. Contact your local representative for more information.

Modularity through subsystems
Subsystems 8097-1 and 8097-2 provide students with hands-on training in the principles and operation of analog and digital radar. Subsystems 8097-3 and 8097-4 adds tracking and active jamming possibilities to the system to train students in the principles and scenarios of Electronic Warfare (EW). Subsystem 8097-6 provides students with training in the principles of electronically steered antennas. Subsystem 8097-A allows radar cross section (RCS) measurement of different targets as well as inverse synthetic aperture radar (ISAR) imagery. Subsystem 8096-B introduces students to the basic principles and operation of synthetic aperture radar (SAR). Finally, subsystem 8097-C demystifies the principles of radar phase-coded pulse compression.

Based on a versatile module
The Radar Training System is based on a reconfigurable training module (RTM) including a powerful DSP and a large FPGA. The RTM allows the Radar Training System to be used in many different modes with little or no hardware changes This "programmable hardware" approach is achieved using a firmware uploaded and executed by the DSP and FPGA chips. The system interacts with the outside world through a series of small, low-cost plug-in modules inserted into the RTM. The RTM, together with the modularity of the system, facilitates expansion of the system without unnecessary duplication of equipment.

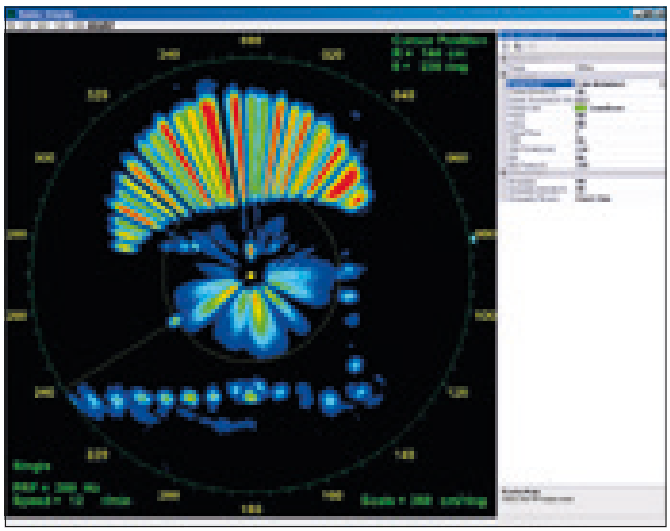
Comprehensive courseware
Manuals contain step-by-step, hands-on exercise procedures that guide the student through various experimentations on numerous radar topics. All experiments are highly repeatable, thanks to the stability of digital processing techniques. This enhances student motivation and system credibility.

Fault insertion
Real system and electronic faults can easily be inserted through the Faults control window in the LVRTS software. Several features are built into the system to enhance its pedagogical usefulness. These are features that would not normally be included in real-world radars.

Safety
The Radar Training System is totally safe for use in a classroom or lab, unlike radars used in the industry. All voltages and microwave power levels are well below accepted safety standards. Low RF power prevents wildlife from being exposed to harmful microwave levels.

LVRTS software

The LVRTS software is a Windows® based application used to download programs into the DSP and FPGA memory of the RTM, to select the type of radar which is implemented. It also has an intuitive user interface to:
– Select the radar processing functions and adjust other parameters of the radar, such as the video gain, detection threshold, etc.
– Control the radar display functions such as the PPI display mode selection, Variable Range Marker (VRM), Electronic Bearing Line (EBL), etc.
– Display diagrams that show how to connect the equipment.
– Display the functional block diagrams of the complete radar and radar processor/display subsystem.
– Connect virtual probes to test points in the block diagrams to observe real signals using the built-in oscilloscope.
– Use the Data Monitor to observe and analyze the signal processing sequence involved in Moving Target Detection
– Insert faults in the system (password-protected feature) for troubleshooting purposes.
– Set the parameters that control the generation of clutter and interference.
– Obtain on-line help screens.



Basic Radar Training System

LabVolt Series 8097-1

The Basic Radar Training System is a complete set of hardware, courseware, and all necessary accessories such as targets and interconnecting cables that allows the principles of pulse, CW Doppler, and FM-CW radar systems to be studied. The Basic Radar Training System consists of a transmitter, a receiver, three instrumentation modules, an antenna with pedestal, a target positioning system, and a set of accessories.

A comprehensive student manual and an instructor guide, which may be ordered separately, are also provided. An oscilloscope is required for target echo visualization on an A-scope display as well as time-domain observation of signals at outputs and test points.

	en	es	fr
Order no.	**8112495**	**8112497**	**8112496**

The most important components at a glance:
- 1x Horn Antenna
- 1x Power Supply/Antenna Motor Driver
- 1x Radar Synchronizer/Antenna Controller
- 1x Rotating-Antenna Pedestal
- 1x Radar Antenna
- 1x Dual-Channel Sampler
- 1x Target Positioning System
- 1x Radar Transmitter
- 1x Radar Receiver
- 1x Accessories for 8097-1

Manual included:

Principles of Radar Systems	en	es	fr
Student Manual	580402	580404	580403
Instructor Guide	580405	580407	580406

Note: PDF version also available.

Additional required equipment
- 1x Dual Trace Oscilloscope (or a similar oscilloscope)

Radar Processor/ Display Add-On

LabVolt Series 8097-2

The Radar Processor/Display is used in conjunction with the Basic Radar Training System to form a complete and modern pulse radar system. The Radar Processor/Display adds the following elements to the Basic Radar Training System: radar echo signal processing functions, PPI display functions, on-screen block diagrams of the complete radar and radar processor/display subsystem, and computer-based instruments (oscilloscope and data monitoring system). Two major types of radar echo signal processing function are available: Moving Target Indication (MTI) and Moving Target Detection (MTD). The Radar Processor/Display also provides computer controlled generation of clutter and interference to allow study of the MTI processing function. The following types of clutter and interference can be generated: sea clutter, rain clutter, second-trace echo, noise, and pulse interference.

The RTM, which uses state-of-the-art digital signal processor (DSP) technology, can be programmed to act as either an analog pulse radar (i.e., a pulse radar with MTI processing) or a digital pulse radar (i.e., a pulse radar using MTD, correlation and interpolation, and surveillance processing).

	en	es	fr
Order no.	**8112498**	**8112500**	**8112499**

The most important components at a glance:
- 1x Power Supply
- 1x Reconfigurable Training Module (RTM)
- 1x Analog/Digital Signal Combiner
- 1x Data Acquisition Interface
- 1x Radar Analog/Digital Output Interface
- 1x Accessories for 8097-2

Manuals included:

Analog MTI Processing	en	es	fr
Student Manual	580412	588936	580413
Digital MTD Processing			
Student Manual	580418	580420	580419
User Guide			
Order no.	580414	580416	580415

Note: PDF version also available.

Additional required equipment
- 1x Dual Trace Oscilloscope (or a similar oscilloscope)
- 1x Radar Host Computer (Or an equivalent Windows® based host computer)
- 1x Basic Radar Training System (8097-1)
- 1x Dual Function Generator (or a similar function generator)
- 1x Frequency Counter (or a similar frequency counter)

Radar Tracking Training System Add-On

LabVolt Series 8097-3

The Radar Tracking Training System adds on to the pulse radar implemented with the Basic Radar Training System and the Radar Processor/Display to form a continuous tracking radar. This radar can track a passive target that moves in the classroom laboratory.

The tracking radar can operate in three different modes (Scan, Manual, and Lock), which are selected through the hand-controller buttons. In scan mode, the antenna rotates at constant speed, allowing observation of targets on the PPI display. In manual mode, the operator can isolate a fixed or moving target of their choice, using the hand controller to control the antenna azimuth and to position an electronic marker (range gate) over the target echo signal. A computer-based O-scope display is used to monitor the position of the range gate relative to the echo signal of the target to be tracked. When the range gate straddles the target echo signal, the lock mode can be activated and the target is automatically tracked in range and azimuth by the system.

	en	es	fr
Order no.	**8112501**	**8112503**	**8112502**

The most important components at a glance:
- 1x Dual Feed Parabolic Antenna
- 1x Radar Target Tracking Interface
- 1x Accessories for 8097-3
- 1x Radar Tracker Hand Controller (USB)

Manual included:

Tracking Radar	en	es	fr
Student Manual	580422		580423

Note: PDF version also available.

Additional required equipment
- 1x Basic Radar Training System (8097-1)
- 1x Radar Processor/Display (8097-2)

Radar Active Target Training System Add-On

LabVolt Series 8097-4

Radar Active Target (RAT) Training System is used in conjunction with the three previous subsystems to train students in the principles and scenarios of EW. This is a truly unique system that places real-time, safe, and unclassified EW demonstrations into the hands of students. The RAT Training System consists of an active jamming pod trainer, an elaborate set of accessories, and a comprehensive student manual.

The jamming pod trainer is a Self-Screening Jammer (SSJ) target that can perform direct or modulated noise jamming as well as repeater jamming. It includes a remote controller to select the type of jamming and set the jamming parameters. The jamming pod trainer and the included accessories are designed for use with the Radar to implement real EW situations. This provides an effective means of introducing students to a real-time jamming situation that necessitates a response, that is, the use of an appropriate ECCM to prevent losing track of the target.

	en	es	fr
Order no.	**8112504**	**8112506**	**8112505**

The most important components at a glance:
- 1x Horn Antenna
- 1x Radar Jamming Pod Trainer Support
- 1x Radar Jamming Pod Trainer
- 1x Power Supply (Radar Electronic Warfare)
- 1x Accessories for 8097-4

Manuals included:

Electronic warfare	en	es	fr
Reference Book	580343		580346
Radar in an Active Target Environment			
Student Manual	580425		580426

Note: PDF version also available.

Additional required equipment
- 1x Basic Radar Training System (8097-1)
- 1x Radar Processor/Display (8097-2)
- 1x Radar Tracking Training System (8097-3)

Radar Phased Array Antenna Training System Add-On

LabVolt Series 8097-6

The Radar Phased Array Antenna Training System is specifically designed to be used with the complete, pulse radar system that can be implemented with the Basic Radar Training System (8097-1) and the Radar Processor/Display (8097-2).

Beam steering in the Radar Phased Array Antenna Training System is achieved using a microwave switch coupled to a Rotman lens and microstrip tapered slot array antennas. Beam steering control can be manual, continuous or synchronized on the PRF (pulse repetition frequency). Scan speeds of up to 1080 scans/min can be achieved, thereby allowing the PPI display (sector scan) of the radar system to be refreshed at much higher rates than with a conventional mechanically rotated parabolic antenna. Targets can thus be followed in near real time.

	en	es	fr
Order no.	**8112507**	**8112509**	**8112508**

The most important components at a glance:
- 1x Phased Array Antenna
- 1x Phased Array Antenna Controller
- 1x Accessories for 8097-6

Manual included:

The Phased Array Antenna	en	es	fr
Student Manual	580428		580429

Note: PDF version also available.

Additional required equipment
- 1x Basic Radar Training System (8097-1)
- 1x Radar Processor/Display (8097-2)

RCS and ISAR Measurement Training System Add-On

LabVolt Series 8097-A

The RCS and ISAR Measurement Training System adds on to the Radar Processor/Display (8097-2) to form a computer-based, pulse-mode system that can measure the radar cross section (RCS) of targets and produce inverse synthetic-aperture radar (ISAR) images of targets.

The system can generate RCS patterns of targets of up to 75 cm (30 in) in length when the longest pulse width is used. The system can also generate high-resolution ISAR images of much larger targets when the shortest pulse width is used. Because the system is based on pulse operation, it does not need to be operated in an anechoic chamber or in an outdoor range. Background clutter is rejected using time-gating and subtraction techniques during the measurement process.

The RCS and ISAR Measurement Training System includes a low-RCS target support to achieve precise RCS measurements; an RCS/ISAR data acquisition interface; an RCS measurement/ISAR imagery software included in the LVRTS software; an RCS/ISAR measurement interface module; a set of accessories including a reflective scale model of a 777 Boeing aircraft; and a system user guide. Note that RTM 9431-2 (and newer) from the Radar Processor/Display add-on is required to use this add-on.

	en	es	fr
Order no.	**8122693**		

The most important components at a glance:
- 1x RCS/ISAR Measurement Interface
- 1x RCS/ISAR Data Acquisition Interface
- 1x Accessories for 8097-A

Additional required equipment
- 1x Basic Radar Training System (8097-1)
- 1x Radar Processor/Display (8097-2)

Optional equipment
- 1x B2 RCS Scale Model
- 1xF-117A RCS Scale Model

Synthetic Aperture Radar (SAR) Training System Add-On

LabVolt Series 8096-B

The Synthetic-Aperture Radar (SAR) Training System adds on to the RCS and ISAR Measurement Training System (8097-A) to form a synthetic aperture radar that can produce high-resolution images. This system introduces students to the basic principles and operation of synthetic aperture radar (SAR).

The SAR Training System synthesizes a large aperture antenna through motion of a small-aperture (low directivity) horn antenna. Motion of the horn antenna is achieved using the Target Positioning System, LabVolt Series 9607-1, included in the Basic Radar Training System, LabVolt Series 8069-1, and an antenna-motion control module (SAR controller). Target radar echoes produced during a complete antenna scan are sampled and stored in the SAR processor then processed using a range Doppler algorithm to obtain high resolution SAR images.

The SAR Training System consist of SAR processing and imagery software included in the LVRTS software, a SAR controller module, the necessary cables and accessories, and a system user guide. Note that RTM 9431-2 (or newer) from the Radar Processor/Display add-on is required to use this add-on. Reflective scale models of aircraft that can be used with the SAR Training System are optionally available.

	en	es	fr
Order no.	**592583**		

The most important components at a glance:
- 1x SAR Controller
- 1x Accessories for 8096-B

Additional required equipment
- 1x Basic Radar Training System (8097-1)
- 1x Radar Processor/Display (8097-2)
- 1x RCS and ISAR Measurement Training System (8097-A)

Optional equipment
- 1x B2 RCS Scale Model
- 1xF-117A RCS Scale Model

Radar Phase-Coded Pulse Compression Training System

LabVolt Series 8097-C

Radar Pulse Compression is a signal processing technique used to increase the range resolution and signal-to-noise ratio of any pulse radar. The design of a radar is usually a question of compromise. In many cases, a trade-off must be made between desirable characteristics. For only a modest increase in cost and complexity, pulse compression improves the range resolution without sacrificing the signal-to-noise ratio.

The Phase-Coded Pulse Compression System is an add-on to the Basic Radar and Radar Processor/Display Training Systems. The system includes the Phase-Coded Pulse Compression Processor that encodes the radar pulses before transmission and compresses the received pulses. It also includes the Pulse Compression Parabolic Dish Antenna, which is designed to prevent internal reflections from interfering with the radar signal, and two attenuators (4 dB and 10 dB) used to facilitate measurements. The Phase-Coded Pulse Compression application is already included in the LVRTS software.

	en	es	fr
Order no.	**8121494**		**8112510**

The most important components at a glance:
- 1x Pulse Compression Radar Antenna
- 1x Phase-Coded Pulse Compression Processor
- 1x Power Cord

Manual included:

Phase-coded pulse compression	en	es	fr
Student Manual	593926		8111158
Instructor Guide	593927		8111156

Note: PDF version also available.

Modules, Accessories, and Optional Components

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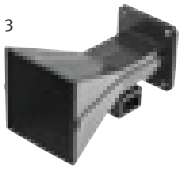

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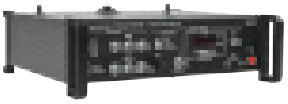

1 **Power Supply**
The power supply is the power source for the Reconfigurable Training Module (RTM) used in various communications training systems. Its back panel has a multi-pin connector output that provides regulated DC voltages. Auto-reset fuses protect the outputs of the Power Supply against short-circuits.

Order no.	**8112514**

2 **Reconfigurable Training Module (RTM)**
The Reconfigurable Training Module (RTM) consists mainly of a powerful digital signal processor (DSP), with three slots on the module front panel for installing interface modules. An Ethernet port (RJ-45) connector, located on the back panel, allows local or distant connection of the RTM to the host computer. The functionality of the training system is determined by downloading a program into the DSP memory using the host computer that runs the software. Electrical power is supplied to the RTM by the Power Supply through a multipin cable that connects to the back panel.

