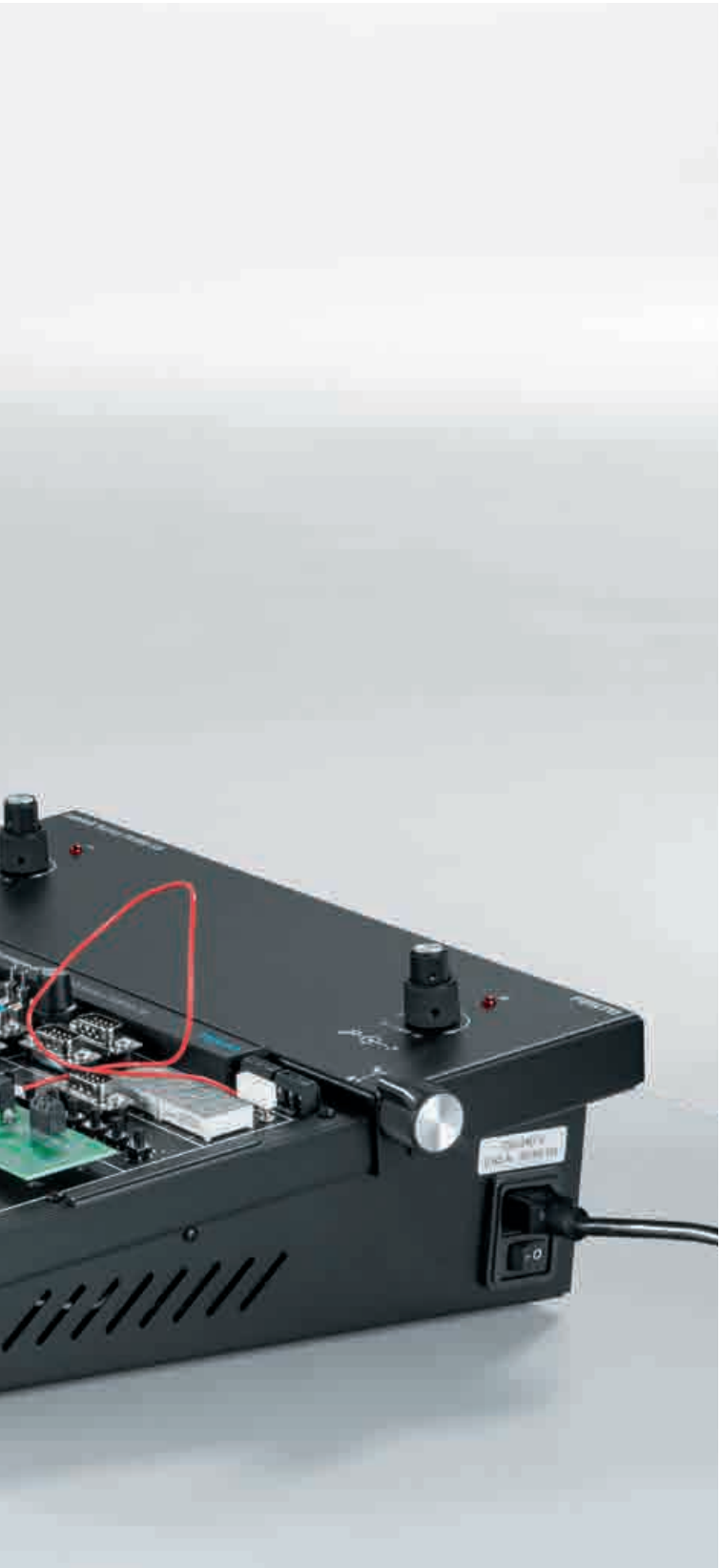
# FACET®

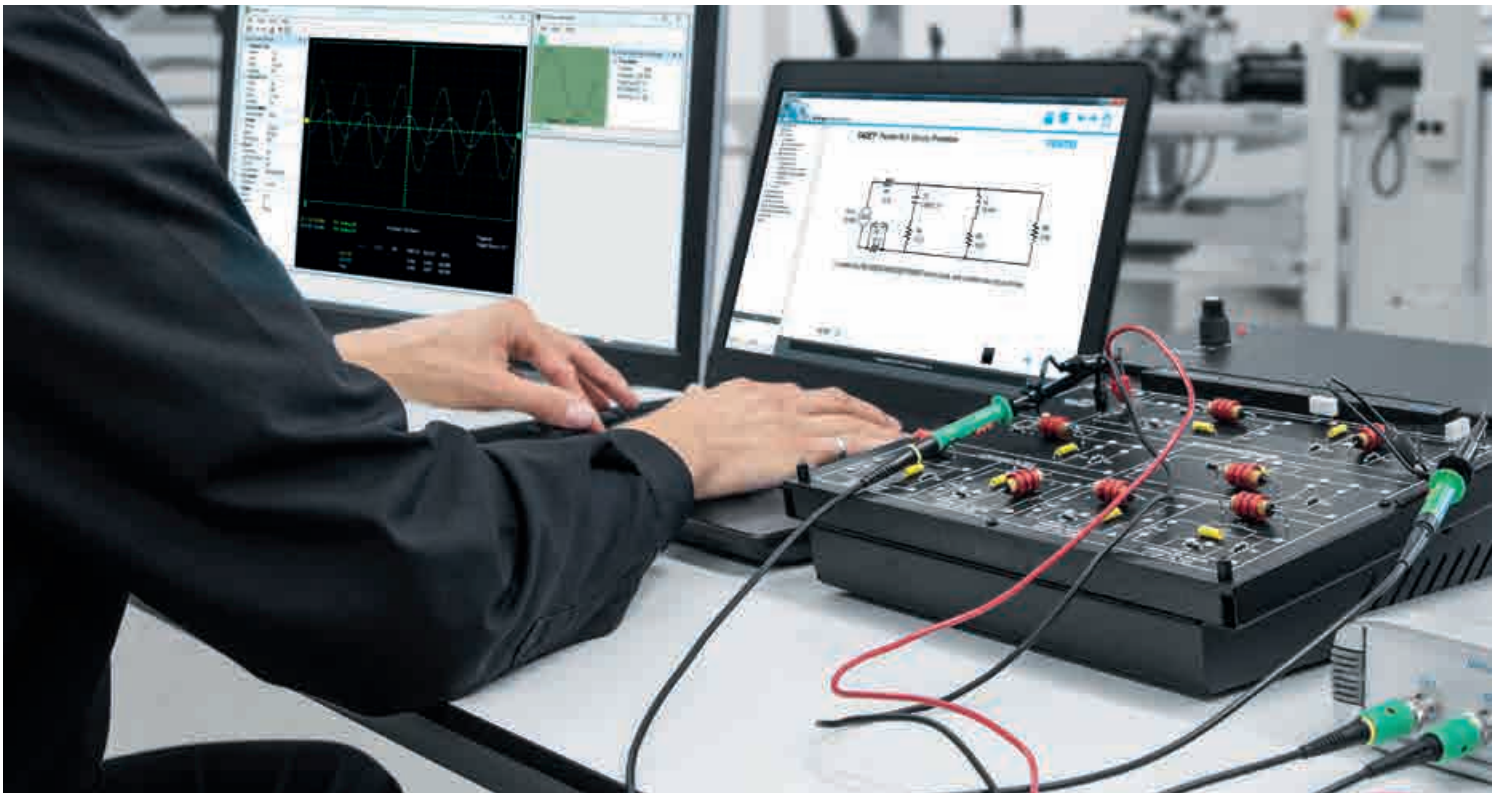
A completely integrated training system for electronics

FESTO

# FACET®



# FACET® and the eSeries



**FACET® and eSeries –**
**A completely integrated system**

The FACET® with eSeries 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 of a series of 30 boards, covering a wide range of electronics topics. Each board comes with comprehensive, hands-on instruction with theory and practice. This courseware is offered in traditional paper format or on a computer-based platform.

The computer-based courseware, called eSeries for FACET®, can run as stand-alone or within the MindSight LMS platform, providing a seamless integration of courseware delivery and classroom management.

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. The courseware can be delivered in a standard, paper-based curriculum or as a computer-based, interactive, multimedia courseware, the eSeries. Furthermore, the eSeries can be ordered as an autonomous courseware or managed by our **L**earning **M**anagement **S**ystem, MindSight. This LMS can be configured as a LAN- or Web-based software.

