Electromechanical Training System
579308 (8010-90)

FESTO

LabVolt Series

Datasheet

Festo Didactic
en 120 V - 60 Hz
09/2020

Table of Contents

General Description

The Electromechanical Training System combines a modular design approach with computer-based data acquisition and control to provide unrivaled training in electromechanical systems. Training is oriented toward today's competence requirements, including electricity fundamentals (i.e., dc power circuits), single-phase and three-phase ac power circuits, power transformers, three-phase transformer banks, permanent magnet dc motors, three-phase rotating machines (induction machine and synchronous machine), and power factor correction. The system features the Four-Quadrant Dynamometer/Power Supply, Model 8960, and the Data Acquisition and Control Interface, Model 9063, two state-of-the-art USB peripherals that greatly enhance the learning experience of students.

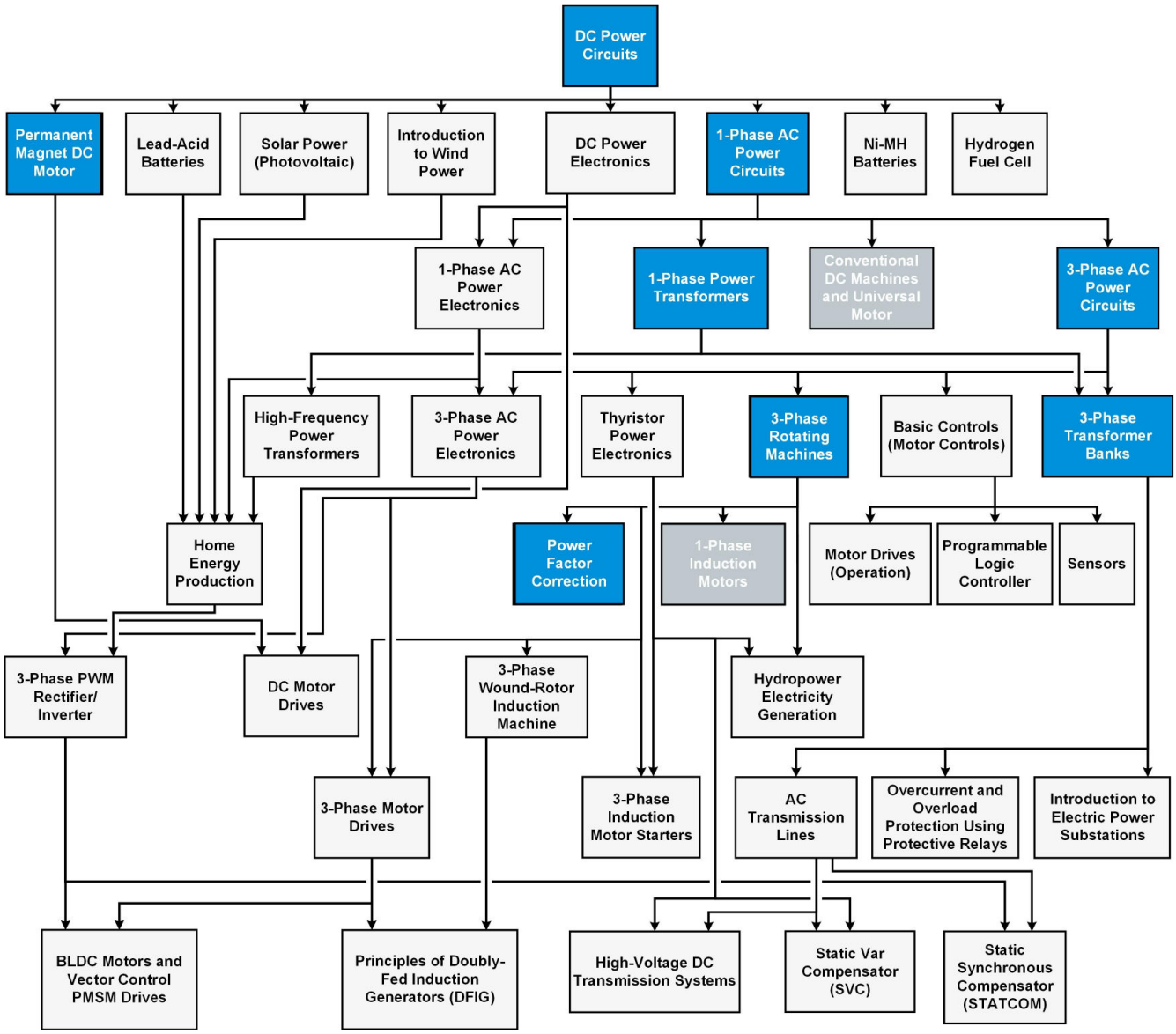
The courseware in the Electromechanical Training System provides students with a sound knowledge of basic electric power technology, including the operation of the permanent magnet dc motor, three-phase induction machine, and three-phase synchronous machine, three rotating machines that are commonly used in numerous applications today.