Order no.	**8094635**

3 **Horn Antenna**
The Horn antenna is used to perform experiments related to a variety of topics, such as FM-CW radar, antenna gain, and microwaves. When used in conjunction with the Radar Antenna, the Horn Antenna allows separate transmission and reception of RF signals. It is also used in certain EW demonstrations.

Order no.	**581847**

4 **Power Supply/ Antenna Motor Driver**
The Power Supply/Antenna motor driver is the physical base for the Basic Radar Training System. The power supply distributes three unregulated dc voltages to the stacked modules through self-aligning connectors. The antenna motor driver supplies power to the Rotating-Antenna Pedestal. The Pulse-Width-Modulated (PWM) motor driver uses a 4-quadrant chopper requiring a command signal from the antenna controller or radar target tracking system.

	en	**es**	**fr**
Order no.	**8084743**	**8104277**	**8104276**

5 **Radar Synchronizer/ Antenna Controller**
The Radar Synchronizer/Antenna Controller is used for Pulse Repetition Frequency (PRF) generation and synchronization of the different radar components. It also controls the operating parameters of the radar antenna.

	en	**es**	**fr**
Order no.	**595986**	**595988**	**595987**

1 **Rotating Antenna Pedestal**
The Rotating antenna pedestal is the mount and drive motor for the radar antenna. It provides the RF connection between the antenna and the radar transmitter and receiver. Antenna position feedback is obtained from an incremental optical shaft encoder, the output of which may be monitored through front-panel test points. The RF section includes a circulator for simultaneous transmission and reception. A rotary joint provides RF coupling to the rotating antenna mount.

	en	es	fr
Order no.	**8112383**	**8112385**	**8112384**

2 **Radar Antenna**
The Radar antenna mounts on the rotating-antenna pedestal and has a miniature plug-in connector for quick RF coupling. It uses an offset-feed design to reduce masking effects. A screen of microwave-radiation absorbing material is also supplied, which, although not required due to the low level of RF power radiated by the system, provides training in microwave safety techniques as well as preventing interference with surrounding radar stations.

Order no.	**581936**

3 **Dual Feed Parabolic Antenna**
The Dual Feed Parabolic Antenna mounts on the rotating antenna pedestal and is fully compatible with the miniature plug-in RF quick connector. The dual-feed horns are connected to a microwave SPDT switch that allows alternating transmission and reception of the signal from each horn through the single rotary joint of the antenna pedestal.

Order no.	**581937**

4 **Pulse Compression Radar Antenna**
The Radar pulse compression antenna mounts on the rotating antenna pedestal and is fully compatible with the miniature plug-in RF quick connector. It uses an offset-feed design to reduce masking effects. It also comprises a low-lost cable for adding delay in pulse-compression exercises.

Order no.	**592570**

5 **Dual-Channel Sampler**
The Dual-channel sampler performs time expansion of the I- and Q-channel baseband signals from the radar receiver to allow further processing and display. It has three switches to select the system observation range, as well as control knobs for adjusting the system range origin, the balance of the I- and Q-channel output signals, and the DC offsets at the I- and Q-channel outputs. A time base output is provided to obtain an A-scope display on a conventional oscilloscope.

	en	es	fr
Order no.	**595989**	**8087049**	**8087048**

6 **Target Positioning System**
Consists of a mobile target table, a remote target controller module connected to the table via a multiway cable, and four types of targets (a sphere, a cylinder, a 90-degree reflector, three metal plates and a plexiglass plate). The surface of the target table measures 90 by 90 cm and is marked with a 1-cm grid. The system provides closed-loop DC servo control of the position and speed of the target in X and Y.

	en	es	fr
Order no.	**8121782**	**8121784**	**8121783**

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Modules, Accessories, and Optional Components

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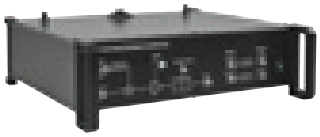

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1 **Radar Jamming Pod Trainer**
Self-screening jammer (SSJ) target in a compact enclosure. It is designed to be placed on the target positioning system to electronically attack the radar training system by masking the target echo signal with noise or causing either range or angle deception. The radar jamming pod trainer mainly consists of an RF signal source, a variable attenuator, transmitting and receiving horn antennas, a signal repeater, an amplitude modulator, and a remote controller.

	en	es	fr
Order no.	**581949**	**581951**	**581950**

Radar Jamming Pod Trainer Support
This support is a mast designed to support the Radar Jamming Pod Trainer when it is used to perform electronic jamming against the Radar. Soft pads allow the mast to glide softly over the surface of the Target Positioning System.

Order no.	**581916**

2 **Power Supply**
The Power supply can be installed under the surface of the target positioning system to provide power to the radar jamming pod trainer. It provides the same unregulated DC voltages as the power supply/antenna motor driver through a multi-pin connector located on its top panel.

	en	es	fr
Order no.	**8095962**	**8101571**	**8101570**

3 **RCS/ISAR Measurement Interface**
The RCS/ISAR measurement Interface contains additional RF circuitry that allows RCS and ISAR measurements to be performed using the basic radar training system and the radar processor/display add-on. This RF circuitry also allows the basic radar training system to be converted into a synthetic aperture radar (SAR).

	en	es	fr
Order no.	**581960**	**587459**	**581961**

4 **Phased Array Antenna**
The phased array antenna is specifically designed to be used with the radar training system. It allows a horizontal sector to be scanned (azimuthal scanning) without any antenna motion. The antenna can be tilted 90° to demonstrate elevation scanning. It consists of a microwave switch coupled to a Rotman lens and microstrip tapered slot array antennas. A built-in circulator allows simultaneous transmission and reception.

	en	es	fr
Order no.	**581966**	**587460**	**581967**

5 **Phased Array Antenna Controller**
The phased array antenna controller is used for beam steering control of the Phased array antenna (PAA). It allows the PAA to be operated in three scan modes: manual, continuous, and PRF locked (radar PRF dependent). The beam sequence can be either linear or pseudo random, or consists of even numbered beams only.

	en	es	fr
Order no.	**581968**	**587461**	**581969**

6 **Phase-Coded Pulse Compression Processor**
The phase-coded pulse compression processor allows to experiment pulse compression with the radar training system. It is divided into three sections: dual-channel sampler, pulse compressor and pulse generator. The dual-channel sampler samples the I- and Q-Channel baseband signals from the receiver and stretch these signals in time to facilitate observation and measurement.

	en	es	fr
Order no.	**592571**		**8108337**

1 **SAR Controller**
The SAR Controller allows motion control of the small-aperture horn antenna installed on the moveable carriage of the Target Positioning System when the Basic Radar Training System is used as a synthetic aperture radar. It also ensures that the radar echo signal acquisition is properly synchronized with the horn antenna motion. The SAR Controller is complemented by the Synthetic Aperture Software – a Windows®-based application, included in the LVRTS software, that allows to produce signals acquired during a scan of the small-aperture horn antenna over the complete aperture length.

	en	es	fr
Order no.	**581970**	**587462**	**581971**

2 **Radar Transmitter**
The Radar Transmitter is an instructional module designed to provide training in system- and module-level troubleshooting. It has switches that the instructor can use to insert faults. It generates an RF signal that can be either frequency modulated or amplitude modulated. It includes an RF oscillator, a pulse generator, and an amplitude modulator.

	en	es	fr
Order no.	**595172**	**8087391**	**8087390**

3 **Radar Receiver**
The Radar Receiver is an instructional module designed to provide training in system- and module-level troubleshooting. It has switches that the instructor can use to insert faults. The Radar Receiver down-converts the received RF signal to baseband directly (homodyne receiver) for the three types of radar that can be implemented (CW, FM-CW, and pulse radars).

	en	es	fr
Order no.	**595990**	**8086690**	**8086689**

4 **Analog/Digital Signal Combiner**
The Analog/Digital Signal Combiner is a compact module designed to be installed into one of the slots on the RTM of the Radar Processor/Display. This module converts the clutter and interference generated by the DSP of the RTM to analog format, and adds it to the I- and Q-channel echo signals coming from the Radar Receiver.

Order no.	**8112776**

5 **Data Acquisition Interface**
The Data Acquisition Interface is a compact module designed to be installed into one of the slots on the RTM of the Radar Processor/Display. This module receives the I- and Q-channel echo signals of the radar, perturbed or not, and converts them to digital format. It also receives the PRF and synchronization signals as well as azimuth information from the Radar Synchronizer/Antenna Controller. All these signals are then routed to the RTM for digital signal processing.

Order no.	**8112777**

6 **Radar Analog/Digital Output Interface**
The Analog/Digital Output Interface is a compact module designed to be installed into one of the slots on the RTM of the Radar Processor/Display. This module provides analog and digital output signals generated by the RTM. The nature of the signals generated depends on the type of radar processing that the RTM performs.

Order no.	**8093433**

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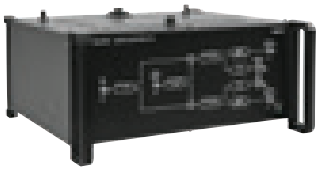

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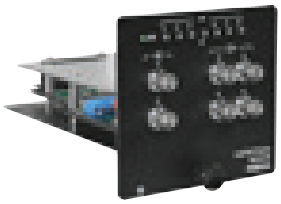

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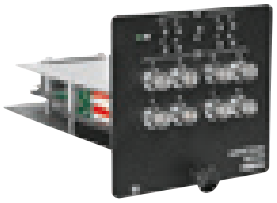

Modules, Accessories, and Optional Components

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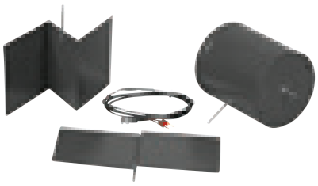

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1 **Radar target tracking interface**
Compact module designed to be installed into one of the slots on the RTM of the radar processor/display. The module provides the lobe switching control signal and the RF circuitry (bias tee and DC blocking capacitor) required to perform lobe switching with the dual feed parabolic antenna.
Order no. **8112778**

2 **RCS/ISAR data acquisition interface**
The RCS/ISAR data acquisition interface is a compact module designed to be installed into one of the slots on the RTM of the radar processor/display. This module receives the I- and Q-channel echo signals of the radar and converts them to digital format. It also receives the PRF and synchronization signals as well as azimuth information from the radar synchronizer/antenna controller. All these signals are then routed to the RTM for digital signal processing.
Order no. **8122692**

3 **Accessories for 8097-1**
Containing all the cables and accessories required for the operation of the basic radar training system. These include: SMA flexible cables, BNC cables, a DB9 cable, an antenna motor driver cable, BNC tees, SMA attenuators, an SMA 50 Ω load, a measuring tape, a level, a waveguide-to-coax adapter, a horn antenna.
Order no. **8112515**

4 **Accessories for 8097-2**
Containing a DB15 cable, a USB port cable, an RJ-45 connector crossover cable, an Ethernet adapter (network card) to be installed in the radar host computer, two semi-circular targets, a multiple target holder to be used with the target positioning system and the LVRTS software CD-ROM.
Order no. **8112516**

5 **Accessories for 8097-3**
Containing a cylinder target, two zigzag targets, and a BNC connector-to-miniature banana jack cable.
Order no. **581984**

Accessories for 8097-4
Containing a chaff cloud simulation device, a multifunction stand, a triangular (stealth) shield to cover the radar jamming pod trainer, radiation absorbing material (RAM), a set of microwave components and cables, and a sample of actual chaff.
Order no. **581985**

Accessories for 8097-6
Containing two short SMA cables with built-in passive limiters, two low-loss long SMA cables, a 30 dB SMA attenuator, a DB25 cable, and a microwave absorbing pen.
Order no. **581987**

6 **Accessories for 8097-A**
Containing a low-RCS target support with a support stand, an adjustable base and long interconnection cables for the rotating-antenna pedestal, additional BNC and SMA cables, a tripod with an antenna mast, a large horn antenna, a small metal plate target, a small metal plate target with radar absorbing material (RAM) on one side, and a reflective aircraft target (777 Boeing scale model).
Order no. **8129037**

7 **Accessories for 8096-B**
Containing two medium-length BNC cables, two long BNC cables, a low loss long SMA cable, a short multiway cable (to connect the SAR controller to the target controller of the target positioning system), a long USB port cable, a two-axis adjustable antenna support, and a radiation absorbing material (RAM) panel.
Order no. **581988**

1 **Radar Tracker Hand Controller**
The radar tracker hand controller is a joystick-type device designed to be connected to a USB port of a personal computer. It is used to select specific targets when the tracking radar is in the manual mode of operation. Fore and aft motion of the handle allows range positioning of a tracking cursor (range gate). Left-right motion of the handle controls the direction of the antenna's rotation, thereby allowing the antenna to be rotated to a specific azimuth.

Order no.	**581992**

2 **Dual Trace Oscilloscope**
Economical and highly reliable solid-state instrument, ideal for general purpose use in laboratory and training applications. Students can measure phase difference between waveforms using the X-Y operation mode, and video signals can be measured quickly with the special TV sync separation circuit. The dual trace oscilloscope includes CH 1, CH 2, CHOP, and ALT display modes. An operating instruction manual, one fuse, one line cord, and two low capacitance probes are provided with the oscilloscope.

Order no.	**580849**

3 **RCS Scale Models**
Scale models of different aircrafts for RCS measurement. Color may vary.

Boeing 777	**582122**
B2	**587493**
F-117A	**587494**

Arbitrary Function Generator
DDS (Direct Digital Synthesized) based signal generator designed to accommodate the Educational and Basic Industrial requirements for an accurate and affordable signal source covering the output of Sine, Square (Pulse), Ramp (Triangle), Noise and Arbitrary waveforms. Model AFG-2005 from GW Instek.

	en	**es**	**fr**
Order no.	**8125246**		

Universal Frequency Counter
Reciprocal 2.4 GHz universal frequency counter with Ratio Function that is microprocessor controlled. The LED display can provide nine digits of resolution using the internal 10s gate time. Model 1823A from B&K Precision.

	en	**es**	**fr**
Order no.	**8112877**		

Radar Host Computer
The radar host computer is a Windows® based computer with the LVRTS software installed, two monitors, and a dual-output display adapter (video card) compatible with Microsoft DirectX® version 9 or later.

120 V/60 Hz	**en**	**es**	**fr**
Order no.	**587465**		**589842**
220 V/50 Hz			
Order no.	**587466**		**589843**
240 V/50 Hz			
Order no.	**587472**		

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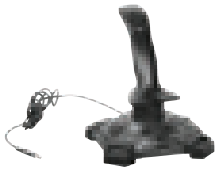

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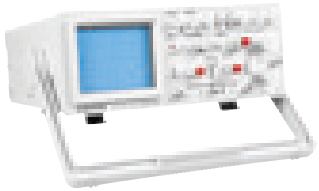


3

Satellite Communication Training System

System-level training using an operational satellite link

LabVolt Series 8093

The Satellite Communications Training System is a versatile training platform designed to teach modern technologies in the classroom using a fully operational satellite link.

The transmitter, receiver, and satellite repeater operate at realistic uplink and downlink frequencies and at safe power levels. The system allows students to observe and study a wide range of telecom concepts, such as digital and analog modulation, scrambling, differential encoding, and frequency conversion as well as concepts specifically related to satellite communications. In addition, since noise and losses affect the performance of all telecom systems, performance-related concepts such as noise figure, figure of merit, link budget, and the performance ratio C/N0 are also covered.

Affordable instrumentation tools

The required Telemetry and Instrumentation Add-On is an economical alternative to expensive, high frequency conventional instruments. This add-on, used in conjunction with the Telemetry and Instrumentation software, provides telemetry with the Satellite Receiver as well as a full suite of virtual instruments. Alternatively, conventional instruments can also be used.

Computer simulation

The Orbit Simulator provides interactive visualization of satellite orbital mechanics and satellite coverage.