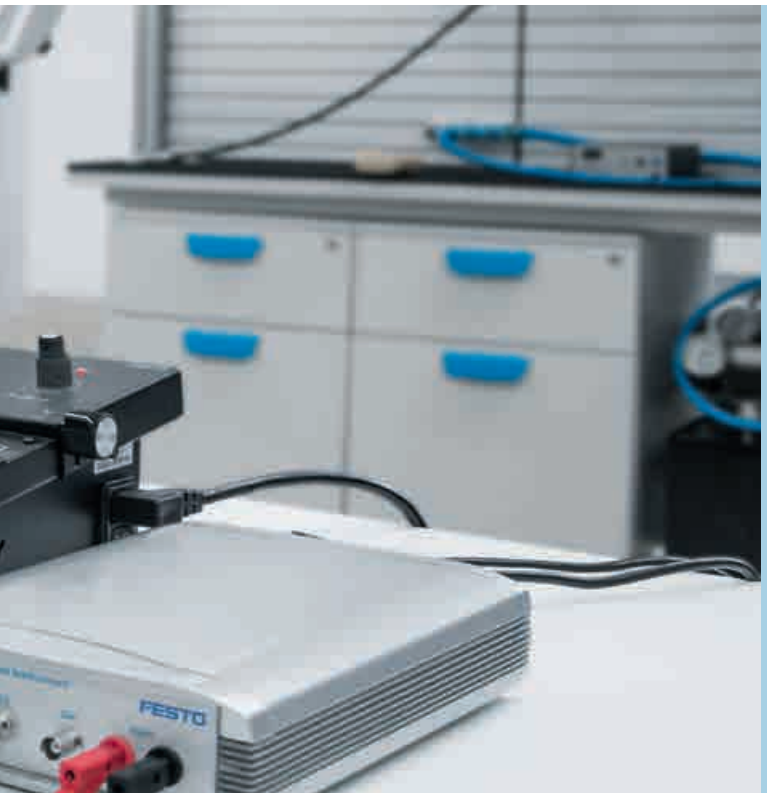
When combined with the LMS MindSight and eSeries courses, FACET® becomes a totally connected learning system for electronics that enhances learning speed and retention. FACET® is suitable for a multitude of training purposes in educational, industrial, R&D, and training laboratories.

**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:
  Paper manual (hard copy)
  or
  Computer-based – eSeries (Web-based or Hosted LMS) or SCORM or Stand-alone
- 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. Pre-wired circuits minimize wiring time.

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

**Hands-on Learning**
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 CMs 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)
- Choice of stand-alone, LAN, or Web-based configuration

# The eSeries Curriculum

## Complete electronics learning solution


The eSeries for FACET® program currently 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
- Microcontroller System Development
- 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

eSeries bundles :

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|---|---|
| Basic EE for MindSight, en | **585750** |
| Basic EE for MindSight, es | **585751** |
| Basic EE for SCORM, en | **585752** |
| Basic EE for Stand-Alone, en | **585753** |
| Basic EE for Stand-Alone, es | **585754** |

Complete bundle eSeries for FACET

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| for MindSight, en | **585743** |
| for MindSight, es | **585744** |
| for SCORM, en | **585745** |
| for Stand-Alone, en | **585746** |
| for Stand-Alone, es | **585747** |

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| Digital&µP for MindSight, en | **585757** |
| Digital&µP for MindSight, es | **585758** |
| Digital&µP for SCORM, en | **585759** |
| Digital&µP for Stand-Alone, en | **585760** |
| Digital&µP for Stand-Alone, es | **585761** |

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| Industrial E for MindSight, en | **585763** |
| Industrial E for MindSight, es | **585764** |
| Industrial E for SCORM, en | **585765** |
| Industrial E for Stand-Alone, en | **585766** |
| Industrial E for Stand-Alone, es | **585767** |

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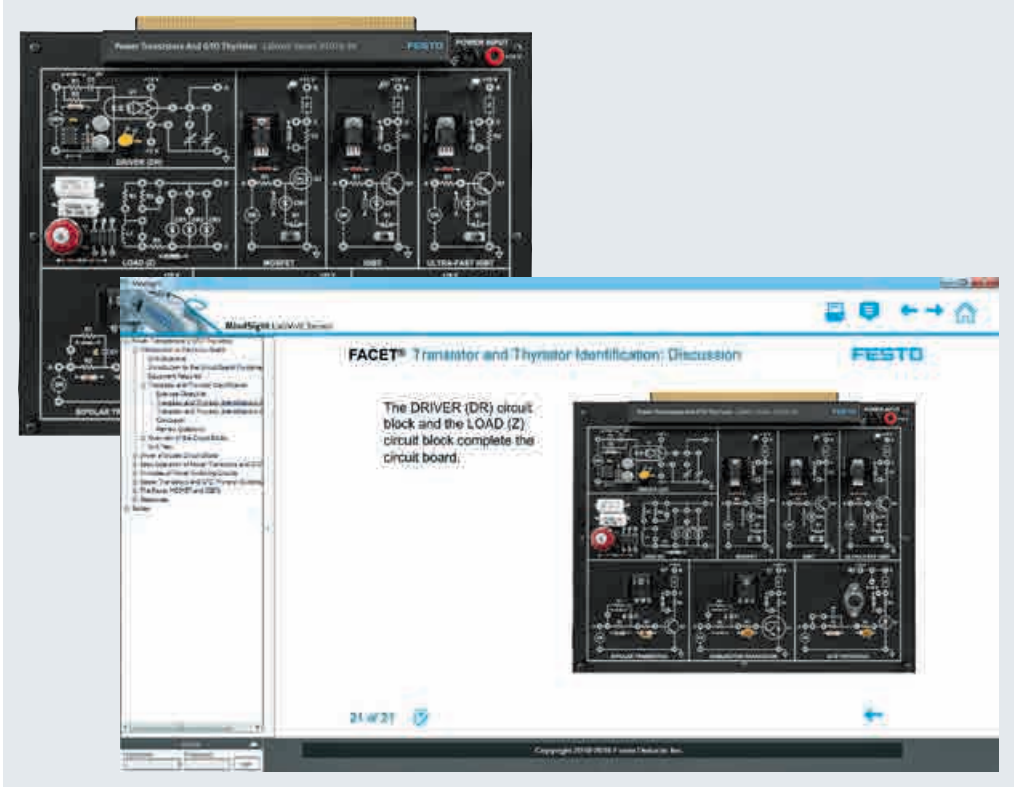
| Comm E for MindSight, en | **585769** |
| Comm E for MindSight, es | **585770** |
| Comm E for SCORM, en | **585771** |
| Comm E for Stand-Alone, en | **585772** |
| Comm E for Stand-Alone, es | **585773** |

**A program designed for student achievement**

Conforming to the highest measures of educational quality, the eSeries for FACET® courseware is designed to facilitate and reinforce progressive mastery of the course material. Delivered by means of student manuals or eSeries for FACET® software, 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 through 12 instructor- or computer-activated fault switches and 20 circuit-modification switches.




**Connected learning**
The eSeries for FACET® enhances learning speed and retention by featuring interactive multimedia courseware with hand-on exercises on pre-wired circuit boards.