Two other rotating machine courses from the Electric Power Technology Training Program can be optionally added to the Electromechanical Training System. These courses complete student training in rotating machinery by adding knowledge of the following conventional rotating machines: separately excited, shunt, series, and compound dc motors, separately excited, shunt, and compound dc generators, universal motor, and single-phase induction motor (capacitor-start and split-phase types). These machines, although still in use today, are less common in modern applications.

The Electromechanical Training System is part of the Electric Power Technology Training Systems, Series 8010. Each training system in Series 8010 is based on the Electric Power Technology Training Program and provides a turn-key solution dealing with some aspects of the wide field of electrical energy. The exhaustive courseware provided with each training system covers all the theory required to perform the laboratory exercises, while review questions and unit tests allow students to test the knowledge they have gained.

The Electric Power Technology Training Program is highly modular in both courseware and hardware. Because of this, courses and equipment from the program are available as required, either individually or in the context of a specific training system. The program covers several different subjects in the field of electrical energy, 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.



The above chart shows all courses in the Electric Power Technology Training Program. Blue boxes highlight courses included in the training system covered in this datasheet, while dark grey boxes, if any, highlight courses that can be optionally added to this training system.

Courseware

Each course in the training system includes a full-color 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. Whenever possible, each course is built to bring the student to actual applications as soon as possible. A full-color instructor guide providing all lab results and answers to questions is also included with each course.

Modular Design Approach

The modular approach for designing the training program and lab equipment enables instructors to start building their electrical-energy laboratory with a basic package of courses and equipment and add new courses and equipment over time without needless duplication of equipment.

All lab equipment consists of modules that can be inserted into a workstation. Module dimensions vary between two standard EMS sizes: full-size and half-size. Symbols and diagrams representing the electrical components in each module are clearly silk-screened on the front panel. Standard, color-coded safety banana jacks are used to provide access to the various components in each module.

Features & Benefits

- The training system teaches the principles of three-phase rotating machines. To this end, students follow a complete curriculum that includes these topics:
  - An introduction to the fundamentals of electricity, beginning with dc power circuits and ac power circuits.
  - More advanced courses that cover different concepts and devices important to the study of three-phase rotating machines, such as single-phase and three-phase ac power circuits, single-phase and three-phase power transformers, and power factor correction.
  - Courses that cover the operation of different rotating machines, such as permanent-magnet dc motors, induction machines, and synchronous machines.
  - Optional courses that cover less common machines, such as conventional dc machines, universal motors, and single-phase induction motors.
- The course curriculum of the Electric Power Technology Training Program is highly flexible and allows a multitude of different customized training solutions.
- The courseware includes student manuals and instructor guides with all the theory required to perform the hands-on experiments.
- All workstations, modules, and components are very sturdy to ensure a prolonged service life in a demanding environment such as a training laboratory.
- The modular design approach of the training equipment allows a large variety of courses to be performed using a small number of modules, without unnecessary duplication of equipment.
- All electrical components can be interconnected without electric shock hazard since all live parts of the connection leads are concealed and insulated.
- All electrical symbols representing the components used in a laboratory exercise are clearly silk-screened on the front panel of the modules.
- The training system includes two highly versatile USB peripherals:
  - Four-Quadrant Dynamometer/Power Supply, Model 8960-2. This module is used as a dc and ac power source. it can also be mechanically coupled to all rotating machines to operate as a prime mover or brake.
  - Data Acquisition and Control Interface, Model 9063. This module gives access to a large variety of computer-based measuring instruments via the LVDAC-EMS software.

- Software upgrades for LVDAC-EMS and firmware upgrades for the Four-Quadrant Dynamometer/Power Supply and Data Acquisition and Control Interface are available for download free of charge on the Festo Didactic website.

List of Equipment

Qty	Description	Model number
1	Workstation	579484 (8134-20)
1	Permanent Magnet DC Motor	8114247 (8213-10)
1	Four-Pole Squirrel-Cage Induction Motor	586267 (8221-20)
1	Synchronous Motor/Generator	579502 (8241-20)
1	Resistive Load	763359 (8311-00)
1	Inductive Load	763362 (8321-00)
1	Capacitive Load	763366 (8331-00)
1	Three-Phase Transformer Bank	579559 (8348-40)
1	Transformer	763371 (8353-00)
1	Synchronizing Module / Three-Phase Contactor	579576 (8621-A0)
1	Lead-Acid Battery Pack	579591 (8802-10)
1	Power Supply	579612 (8823-00)
1	Timing Belt	579637 (8942-00)
1	Connection Lead Set	579638 (8951-L0)
1	Four-Quadrant Dynamometer/Power Supply	579648 (8960-C0)
1	Data Acquisition and Control Interface	579692 (9063-G0)
1	24 V AC Power Supply	579696 (30004-20)