Highlights

- Real-time data transmission over the satellite link
- License-free transmission and low power levels for complete safety
- Reflects current standards and modulation types
- Includes both analog and digital modulators/demodulators
- Fault-insertion capability to teach troubleshooting
- Comprehensive courseware
- Orbit Simulator software available
- Virtual telemetry/instrumentation

Training content

- Satellite Communication Fundamentals
- Analog and Digital Transmission
- Link Characteristics/Performance
- Orbital Mechanics
- Satellite Orbits and Coverage
- Troubleshooting

Satellite Communications Training System

LabVolt Series 8093

The Basic Satellite Communications Training System is a state-of-the-art training system that covers the field of satellite communications. Specifically designed for hands-on training, the system covers modern satellite communication technologies including analog and digital modulation. This system is designed to use realistic satellite uplink and downlink frequencies at safe power levels and to reflect the standards commonly used in modern satellite communications systems

	en	es	fr
120V/60Hz	**582081**	**589201**	
220V/50Hz	**582082**		
240V/50Hz	**582083**		

The most important components, at a glance:
– 1x Earth Station Transmitter
– 1x Earth Station Receiver
– 1x Satellite Repeater
– 1x Cables and Accessories*
– 1x Orbit Simulator Software
– 3x Power Cords
* Include SMA cables, BNC cables, USB cables, 2x small-aperture horn antennas, 2x large-aperture horn antennas, 4x horn antenna supports, an attenuator, and adapters.
Order no. 581876

Manuals included:
Principles of Satellite Communications

Student Manual, en	580537
Instructor Guide, en	580538

Link Characteristics and Performance

Student Manual, en	580541
Instructor Guide, en	580542

Satellite Orbits, Coverage, and Antenna Alignment

Student Manual, en	580610
Instructor Guide, en	580611

Note: PDF version also available.

Additional required equipment
– 1x Telemetry and Instrumentation Add-on (8093-1)
(or instruments provided by the customer: 0–12 GHz spectrum analyzer, oscilloscope, BER indicator, function generator, and one or more data generators)

Telemetry and Instrumentation – Add-On

LabVolt Series 8093-1

The Telemetry and Instrumentation Add-On is used with the Telemetry and Instrumentation software to provide virtual instruments and telemetry with the repeater. This add-on consists of the Data Generation/ Acquisition Interface, and the Virtual Instrument Package. These modules, used in conjunction with the Telemetry and Instrumentation software, provide virtual instruments designed for the display and measurement of the baseband, IF and RF signals present in the system as well as virtual generators used to generate analog and digital baseband signals for transmission.

	en	es	fr
120V/60Hz	**582084**	**589202**	
220V/50Hz	**582085**	**594504**	
240V/50Hz	**582086**		

Host computer
Pentium-type personal computer running under a Windows® operating system with the LVSAT software preinstalled required for both systems.

	en	es	fr
120V/60Hz	**587470**		**589846**
220V/50Hz	**587471**		**589847**
240V/50Hz	**587469**		

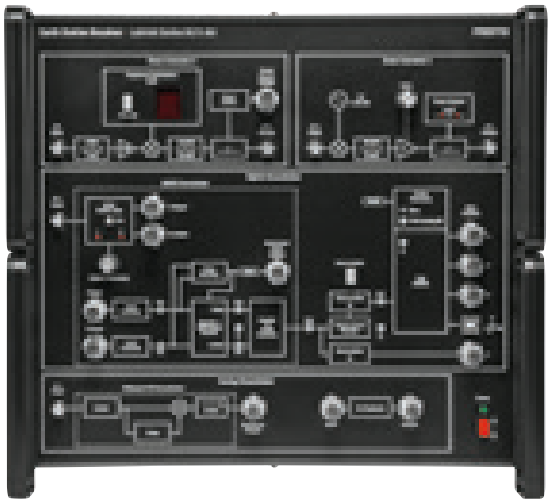
Modules

Earth Station Transmitter
The Earth Station Transmitter is designed to teach ground-segment signal processing, modulation, and frequency conversion techniques. It includes an Analog Modulator and a Digital Modulator as well as two up-converters. The Analog Modulator section provides pre-emphasis baseband processing as well as wideband FM modulation, both commonly used in satellite communications systems. The 10 MHz bandwidth is sufficient for transmitting one composite television signal.

The Digital Modulator section provides time-division multiplexing (TDM), scrambling, encoding and digital modulation. The TDM multiplexer allows multiplexing up to four data streams at a maximum data rate of 4 Mbit/s per stream.

A Scrambler is used to ensure frequent transitions in the data and to spread the power smoothly over the available bandwidth. A Clock & Frame Encoder is used to add transitions to the multiplexed data to ensure reliable clock recovery in the receiver as well as control bits for frame synchronization. Both the Scrambler and the Clock & Frame Encoder can be switched on or off independently.

The Digital Modulator section uses DQPSK (differential quadrature phase-shift keying) modulation, a type of digital modulation commonly used in satellite communications systems. BNC connectors provide access to the I and Q channel signals of the DQPSK modulator. Front-panel test points provide access to signals at each intermediate stage of the modulation process. After modulation, either analog or digital, the signal is converted to a frequency (around 11 GHz) by the two stages of up-conversion."



Earth Station Receiver
The Earth Station Receiver is designed to teach ground-segment frequency conversion, demodulation, and signal processing techniques. It includes two down converters as well as an Analog Demodulator and a Digital Demodulator. A large-aperture horn antenna connected to the integrated LNA (low-noise amplifier) receives the downlink signal from the Satellite Repeater. This antenna is connected to the RF Input of Down Converter 2, which includes a Channel selector to select one of six downlink frequencies in the 9 GHz range. Down Converter 2, which also includes a Power Sensor to facilitate measurement of the received power level, shifts the signal down to the 1.56 GHz range (IF 2). Down Converter 1 further shifts the signal down to the 280 MHz range (IF 1). An SMA cable is used to connect the IF 1 signal to either the Analog Demodulator or the Digital Demodulator section.

The Analog Demodulator section provides wideband FM demodulation as well as de-emphasis baseband processing. The Digital Demodulator section provides DQPSK demodulation, decoding, descrambling and demultiplexing. Front-panel test points provide access to signals at each intermediate stage of the demodulation process. The DQPSK demodulator uses a Costas loop to recover the carrier from the IF 1 signal. BNC connectors provide access to the I and Q channel signals of the QPSK Costas loop. The demodulator also has a Clock Recovery block to recover a clock signal which is made available at a BNC connector.

The serial data from the DQPSK demodulator is sent through a Clock & Frame Decoder and a Descrambler and then to the TDM demultiplexer which demultiplexes the data into four data streams.

	en	es	fr
Order no.	**581864**	**589203**	

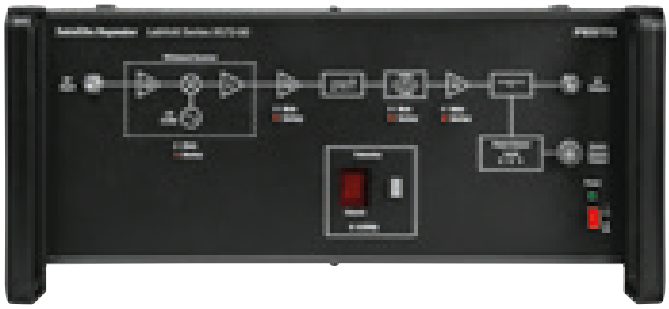
Additional required equipment:

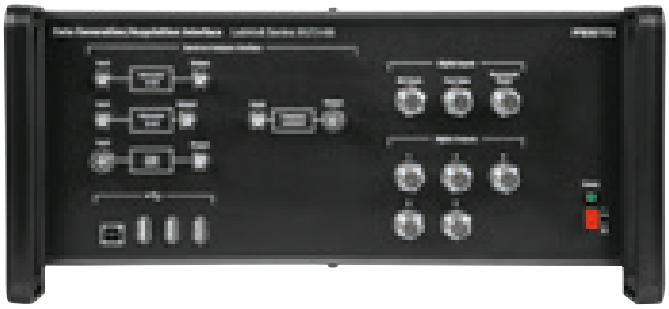
1x Power cord, Type F	789182
1x Power cord, Type B	789405
1x Power cord, Type I	789406

	en	es	fr
Order no.	**581867**	**589204**	

Additional required equipment:

1x Power cord, Type F	789182
1x Power cord, Type B	789405
1x Power cord, Type I	789406





Satellite Repeater
The Satellite Repeater is designed to teach the operation of a transparent satellite payload, including telemetry and remote troubleshooting and maintenance using redundancy switching. A small-aperture horn antenna receives the uplink signal from the Earth Station Transmitter. A low-noise block (LNB) shifts all frequencies in the uplink signal range (11 GHz) to the downlink frequency range (9 GHz). The bandwidth of the LNB is sufficient to include all six channels. A single Satellite Repeater can therefore be used with up to six different earth stations simultaneously (note that physical constrains might prevent the user from being able to create such a set up).

The functional blocks after the LNB implement a single transponder. These blocks include a variable-gain amplifier (VGA), an isolator, a band-pass filter and a power amplifier (PA). The LNB, VGA, filter and PA each have a MAIN and a BACKUP LED. Internal circuits controlled by telemetry simulate faults and redundancy switching for troubleshooting exercises. A Power Sensor facilitates direct measurement of the power level of the transmitted downlink signal. This power level, as well as the status of the redundant functional blocks, can be monitored at the earth station via the telemetry link. Another small-aperture horn antenna transmits the downlink signal to the Earth Station Receiver.

Data Generation/Acquisition Interface
The Data Generation/Acquisition Interface is part of the Telemetry and Instrumentation Add-On. It provides a physical interface (BNC input and output connectors) for the digital generators and digital instruments of the Telemetry and Instrumentation software.

The module also provides a Spectrum Analyzer Interface for use with the Virtual Instrument Package. This interface includes two attenuators and a probe buffer. Any one of these can be connected to a software-controlled frequency converter which shifts the frequency of the signal to a range compatible with the Virtual Instrument. Together, the Spectrum Analyzer Interface, the Virtual Instrument Package, and the software provide a virtual spectrum analyzer covering four frequency ranges from DC to over 11 GHz, allowing the frequency-domain display and measurement of all signals in the training system.

The Data Generation/Acquisition Interface also contains the circuitry and the antenna required for telemetry, over a dedicated RF link, with the Satellite Repeater. The Data Generation and Acquisition Interface communicates with the host computer via a USB port and includes a 3-port USB bridge with front-panel connectors to facilitate interfacing the other modules with the host computer.

The Virtual Instrument Package is included with this equipment. The Virtual Instrument Package is an interface module that provides highspeed sampling (up to 1 GS/s) and generation of analog signals. It interfaces to a computer's USB port and is used in conjunction with the Telemetry and Instrumentation software to implement all the analog virtual instruments required to perform the laboratory exercises.

	en	es	fr
Order no.	**581870**	**589205**	

Additional required equipment:

1x Power cord, Type F	789182
1x Power cord, Type B	789405
1x Power cord, Type I	789406

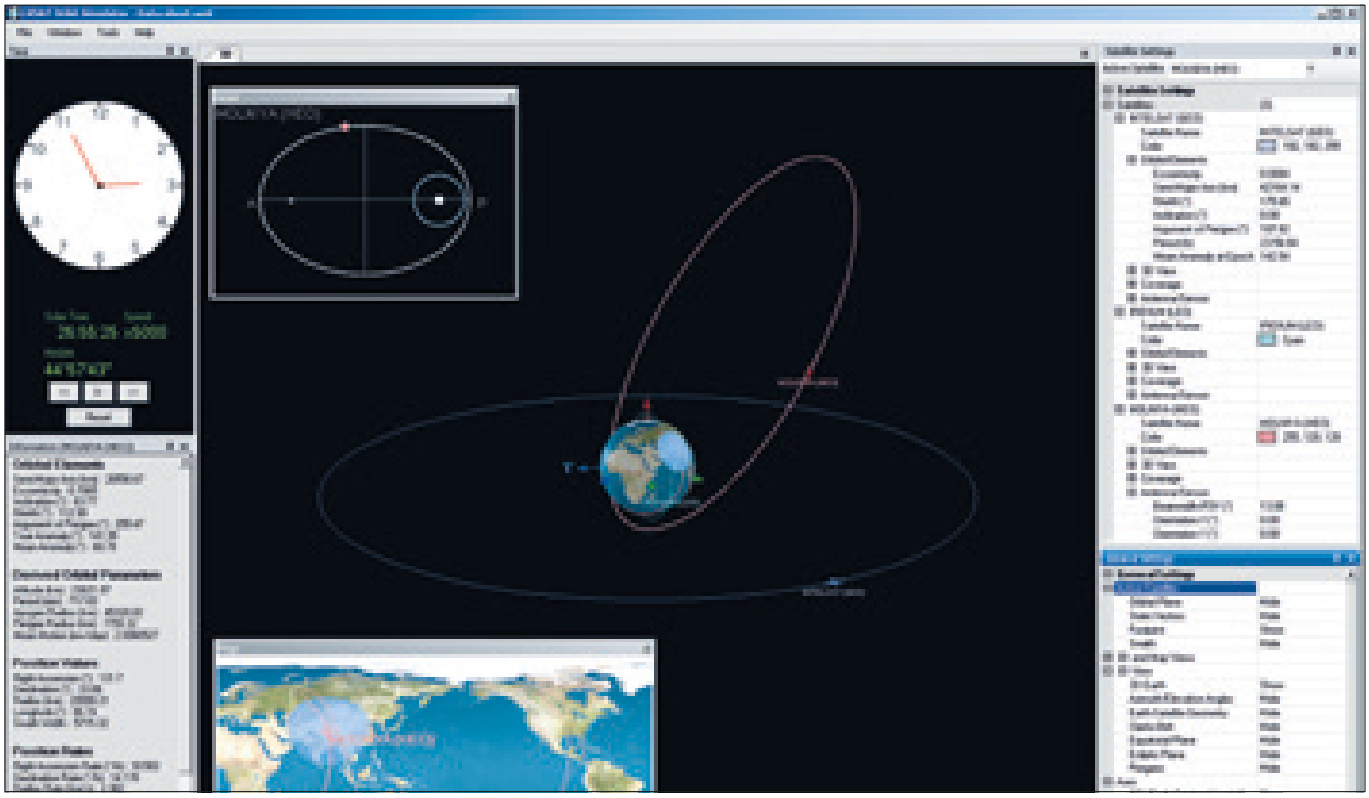
	en	es	fr
Order no.	**581873**	**589206**	

Additional required equipment:

1x Power cord, Type F	789182
1x Power cord, Type B	789405
1x Power cord, Type I	789406

Orbit Simulator Software

Interactive visualization of satellite orbital mechanics and satellite coverage



Because the space segment is an essential part of every satellite system, whether it is intended for communications, remote sensing, reconnaissance, navigation, scientific research, mapping, or disaster detection and relief or for any other application, it is vitally important to understand the behavior of the satellites when designing, using or maintaining a satellite system. For this reason, educational programs for these fields usually cover orbital mechanics and satellite coverage.

Interactive 2D and 3D animations
The Orbit Simulator software is a highly motivating and interactive tool designed to help students visualize and grasp these important concepts. This software provides 2D and 3D animated views of the e arth and orbiting satellites as well as a plane view of one orbit. Students can display typical orbits of existing satellites, such as geosynchronous, geostationary, quasi-geostationary, quasi-zenith, polar, LEO, MEO and highly elliptical (e.g. Molniya) orbits and create their own satellites by entering the appropriate orbital elements. They can also modify the orbital elements of any satellite and observe the result. The animation can be viewed in real time, accelerated or stopped.

The software demonstrates various aspects of satellite coverage such as visibility, footprints, elevation contours, time of visibility, revisit time, swath, satellite constellations, global and spot satellite antenna beams, and instantaneous and long-term coverage. It also helps students understand factors critical to the alignment of earth station antennas to geostationary satellites such as satellite longitude, antenna look angles and polarization angle (skew).

The Orbit Simulator Software includes three software applications: Orbit Simulator, Telemetry and Instrumentation, and Data Transfer. For convenience. The installation program allows installing some or all the applications, depending on the equipment purchased by the user.

Highlights
- Use simulation to help students understand the behavior of the satellites when designing, using or maintaining a satellite system
- Demonstrate various aspects of satellite coverage
- Practice antenna alignment with real geostationary satellites (requires user-provided equipment)
- Students can see unfamiliar concepts in action, such as inertial and rotating frames of reference and coordinate systems, etc.