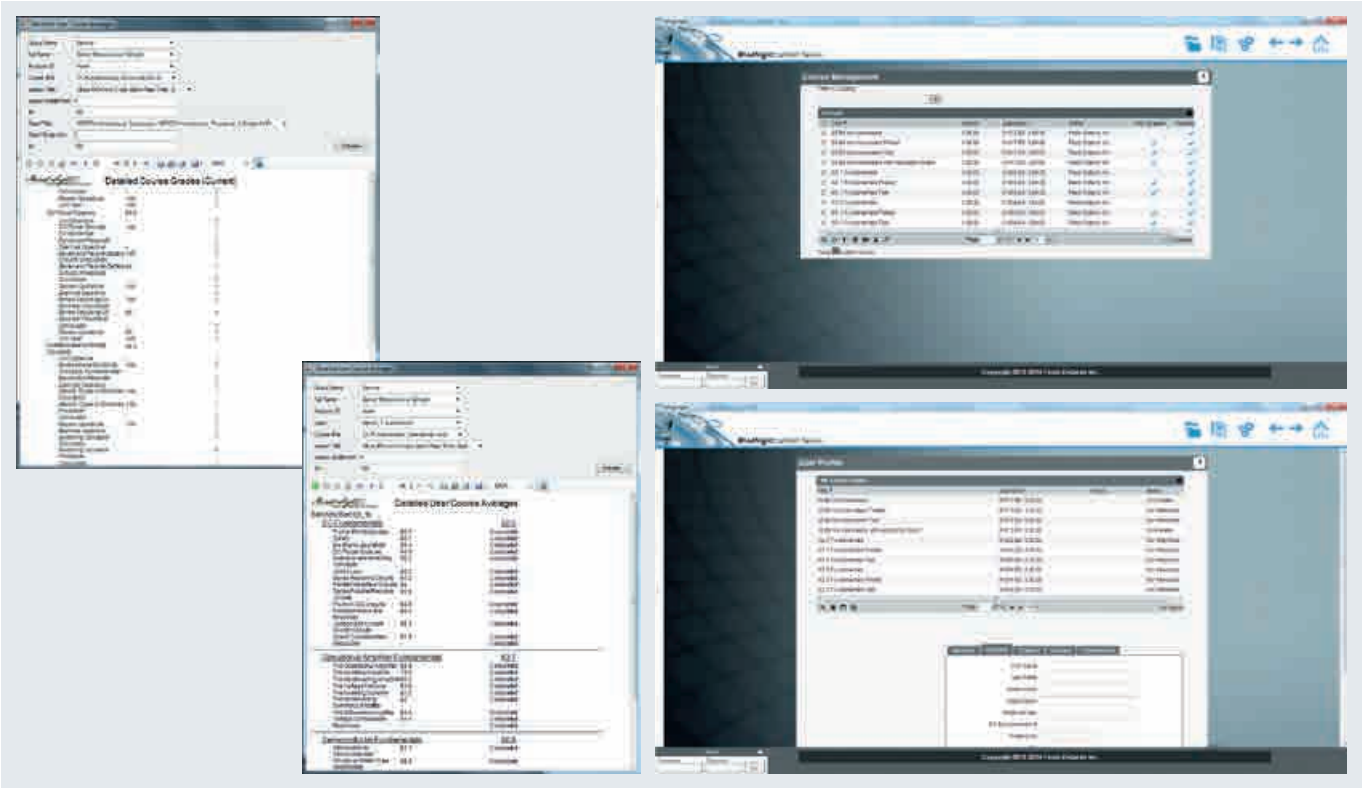
**For circuit comprehension and analysis**
Students perform experiments on a wide range of electronics and electricity training modules that combine theory and application with live connection to base unit and board. This provides practical skills training over a full curriculum on electronic/electricity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

**Flexibility**
eSeries for FACET® can be ordered in three different formats.
– First option is as stand-alone courses, i.e., no need for LMS.
– Secondly, with our MindSight Learning Management system (LMS). This powerful LMS is used to present, report, and customize the technical subjects for each of FACET®'s extensive line of training modules.
– Finally, all eSeries courses are available as SCORM-compliant, so they are usable with other learning management systems.

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

**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.

# MindSight
## A powerful LMS



MindSight is a powerful platform that operates all components of the multimedia curriculum, as well as the classroom management system.

This powerful LMS is used to present, report, and customize the technical subjects for each eSeries for FACET® extensive line of training modules. It offers full management of classroom, groups, and content access.

MindSight allows instructors to manage enrollment, schedule learning activities, communicate with users, customize courseware, and track and report individual achievement. Course content and class management are controlled from the instructor-access controlled software.

MindSight can be connected to a workstation with training hardware, or as a stand-alone, e-learning program without hardware.

**MindSight provides these features:**

**Classroom management**
- Add and delete students
- Create groups
- Create and delete passwords
- Run activity and assessment reports

**Content Management**
- Import additional MindSight content from CD, DVD, or external device
- Manage course catalogs
- Upload new SCORM courses
- Add a new catalog
- Manage catalogs
- Assign User Groups to catalogs

**Teacher Annotations**
Teachers can change words or paragraphs and add additional text, supplementary information, or instructions within the curriculum.

**Course Content Editing**
Easy-to-use tools enable the addition of information, course building from existing content, and SCORM package uploading. Tools also enable you to run external applications.

**Access to students' electronic journals**
Instructors can communicate with students about notes they save in the journals, projects, progress, etc.

**Announcement Posting**
Teachers can send messages to the entire class in one easy step.

**Real-Time Journal/Blog**
Instructors can communicate in writing with selected students. The blog feature enhances communication among teachers and students.

**Application Tab**
Any application can be linked to the application tab and launched from this tab in the top right corner of the screen.

**Student Notes**
Each content screen displays a student notes icon that opens a note-taking window in front of the content screen. Students can see the content about which they are taking notes. These notes can then be printed out individually or exported to a single file for printing.

**Reporting**
Teachers can run reports by Courses or Students. More reports features, including Competencies and Standards, are currently in development.

**More options**
There are two possible configurations for MindSight:
– LAN-based
– Web-based

For the LAN-based solution, we supply MindSight with a “plug-and-play” network appliance that comes with pre-installed management and communication software, providing a fully-supported network without disturbing an existing network. MindSight is connected to its LAN, and a client software is installed on each workstation.

In the case of a Web-based configuration, each workstation is linked to the Web. A client software is installed on each workstation and the data are hosted on our server. A licensing fee for such usage will apply.

**Requirements to run MindSight**

Server requirements:
Recommendations are for server connectivity. Network appliance itself is supplied by Festo and requires a 10 Mb Ethernet LAN connection.

Recommended access to internet via port 80/443 (HTTP/SSL) or via proxy server will allow for quick and easy registration and updating.

Client Workstation, recommended:
– Internet Explorer 7
– .NET 3.0 framework
– Flash 8
(multimedia may require Flash 9)
– Sound card
– 100Mb Ethernet
– 1280 pixel width display resolution

Client Workstation, minimum:
– Microsoft Windows XP
– Internet Explorer 6
– .NET 3.0 framework
– Flash 8
(multimedia may require Flash 9)
– Sound card
– 10 Mb Ethernet
– 1024 pixel width display resolution

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| MindSight — LAN | **588921** |
| MindSight — WEB | **589244** |

# The FACET® base units

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

2

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 by the teacher via a USB port 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 automatically switched in and out 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 Circuit Modification (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**

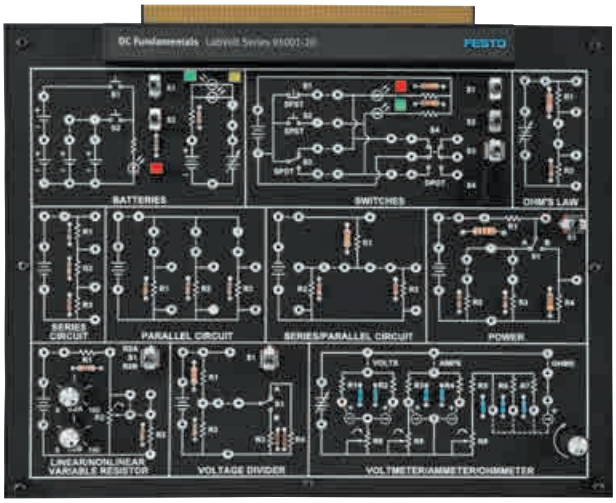
Connector as per SEV 1011 for CH
Order no. **582150**

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

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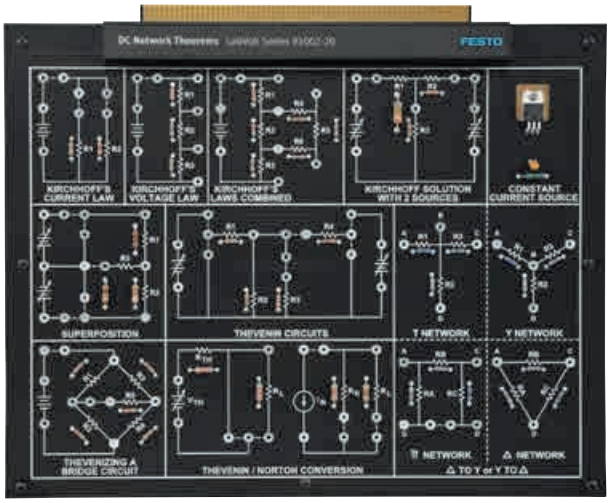
| DC Fundamentals 91001 en | **580877** |
| DC Fundamentals 91001 fr | **580878** |
| DC Fundamentals 91001 es | **580879** |
| Workbooks, also order: | |
| Student manual, en | 580644 |
| Instructor guide, en | 580647 |
| Supplementary media: | |
| eSeries for MindSight, en | 580868 |
| eSeries for MindSight, es | 580869 |
| eSeries for Stand-Alone, en | 580871 |
| eSeries for Stand-Alone, es | 580872 |