List of Manuals

Description	Manual number
Power Factor Correction (Student Manual)	579334 (20116-00)
Power Factor Correction (Instructor Guide)	579335 (20116-10)
DC Power Circuits (Student Manual)	579339 (86350-00)
DC Power Circuits (Instructor Guide)	579341 (86350-10)
Single-Phase AC Power Circuits (Student Manual)	579366 (86358-00)
Single-Phase AC Power Circuits (Instructor Guide)	579368 (86358-10)
Three-Phase AC Power Circuits (Student Manual)	579374 (86360-00)
Three-Phase AC Power Circuits (Instructor Guide)	579378 (86360-10)
Three-Phase Rotating Machines (Student Manual)	579407 (86364-00)
Three-Phase Rotating Machines (Instructor Guide)	579409 (86364-10)
Single-Phase Power Transformers (Student Manual)	579437 (86377-00)
Single-Phase Power Transformers (Instructor Guide)	579439 (86377-10)
Three-Phase Transformer Banks (Student Manual)	579448 (86379-00)
Three-Phase Transformer Banks (Instructor Guide)	579451 (86379-10)
Electric Power Technology Training Equipment (User Guide)	584778 (38486-E0)
Computer-Based Instruments for EMS (User Guide)	585219 (86718-E0)
Permanent Magnet DC Machine (Instructor Guide)	8113732
Permanent Magnet DC Machine (Student Manual)	8113734

Table of Contents of the Manual(s)

- 1 General Safety Recommendations
- 2 System Power Requirements
- 3 Quick Start Installation Guide
- 4 Equipment Installation
- 5 Modules Handling, Installation, and Removal
- 6 Equipment Maintenance
- A Connection of the Power Supply to the AC Power Network
- B Description, Specifications, and Operation of the EMS Modules

Computer-Based Instruments for EMS (User Guide) (585219 (86718-E0))

- 1 Familiarization with the Metering Window and the Data Table
- 2 Familiarization with the Oscilloscope
- 3 Familiarization with the Phasor Analyzer
- 4 Familiarization with the Harmonic Analyzer
- 5 Measuring Three-Phase Power Using the Metering Window

Additional Equipment Required to Perform the Exercises

Qty	Description	Model number
2	Digital Multimeter	579782 (8946-20)
1	Personal Computer	579785 (8990-00) [1]

Optional Equipment

Qty	Description	Model number
1	Mobile Workstation	579755 (8110-20) [2]
1	Storage Shelves	579756 (8150-10)
1	Full-Size Blank EMS Module	579757 (8160-00)
1	Half-Size Blank EMS Module	579758 (8161-00)
1	DC Motor/Generator	579759 (8211-00)
1	Capacitor-Start Motor	579767 (8251-00)
1	Universal Motor	579774 (8254-00)
1	Resistive Load	763359 (8311-00)
1	Low-Voltage Resistive Load	763361 (8311-A0)
1	Power Supply	579603 (8821-20) [3]
1	Multimeters Module	586888 (8946-A0) [4]
1	Textbook – Electrical Machines, Drives, and Power Systems, T. Wildi	579700 (17708-00)
1	Electromechanical Training System (Manuals on CD-ROM)	579707 (86357-A0)

Optional Manual(s)

[1] Refer to the Computer Requirements in the System Specifications section of this datasheet if the computer is to be provided by the end-user. Note that only one computer is required per station.

[2] Can replace the Workstation, Model 8134.

[3] Remove the Power Supply, Model 8823, and the 24 V AC Power Supply, Model 30004-2, included in this training system when ordering the Power Supply, Model 8821-2.

[4] Can replace the Digital Multimeter, Model 8946-2.

Qty	Description	Model number
1	Conventional DC Machines and Universal Motor (Student Manual)	579469 (88943-00) [5]
1	Conventional DC Machines and Universal Motor (Instructor Guide)	579470 (88943-10)
1	Single-Phase Induction Motors (Student Manual)	579474 (88944-00) [6]
1	Single-Phase Induction Motors (Instructor Guide)	579476 (88944-10)

System Specifications

Parameter	Value
System Requirements	
Maximum Current	10 A
Typical Current	1.5 A per student group
AC Power Network Installation	3 phases (120/208 V – 60 Hz), star (wye) configuration including neutral and ground wires, protected by a 20 A circuit breaker
AC Power Network Connector	NEMA L21-20
Computer Requirements	A currently available personal computer with USB 2.0 ports, running under one of the following operating systems: Windows® 7 or Windows® 8.
Physical Characteristics	
Intended Location	On a table able to support the weight of the workstation and installed equipment
Dimensions (H x W x D)	900 x 930 x 530 mm (35.4 x 36.6 x 20.9 in)
Net Weight	205 kg (451 lb)
EMS Modules	
Full-Size Dimensions (H x W x D)	308 x 287 x 440 mm (12.1 x 11.3 x 17.3 in)
Half-Size Dimensions (H x W x D)	154 x 287 x 440 mm (6.1 x 11.3 x 17.3 in)

Equipment Description

Workstation
579484 (8134-20)

The Workstation is a fully assembled workstation that serves the same purpose as the Mobile Workstation, Model 8110-2, but has no storage cabinet or pull-out work surface. This workstation is intended for use on a bench (not supplied) and is fitted with rubber feet to protect the bench top. Alternatively, this workstation can be mounted on either a Mobile Storage Cabinet, Model 89117-1, to make a Mobile Workstation, Model 8110-2, or on a Mobile Base, Model 88863, to make a mobile workstation without storage cabinet. In that case, it is possible to mount and lock a second Workstation, Model 8134-2, on top of the first Workstation to double the space available for EMS modules.