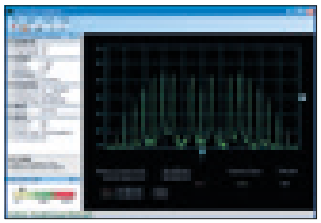
Training content
- Satellite orbits
- Coverage
- Antenna alignment

	en	es	fr
Single license for 1 user	**581877**	**581879**	**581878**

Notes:

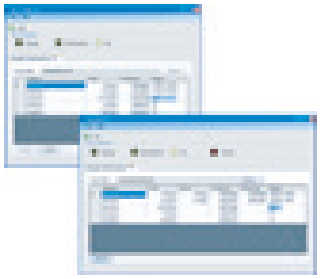
Several license options are available; please contact us.

Manuals “Satellite Communications Training System” and “Satellite Orbits, Coverage, and Antenna Alignment” are provided with the software.



Telemetry and Instrumentation

Used in conjunction with the Telemetry and Instrumentation Add-On, the software application provides a user interface for telemetry with the Satellite Repeater. It also provides the following virtual instruments: an oscilloscope, a spectrum analyzer (illustrated), a true RMS Voltmeter/Power Meter, a BER Tester, a waveform Generator, and three user-configurable binary sequence generators.



Data Transfer

The Data Transfer software consists of two separate applications designed to demonstrate the transfer of computer data over a satellite link. Data is sent using the Data Transmitter application via the Earth Station Transmitter. The data is received using the Data Receiver application via the Earth Station Receiver. The Data Transfer applications can be run on the same computer or on two different computers.

Antenna Training and Measuring System

Experimentation on antennas in the 1 GHz and 10 GHz bands

LabVolt Series 8092

The Antenna Training and Measuring System (ATMS) provides teachers and students with training materials for hands-on experimentation on antennas in the 1-GHz and 10-GHz bands. A convenient and powerful antenna measuring system, the ATMS can also be utilized by design and research teams.

The complete Antenna Training and Measuring System includes a set of 1-GHz antennas, a set of 10-GHz antennas, an RF Generator, a receiving system, and the Data Acquisition and Management Software for Antennas (LVDAM-ANT), a user-friendly software operating under the Microsoft® Windows™ environment. The receiving system consists of a rotating Antenna Positioner linked to a Data Acquisition Interface connected to the USB port of a personal computer.

Expansion options

The ATMS is a self-contained, stand-alone system that does not require other microwave equipment. However, optional antennas, a two-element phasing kit, and a set of RCS demonstration accessories can be added to the ATMS to enhance the scope of experimentation on antennas and reflectors.

Furthermore, the ATMS is compatible with the 10.5-GHz Microwave Technology Training System, LabVolt Series 8090 or 8091. The VSWR Meter and the Power Meter of the Microwave Technology Training System, along with microwave components such as the slotted line, the Gunn oscillator, attenuators, and couplers, can be used for various creative laboratory projects.

Highlights

- Convenient and powerful antenna measuring system that can also be utilized by design and research teams
- Stand-alone system requiring no other microwave equipment
- Provides system-level, hands-on experimentation on antennas in the 1-GHz and 10-GHz bands in the classroom
- Rugged, high-quality components designed for hands-on training purposes
- Meets a variety of needs and budgets because of options
- Does not require an anechoic chamber
- Devices and components fabricated from electroless-plated brass to standard X-band waveguide dimensions
- Waveguide flanges are joined by precision quick fasteners, allowing rapid assembly and disassembly of microwave circuits

Training content

- Basic antenna measurements, including: beamwidth, gain, impedance, directivity, polarization and the radiation pattern.
- Experimentation with different antenna types
- Microstrip and array antennas

	en	es	fr
120V/60Hz	**582074**	**582076**	**582075**
220V/50Hz	**582077**	**582079**	**582078**
240V/50Hz	**582080**		

The most important components at a glance:
– 1x X RF Generator
– 1x Antenna Positioner
– 1x Data Acquisition Interface/Power Supply
– 1x Horn Antenna, Small Aperture
– 2x Horn Antenna, Large Aperture
– 2x Helical Antenna, Right-Hand Circular Polarization
– 1x Helical Antenna, Left-Hand Circular Polarization
– 1x Patch Antennas
– 1x Slotted-Waveguide Antenna
– 1x Open-Ended Waveguide Antenna
– 1x Yagi Antenna
– 1x Wire Antenna
– 1x Cables and Accessories
– 1x Waveguide Accessories
– 1x Antenna Support
– 1x Storage Module

Manual included:

Antenna Fundamentals	en	es	fr
Student Manual	580303	580306	580304
Instructor Guide	580310	580312	580311

Note: PDF version also available.

Additional required equipment

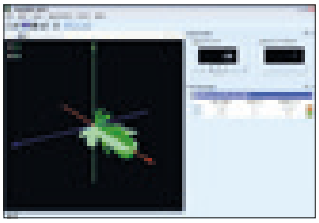
1x Personal computer running under Windows 10 (or equivalent)

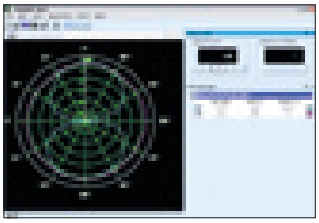
Optional equipment:
– 1x Antenna Positioner, RCS Ready
– 1x RCS Demonstration Accessories
– 1x Directional Coupler, 1 GHz
– 1x Multi-Beam Array Antenna
– 2x Log-Periodic Antenna
– 1x Two-Element Phasing Kit
– 1x Parabolic Reflector

Antennas
The ATMS provides a great variety of antennas. Except for the horn- and waveguide-type antennas, connection to each antenna is made through an SMA connector. The 1-GHz and 10- GHz antennas available in the ATMS are listed below:

1-GHz Antennas:
– Dipoles (λ/2, λ, 3λ/2)
– Folded Dipole
– Folded Dipole with Balun
– Monopole (over ground plane)
– Drooping Monopole
– Loops (circular, square, lozenge)
– Fixed Yag
– Adjustable Yagi

10-GHz Antennas:
– Open-Ended Waveguide
– Slotted Waveguide (single and multi-slots)
– Horns (small and large aperture)
– Helical (right-hand and left-hand circular polarization)
– Patch (rectangular, parallel-fed array, series-fed array)





Computer-based data acquisition with the LVDAM software
The LVDAM-ANT package provides a toolbox for controlling antenna rotation and data acquisition, as well as for displaying measured antenna characteristics in the E and the H planes. It also includes algorithms for estimating beam width and antenna gain from measurements or from external data.

LVDAM-ANT can be downloaded for free from our website.

Modules, Accessories, and Optional Components

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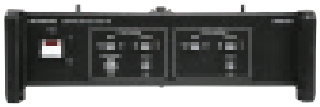

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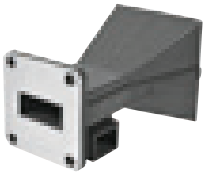

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7


1 RF Generator
The RF Generator contains 2x independent generators, one at 915 MHz and the other at 10.5 GHz, both capable of producing a CW or 1 kHz square wave AM modulated RF signal. Each generator has a push-button switch for turning RF power on and off, a LED that flashes on and off when RF power is turned on, and an SMA output connector. The oscillator in the generator can be tuned from 700 to 1200 MHz via an external tuning voltage input. The RF Generator is self-powered and has a standard unregulated dc power bus to supply power to other compatible modules through its top panel connector.

	en	es	fr
Order no.	**8095643**	**8095815**	**8095814**

2 **Antenna Positioner**
The Antenna Positioner consists of the mast for the receiving antenna (antenna under test), a drive motor, a signal detector, a variable attenuator, and a shaft encoder. The drive motor is used to rotate the mast while the rotation is controlled by the LVDAM-ANT software via the Data Acquisition Interface. An SMA connector allows a connection to be made between the receiving antenna and the signal detector. This detector provides a signal whose voltage depends on the level of the RF signal received. This signal is available on a BNC connector for connection to the Data Acquisition Interface. The variable attenuator allows adjustments to be made to the sensitivity of the receiving system according to the strength of the received signal, in order to prevent system saturation.

	en	es	fr
Order no.	**581819**	**581821**	**581820**

3 **Data Acquisition Interface/ Power Supply**
The Data Acquisition Interface links the Antenna Positioner with the personal computer that runs the LVDAM-ANT software. The Data Acquisition Interface converts the received signal coming from the Antenna Positioner into a digital signal which can be used by the computer.

120V/60Hz	en	es	fr
Order no.	**581825**	**581827**	**581826**
220V/50Hz			
Order no.	**581828**	**581830**	**581829**
240V/50Hz			
Order no.	**581831**		

4 **Horn Antenna**
WR90 waveguide-type pyramidal horn antenna.

Small aperture	**581848**
Large aperture	**581852**

5 **Helical Antenna, Circular Polarization**
Helical antenna with SMA connector. The antenna is protected with a Plexiglas dome.

Right-hand circular polarization	**581853**
Left-handcircular polarization	**581854**

6 Patch Antennas
The Patch Antennas set consists of three (rectangular, series-fed array and parallel-fed array) microstrip patch antennas with SMA connector that operate at a frequency of 10.525 GHz.

Order no.	**581855**

7 **Slotted-Waveguide Antenna**
Light-weight, small-size WR90 waveguide-type slotted antenna. The slot antenna is of the “standing wave array” type. The array is terminated by a short circuit at the end of the waveguide.

Order no.	**581856**

1 **Open-Ended Waveguide Antenna**
The Open-Ended Waveguide Antenna is of the WR90 type.

Order no.	**581857**

2 **Yagi Antenna**
Six-element Yagi-Uda parasitic array antenna with SMA connector.

Order no.	**581860**

3 **Wire Antennas**
Kit consisting of an active element and a set of parasitic elements which can be assembled to obtain various types of antennas (e.g. Yagi antenna, loop antenna, folded-dipole antenna, dipole antenna).

Order no.	**581861**

4 **Cables and Accessories**
The Cables and Accessories package contains the various cables and accessories required to perform the exercises in the program training manuals. The accessories package contains the following parts: Three different lengths of coaxial cables terminated with SMA connectors, all required cables (3) to connect the different equipment together. These accessories come in a convenient plastic storage case.

Order no.	**581914**

5 **Waveguide Accessories**
Kit containing the accessories required when using the horn- and waveguide-type antennas of the ATMS. The kit includes quick-lock fasteners, waveguide-to-coaxial cable adapters (SMA connector), a waveguide plastic holder, a waveguide short-circuit, and copper tape to modify the characteristics of the slotted waveguide and patch antennas.

Order no.	**581912**

6 **Antenna Support**
Support used as a mount for the fixed (transmitting) antenna of the ATMS. It comes with different adapters to mount different types of antennas.

Order no.	**581915**

7 **Storage Module**
Storage cabinet for storing equipment included in the Antenna Training and Measuring System.

Order no.	**581918**

Directional Coupler, 1 GHz
The Directional Coupler consists of an AtlanTecRF A2023-20 directional coupler used in different microwave and antenna training systems.

Order no.	**581841**

Personal Computer
Desktop computer running under Windows® 7 or later. A monitor, keyboard, and mouse are included.

120 V/60 Hz	**en**	**es**	**fr**
Order no.	**579785**		**589839**
220 V/50 Hz			
Order no.	**579787**		**589840**
240 V/50 Hz			
Order no.	**587003**		

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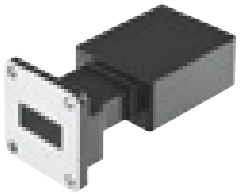

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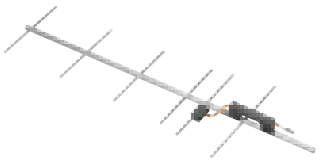

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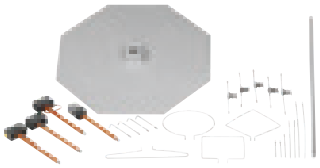

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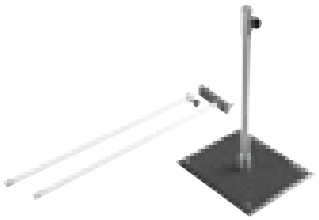

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Modules, Accessories, and Optional Components

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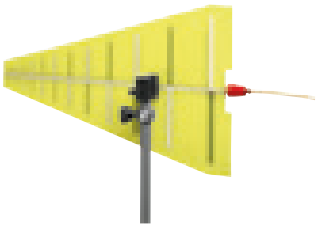

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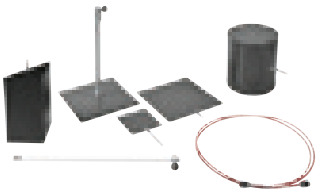


1 **Antenna Positioner, RCS Ready**
This variant of the Antenna Positioner is provided with an auxiliary RF input coupled to an RF signal detector. These additional components are required when the ATMS is used with the optional RCS Demonstration Accessories, to measure and observe the near-field or far-field relative Radar Cross Section (RCS) of reflecting objects (targets). RCS patterns of targets with different shapes are acquired, displayed, and stored using the LVDAM-ANT software the same way as antenna radiation patterns are. The ATMS and RCS Demonstration Accessories allow quasi-monostatic and bi-static RCS measurements to be performed. The standard Antenna Positioner is no longer required when the Antenna Positioner, RCS Ready is ordered. A switch on the front panel of the Antenna Positioner allows selection between the RF input mounted on the base of the rotating mast and the auxiliary RF input.

The RCS demonstration accessories are required to perform RCS measurements.

	en	es	fr
Order no.	**581822**	**581824**	**581823**

4 **RCS Demonstration Accessories**
The RCS Demonstration Accessories kit contains all the accessories required to measure the relative RCS pattern of targets using the ATMS. It includes targets of various shapes (small and large metal plates, cylinder, and prism-shaped target), a 2 m SMA cable, a fixed antenna support, and an antenna mounting pole.

Order no.	**581913**

2 **Multi-Beam Array Antenna**
The Multi-Beam Array Antenna (MBAA) is designed to operate in the X-band (8-12.4 GHz) and provides students with training in phased array antenna theory. It allows hands-on experimentation in Advanced antenna principles used in the fields of radar imagery as well as satellite and space-diversity communication systems. The MBAA is mechanically designed to provide easy installation on the ATMS Antenna Positioner. The student manual included with the MBAA deals with the multi-beam array antenna theory and design, antenna beam characteristics, and beam combination effects. The student manual “The Multi-Beam Array Antenna” (order no. 580347) is included.

Order no.	**581858**

3 **Log-Periodic Antenna**
The Log-Periodic Antenna is designed to familiarize students with the principles of frequency independent antennas. The nominal frequency range of the Log-Periodic Antenna is 700 to 3600 MHz, but it can be operated from 700 to 1200 MHz when used with the ATMS (by tuning the frequency of the ATMS 1-GHz RF Generator). It is recommended to use two log-periodic antennas: one for transmission and the other for reception.

Order no.	**581862**

1 **Two-Element Phasing Kit**
The Two-Element Phasing Kit enables students to observe the effects of antenna phasing on the resulting antenna radiation pattern (combined radiation pattern). Different combined radiation patterns such as end fire, broadside, and cardioid can be obtained. These can be measured, stored, and analyzed using the ATMS. The Two Element Phasing Kit consists of an additional drooping monopole antenna (one is already included in the ATMS), an additional antenna mast with vertical mounting clips (one is already included in the ATMS), a power splitter/combiner, and a set of RF cables of different lengths. Phase shifts of 0, 90, and 180 degrees can be produced with the supplied RF cables. Other phase shifts can be produced by using RF cables having lengths that differ from those of the supplied RF cables.

Order no.	**581863**

2 **Parabolic Reflector**
The Parabolic Reflector allows students to study the characteristics of the parabolic antenna, one of today's most widely used antennas, that finds applications in cellular telephony, satellite communications, radars, etc. The Parabolic Reflector mainly consists of a parabolic reflector and a chassis. It allows a complete parabolic antenna to be assembled using the small aperture horn antenna included in the ATMS. A mast included in the Parabolic Reflector allows the assembled parabolic antenna to be installed on the ATMS Antenna Positioner. This mast also allows the parabolic antenna to be tilted 90° for either vertical or horizontal polarization.