# 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

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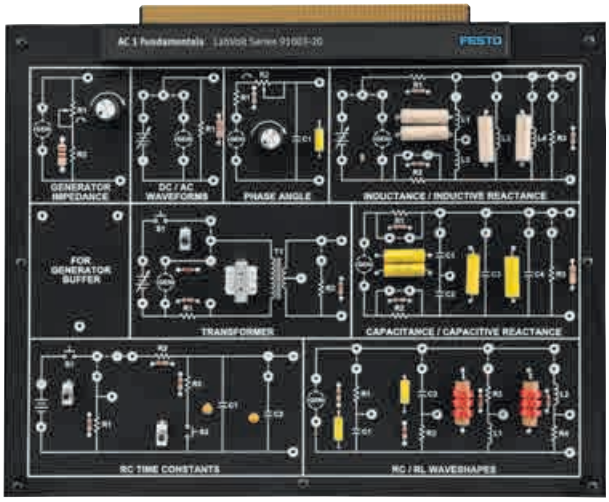
| DC Network Theorems 91002 en | **580889** |
| DC Network Theorems 91002 fr | **580890** |
| DC Network Theorems 91002 es | **580891** |
| Workbooks, also order: | |
| Student manual, en | 589693 |
| Instructor guide, en | 580655 |
| Supplementary media: | |
| eSeries for MindSight, en | 580880 |
| eSeries for MindSight, es | 580881 |
| eSeries for Stand-Alone, en | 580883 |
| eSeries for Stand-Alone, es | 580884 |

# 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

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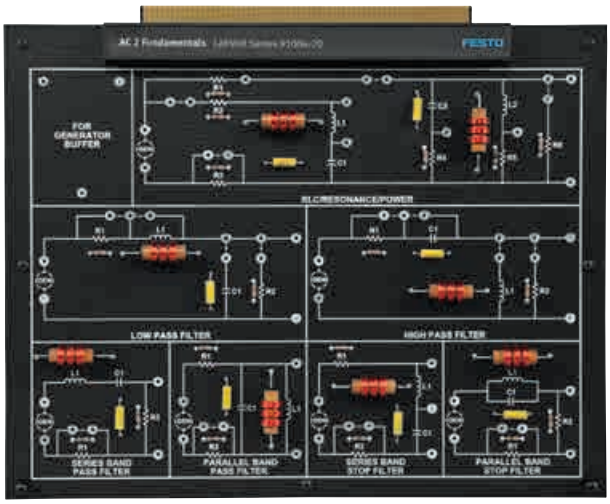
| AC 1 Fundamentals 91003 en | **580901** |
| AC 1 Fundamentals 91003 fr | **580902** |
| AC 1 Fundamentals 91003 es | **580903** |
| Workbooks, also order: | |
| Student manual, en | 580661 |
| Instructor guide, en | 580664 |
| Supplementary media: | |
| eSeries for MindSight, en | 580892 |
| eSeries for MindSight, es | 580893 |
| eSeries for Stand-Alone, en | 580895 |
| eSeries for Stand-Alone, es | 580896 |

# 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

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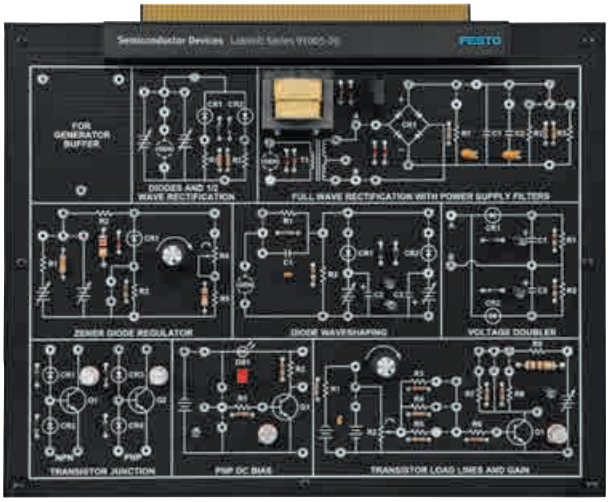
| AC 2 Fundamentals 91004 en | **580913** |
| AC 2 Fundamentals 91004 fr | **580914** |
| AC 2 Fundamentals 91004 es | **580915** |
| Workbooks, also order: | |
| Student manual, en | 580670 |
| Instructor guide, en | 580673 |
| Supplementary media: | |
| eSeries for MindSight, en | 580904 |
| eSeries for MindSight, es | 580905 |
| eSeries for Stand-Alone, en | 580907 |
| eSeries for Stand-Alone, es | 580908 |

# Semiconductor Devices
## Circuit Board 91005



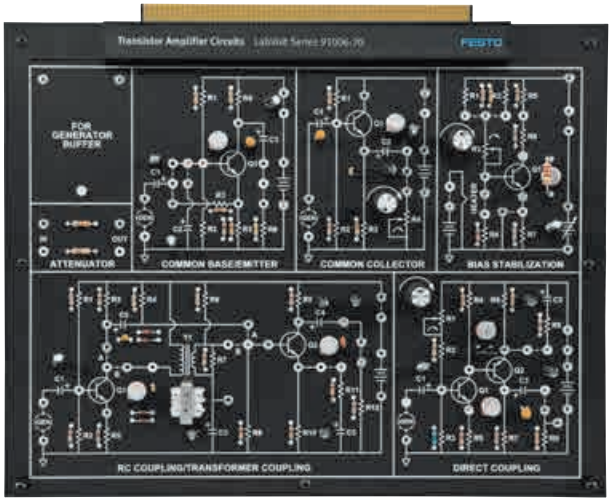

The Semiconductor Devices Circuit Board contains nine circuit blocks pertaining to skills training in semiconductor circuits.

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

# 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

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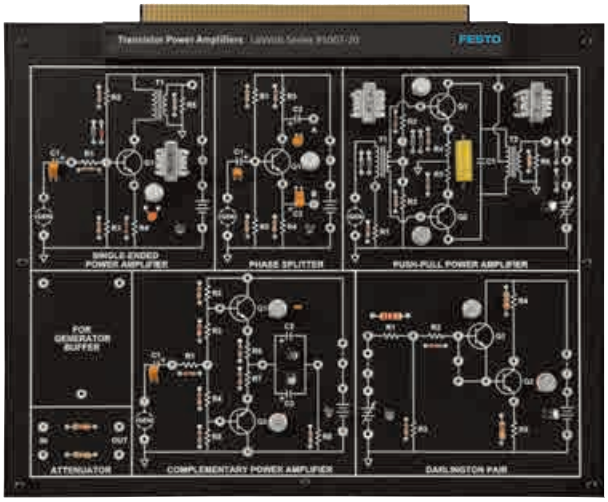
| Semiconductor Devices 91005 en | **580925** |
| Semiconductor Devices 91005 fr | **580926** |
| Semiconductor Devices 91005 es | **580927** |
| Workbooks, also order: | |
| Student manual, en | 589694 |
| Instructor guide, en | 580681 |
| Supplementary media: | |
| eSeries for MindSight, en | 580916 |
| eSeries for MindSight, es | 580917 |
| eSeries for Stand-Alone, en | 580919 |
| eSeries for Stand-Alone, es | 580920 |

| | |
|---|---|
| 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 |
| Supplementary media: | |
| eSeries for MindSight, en | 580928 |
| eSeries for MindSight, es | 580929 |
| eSeries for Stand-Alone, en | 580931 |
| eSeries for Stand-Alone, es | 580932 |

# Transistor Power Amplifiers
## Circuit Board 91007

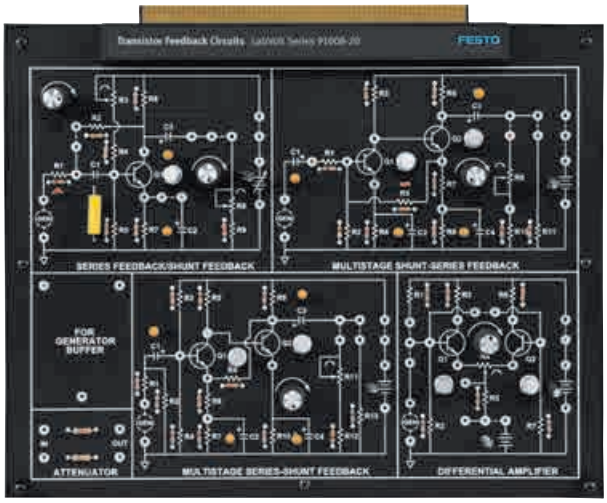



The Transistor Power Amplifiers Circuit Board is designed to teach troubleshooting of transistor power amplifier circuitry.