[5] To perform the exercises in this optional course, the following equipment is required: DC Motor/Generator, Model 8211, Universal Motor, Model 8254, and Power Supply, Model 8821-2.

[6] To perform the exercises in this optional course, the following equipment is required: Capacitor-Start Motor, Model 8251, and Power Supply, Model 8821-2.

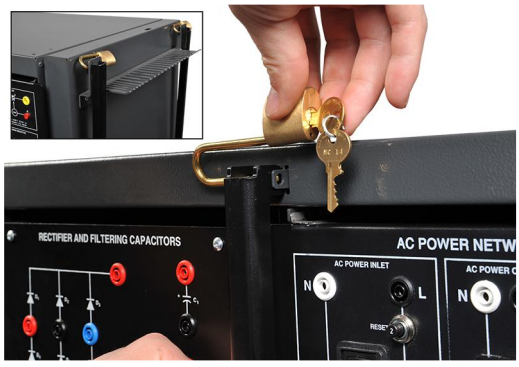
The Workstation consists of three rows of compartments designed to house EMS modules. Two of these rows have full-height compartments while the other row has half-height compartments. Each row of full-height compartments can accommodate up to three full-size EMS modules or six half-size EMS modules whereas the row of half-height compartments can accommodate up to three half-size EMS modules.

Module Installation

The EMS modules are guided into position along stainless steel guide rails. Separators between each bay of the workstation ensure perfect alignment of the EMS modules and allow their easy insertion in the workstation. A holding mechanism ensures that each EMS module stays in place once it is installed in a compartment of the workstation. Front-mounted push levers allow all EMS modules on a single row to be released for easy removal.

Safety Padlock Bars

Two safety padlock bars on the front of the workstation prevent students from removing EMS modules during laboratory exercises. The bars can be removed and locked to the side of the workstation when the safety lock is not necessary.



Additional Information

Six holes in the rear panel of the workstation allow connection to a power supply, as well as the connection of 2 kW machines to their interconnection modules. Assembly of the workstation before painting ensures that each EMS module in the workstation is correctly grounded.

Manual

Description	Manual number
Electric Power Technology Training Equipment (User Guide)	584778 (38486-E0)

Table of Contents of the Manual(s)

Electric Power Technology Training Equipment (User Guide) (584778 (38486-E0))

Optional Equipment

Qty	Description	Model number
1	Industrial Controls Single-Rail Workstation	581243 (3105-A0) [7]
1	Industrial Controls Double-Rail Workstation	585964 (3105-B0) [8]
1	All-in-One Touch Screen Computer (including Monitor Stand with Articulating Arm)	8108708 (8990-A0)
1	Dust Cover for Workstations	587004 (8991-00)
1	Mounting Stand with Articulating Arm	8108710 (36653-A0)
1	Mobile Base	587518 (88863-00)
1	Mobile Storage Cabinet	587519 (89117-10)

Specifications

Parameter	Value
Physical Characteristics	
Intended Location	On a table able to support the weight of the workstation and installed equipment
Dimensions (H x W x D)	890 x 935 x 465 mm (35.0 x 36.8 x 18.3 in)
Net Weight	31.8 kg (70 lb)

[7] This add-on workstation allows modules from the Industrial Controls Training Systems, Models 8036, to be installed in the EMS workstation. Refer to the 8036 datasheet for more information.

[8] This add-on workstation allows modules from the Industrial Controls Training Systems, Models 8036, to be installed in the EMS workstation. Refer to the 8036 datasheet for more information.

Permanent Magnet DC Motor
8114247 (8213-10)