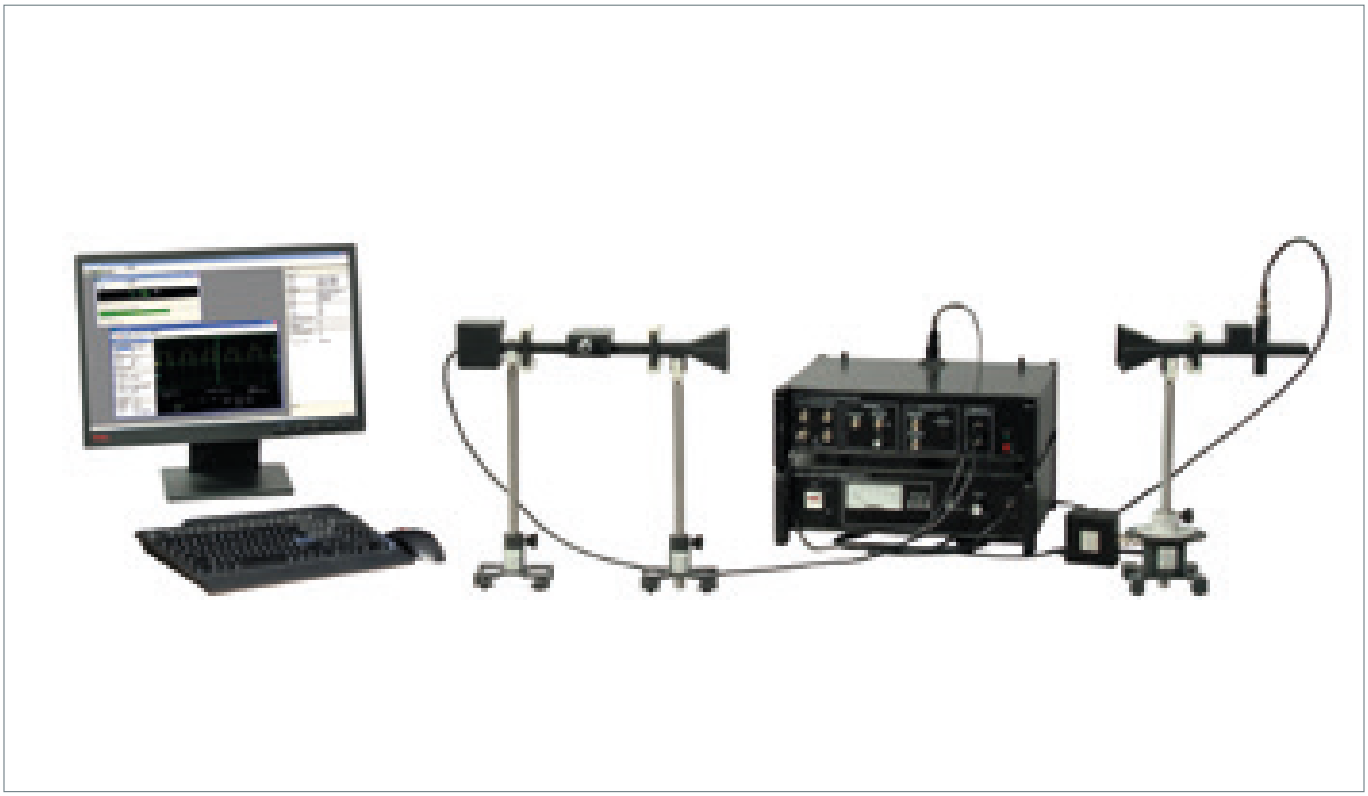
Order no.	**581917**

1

2

Computer-Assisted Microwave Technology Training System

Safe training in the classroom, enhanced by computerized tools



LabVolt Series 8091

The Computer-Assisted Microwave Technology Training System is a complete, state-of-the-art microwave training program that includes data acquisition and instrumentation.

Specifically designed for hands-on training, this integrated package of software, hardware, and courseware contains all power supplies, high quality microwave components, and accessories required to perform the experiments.

It meets a variety of needs and budgets because of subsystems and options.

Computer-based data acquisition

The experiments are performed using the Data Acquisition and Management for Microwave systems software (LVDAM-MW). This modern software is built around a Data Acquisition Interface (DAI), that performs 12-bit A/D acquisition on four channels.

The software uses the acquired data received from the interface to calculate and display the values of power and SWR measurements on a computer screen. This approach eliminates the need for a separate power meter and standing-wave ratio (SWR) meter, thereby providing high flexibility at a reduced cost.

Highlights

- Hands-on, system-level training in microwave technologies
- Rugged, high-quality components designed for educational purposes
- Each component is identified with standard micro-wave symbol
- Microwave devices and components fabricated from electroless-plated brass to standard X-band waveguide dimensions
- Waveguide flanges joined by precision quick fasteners, allowing rapid assembly and disassembly of system configurations
- USB Data Acquisition Interface (DAI) providing virtual instrumentation for the LVDAM®-MW software
- Comprehensive courseware

LVDAM-MW Software

The LVDAM-MW software includes the following virtual instruments and tools:

- A Power Meter displaying either the relative power or absolute power of microwave signals
- A SWR Meter displaying the standing-wave ratio along a waveguide or the power relative to a reference set by the user
- A Data Table used to record and save the values of parameters measured during a work session. A Graph function allows the user to plot the relationships between the parameters
- A Smith Chart used to evaluate the transmission line parameters: the impedance, the admittance, the SWR, the reflection coefficient, and the transmission coefficient.
- An oscilloscope displaying analog or digital waveforms

The software LVDAM-MW can be downloaded for free on our website:
→ labvolt.festo.com

Microwave Technology Training System with LVDAM-MW

	en	es	fr
120 V/60 Hz	**582068**	**582069**	
220 V/50 Hz	**582070**	**582071**	
240 V/50 Hz	**582072**		

The most important components at a glance:
- 1x Gunn Oscillator Power Supply
- 1x Data Acquisition Interface
- 1x Gunn Oscillator
- 1x Slotted Line
- 1x Thermistor Mount
- 1x Crystal Detector
- 1x Directional Coupler, 10 GHz
- 1x Slide-Screw Tuner
- 2x Matched Load
- 1x Variable Attenuator
- 1x Fixed Attenuator, 6 dB
- 1x Fixed Attenuator, 30 dB
- 2x Horn Antenna
- 1x Microwave Accessories
- 1x Hybrid Tee
- 1x PIN Diodex
- 1x Video Amplifier
- 1x Leads and Accessories
- 2x Waveguide Support
- 1x Antenna Azimuth Indicator
- 1x Amplifier
- 1x Storage Tray
- 1x Storage for PIN Diode and Hybrid Tee

Manual included:
Microwave Fundamentals

Student Manual, en	580503
Instructor Guide, en	580504

Note: PDF version also available.

Optional equipment
- 1x Variable RF Oscillator and Resonant-Cavity Frequency Meter
- 1x Power Supply/Dual Audio Amplifier

Variable RF Oscillator and Resonant-Cavity Frequency Meter – Add-On

The Variable RF Oscillator and Resonant-Cavity Frequency Meter package is an add-on to the Computer- Assisted Microwave Technology Training System that contains a variable RF oscillator and a resonant-cavity frequency meter. This add-on allows the study of variable-frequency microwave measurements and applications.

	en	es	fr
Order no.	**582073**	**589212**	

The most important components at a glance:
- 1x Voltage-Controlled RF Oscillator
- 1x Resonant-Cavity Frequency Meter
- 1x Storage for Frequency Measurement Devices

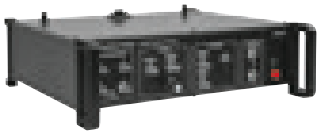
Manuals included:
Microwave Variable-Frequency Measurements and Applications

Student Manual, en	580507
Instructor Guide, en	580508

Required equipment:
- 1x Microwave Technology Training System with LVDAM-MW
- 1x Personal Computer (or equivalent)

Modules, Accessories, and Optional Components

1



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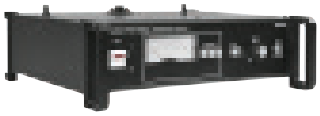

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1 **Data Acquisition Interface**
The Data Acquisition Interface (DAI) provides the following instrumentation for the designed LVDAM-MW software: Power Meter, SWR Meter, and Oscilloscope, thereby eliminating the need for separate instruments. The LVDAM-MW software includes the following instrumentation: SWR Meter, Power Meter, Dual-Trace Oscilloscope, and PIN Diode Bias Meter.
– It dispenses with the need for the SWR Meter, Power Meter, or any equivalent.
– The LVDAM-MW software displays the bias voltage and current used to drive the PIN Diode, and the operating frequency of the Voltage-Controlled RF Oscillator, thereby eliminating the need for separate ammeter, voltmeter, and frequency meter.
– The software allows the user to record, save, print, import, and export data, graphs, and the Smith Chart.

120 V/60 Hz	**en**	**es**	**fr**
Order no.	**581832**	**581833**	**594503**

2 **Gunn Oscillator Power Supply**
The Gunn Oscillator Power Supply is intended for use with the Gunn Oscillator. The OUTPUT of the Gunn Oscillator Power Supply connects to the Gunn Oscillator. If the Data Acquisition Interface is used, it connects to the Gunn Oscillator via a power switch inside the Data Acquisition Interface.

120 V/60 Hz	**en**	**es**	**fr**
Order no.	**581799**	**581801**	**581800**
220 V/50 Hz			
Order no.	**581802**	**581804**	**581803**
240 V/50 Hz			
Order no.	**581805**		

3 **Gunn Oscillator**
The Gunn Oscillator provides the microwave signal source used in various microwave training systems. This oscillator generates a microwave signal having a frequency of 10.525 GHz. The power of the microwave signal generated by the Gunn Oscillator can be varied by varying the voltage applied to this oscillator by the Gunn Oscillator Power Supply.

Order no.	**581834**

Voltage-Controlled RF Oscillator
The Voltage-Controlled RF Oscillator is a module used in certain exercises of the Microwave Training System. A built-in prescaler facilitates frequency measurement of the microwave signal produced by the voltage-controlled oscillator (VCO).

Order no.	**8098726**

1 **Thermistor Mount**
The Thermistor Mount consists of a thermistor that is permanently housed in a waveguide section.

Order no.	**581837**

2 **Crystal Detector**
The Crystal Detector is required to measure power or attenuation using the SWR Meter.

Order no.	**581838**

3 **Directional Coupler, 10 GHz**
The Directional Coupler is formed by the superposition of two crossed waveguides sharing a common wall. The waveguides are at right angles to each other. Two cruciform openings located a quarter wavelength (λ/4) apart are made in the common wall.

Order no.	**581839**

4 **Resonant-Cavity Frequency Meter**
The Resonant-Cavity Frequency Meter is a device used in the Microwave Training System to perform frequency measurements.

Order no.	**581840**

5 **Slide-Screw Tuner**
The Slide-Screw Tuner consists of a variable susceptance of adjustable position that allows the matching of a load to be carried out without calculations.

Order no.	**581842**

6 **Slotted Line**
Can be used to measure the distance between the minima and the maxima of a standing wave. It consists of a low-loss waveguide section with a narrow, longitudinal slot in the top wall.

Order no.	**581836**

7 **Matched Load**
The Matched Load consists of a WR90 waveguide-type load having a standing wave ratio (SWR) of 1.03 and that operates at a frequency of 10.525 GHz (typical).

Order no.	**581843**

8 **Variable Attenuator**
The Variable Attenuator is a device used to reduce the power level at the input of microwave components. It is of the side vane type. A plastic fiberglass blade with a resistive coating is used to produce attenuation.

Order no.	**581844**

Fixed Attenuator
WR90 waveguide-type attenuator that consists of a section of waveguide providing a fixed attenuation of 6 or 30 dB, and operating at a frequency of 10.525 GHz (typical).

6 dB	**581845**
30 dB	**581846**

9 **Horn Antenna**
Used to perform experiments related to antenna propagation, wireless transmission and microwaves optics.

Order no.	**581847**

10 **Hybrid Tee**
The Hybrid Tee, also called magic tee, is a combination of a H-plane tee and a E-plane tee. It has four arms:
– The H-(Σ) plane arm, which is in the direction of the H (magnetic) field.
– The E-(Δ) plane arm, which is in the direction of the E (electric) field.
– Two lateral arms. The lateral arms are disposed about an imaginary plane dividing the H- and E-plane arms symmetrically.

Order no.	**581850**

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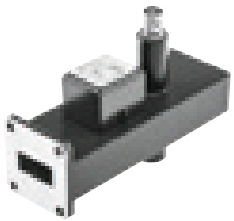

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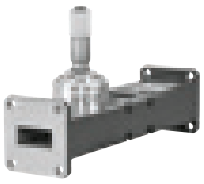

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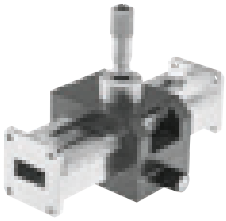

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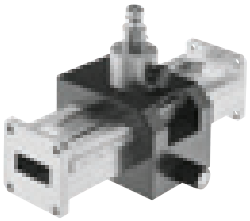

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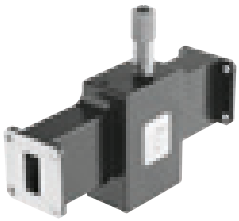

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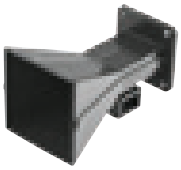

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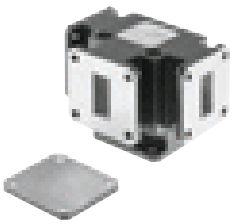

Modules, Accessories, and Optional Components

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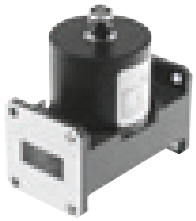

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1 **PIN Diode**
A semiconductor device that acts like a variable resistor at microwave frequencies. The resistance of the diode is controlled by varying the DC current used to forward bias the diode. PIN diodes are used in numerous microwave and wireless applications.

Order no.	**581851**

2 **Video Amplifier**
Video signal amplifier that has a gain adjustable up to 50 dB and a bandwidth of 5 MHz

Order no.	**581904**

3 **Waveguide Support**
Set of supports allowing the secure mounting of microwave setups at various heights.

Order no.	**581909**

4 Antenna Azimuth Indicator
Rotating support that is used to turn the mast of an antenna over a 360° range. A graduated scale on the mast indicates the current orientation of the antenna.

Order no.	**581910**

5 Amplifier
Low-noise, high-gain audio amplifier that is used to amplify the signals produced by the Crystal Detector and the Slotted Line.

Order no.	**581911**

6 Storage Tray
Storage box for storing microwave components and accessories.

Storage for the equipment included with the training system

Order no.	**581919**

Storage for PIN Diode and Hybrid Tee

Order no.	**581920**

Storage for Frequency Measurement Devices

Order no.	**581921**

Leads and Accessories
Kit containing the various cables and accessories required to perform the exercises in the program training manuals. The accessories package contains the following parts: two different lengths of coaxial cables terminated with BNC connectors, a BNC T-connector, microwave quick fasteners. One kit comes with a plastic reflector and a steel reflector as well. These accessories are provided in a convenient plastic storage case. The reflectors can be stored in the storage tray.

With reflectors

Order no.	**581907**

Without reflectors

Order no.	**581908**

Summing Amplifier
Audio amplifier used for wireless microwave transmission. The amplifier adds the signal produced at the output of the Gunn Oscillator Power Supply to a modulating audio signal. The resulting signal is applied to the Gunn Oscillator for transmission into space. The student manual “Microwave transmission demonstration” is included.

Order no.	**581993**

Personal Computer
Desktop computer running under Windows® 7 or later. A monitor, keyboard, and mouse are included.

120 V/60 Hz	**en**	**es**	**fr**
Order no.	**579785**		**589839**
220 V/50 Hz			
Order no.	**579787**		**589840**
240 V/50 Hz			
Order no.	**587003**		

Telephony Training Systems

Study of telephone networks

LabVolt Series 8086

The Telephony Training Systems (TTS) are powerful learning tools that allow students to become familiar with the operation of telephone networks and digital private automatic branch exchanges (PABX), as well as Integrated Services Digital Network (ISDN).