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 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 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 |
| Supplementary media: | |
| eSeries for MindSight, en | 580940 |
| eSeries for MindSight, es | 580941 |
| eSeries for Stand-Alone, en | 580943 |
| eSeries for Stand-Alone, es | 580944 |

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|---|---|
| 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 |
| Supplementary media: | |
| eSeries for MindSight, en | 580952 |
| eSeries for MindSight, es | 580953 |
| eSeries for Stand-Alone, en | 580955 |
| eSeries for Stand-Alone, es | 580956 |

# Power Supply Regulation Circuits
## Circuit Board 91009

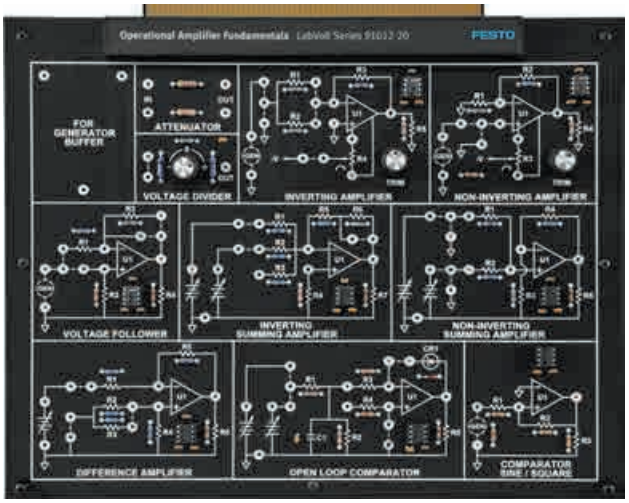

The Power Supply Regulation Circuits Board provides comprehensive, hands-on instruction in the terminology, principles, and applications of power supply regulation circuits.

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 |
| Supplementary media: | |
| eSeries for MindSight, en | 580964 |
| eSeries for MindSight, es | 580965 |
| eSeries for Stand-Alone, en | 580967 |
| eSeries for Stand-Alone, es | 580968 |

# 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
- 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

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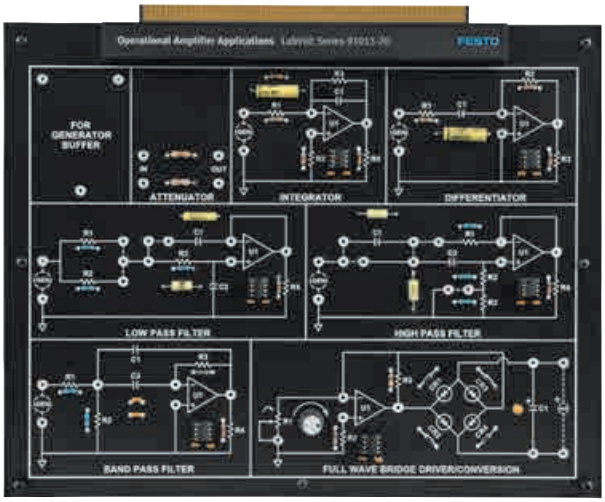
|---|---|
| Operational Amplifier Fundamentals 91012 en | **581009** |
| Operational Amplifier Fundamentals 91012 fr | **581010** |
| Operational Amplifier Fundamentals 91012 es | **581011** |
| Workbooks, also order: | |
| Student manual, en | 580736 |
| Instructor guide, en | 580739 |
| Supplementary media: | |
| eSeries for MindSight, en | 581000 |
| eSeries for MindSight, es | 581001 |
| eSeries for Stand-Alone, en | 581003 |
| eSeries for Stand-Alone, es | 581004 |

# 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

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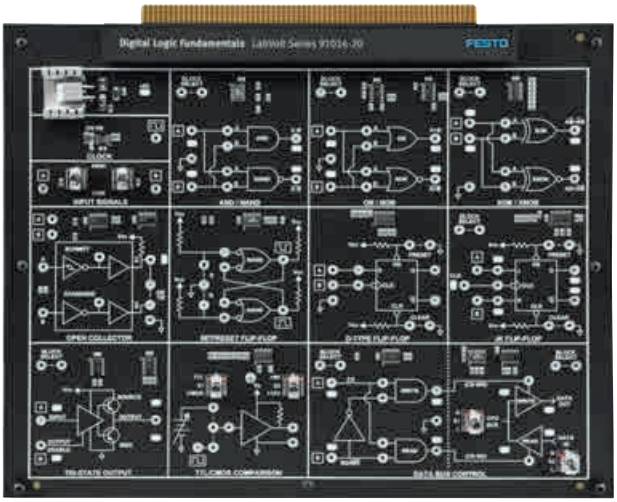
|---|---|
| Operational Amplifier Applications 91013 en | **581021** |
| Operational Amplifier Applications 91013 fr | **581022** |
| Operational Amplifier Applications 91013 es | **581023** |
| Workbooks, also order: | |
| Student manual, en | 589700 |
| Instructor guide, en | 580747 |
| Supplementary media: | |
| eSeries for MindSight, en | 581012 |
| eSeries for MindSight, es | 581013 |
| eSeries for Stand-Alone, en | 581015 |
| eSeries for Stand-Alone, es | 581016 |

# 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

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|---|---|
| Digital Logic Fundamentals 91014 en | **581033** |
| Digital Logic Fundamentals 91014 fr | **581034** |
| Digital Logic Fundamentals 91014 es | **581035** |
| Workbooks, also order: | |
| Student manual, en | 589102 |
| Instructor guide, en | 580755 |
| Supplementary media: | |
| eSeries for MindSight, en | 581024 |
| eSeries for MindSight, es | 581025 |
| eSeries for Stand-Alone, en | 581027 |
| eSeries for Stand-Alone, es | 581028 |

# 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

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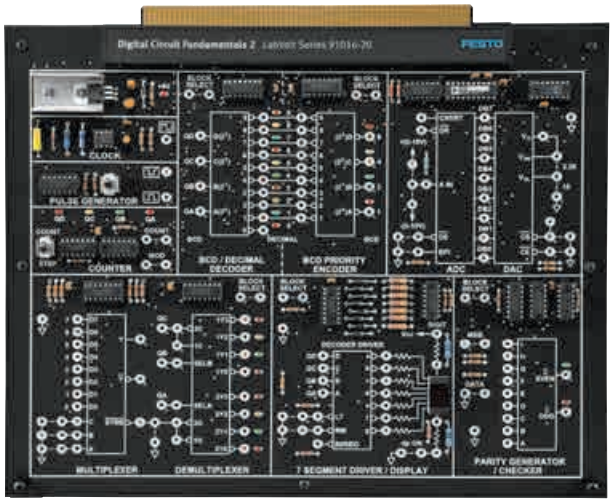
|---|---|
| Digital Circuit Fundamentals 1, 91015 en | **581045** |
| Digital Circuit Fundamentals 1, 91015 fr | **581046** |
| Digital Circuit Fundamentals 1, 91015 es | **581047** |
| Workbooks, also order: | |
| Student manual, en | 585383 |
| Instructor guide, en | 580763 |
| Supplementary media: | |
| eSeries for MindSight, en | 581036 |
| eSeries for MindSight, es | 581037 |
| eSeries for Stand-Alone, en | 581039 |
| eSeries for Stand-Alone, es | 581040 |

# 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

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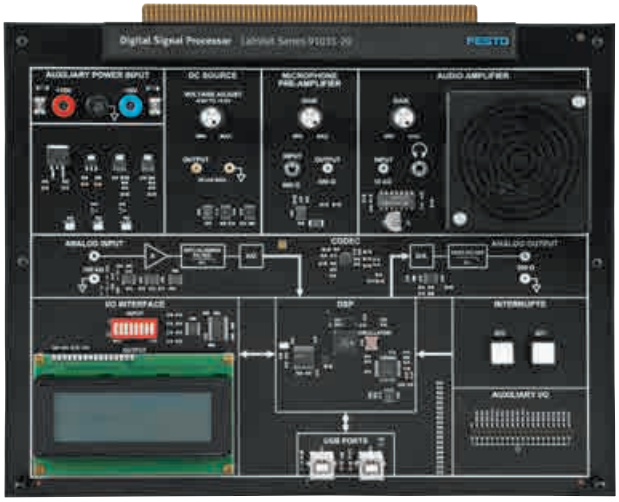
|---|---|
| Digital Circuit Fundamentals 2, 91016 en | **581057** |
| Digital Circuit Fundamentals 2, 91016 fr | **581058** |
| Digital Circuit Fundamentals 2, 91016 es | **581059** |
| Workbooks, also order: | |
| Student manual, en | 589701 |
| Instructor guide, en | 580771 |
| Supplementary media: | |
| eSeries for MindSight, en | 581048 |
| eSeries for MindSight, es | 581049 |
| eSeries for Stand-Alone, en | 581051 |
| eSeries for Stand-Alone, es | 581052 |

# 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

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|---|---|
| Digital Signal Processor 91031 en | **585736** |
| Digital Signal Processor 91031 fr | **585737** |
| Workbooks, also order: | |
| Student manual, en | 583850 |
| Instructor guide, en | 583851 |
| Supplementary media: | |
| eSeries for MindSight, en | 593578 |
| eSeries for Stand-Alone, en | 593580 |

# Microcontroller System Development
## Circuit Board 91030

The Microcontroller System Development course provides comprehensive, hands-on instruction in the terminology, principles, and applications of microcontroller programming.