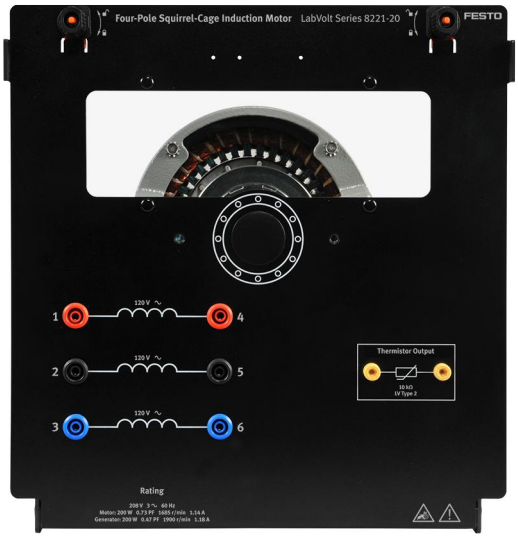
The Permanent Magnet DC Motor is a high-speed, brushed dc motor mounted in a full-size EMS module. The magnetic field required for motor operation is produced by powerful permanent magnets mounted on the motor stator. Connections to the motor are made through color-coded safety banana jacks located on the front panel on the module. Power to the motor must be fed by an external dc power source. A toggle switch mounted on the front panel can be used to switch dc power to the motor on and off when the motor is connected to a battery pack. When driven by a prime mover, the Permanent Magnet DC Motor operates as a dc generator.

The front panel of the Permanent Magnet DC Motor module can be opened to install a Timing Belt, Model 8942, on the pulley of the motor shaft. This permits mechanical coupling of this motor to the Four-Quadrant Dynamometer/Power Supply, Model 8960. The diameter of the Permanent Magnet DC Motor pulley is smaller (12 teeth) than that of the pulleys of the Four-Quadrant Dynamometer/Power Supply (24 teeth). This difference of pulley ratio (12 to 24) permits adapting the speed (0 4000 r/min) of the Permanent Magnet DC Motor to the speed of the Four-Quadrant Dynamometer/Power Supply (between 0 2000 r/min).

Specifications

Parameter	Value
Nominal Characteristics	
Power	220 W
Voltage	48 V
Current	5.0 A
Speed	3825 rpm
Duty Cycle	15 min ON / 60 min OFF
Pulley	
Number of teeth	12
Physical Characteristics	
Dimensions (H x W x D)	308 x 291 x 440 mm (2.1 x 11.5 x 17.3 in)
Net Weight	7.6 kg (16.8 lb)

Four-Pole Squirrel-Cage Induction Motor 586267 (8221-20)



The Four-Pole Squirrel-Cage Induction Motor is a 0.2 kW squirrel-cage induction machine mounted in a full-size EMS module. The machine stator windings are independently connected (six jacks), allowing connection in either wye or delta configuration. Connections to the machine are made through color-coded safety banana jacks located on the front panel on the module. The machine has a thermistor output that allows monitoring of the machine internal temperature to prevent overheating. A tensioner bearing can be ordered as an option.

The front panel of the Four-Pole Squirrel-Cage Induction Motor module can be opened to install a Timing Belt, Model 8942, on the pulley of the machine shaft. This permits mechanical coupling of this machine to the Four-Quadrant Dynamometer/Power Supply, Model 8960. When driven by a prime mover, the Four-Pole Squirrel-Cage Induction Motor operates as a three-phase asynchronous generator.

Specifications

Parameter	Value
Motor	
Stator Voltage	120/208 V, 3-phase
Mechanical Power	200 W
Nominal Speed	1685 r/min
Nominal Current	1.14 A
Power factor	0.73
Generator	
Stator Voltage	120/208 V, 3-phase
Output Power	200 W
Nominal Speed	1900 r/min
Nominal Current	1.18 A
Power factor	0.47
Protection	
Type	10 kΩ thermistor, type 2, in the stator windings
Physical Characteristics	
Dimensions (H x W x D)	308 x 287 x 440 mm (12.1 x 11.3 x 17.3 in)
Net Weight	TBE

Synchronous Motor/Generator 579502 (8241-20)

The Synchronous Motor/Generator is a 0.2 kW three-phase synchronous machine mounted in a full-size EMS module. This machine can be operated either as a three-phase motor or a three-phase generator. Each phase of the machine stator windings is independently terminated and identified on the front panel to allow operation in either wye or delta configuration. The machine rotor is equipped with a squirrel-cage damper. Variable dc excitation to the rotor field windings is fed through externally mounted slip rings and brushes that are wired to a rheostat and control switch located on the front panel.

Connections to the machine are made through color-coded safety banana jacks located on the front panel of the module. This front panel of the module can be opened to install a Timing Belt, Model 8942, on the pulley of the machine shaft. This permits mechanical coupling of the machine to the Four-Quadrant Dynamometer/Power Supply, Model 8960. The machine has a thermistor output that allows monitoring of the machine internal temperature to prevent overheating.

Specifications

Parameter	Value
Power Requirement	120/208 V
Motor	
Stator Voltage	120/208 V, three-phase
Rotor Voltage	0-150 V dc
Output Power	200 W
Synchronous Speed	1800 r/min
Full-Load Current	0.55 A
Power Factor	1
Generator	
Stator Voltage	120/208 V, three-phase
Rotor Voltage	0-150 V dc
Output Power	200 VA
Synchronous Speed	1800 r/min
Power Factor	0.8
Protection	
Type	10 kΩ thermistor, type 2, in the stator winding, and rotor field bimetal thermal protection
Physical Characteristics	
Dimensions (H x W x D)	308 x 291 x 440 mm (12.1 x 11.5 x 17.3 in)
Net Weight	TBE

Resistive Load
763359 (8311-00)

The Resistive Load consists of a module housing nine wire-wound power resistors arranged in three identical banks. Each bank consists of three resistors connected in parallel that can be switched on or off with toggle switches to obtain various resistance values. This allows the total (equivalent) resistance of each bank to be increased or decreased by steps. Six safety banana jacks on the module front panel provide access to each resistor bank. The three resistor banks can be connected separately for operation in three-phase circuits. Also, the three resistor banks can be connected together for operation in single-phase circuits.