Its gradual didactic approach allows students to start with the essentials, then study of high-level architecture of the systems, the workflow of each function, and interactions between systems. The basic TTS contains all the equipment and courseware material required to cover Analog Access to the Telephone Network and Central Office Operation. Add-ons can be purchased to cover Digital PABX, PABX Analog Trunk, and Digital Trunk.

The RTM: a versatile module

The TTS are built upon the Reconfigurable Training Module (RTM), which can be programmed to act as different parts of a telephone network. Interface cards that students install in the training module allow connection of real analog and digital telephone sets and trunk lines. A central office (CO) is easily implemented by inserting an analog line interface card into a training module programmed to act as a central office. Similarly, a digital PABX is implemented by inserting a digital telephone interface card into a training module programmed to act as a PABX.

Highlights

- DSP-based processing allows flexibility and provides real-life experience
- DSP-based reconfigurable training system easily upgradable to new standards and systems
- Can be configured for different international standards
- When configured as a digital PABX or when a digital trunk is set up, system allows study of the physical and network layers
- Can be configured as a digital CO of the public switched telephone network (PSTN) or as a digital PABX
- Comprehensive curriculum
- Fault-insertion capability for troubleshooting purposes
- Minimal hardware interfaces are required
- Enhanced flexibility through the elimination of front panel controls and diagrams
- Software allows display of diagrams, signal observation, settings changes, etc.

Training content

- Analog Access to the Telephone Network
- Central Office Operation
- Digital PABX
- PABX Analog Trunk
- Digital Trunk

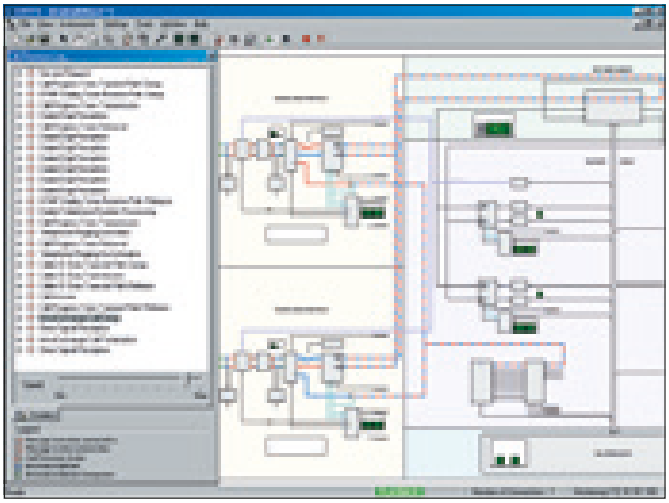
Introduction to ISDN
The TTS also introduce students to the Integrated Services Digital Network (ISDN). The digital PABX which can be setup with the TTS uses digital telephone sets of the ISDN type and ISDN basic rate interfaces.

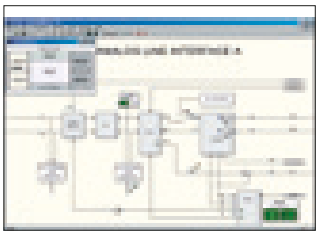
The digital trunk that can be set up to interconnect two CO's implemented with the TTS uses ISDN primary rate interfaces. Thus, while performing the courseware material for the digital PABX and the digital trunk, students are introduced to the following two major aspects of ISDN: the physical layer (layer 1) and the network layer (layer 3). Layer 1 defines the physical support and the nature of the electrical signals used in ISDN interfaces. Layer 3 defines the digital signaling protocol used in the ISDN to establish and release connections (telephone calls).

A powerful data-logging instrument in the LVTTS software, referred to as the Call Processor Log, allows recording of all ISDN layer-3 messages that are exchanged between ISDN entities (call processor in a CO or PABX, digital telephone sets) during telephone calls. This enables student to easily observe the sequence of ISDN layer-3 messages that are used to establish a call, place a call on hold, initiate a conference call, terminate a call, etc. The Call Processor Log can also display the detailed contents of the ISDN layer-3 messages recorded, thereby allowing thorough investigation of the ISDN signaling protocol.

LVTTS Software: control, measurement and recording
A host computer connected to the Reconfigurable Training Module is required to run the Telephony Training System (LVTTS) software. This Windows®-based software is used to download programs into the DSP memory of the RTM. The LVTTS software also has an intuitive user interface to:
– Display the functional block diagram of the telephony equipment (CO, digital PABX, etc.) implemented in the Reconfigurable Training Module
– Change various system settings and options, such as the telephone ringing cadence, companding type, subscriber names and phone numbers, etc.
– Observe real signals throughout the system in both the time and frequency domains using modern virtual instruments
– Perform step-by-step observation of call routing sequences by recording all the events that occur during a call and then playing back these events
– Insert faults in the system (password-protected feature) for troubleshooting purposes

LVTTS software can be downloaded for free from our website.





Telephony Training Systems

Telephony Training System – Analog Telephone
LabVolt Series 8086-1

This basic system contains all the equipment and courseware material required to cover Analog Access to the Telephone Network and Central Office Operation.

	en	es	fr
120V/60Hz	**587496**	**587498**	**587497**
220V/50Hz	**587499**	**587501**	**587500**
240V/50Hz	**587495**		

The most important components at a glance:
– 1x Power Supply
– 1x Reconfigurable Training Module (RTM)
– 1x Dual Analog Line Interface
– 1x Software and Accessories
– 2x Analog Telephone Set

Manuals included:

Analog Access to the Telephone Network	en	es	fr
Student Manual	584279	584281	584280
Instructor Guide	584286	584288	584287
Central Office Operation	**en**	**es**	**fr**
Student Manual	584302	584304	584303
Instructor Guide	584305	584307	584306

Additional required equipment
– 1x Personal Computer (or equivalent)

Telephony Training System – Digital Telephone Add-On
LabVolt Series 8086-2

The Digital Telephone Add-On is a PABX add-on to the basic TTS – Analog System (8086-1). It adds a digital telephone, as well as the required interface, to the training system.

	en	es	fr
120V/60Hz	**587502**	**587504**	**587503**

The most important components at a glance:
– 1x Digital Telephone Interface
– 2x Digital Telephone Set

Manual included:

Private Automatic Branch Exchange (PABX)	en	es	fr
Student Manual	584308	584310	584309
Instructor Guide	584311	584313	584312

Additional required equipment:
– 1x Digital Telephone Interface
– 1x TTS – Analog Telephone LabVolt Series 8086-10
– 1x Personal computer (or equivalent)

Telephony Training System – Analog Trunk Add-On
LabVolt Series 8086-3

The TTS – Analog Trunk Add-On is an add-on to the Telephony Training System (8086-1). It consists of an Analog Trunk Interface that can be installed in the Reconfigurable Training Module. Note that two Reconfigurable Training Modules are required.

	en	es	fr
120V/60Hz	**587505**	**587507**	**587506**

The most important components at a glance:
– 1x PABX Analog Trunk Interface

Manual included:

PABX Analog Trunk	en	es	fr
Student Manual	584356	584358	584357
Instructor Guide	584359	584361	584360

Additional required equipment:
– 1x TTS – Analog Telephone LabVolt Series 8086-1
– 1x TTS – Digital Telephone Add-On LabVolt Series 8086-2
– 1x Reconfigurable Training Module*
– 1x Personal Computer (or equivalent)
* In addition to the one included with the TTS 8086-1.

Telephony Training System – Digital Trunk Add-On
LabVolt Series 8086-4

The TTS – Digital Trunk Add-On is an add-on to the Telephony Training System (8086-1). It consists of a Digital Trunk Interface that can be installed in the Reconfigurable Training Module. Note that two Reconfigurable Training Modules are required.

	en	es	fr
Order no.	**587508**	**587510**	**587509**

The most important components at a glance:
– 1x Digital Trunk Interface

Manual included:

Digital Trunk	en	es	fr
Student Manual	584372	584374	584373
Instructor Guide	584375	584377	584376

Additional required equipment:
– 1x TTS – Analog Telephone LabVolt Series 8086-1
– 1x Reconfigurable Training Module*
– 1x Dual Line Analog Interface*
– 1x Digital Trunk Interface**
– 1x Personal Computer (or equivalent)
* In addition to the one included with the TTS LabVolt Series 8086-1.
** In addition to the on included in the Digital Trunk Add-on 8086-4.

Modules, Accessories, and Optional Components

1 **Power Supply**
Power source for the Reconfigurable Training Module (RTM). Its back panel has two multi-pin connector outputs that provide regulated dc voltages. Its front panel has two outputs that supply the ac power network voltage to power the analog telephones. Each multi-pin connector output can supply power to one RTM.

120V/60Hz	**581571**
220V/50Hz	**581572**
240V/50Hz	**581573**

2 **Reconfigurable Training Module**
The Reconfigurable Training Module (RTM) consists mainly of a powerful digital signal processor (DSP), with three slots on the module front panel for installing interface modules. An Ethernet port (RJ-45) connector allows connection of the RTM to the host computer. The functionality of the training system is determined by downloading a program into the DSP memory using the computer that runs the software.

Order no.	**587443**

3 **Dual Analog Line Interface**
Module designed to be installed into the RTM that acts as a digital CO. It contains two standard line interfaces providing analog telephone sets with an analog access to the CO implemented with the RTM.

Order no.	**587444**

Software and Accessories
Set that mainly consists of the LVTTS software, interconnection cables, an Ethernet adapter (network card) to be installed in the host computer, and speakers.

Order no.	**587448**

4 **Digital Telephone Interface**
Module designed to be installed into the RTM that acts as a digital PABX. It can interface four digital telephone sets with the PABX implemented with the RTM.

Order no.	**587445**

5 **PABX Analog Trunk Interface**
Module designed to be installed into the RTM that acts as an analog trunk. It connects the PABX implemented with the RTM to a CO implemented with another RTM, through an analog trunk line.

Order no.	**587446**

6 **Digital Trunk Interface**
Module designed to be installed into the RTM that acts as a digital trunk. It allows connection of the CO implemented with the RTM to another CO implemented with a second RTM, via two digital trunk line (only one is included with the module) operating at the DS1 or E1 time-division multiplexing format.

Order no.	**587447**

7 **Analog Telephone Set**
Conventional telephone unit with speaker phone, LCD display, caller identification function, multiple phone number memory, and one-touch call buttons.

Order no.	**587449**

8 **Digital Telephone Set**
Voice-only ISDN-type telephone provided with basic ISDN functions, programmable call appearance/function buttons, tiltable LCD display, and semi duplex speaker.

Order no.	**587450**

Personal Computer
Desktop computer running under Windows® 7 or later. A monitor, keyboard, and mouse are included.

120 V, 60 Hz	**en**	**es**	**fr**
Order no.	**579785**		**589839**
220 V, 50 Hz			
Order no.	**579787**		**589840**
240 V, 50 Hz			
Order no.	**587003**		

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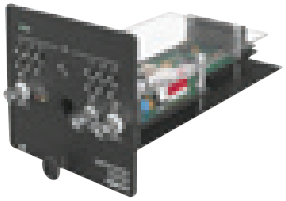

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8


Communications Technologies Training Systems

Practical training in a wide range of communications technologies

LabVolt Series 8087

The Communications Technologies Training Systems are specifically designed for hands-on training in a wide range of communication technologies. Training starts from the basic pulse modulation techniques (PAM, PWM, and PPM), covers the various digital modulation schemes used in data transmission (PCM, DPCM, Delta CVSD, ASK, FSK, BPSK, QPSK, and QAM), and extends to modern, spectrally efficient, digital communication techniques such as ADSL, CDMA and spread spectrum technologies (direct-sequence spread spectrum and frequency-hopping spread spectrum).

Detailed courseware

The courseware consists of a series of student manuals covering the different technologies, as well as instructor guides that provide the answers to procedure step questions and review questions. The training systems and the accompanying courseware provide a complete study program.

Highlights

- Real system and real frequencies, not simulations, reflecting the standards commonly used in modern communications systems
- Flexible, open system using a high-performance DSP-based Reconfigurable Training Module (RTM)
- Comprehensive courseware providing a complete study program
- Fault-insertion capability for troubleshooting exercises
- MATLAB® Import/Export in ADSL applications
- Short-circuit-proof, low-power for safety
- Front-panel access to signals
- Windows-based Communications Technologies (LVCT) software provides the user interface and configures the RTM to implement the selected communications

Training content

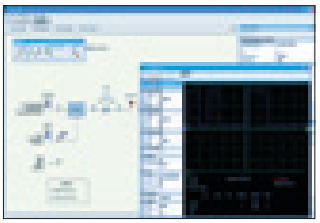
- Pulse Modulation and Sampling (PAM/PWM/PPM)
- Digital Modulation (PCM/DPCM/Delta)
- Basic Modems and Data Transmission (ASK/FSK/BPSK)
- Quadrature Phase Shift Keying (QPSK/DQPSK)
- Quadrature Amplitude Modulation (QAM/DQAM)
- Asymmetric Digital Subscriber Line (ADSL)
- Spread Spectrum (DSSS/FHSS/CDMA)
- Troubleshooting

A wide learning scope
Through the study of ADSL, the training systems also introduces various essential underlying technologies such as discrete multi-tone (DMT) modulation, orthogonal frequency division multiplexing (OFDM), data scrambling, convolutional coding, trellis-coded modulation (TCM), forward error correction (FEC) using Reed-Solomon codes, data interleaving, and Viterbi decoding.

Similarly, study of the spread spectrum technologies using the training systems allows coverage of several other relevant topics such as the principles of code-division multiple access (CDMA), Gold code sequence generation, auto-correlation and cross-correlation properties of code sequences, as well as an introduction to modern applications of these technologies such as CDMA-based cellular telephony, Global Positioning System (GPS), residential cordless telephone sets, Bluetooth specification for wireless personal area networks (WPAN), etc.

LVCT software
Each of the communications technologies to be studied is provided as an application that can be selected from a menu. Once loaded into the LVCT software, the selected application configures the RTM to implement the communications technology, and provides to students a specially designed user interface. A wide variety of applications are available, covering many current and evolving communications technologies.

Because the Communications Technologies Training Systems are open, reconfigurable systems, they can be upgraded at any time to cover additional technologies simply by purchasing additional applications. The LVCT software provides settings for full user control over the operating parameters of each communications technology application. Functional block diagrams for the circuits involved are shown on screen. The digital or analog signals at various points in the circuits can be viewed and analyzed using the virtual instruments included in the software. In addition, the most important of these signals are made available at physical connectors on the RTM and can be displayed and measured using conventional instruments.



Note: A Communications Technologies Host Computer (or equivalent) is required for all systems.

Communications Technologies Training System 4
LabVolt Series 8087-4

The Communications Technologies Training System 4 includes the PAM/ PWM/ PPM applications, the PCM/ DPCM/Delta Modulation applications, the ASK/ FSK/BPSK applications, and the QPSK/QAM/ADSL applications, as well as the corresponding courseware.

	en	es	fr
120V/60Hz	**582032**	**589848**	**582033**
220V/50Hz	**582034**		**589051**
240V/50Hz	**582035**		

Communications Technologies Training System 5
LabVolt Series 8087-5

The Communications Technologies Training System 5 includes the PAM/PWM/ PPM applications, the PCM/DPCM/Delta Modulation applications, the ASK/ FSK/BPSK Applications, the QPSK/QAM/ADSL applications, and the DSSS/ FHSS/CDMA applications, as well as the corresponding courseware.

	en	es	fr
120V/60 Hz	**582036**	**589211**	**582037**
220V/50 Hz	**582038**		**582039**
240V/50 Hz	**582040**		

The most important components at a glance:
- 1x Power Supply
- 1x Reconfigurable Training Module (RTM)
- 1x LVCT Software
- 1x Data Acquisition Interface
- 1x Analog/Digital Output Interfacex
- 1x Vocoder*
- 1x Cables and accessories

* Only included with the 8087-5 system

Manuals included:

	en	es	fr
Pulse Modulation and Sampling (PAM/PWM/PPM)			
Student Manual	584875		584876
Instructor Guide	584881		584882
Digital Modulation (PCM/DPCM/Delta)			
Student Manual	584883		584884
Instructor Guide	584885		584886
Basic Modems and Data Transmission (ASK/FSK/BPSK)			
Student Manual	584887		584888
Instructor Guide	584889		584890
Quadrature Phase Shift Keying (QPSK/DQPSK)			
Student Manual	584891		584892
Instructor Guide	584893		584894
Quadrature Amplitude Modulation (QAM/DQAM)			
Student Manual	584895		584896
Instructor Guide	584898		584899
Asymmetric Digital Subscriber Line (ADSL)			
Student Manual	584900		584901
Instructor Guide	584903		584904
Spread Spectrum (DSSS/FHSS/CDMA)*			
Student Manual	585064		585065
Instructor Guide	585066		585067

* Only included with the 8087-5 system
Note: PDF version also available.