This board features a USB programmable PIC microcontroller; on-board peripherals include LEDs, switches, 7-segment single or QUAD display, LCD display, keypad, light sensor, variable voltage source for A/D acquisition, and Vernier™ sensors inputs. An extension surface expands the capabilities of this board for breadboarding or for a wide range of projects using optional E-Blocks. The chip is programmed with FlowCode, included as a single-license, academic FlowCode v7. Students learn programming using a graphical programming environment, enabling them to quickly and easily develop complex electronic systems.

This academic version includes a range of templates and macros for popular add-on E-Block kits.

The board can either be used with the FACET® base unit or as a stand-alone trainer.

**Topic Coverage**
- Digital vs. Analog
- Inputs and Outputs
- Memory
- 16F877A Architecture
- Programming
- Digital Outputs and Clocking
- Digital Inputs
- Basic Loops
- Display a Message
- Calculations and Input Conditioning
- Decisions and Macros
- The 7-Segment Display
- String Variables and ASCII Code
- A Simple Hi-Fi

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|---|---|
| Microcontroller System Development 91030 en | **581210** |
| Microcontroller System Development 91030 fr | **581211** |
| Microcontroller System Development 91030 es | **581212** |
| Workbooks, also order: | |
| Instructor guide, en | 580487 |
| Supplementary media: | |
| eSeries for MindSight, en | 581203 |
| eSeries for MindSight, es | 581204 |
| eSeries for Stand-Alone, en | 581206 |
| eSeries for Stand-Alone, es | 581207 |

# Add-on for FACET®
# Microcontroller Board: the E-Blocks kits

**Add-on kits: project oriented**
The add-on kits for microcontroller consist of a number of E-Blocks boards and advanced modules which form complete solutions.

The kit uses the macros included in FlowCode to facilitate investigation and allow students to concentrate on information flow and programming strategy without getting bogged down in programming and syntax.

**Courseware included**
All kits include courseware presented as project training.

**Packaged conveniences**
E-Blocks boards are fitted with clear acrylic covers which prevent links and chips from being removed.
The solutions are pre-assembled, factory tested and are shipped in rugged plastic trays for convenient storage and transport.

**Bluetooth Communications**
The Bluetooth Communications kit allows students to carry out in-depth investigations into Bluetooth technology, including the SPP profile, headset profile, and data profiles. In addition, other protocols in the Bluetooth stack, such as SDP, TCS, HDLC, PPP, can be examined.

This solution forms a complete Bluetooth transmitter-receiver solution using two workstations.

**Internet Communications**
The Embedded Internet Training Solution kit allows students to carry out in-depth investigations into internet technology by forming a complete Web server. When used in conjunction with a PC and Web browser, students can conduct a range of experiments to understand and investigate ASP, HTTP, TCP, IP, UDP, ICMP, ARP protocols and communications layers and their OSI linkage, as well as DLC and MAC protocols. The solution also allows students to carry out simple web-based control over the internet.

| | |
|---|---|
| Bluetooth Communications | **585801** |
| Internet Communications | **585802** |
| Mobile Telephony | **585803** |
| RFID | **585804** |
| USB communication | **585805** |
| CAN bus | **589988** |
| Zigbee | **589989** |

**Mobile Telephony**
This solution can be used to provide a complete course in developing communication systems. The Mobile Communications System is controlled by the microcontroller board, while Flowcode™ macros allow students to understand communications programs and strategies. Flow chart programming is well-supported using Flowcode. Pre-written, high-level flow chart routines have been included to allow designs using the Mobile Communications System to be assembled in a matter of hours. Students learn about sending and receiving text messages in mobile phone systems, modern control and messaging, RS232 communications and handshaking protocols, plus much more.

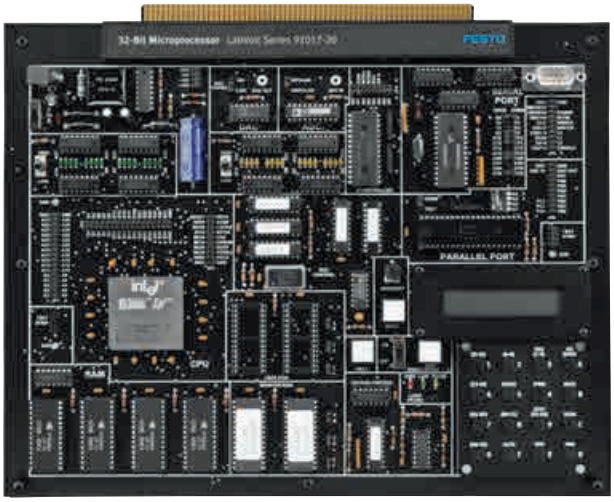
**RFID**
The E-Blocks RFID kit can be used to provide a complete course in developing RFID systems. This will give students an understanding of the programming techniques involved in developing RFID systems. An E-Blocks RFID board and four RFID tags embedded into credit cards are included.

**USB**
This solution allows students to carry out a number of practical exercises in USB technology. Students learn about USB by developing eight different systems: Mouse, Joystick, Temperature logger, USB terminal, USB to RS232 converter, Basic slave, Storage scope, and Oscilloscope with variable trigger. Some of these experiments are accompanied by programs written in Visual Basic. Working through the exercises, students build a good understanding of the various types of USB systems, including Human Interface Devices, Communications Devices, and Slave devices.

**CAN**
This training solution is designed to facilitate the development and investigation of systems that use the CAN bus protocol for communications. The solution uses four FACET® workstations and comprise four fully programmable CAN nodes which mimic ECUs in an automotive application. These are mounted on rugged backplanes and are fitted with ancillary circuit boards which mimic the functions of indicator lamps, switches, and sensors. These supplies allow students to program each of the four nodes to form a fully functioning CAN system in flow charts. The solution is suitable for automotive students who simply need to understand how CAN works, as well as for electronics students who want to understand protocols. The software supplied operates at several levels so that different types of students are exposed only to the relevant details of the CAN system. A CAN bus analyzer and message generator is supplied with the solution.

**ZigBee**
The ZigBee training solution can be used to provide a complete course in developing wireless area networks based on the ZigBee standard. This will give students who are familiar with microcontrollers an understanding of the programming techniques involved in developing ZigBee wireless communication systems, as well as an understanding of how these systems are developed from scratch. A ZigBee packet analyzer is included. Students learn about ZigBee by carrying out a number of exercises using the hardware provided and Flowcode™ software.