The Resistive Load is commonly used in conjunction with other basic load modules, like the Inductive Load and the Capacitive Load to experiment with the effects of different types of load on a circuit.

Specifications

Parameter	Value
Resistors	
Quantity	Three identical banks of three resistors
Resistance Values (Each Group)	300/600/1200 Ω
Nominal Voltage	120 V ac/dc
Resistance Value Accuracy	± 5%
Load at Nominal Voltage (Each Bank)	
Power	12-84 W
Current	0.1-0.7 A
Steps	Seven, of equal increment
Current Increment	0.1 A
Physical Characteristics	
Dimensions (H x W x D)	154 x 287 x 410 mm (6.1 x 11.3 x 16.1 in)
Net Weight	4.5 kg (9.9 lb)
Color	
Front panel color	Black

Inductive Load
763362 (8321-00)

The Inductive Load consists of a module housing nine iron-core power inductors arranged in three identical banks. Each bank consists of three inductors connected in parallel that can be switched on or off with toggle switches to obtain various inductance values. This allows the equivalent inductance of each bank to be increased or decreased by steps. Six safety banana jacks on the module front panel provide access to each inductor bank. The three inductor banks

can be connected separately for operation in three-phase circuits. Also, the three inductor banks can be connected together for operation in single-phase circuits.

The Inductive Load is commonly used in conjunction with other basic load modules, like the Resistive Load and the Capacitive Load to experiment with the effects of different types of load on a circuit.

Specifications

Parameter	Value
Inductors	
Quantity	Three identical banks of three inductors
Inductance Values (Each Bank)	0.8/1.6/3.2 H
Reactance Values (Each Bank)	300/600/1200 Ω
Nominal Voltage	120 V – 60 Hz
Inductance Value Accuracy	± 5%
Load at Nominal Voltage (Each Bank)	
Reactive Power	12-84 var
Current	0.1-0.7 A
Steps	Seven, of equal increment
Current Increment	0.1 A
Physical Characteristics	
Dimensions (H x W x D)	154 x 287 x 410 mm (6.1 x 11.3 x 16.1 in)
Net Weight	10.1 kg (22.3 lb)

Capacitive Load 763366 (8331-00)

The Capacitive Load consists of a module housing nine capacitors arranged in three identical banks. Each bank consists of three capacitors connected in parallel that can be switched on or off with toggle switches to obtain various capacitance values. This allows the equivalent capacitance of each bank to be increased or decreased by steps. Six safety banana jacks on the module front panel provide access to each capacitor bank. The three capacitor banks can be connected separately for operation in three-phase circuits. Also, the three capacitor banks can be connected together for operation in single-phase circuits.

A permanently connected discharge resistor reduces the voltage across the terminals of each bank of capacitors to 5% of the applied voltage within 25 seconds after the load is disconnected from the supply. The Capacitive Load may be used with both dc and ac power.

The Capacitive Load is commonly used in conjunction with the other basic load modules, the Resistive Load and the Inductive Load to experiment with the effects of different types of load on a circuit.

Specifications

Parameter	Value
Capacitors	
Quantity	Three identical banks of three capacitors
Capacitance Values (Each Bank)	2.2/4.4/8.8 µF
Reactance Values (Each Bank)	300/600/1200 Ω
Nominal Voltage	120 V – 60 Hz
Maximum Voltage	230 V

Parameter	Value
Capacitance Value Accuracy	± 5%
Load at Nominal Voltage (Each Bank)	
Reactive Power	12-84 var
Current	0.1-0.7 A
Steps	Seven, of equal increment
Current Increment	0.1 A
Physical Characteristics	
Dimensions (H x W x D)	154 x 287 x 410 mm (6.1 x 11.3 x 16.1 in)
Net Weight	5.7 kg (12.6 lb)

Three-Phase Transformer Bank 579559 (8348-40)

The Three-Phase Transformer Bank consists of three independent power transformers enclosed in a module. Safety banana jacks on the module front panel provide individual access to the windings of each power transformer, allowing connection in either wye or delta configuration. The transformer windings are polarized and the polarity of each winding is indicated by a small dot on the module front panel. Resettable fuses protect the primary and secondary windings of each transformer against overcurrents. Fuse status lamps on the module front panel turn on when the resettable fuses open.