Modules, Accessories, and Optional Components

Software

1

2

3

4

5

1 **Power Supply**
The Power Supply is the power source for the Reconfigurable Training Module (RTM) used in various communications training systems. Its back panel has two multi-pin connector outputs that provide regulated dc voltages. Each multi-pin connector output can supply power to one RTM. Auto-reset fuses protect the outputs of the Power Supply against short-circuits.

Order no.	**593595**

2 **Reconfigurable Training Module**
The Reconfigurable Training Module (RTM) consists mainly of a powerful digital signal processor (DSP), with three slots on the module front panel for installing interface modules. An Ethernet port (RJ-45) connector, located on the back panel, allows connection of the RTM to the host computer. The functionality of the training system is determined by downloading a program into the DSP memory using the host computer that runs the software.

Order no.	**587443**

3 **Data Acquisition Interface**
The Data Acquisition Interface is a compact module designed to be installed into one of the slots of the Reconfigurable Training Module (RTM). This module provides input connectors for analog and digital signals so they can be processed by the RTM. It has two input BNC connectors for analog signals and four for digital signals.

Order no.	**581692**

4 **Analog/Digital Output Interface**
The Analog/Digital Output Interface is a compact module designed to be installed into one of the slots of the Reconfigurable Training Module (RTM). This module provides output connectors for analog and digital signals generated by the RTM. It has four output BNC connectors for analog signals and four for digital signals.

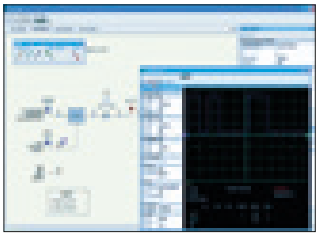
Order no.	**581693**

5 **Vocoder Interface**
Compact module designed to be installed into one of the slots of the Reconfigurable Training Module (RTM). It allows the study of digitized voice transmission in a CDMA environment using reduced data rates, with or without forward error correction (FEC). This module uses two voice encoders to simultaneously encode two audio channels and uses one voice decoder to decode the selected channel.

Order no.	**581694**

Cables and Accessories
The Cables and Accessories set contains BNC cables for making external connections to the interface modules in the Reconfigurable Training Module (RTM), a USB cable, an RJ-45 crossover connector cable, and an Ethernet adapter (network card) to be installed in the host computer.

Order no.	**581797**



LVCT Software
The Communications Technologies (LVCT) software provides a user interface for the system. Each different communications technology is presented as a separate application. On start-up, the user selects the desired application in the Application Selection dialog box. Then the LVCT software loads the signal processing routines used to implement that application in the RTM.

The software includes the following virtual instruments: an oscilloscope, a spectrum analyzer, a true RMS Voltmeter, a Logic Analyzer, a constellation viewer and a Data Table. The user interface includes tables of settings that allow changing various software parameters to control the system or to configure the virtual instruments and the generators (function generators and clock generators) provided in the applications. In addition, faults can be inserted into the circuits by the instructor for troubleshooting exercises. A user guide is included.

Various application sets are available for the LVCT Software: PAM, PWM, PPM, PCM, DPCM, Delta Modulation, ASK, FSK, BPSK, QPSK, QAM, ADSL, DSSS, FHSS, CDMA.
The software can be downloaded free of charge from our website
→ labvolt.festo.com
Connection to the equipment is required to perform measurement.

Accessories and Optional Components

1

1 Tabletop power supply unit
– Input voltage: 85 – 265 V AC (47 – 63 Hz)
– Output voltage: 24 V DC, short-circuit-proof
– Output current: max. 4.5 A
– Dimensions: 75 x 155 x 235 mm
Without power cable

Order no.	**8049633**

With IEC power cable, 1.3 m, with:
Connector as per CEE 7/VII for DE, FR, NO, SE, FI, PT, ES, AT, NL, BE, GR, TR, IT, DK, IR, ID

Order no.	**162417**

Connector as per NEMA 5-15 for US, CA, Central America, BR, CO, EC, KR, TW, TH, PH, JP

Order no.	**162418**

Connector as per BS 1363 for GB, IE, MY, SG, UA, HK, AE

Order no.	**162419**

Connector as per AS 3112 for AU, NZ, CN, AR

Order no.	**162380**

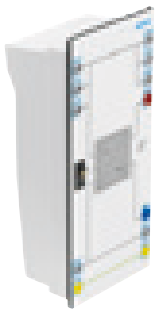
Connector as per SEV 1011 for CH

Order no.	**162381**

Connector as per SANS 164-1 for ZA, IN, PT, SG, HK, (GB), (AE)

Order no.	**162382**

2

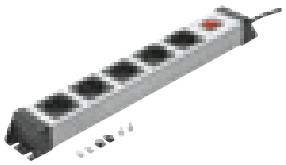


3

2 EduTrainer® 24 V power supply unit
– Input voltage: 1 AC/110 – 230 V (47 – 63 Hz)
– Output voltage: 24 V DC, short-circuit-proof
– Output current: Max. 4.5 A
– Front plate: 133 x 297 mm
– Console housing with rubber feet for use in an A4 frame or on tabletop
– Connection via 4 mm safety plugs
– Through-hole for 3 AC/400 V

Order no.	**571813**

4



3 Power supply unit for mounting frame
– Input voltage: 85 – 265 V AC (47 – 63 Hz)
– Output voltage: 24 V DC, short-circuit-proof
– Output current: max. 4.5 A
– Dimensions: 170 x 240 x 92 mm
Without power cable

Order no.	**8049382**

With IEC power cable, 1.3 m, with:
Connector as per CEE 7/VII for DE, FR, NO, SE, FI, PT, ES, AT, NL, BE, GR, TR, IT, DK, IR, ID

Order no.	**159396**

Connector as per NEMA 5-15 for US, CA, Central America, BR, CO, EC, KR, TW, TH, PH, JP

Order no.	**162411**

Connector as per BS 1363 for GB, IE, MY, SG, UA, HK, AE

Order no.	**162412**

Connector as per AS 3112 for AU, NZ, CN, AR

Order no.	**162413**

Connector as per SEV 1011 for CH

Order no.	**162414**

Connector as per SANS 164-1 for ZA, IN, PT, SG, HK, (GB), (AE)

Order no.	**162415**

4 5-fold plug socket strip with switch
Impact and shatter resistant plug socket strip with tamper-proof cover, 4 mounting points and mounting attachments.
With power supply plug suitable for: DE, FR, NO, SE, FI, PT, ES, AT, NL, BE, GR, TR, IT, DK, IR, ID

Order no.	**380707**

5

5 IEC power cable
One side designed as a connector and one side with a country-specific plug.
Connector as per CEE 7/VII for DE, FR, NO, SE, FI, PT, ES, AT, NL, BE, GR, TR, IT, DK, IR, ID

Order no.	**247661**

Connector as per NEMA 5-15 for US, CA, Central America, BR, CO, EC, KR, TW, TH, PH, JP

Order no.	**350362**

Connector as per BS 1363 for GB, IE, MY, SG, UA, HK, AE

Order no.	**350363**

Connector as per AS 3112 for AU, NZ, CN, AR

Order no.	**350364**

Connector as per SEV 1011 for CH

Order no.	**350366**

Connector as per SANS 164-1 for ZA, IN, PT, SG, HK, (GB), (AE)

Order no.	**350367**

6

6 IEC power cable 90°
One end fitted with a 90° IEC connector and the other fitted with a country-specific connector. Preferred version for EduTrainer® Universal.
Connector as per CEE 7/VII for DE, FR, NO, SE, FI, PT, ES, AT, NL, BE, GR, TR, IT, DK, IR, ID

Order no.	**549860**

Connector as per NEMA 5-15 for US, CA, Central America, BR, CO, EC, KR, TW, TH, PH, JP

Order no.	**549861**

Connector as per BS 1363 for GB, IE, MY, SG, UA, HK, AE

Order no.	**549862**

Connector as per AS 3112 for AU, NZ, CN, AR

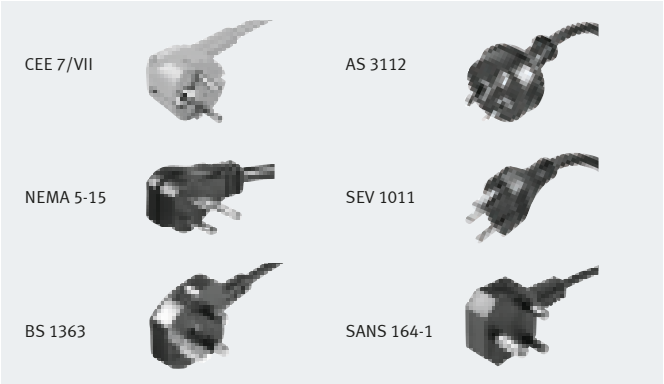
Order no.	**549863**

Connector as per SEV 1011 for CH

Order no.	**549864**

Connector as per SANS 164-1 for ZA, IN, PT, SG, HK, (GB), (AE)

Order no.	**549865**



4 mm Safety laboratory cables
– Plugs with rigid protective sleeve and axial socket
– Conductor cross section: 1 mm²
– 1000 V CAT II
– Rated current: 16 A

4 mm Safety laboratory cables, 98 pieces, red and blue
Complete set, consisting of 98 safety laboratory cables with 4 mm safety plugs in the colors red and blue:
– 10x red 50 mm
– 10x blue 50 mm
– 26x red 300 mm
– 11x blue 300 mm
– 21x red 500 mm
– 12x blue 500 mm
– 3x red 1000 mm
– 3x blue 1000 mm
– 1x red 1500 mm
– 1x blue 1500 mm
For the third cable color, safety laboratory cables, 47 pieces, black, are suitable (order no. 8092667)

Order no.	**8092666**

4 mm Safety laboratory cables, 47 pieces, black
Complete set, consisting of 47 safety laboratory cables with 4 mm safety plugs in the color black:
– 8x black 50 mm
– 18x black 300 mm
– 18x black 500 mm
– 2x black 1000 mm
– 1x black 1500 mm

Order no.	**8092667**

4 mm Safety laboratory cables, 106 pieces, red, blue and black
Complete set, consisting of 106 safety laboratory cables with 4 mm safety plugs in the colors red, blue and black:
– 10x red 50 mm
– 10x blue 50 mm
– 8x black 50 mm
– 8x red 300 mm
– 8x blue 300 mm
– 18x black 300 mm
– 8x red 500 mm
– 8x blue 500 mm
– 18x black 500 mm
– 2x red 1000 mm
– 3x blue 1000 mm
– 2x black 1000 mm
– 1x red 1500 mm
– 1x blue 1500 mm
– 1x black 1500 mm

Order no.	**8092668**

4 mm safety laboratory cables, 58 pieces, brown, black, gray, and blue, with gray plugs
Complete set, consisting of 58 safety laboratory cables with 4 mm safety plugs in brown, black, gray, and blue, with gray plugs:
– 6x gray 50 mm
– 5x gray 300 mm
– 5x brown 300 mm
– 5x black 300 mm
– 5x blue 300 mm
– 4x gray 500 mm
– 4x brown 500 mm
– 4x black 500 mm
– 4x blue 500 mm
– 2x gray 1000 mm
– 2x brown 1000 mm
– 2x black 1000 mm
– 2x blue 1000 mm
– 2x gray 1500 mm
– 2x brown 1500 mm
– 2x black 1500 mm
– 2x blue 1500 mm

Order no.	**8092669**

4 mm safety laboratory cables and safety jumper plugs, 14 pieces, green-yellow
Complete set, consisting of 8x 4 mm safety laboratory cables and 6x safety jumper plugs in the color green-yellow:
4 mm Safety laboratory cables:
– 2x 300 mm
– 2x 500 mm
– 2x 1000 mm
– 2x 1500 mm
4 mm Safety jumper plugs:
– 6x 19 mm

Order no.	**8092672**

4 mm safety laboratory cables, 50 mm

red	**8092626**
blue	**8092627**
black	**8092628**
gray-gray	**8092629**

4 mm safety laboratory cables, 300 mm

red	**8092630**
blue	**8092631**
black	**8092632**
gray-gray	**8092633**
brown-gray	**8092634**
black-gray	**8092635**
blue-gray	**8092636**
yellow	**8092637**
green/yellow-yellow	**8092638**

4 mm safety laboratory cables, 500 mm

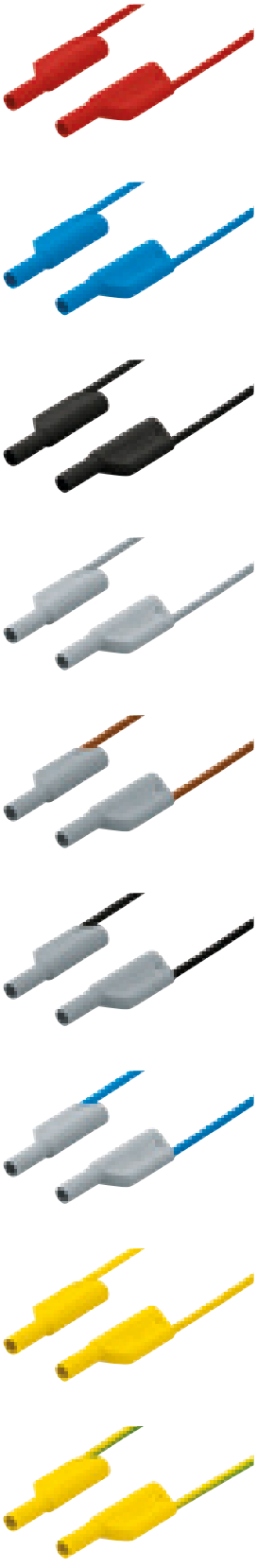
red	**8092639**
blue	**8092640**
black	**8092641**
gray-gray	**8092642**
brown-gray	**8092643**
black-gray	**8092644**
blue-gray	**8092645**
yellow	**8092646**
green/yellow-yellow	**8092647**

4 mm safety laboratory cables, 1000 mm

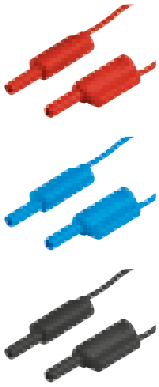
red	**8092648**
blue	**8092649**
black	**8092650**
gray-gray	**8092651**
brown-gray	**8092652**
black-gray	**8092653**
blue-gray	**8092654**
yellow	**8092655**
green/yellow-yellow	**8092656**

4 mm safety laboratory cables, 1500 mm

red	**8092657**
blue	**8092658**
black	**8092659**
gray-gray	**8092660**
brown-gray	**8092661**
black-gray	**8092662**
blue-gray	**8092663**
yellow	**8092664**
green/yellow-yellow	**8092665**



Accessories and Optional Components



Safety jumper plugs
– Plugs with rigid protective sleeve
– Plug spacing: 19 mm
– 1000 V CAT II
– Rated current: 16 A

Safety jumper plugs, 36 pieces, red, blue, gray, gray-blue
Complete set, consisting of 36 safety jumper plugs in the colors red, blue, gray, gray-blue:
– 8x red
– 8x blue
– 16x gray
– 4x gray-blue

Order no.	**8092677**

Safety jumper plugs, 28 pieces, gray-black
Complete set, consisting of 28 gray-black safety jumper plugs. Suitable for the universal patch panel EduTrainer®, the jumper plugs are used to clearly establish connections when designing circuits:
– 28x gray-black