# 32-Bit Microprocessor
## Circuit Board 91017




This board provides 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

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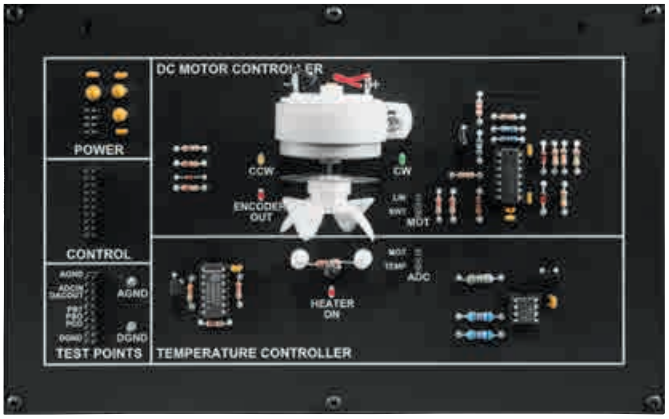
|---|---|
| 32-Bit Microprocessor 91017 en | **581069** |
| 32-Bit Microprocessor 91017 fr | **581070** |
| 32-Bit Microprocessor 91017 es | **581071** |
| Workbooks, also order: | |
| Student manual, en | 589702 |
| Instructor guide, en | 580779 |
| Supplementary media: | |
| eSeries for MindSight, en | 581060 |
| eSeries for MindSight, en | 581061 |
| eSeries for Stand-Alone, en | 581063 |
| eSeries for Stand-Alone, es | 581064 |

# 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.

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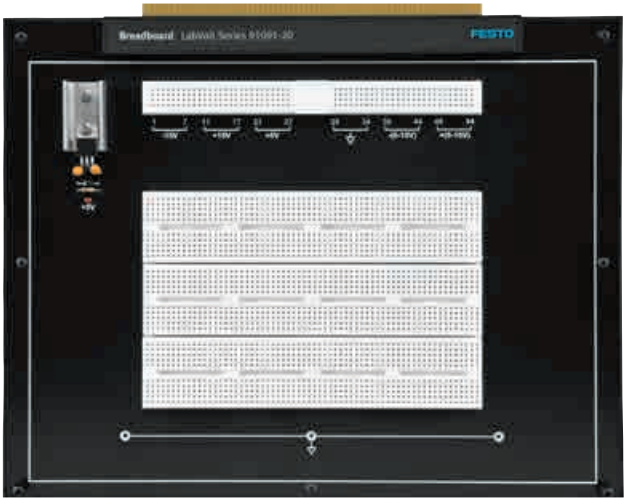
|---|---|
| Microprocessor Application Board 91602 en | **581224** |
| Workbooks, also order: | |
| Student manual, en | 585395 |

# 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.

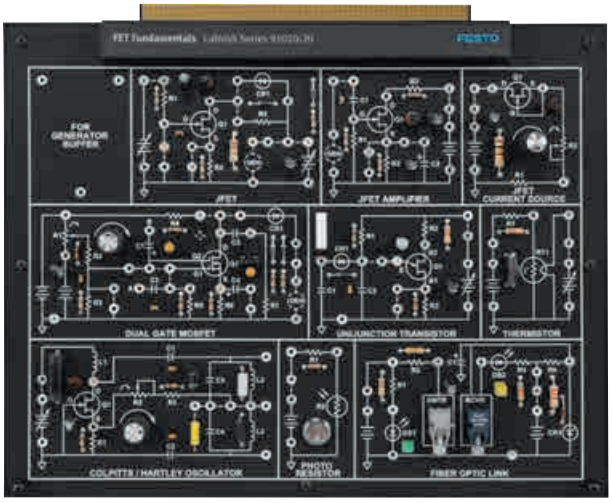
Students gain the understanding of the physical characteristics of components like pinouts, size, power, and impedance voltage limits. The breadboard comes with all the leads and components required to connect the studied circuits. These circuits include astable, bistable, and monostable multibrators, 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 | 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 |
| Supplementary media: | |
| eSeries for MindSight, en | 580976 |
| eSeries for MindSight, es | 580977 |
| eSeries for Stand-Alone, en | 580979 |
| eSeries for Stand-Alone, es | 580980 |

# Transducer Fundamentals
## Circuit Board 91019

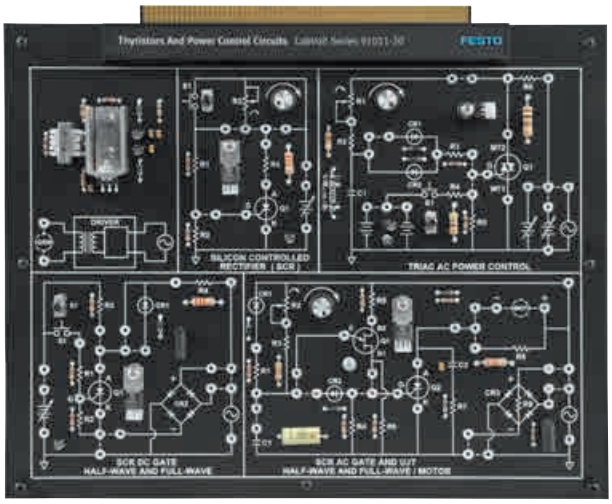

The Transducer Fundamentals course guides students through the circuits and devices used to interface computer and control circuits. Students learn the principles of input and output transducers and how physical quantities, such as heat, position, proximity, and force, are converted to electrical signals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

| | |
|---|---|
| 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 |
| Supplementary media: | |
| eSeries for MindSight, en | 581087 |
| eSeries for MindSight, es | 581088 |
| eSeries for Stand-Alone, en | 581090 |
| eSeries for Stand-Alone, es | 581091 |

# Thyristor and Power Control Circuits
## Circuit Board 91011



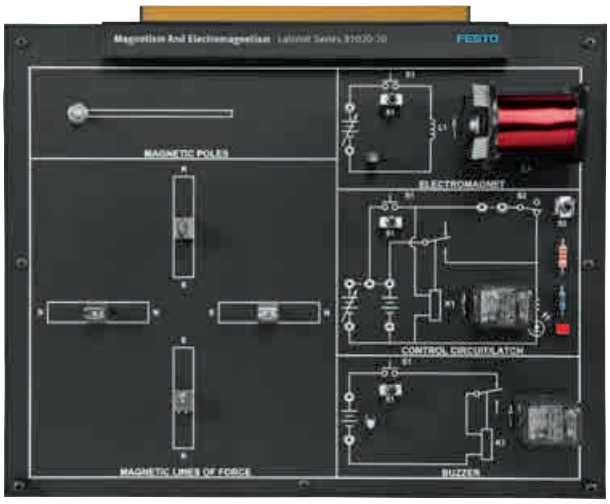

The Thyristor and Power Control Circuits course provides comprehensive, hands-on instruction in the fundamental terminology, principles, and applications of thyristor and power control circuits.

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 |
| Supplementary media: | |
| eSeries for MindSight, en | 580988 |
| eSeries for MindSight, es | 580989 |
| eSeries for Stand-Alone, en | 580991 |
| eSeries for Stand-Alone, es | 580992 |

# 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

# 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).

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|---|---|
| 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 |
| Supplementary media: | |
| eSeries for MindSight, en | 581099 |
| eSeries for MindSight, es | 581100 |
| eSeries for Stand-Alone, en | 581102 |
| eSeries for Stand-Alone, es | 581103 |

| | |
|---|---|
| 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 |
| Supplementary media: | |
| eSeries for MindSight, en | 581138 |
| eSeries for MindSight, es | 581139 |
| eSeries for Stand-Alone, en | 581141 |
| eSeries for Stand-Alone, es | 581142 |

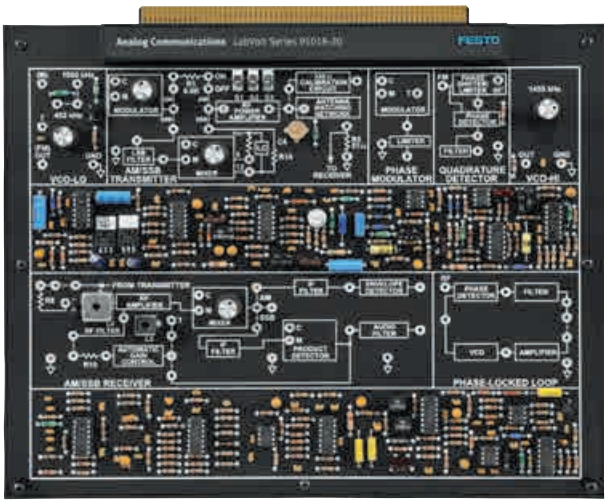
# Power Transistors and GTO Thyristors
## Circuit Board 91026


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 | 589710 |
| Instructor guide, en | 580847 |
| Supplementary media: | |
| eSeries for MindSight, en | 581162 |
| eSeries for MindSight, es | 581163 |
| eSeries for Stand-Alone, en | 581165 |
| eSeries for Stand-Alone, es | 581166 |