Specifications

Parameter	Value
Rating (Each Transformer)	
Primary Voltage	208 V
Secondary Voltage	208/120 V
Power	250 VA
Full-Load Current	1.2 A
Physical Characteristics	
Dimensions (H x W x D)	154 x 287 x 410 mm (6.1 x 11.3 x 16.1 in)
Net Weight	13.9 kg (30.6 lb)

Transformer 763371 (8353-00)

The Transformer consists of a power transformer enclosed in a module. Both the primary and secondary sides of the Transformer are made of two identical separate windings. Banana jacks on the module front panel provide access to each winding, allowing connection in a variety of configurations. The Transformer has a turns ratio of 1:5, when considering the totality of its primary and secondary windings. The Transformer windings are polarized and the polarity of

each winding is indicated by a small dot on the module front panel. A thermistor output allows monitoring of transformer temperature to prevent overheating. A typical application of the Transformer is to convert the energy stored in batteries to a suitable voltage level (for example, to the level of the ac power network voltage).

Specifications

Parameter	Value
Nominal Power	240 VA
Primary Rating (2 windings)	24 V AC – 5 A for each winding
Secondary Rating (2 windings)	120 V ac – 1 A for each winding
Protection	10 kΩ thermistor, type 2
Physical Characteristics	
Dimensions (H x W x D)	154 x 287 x 440 mm (6.1 x 11.3 x 16.1 in)
Net Weight	TBE

Synchronizing Module / Three-Phase Contactor 579576 (8621-A0)

The Synchronizing Module / Three-Phase Contactor is a 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. The Synchronizing Module / Three-Phase Contactor consists of a three-phase contactor whose coil can be energized either manually with a toggle switch, or automatically with a thyristor fired by applying to the Remote Control input of the module, a low-level (TTL) signal from the Data Acquisition and Control Interface, Model 9063. Six safety banana jacks (one pair per phase) allow connection of electric devices or ac power sources across the contacts of the three-phase contactor. Three indicator lamps indicate the relative level of the voltage across their corresponding contact terminals.

Specifications

Parameter	Value
Contactor	
Power Input	120 V – 100 mA – 60 Hz
Contacts	400 V – 3 A ac
Light Bulbs (3)	
Rating	28 V – 2.3 W – T 3 1/4
Remote Control Input	
Voltage	0/3.5-5 V dc
Physical Characteristics	
Dimensions (H x W x D)	154 x 287 x 440 mm (6.1 x 11.3 x 17.3 in)
Net Weight	3.6 kg (7.9 lb)
Shipping Weight	5.2 kg (11.4 lb)

Lead-Acid Battery Pack
579591 (8802-10)

The Lead-Acid Battery Pack is a half-size EMS module housing four 12 V lead-acid batteries connected in series. The Lead-Acid Battery Pack thus provides a fixed dc voltage of 48 V, available at two color-coded safety banana jacks on the module front panel. Three battery voltage test points allow measurement of the voltage provided by each of the four 12 V batteries. A parallel charging input terminal permits the charging of several Lead Acid Battery Packs connected in parallel at the same time. The Lead-Acid Battery Pack is protected against overcurrents and short-circuits. The Lead-Acid Battery Pack can be used as a 48 V dc power source, and in energy production and storage applications implemented with the Electricity and New Energy Training Equipment.

Specifications

Parameter	Value
Battery Pack	
Type	4 valve-regulated lead-acid batteries
Voltage	48 V (12 V for each battery)
Capacity	9 Ah
Maximum Charge Current	2.7 A
Maximum Discharge Current	7 A
Parallel Charging Input	58 V maximum
Overcurrent Protection	
Battery Pack Fuse	10 A
Test Point Limiting Resistors (3)	1 kΩ
Physical Characteristics	
Dimensions (H x W x D)	154 x 287 x 440 mm (6.1 x 11.3 x 17.3 in)
Net Weight	TBE

Power Supply
579612 (8823-00)

The 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. It can be used to power most of the EMS modules of the Electricity and New Energy Training Equipment. Color-coded safety banana jacks provide access to both power sources. Independent circuit breakers, with a reset button on the front panel of the module, protect the inputs and outputs from overcurrent conditions. Indicator lamps allow monitoring the presence of input voltage on each phase.

Specifications

Parameter	Value
Power Requirements	
Maximum Current	10 A
AC Power Network Installation	3 phases (120/208 V – 60 Hz), star (wye) configuration including neutral and ground wires, protected by a 20 A circuit breaker
AC Power Network Connector	NEMA L21-20
Outputs	
Fixed AC 3-Phase	120/208 V – 5 A
Fixed DC	120 V – 4 A
Included Power Cord	3 m (10 ft)
Physical Characteristics	
Dimensions (H x W x D)	212 x 287 x 496 mm (8.3 x 11.3 x 19.5 in)
Net Weight	5.7 kg (12.5 lb)

Timing Belt
579637 (8942-00)

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.