Order no.	**571809**

Safety jumper plugs, 19 mm

red	**572097**
blue	**572098**
black	**572099**
gray	**572100**
gray-blue	**572120**
gray-black	**572121**
green-yellow	**572101**

2 mm Safety laboratory cables
– Plugs with rigid protective sleeve and axial socket
– Conductor cross section: 0,5 mm²
– 500 V CAT II
– Rated current: 5 A

2 mm Safety laboratory cables, 60 pieces, red, blue and black
Complete set, consisting of 60 safety laboratory cables with 2 mm safety plugs in the colors red, blue and black:
– 11x red 100 mm
– 11x blue 100 mm
– 20x black 100 mm
– 2x red 200 mm
– 2x blue 200 mm
– 10x black 200 mm
– 2x black 300 mm
– 2x black 500 mm

Order no.	**574206**

2 mm Safety laboratory cables, 100 mm

red	**574198**
blue	**574199**
black	**574200**

2 mm Safety laboratory cables, 200 mm

red	**574201**
blue	**574202**
black	**574203**

2 mm Safety laboratory cables, 300 mm

red	**576297**
blue	**576298**
black	**574204**

2 mm Safety laboratory cables, 500 mm

red	**576295**
blue	**576296**
black	**574205**

Measuring lead holder
Mobile measuring lead holder with storage box.
– Dimensions (W x H x D)
  54 x 135 x 54 cm
– Storage dimensions (W x D)
  42 x 51 cm

Order no.	**8043430**

Protective conductor cables with special connector
– Special sockets 6 mm
– Conductor cross section: 4 mm²
– Both sides are equipped with a special socket
– Special connectors are unmistakable with 4 mm safety cables
– Easy to recognize, allows simple checking of safety-relevant connections at the workplace

1 **Protective conductor cables with special connector, 14 pieces**
Complete set, consisting of 14 preassembled cables with 6 mm special socket for protective earth connection:
– 8x 100 mm
– 3x 400 mm
– 3x 1500 mm

Order no.	**8067503**

Protective earth cable with special connector

100 mm	**8067504**
400 mm	**8067505**
1500 mm	**8067506**

2 **Adapter from 4 mm safety socket plug to special connector, 20 pieces**
– Connector pin: 6 mm
– To insert into a 4 mm safety socket
– Special connectors are unmistakable with 4 mm safety cables
– Simple to mount with the assembly tool
– Permanent retention and conversion
– 20x adapters
– 1x assembly tool
– 1x assembly instructions

Order no.	**8067500**

3 **BNC – 4 mm**
Safety measuring adapter
Measuring lead for BNC plug on 4 mm safety plug
– BNC plug insulated
– 4 mm plug with rigid protective sleeve and axial socket
– 600 V CAT II
– Length: 1600 mm

Order no.	**8023959**

4 **4 mm – 2 mm**
Safety measuring adapter
Measuring adapter 4 mm safety plug on 2 mm safety socket
– With rigid protective sleeve and axial socket
– 600 V CAT II
– Load capacity: 5 A

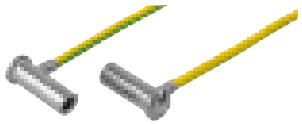
Order no.	**8023960**

5 **Set of 4 mm angled safety adapters, 20 pieces, clevis**
Set comprising 20 angled adapters with rigid protective sleeve and open clevis end for the bonding of devices.
– Clevis width: 7.5 mm
– Clevis length: 12 mm
– Suitable for M4 screws
– 1000 V CAT II
– Load capacity: 16 A

gray	**576287**
black	**576288**

6 **Set of 4 mm angled safety adapters, 20 pieces, pin**
Set comprising 20 angled adapters with rigid protective sleeve and open pin end for the bonding of devices.
– Pin width: 2 mm
– Pin length: 12 mm
– 1000 V CAT II
– Load capacity: 16 A

gray	**576285**
black	**576286**

1


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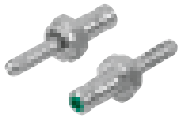

3


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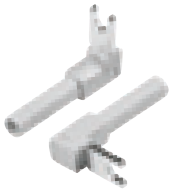

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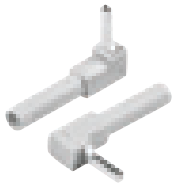

Accessories and Optional Components

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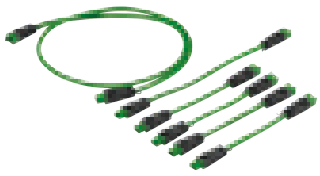

7

1 **Set of empty component housings, 2-pin**
Set of ten 2-pin housings, suitable for equipment set for basic principles of electrical engineering/electronics, consisting of
– Housing upper part, grey, blank
– Housing base, transparent
– Printed circuit board with universal layout and imprinted 4 mm push-in sleeves
For equipment with commercially available 2-pin wired components.

Order no.	**576289**

2 **Set of empty component housings, 3-pin**
Set of ten 3-pin housings, suitable for equipment set for basic principles of electrical engineering/electronics, consisting of
– Housing upper part, grey, blank
– Housing base, transparent
– Printed circuit board with universal layout and imprinted 4 mm push-in sleeves
For equipment with commercially available 3-pin wired components.

Order no.	**576290**

3 **Operational amplifier**
For constructing amplifier circuits.
– Supply voltage +/-15 V DC via 2 mm safety plug
– Output short circuit proof
– Offset compensation possible with potentiometer
– OP type LM741

Order no.	**576621**

4 **IC zero insertion force socket**
High-quality IC socket for tool-free adaptation of ICs, compatible with digital technology.
– 16 pins in a 2.54 mm grid
– Tool-free assembly using clamping lever
– Contacting with 2 mm safety plug

Order no.	**576623**

5 **I/O level converter 5 V ‹–› 24 V**
I/O level converter for the implementation of digital inputs and outputs for digital technology or microcontrollers on functional models.
– Supply voltage DC/24 V via 4 mm safety plug
– 8 inputs 5 V via 2 mm safety plug
– 8 outputs 5 V via 2 mm safety plug
– SysLink connection with 8 inputs and 8 outputs 24 V
– Acceptable current load per DC/24 V output 300 mA, protected against short circuits and overloads
– Sum of the output currents: max. 2 A

Order no.	**576622**

6 **KNX cable set**
Complete set comprising 6 KNX cables. Pre-assembled with KNX system plugs to fit KNX EduTrainers®.
– Conductor cross section: 2 x 2 x 0.8 mm^2
– 4x 100 mm
– 1x 200 mm
– 1x 1000 mm

Order no.	**8023965**

7 **A4 empty housing**
Medium-grey front panel with removable protective sheet, rear cover, rubber feet and screws fully mounted.
– Front panel: 133 x 297 mm
– Front panel: 266 x 297 mm
– Front panel: 399 x 297 mm
– Depth: 90 mm

133 x 297 mm	**8023974**
266 x 297 mm	**8023975**
399 x 297 mm	**8023976**

1 **Fluke 115 digital multimeter**
Standard meter for basic training in electrical engineering.

Automatic and manual range selection, 4-digit illuminated LCD display for measuring direct and alternating voltage, direct and alternating current, resistance, continuity, frequency, capacitance, diode test, min./max./mean value, display hold, bar graph, true effective value measurement (TRMS).
– Voltage: 0.1 mV – 600 V
– Current: 0.1 mA – 10 A
– Resistance: 0.1 Ω – 40 MΩ
– Frequency: 0.01 Hz – 50 kHz
– Capacitance: 1 nF – 10,000 µF
– Measuring circuit category CAT III/600 V

Scope of delivery
– Measuring cables
– Holster
– 9 V battery
– Manual

Order no. **571830**

2 **Fluke 179 digital multimeter**
Meter for higher requirements in basic training.

Automatic and manual range selection, 4-digit illuminated LCD display for measuring direct and alternating voltage, direct and alternating current, resistance, continuity, frequency, capacitance, diode test, temperature measurement, min./max./mean value, display hold, bar graph, true effective value measurement (TRMS).
– Voltage: 0.1 mV – 1,000 V
– Current: 0.01 mA – 10 A
– Resistance: 0.1 Ω – 50 MΩ
– Frequency: 0.01 Hz – 100 kHz
– Capacitance: 1 nF – 10,000 µF
– Measuring circuit category CAT III/1000 V
– Measuring circuit category CAT IV/600 V

Scope of delivery
– Measuring cables
– 80BK temperature probe
– Holster
– 9 V battery
– Manual

Order no. **571831**

3 **Beha-Amprobe**
AM-510 digital multimeter
Simple entry-level device for basic training.

Automatic and manual range selection, 3¾-digit LCD display, measurement of direct and alternating voltage, direct and alternating current, resistance, continuity, flow diode test, capacity and frequency measurement.
– Voltage: 1 mV – 600 V
– Current: 0.1 µA – 10 A
– Resistance: 0.1 Ω – 40 MΩ
– Frequency: 1 Hz – 10 MHz
– Capacity: 0.01 nF – 100 µF
– Measuring circuit category CAT III/600 V

Scope of delivery
– Measuring leads
– Battery
– Operating instructions

Order no. **8040005**

4 **Beha-Amprobe**
AM-555 digital multimeter
Low-cost device with a full range of functions for basic training.

Automatic and manual range selection, 3¾-digit LCD display, measurement of direct and alternating voltage, direct and alternating current, resistance, continuity, flow, diode test, capacity and frequency measurement, temperature measurement. Min/max, data hold, bar display (61 segments), real effective value measurement (TRMS).
– Voltage: 1 mV – 1000 V
– Current: 0.1 µA – 20 A
– Resistance: 0.1 Ω – 60 MΩ
– Frequency: 1 Hz – 60 MHz
– Capacity: 60 nF – 60 µF
– Measuring circuit category CAT III/1000 V
– Measuring circuit category CAT IV/600 V

Scope of delivery
– Measuring leads
– Temperature probe
– Carry strap
– Battery
– Operating instructions

Order no. **8089140**

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Accessories and Optional Components

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1 **Fluke 1664 FC installation tester for VDE 0100**
Installation tester for testing and accepting stationary installations as per VDE 0100/0413 and the international standard IEC 60364. Perfect for the practical demonstration of electrical protective measures in combination with our EduTrainers® for power supply systems and protective measures, and particularly for testing type B RCDs.

For all basic installation tests including continuity, insulation, loop impedance, trigger time and trigger current of the residual current protective devices (residual current devices), measuring ground resistance and phase sequence, including insulation pre-test to protect connected devices from damage. Internal memory, PC interface or Fluke Connect for documentation and reporting.

Scope of delivery
– Hard-shell case
– Set of measuring cables
– Quick guide, CD manual
– AA batteries
– Padded carrying strap

Order no.	**8064024**

2 **Beha-Amprobe Telaris ProInstall-0100 installation meter**
Low-cost installation tester with a good range of functions for testing the safety of electrical systems and work with our EduTrainern® for power supply systems and protective measures, without test options for RCDs Type B.

For testing and acceptance of fixed electrical installations in accordance with: DIN VDE 0100,ÖVE E 8001, NIV/NIN 2010, BS 7671, IEC 60364. Light and compact portable device with a clear user interface, a large backlit LCD display and a data logging function with a PC download. For all fundamental installation tests including insulation resistance, loop impedance and short circuit measurement, triggering time and tripping current of RCDs/quick-acting protective devices, low-ohm measurement and rotary field testing.

Scope of delivery
– Set of measuring cables
– Carrying strap
– Carrying case
– Brief instruction, manual on CD
– Batteries

Order no.	**8040008**

Software for Beha-Amprobe Telaris ProInstall-0100
Convenient, extendible software for logging measurement data per DIN VDE 0100/0105. Log design per ZVEH protocol. Includes interface adapter TL USB.

Order no.	**8040009**

3 **T110 VDE voltage and continuity tester**
Ideally suited for basic training in electrical engineering, with switching load.

VDE-tested and EN 61243-3:2010-compliant, with measurement peaks per the safety regulation HSE GS 38. With its robust and ergonomic plastic housing and the thicker measuring lead with a wear indicator, T110 is ideal for mobile use. Equipped with a direction of rotation indicator for three-phase systems and functions for testing RCDs via loads which can be switched with two-button operation. Also includes a special electric flashlight function for working in dark environments.
– Voltage: 12 – 690 V
– Rotary field: 100 – 690 V
– Flow: 0 – 400 kΩ
– Frequency: 0/40 – 400 Hz
– Measuring circuit category CAT III/690 V
– Measuring circuit category CAT IV/600 V

Scope of delivery
– Batteries
– Brief instructions

Order no.	**8040007**

Delta/Star (Wye) Distribution Transformer, 5.4 kVA
A three-phase transformer that allows the mains voltage of an ac power network (i.e., the local ac power network voltage) to be adjusted, as well as the conversion of an ac power network from a delta configuration (three lines and a ground) to a star (wye) configuration (three lines, a neutral, and a ground).

The star (wye) configuration is necessary for some exercises. Many mains voltage values are available. The device operates at a nominal power of 5.4 kVA.

120 V 60 Hz

Order no.	**586845**

240 V 50 Hz

Order no.	**586846**

1 **Tektronix TBS1052B-EDU**
digital storage oscilloscope
Standard oscilloscope for visualizing relationships during basic training in electrical engineering.

Curves can be traced and evaluated on a PC.
– Display: colored
– Bandwidth: 50 MHz
– Channels: 2
– Time base: 2,5 ns – 50 s/div
– Sampling rate: 1.0 GS/s
– Resolution: 8 bits
– Y deflection: 2 mV/div – 5 V/div
– Interface: USB

Scope of delivery
– Mains cable
– 2x TPP0051 probe
– Documentation

Order no. **571845**

Tektronix TBS2074
digital storage oscilloscope
– Display: Color WVGA, 9” W, resolution 800 x 480
– Bandwidth: 70 MHz
– Channels: 4
– Sampling rate: 1.0 GS/s
– Resolution: 8 bits
– Interface: 2x USB2.0, Wifi, Ethernet port
– Record length : 20 Mpoints
– 32 automated measurement mode
– CE, UL, CSA

Scope of delivery
– Power cord
– 4x probes TPP0100
– Documentation CD
– Installation, safety, programmer manuals
– Calibration certificate

Order no. **8068879**

2 **Amprobe AC50A**
digital leakage current clamp
This current clamp is ideally suited to measuring discharge currents (leakage currents) and differential currents (to BGV A3).

In addition to the current clamp function, this current clamp also includes the most common multimeter functions via measuring cables such as voltage measurement, resistance and continuity.
– Voltage AC: 0.1 – 400 V
– Current AC: 0.01 mA – 60 A
– Resistance: 0.1 – 400 Ω
– Frequency range: 40 Hz – 1 kHz
– Measuring circuit category CAT IV/600 V

Scope of delivery
– Measuring cables
– Bag
– 1.5 V battery
– Manual

Order no. **571848**

3 **Function generator**
– Signal types: Sinusoidal, square, triangular, TTL
– Frequency range: 0.1 Hz – 500 kHz
– Voltage output: DC
– Offset: -15 – +15 V
– Voltage amplitude: 0 – 30 V

Order no. **152918**

4 **Cable BNC – 4 mm**
Cable with BNC socket and 2 jack-plugs (4 mm). For use in conjunction with a function generator and oscilloscope.

Order no. **152919**

Cable BNC – BNC

Order no. **158357**

T-piece BNC

Order no. **159298**

5 **Amprobe rotary field and motor direction-of-rotation indicator PRM-6-EUR**
Phase sequence checker for basic training in three-phase technology and drive technology.

Functions
– Rotary field display
– Display of a missing or incorrectly connected external conductor
– Contactless motor direction-of-rotation indicator with running motors
– Voltage-free determination of motor connections (U, V, W) using a manual drive

Device information
– Voltage range from 40 to 700 V
– Frequency range 16 to 400 Hz
– Measurement category CAT IV, 600 V
– Sturdy housing with protective rubber cover
– Removable measuring cables
– Background lighting
– Rotary field direction check also with or without de-energized battery possible

Scope of delivery
– 3 measuring cables
– 3 probe tips
– 3 crocodile clamps
– Operating instructions
– Carrying case
– Batteries

Order no. **8081205**

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Services

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