# 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

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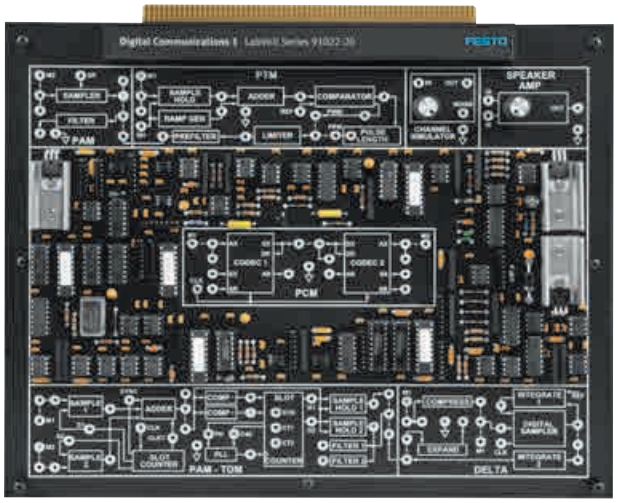
|---|---|
| Analog Communications 91018 en | **581084** |
| Analog Communications 91018 fr | **581085** |
| Analog Communications 91018 es | **581086** |
| Workbooks, also order: | |
| Student manual, en | 589703 |
| Instructor guide, en | 580787 |
| Supplementary media: | |
| eSeries for MindSight, en | 581075 |
| eSeries for MindSight, es | 581076 |
| eSeries for Stand-Alone, en | 581078 |
| eSeries for Stand-Alone, es | 581079 |

# Digital Communications 1
## Circuit Board 91022



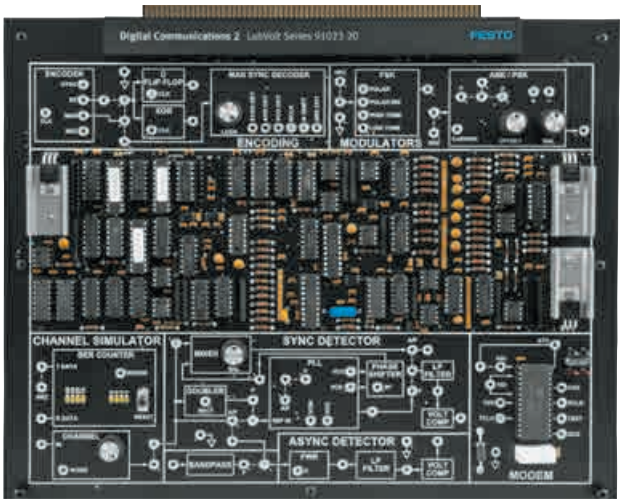

The Digital Communications 1 course provides comprehensive, hands-on instruction in the terminology, principles, and applications of digital circuits, including: Sampler, Sample/Hold, Adder, Ramp Generator, Comparator, Limiter, Filter, CODEC, PLL, Compressor, Expander, Integrator, Differentiator, Latched 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 |
| Supplementary media: | |
| eSeries for MindSight, en | 581114 |
| eSeries for MindSight, es | 581115 |
| eSeries for Stand-Alone, en | 581117 |
| eSeries for Stand-Alone, es | 581118 |

# 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 |
| Supplementary media: | |
| eSeries for MindSight, en | 581126 |
| eSeries for MindSight, es | 581127 |
| eSeries for Stand-Alone, en | 581129 |
| eSeries for Stand-Alone, es | 581130 |

# 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

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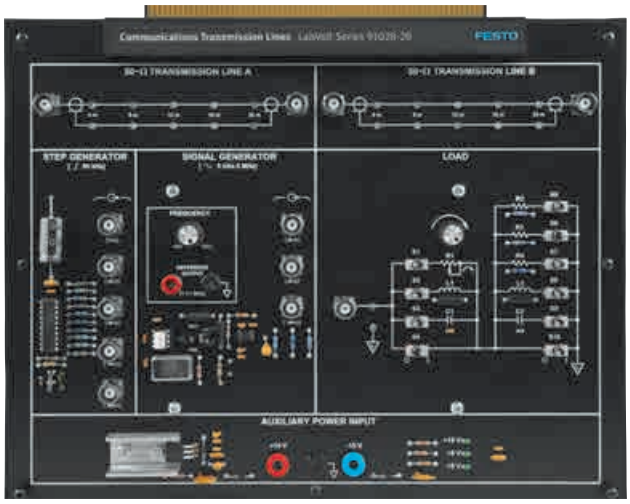
|---|---|
| Fiber Optic Communications 91025 en | **581159** |
| Fiber Optic Communications 91025 fr | **581160** |
| Fiber Optic Communications 91025 es | **581161** |
| Workbooks, also order: | |
| Student manual, en | 589709 |
| Instructor guide, en | 580835 |
| Supplementary media: | |
| eSeries for MindSight, en | 581150 |
| eSeries for MindSight, es | 581151 |
| eSeries for Stand-Alone, en | 581153 |
| eSeries for Stand-Alone, es | 581154 |

# 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

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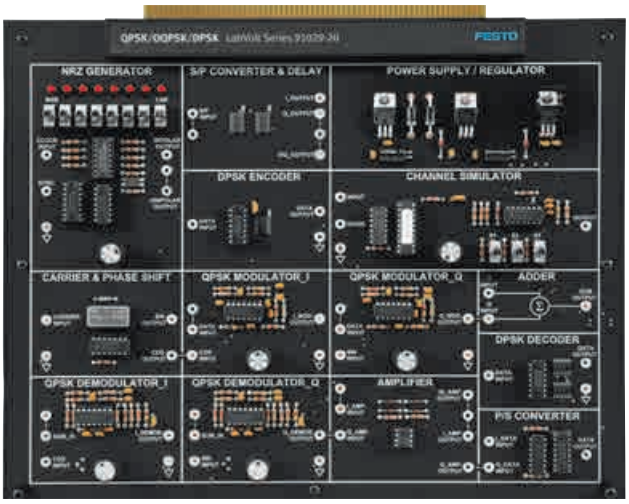
|---|---|
| Communications Transmission Lines 91028 en | **581192** |
| Communications Transmission Lines 91028 fr | **581193** |
| Communications Transmission Lines 91028 es | **581194** |
| Workbooks, also order: | |
| Student manual, en | 589689 |
| Instructor guide, en | 580361 |
| Supplementary media: | |
| eSeries for MindSight, en | 581186 |
| eSeries for MindSight, es | 581187 |
| eSeries for Stand-Alone, en | 581189 |
| eSeries for Stand-Alone, es | 581190 |

# 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 | 589690 |
| Instructor guide, en | 580439 |
| Supplementary media: | |
| eSeries for MindSight, en | 581195 |
| eSeries for MindSight, es | 581196 |
| eSeries for Stand-Alone, en | 581198 |
| eSeries for Stand-Alone, es | 581199 |

# Accessories

## Virtual Instrument Package, Model 1250

**A powerful package**
The Virtual Instrument Package, Model 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: XP, Vista, Windows 7, and Windows 8.

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.

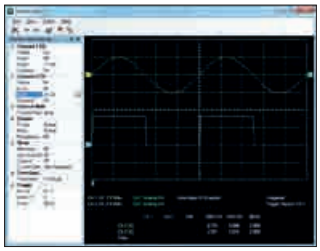
The Virtual Instrument unit also generates signal samples (data) that are converted to analog format to produce the output signal.

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).

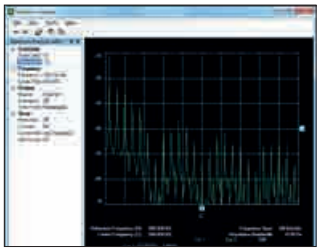
**Virtual Instrument Package, Model 1250**

| | |
|---|---|
| with NEMA cord line | |
| en | **580856** |
| fr | **580857** |
| es | **580858** |
| with CEE7 cord line | |
| en | **580859** |
| fr | **580860** |
| es | **580861** |
| with AS 3112 cord line | |
| en | **580862** |

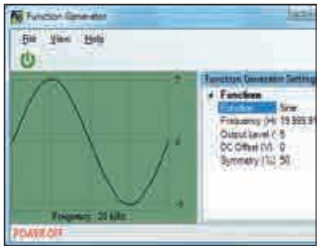

**Multimeter**
The Multimeter has one input channel sampled at a rate of 1 GS/s and can measure the AC and DC values of voltage and current as well as resistance, like any conventional multimeter.



**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, Model 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, Model 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, Model 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.

| Part no. | **585728** |
|---|---|

**Accessory Kit, Model 91052**
The Accessory Kit is a replacement kit that contains the same accessories as those provided with any of the FACET® base units, Model 91000. The kit consists of miniature banana-jack jumpers and leads, alligator clips, and test point pins.

| Part no. | **581215** |
|---|---|

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