Specifications

Parameter	Value
Physical Characteristics	
Pitch	9.5 mm (0.375 in)
Pitch Length	819 mm (32.25 in)
Number of Teeth	86
Dimensions (Width)	12.7 mm (0.5 in)
Net Weight	0.1 kg (0.2 lb)

Connection Lead Set
579638 (8951-L0)

This Connection Lead Set consists of 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.

Specifications

Parameter	Value
4 mm Safety Banana Plug Leads Characteristics	
Cross Section	1 mm² (1974 cmil)
Rated Current	19 A
Rated Voltage	600 V, CAT II
4 mm Safety Banana Plug Leads Quantities	
Yellow, 30 cm (12 in)	20
Red, 60 cm (24 in)	10
Blue, 90 cm (36 in)	4
2 mm Safety Banana Plug Leads Characteristics	
Cross Section	0.5 mm² (987 cmils)
Rated Current	10 A
Rated Voltage	30 V ac / 60 V dc
2 mm Safety Banana Plug Leads Quantities	
Red, 60 cm (24 in)	4

Four-Quadrant Dynamometer/Power Supply 579648 (8960-C0)

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 (i.e., a mechanical load) or a fully configurable prime mover (i.e., a motor drive). 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. 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.

Two modes are available to control the function which the Four-Quadrant Dynamometer/Power Supply performs: Manual and Computer-Based.

In the Manual control mode, the module operates as a stand-alone unit, and the function performed is selected, set, and monitored using front-panel mounted controls and display. This mode provides access to all basic functions. In the Computer-Based control mode, the function performed by the module is selected, set, and monitored using the LVDAC-EMS software. In this mode, communication between the Four-Quadrant Dynamometer/Power Supply and the host computer running the LVDAC-EMS software is achieved through a USB connection. This mode provides access to all basic functions, as well as to additional advanced functions.

Model 8960-C includes the Four-Quadrant Dynamometer/Power Supply, Model 8960-2, with the following function sets activated:

- Standard Functions (Manual Control), Model 8968-1
- Standard Functions (Computer-Based Control), Model 8968-2

Additional Equipment Required to Perform the Exercises

Qty	Description	Model number
1	Personal Computer	579785 (8990-00) [9]

Specifications

Parameter	Value
Dynamometer Mode	
Magnetic Torque	0 to 3 N·m (0 to 27 lbf·in)

[9] Refer to the Computer Requirements in the System Specifications section of this datasheet if the computer is to be provided by the end-user. Note that only one computer is required per station.

Parameter	Value
Direction of Rotation	CW / CCW
Speed	0 to 2500 r/min
Nominal Power	350 W
Power Supply Mode	
DC Voltage	0 to ± 150 V
AC Voltage (RMS)	0 to 105 V (no-load)
DC Current	0 to ± 5 A
AC Current (RMS)	0 to 3.5 A
Maximum Output Power	500 W
AC Frequency	10 to 120 Hz
Control Functions	
Activated Sets	Standard Functions (Manual Control), Model 8968-1
	Standard Functions (Computer-Based Control), Model 8968-2
Liquid-Crystal Display (LCD)	76 mm (3 in), monochrome, background-illuminated, 240 x 160 dots
Control Inputs	
Command Input	0 to ± 10 V
Thermistor Input	10 kΩ, type 1
Control Outputs	
Shaft Encoder	Quadrature encoder (A-B) - 360 pulses/revolution - TTL compatible
Torque Output Sensitivity	0.3 N·m/V (2.655 lbf·in/V)
Speed Output Sensitivity	500 r/min/V
Communication Port	USB 2.0
Power Requirements	120 V - 6 A - 60 Hz, must include live, neutral, and ground wires
Computer Requirements	A currently available personal computer with USB 2.0 ports, running under one of the following operating systems: Windows® 7 or Windows® 8.
Physical Characteristics	
Dimensions (H x W x D)	308 x 287 x 490 mm (12.1 x 11.3 x 19.3 in)
Net Weight	19.5 kg (43.0 lb)

Standard Functions (manual control) Set 581436 (8968-10)

The Standard Functions (manual control) Set is a package of control functions that can be activated in the Four-Quadrant Dynamometer/Power Supply, Model 8960-2, enabling the module to perform a wide variety of functions in each of its two operating modes (Dynamometer and Power Supply).

The set allows only manual control of the functions. This means that the Four-Quadrant Dynamometer/Power Supply operates as a stand-alone unit, and the function performed is selected, set, and monitored using front-panel mounted controls and display. The following control functions are available in the set:

Dynamometer operating mode

- Two-Quadrant, Constant-Torque Brake
- Clockwise Prime Mover/Brake
- Counterclockwise Prime Mover/Brake
- Clockwise Constant-Speed Prime Mover/Brake
- Counterclockwise Constant-Speed Prime Mover/Brake
- Positive Constant-Torque Prime Mover/Brake
- Negative Constant-Torque Prime Mover/Brake

Power Supply operating mode

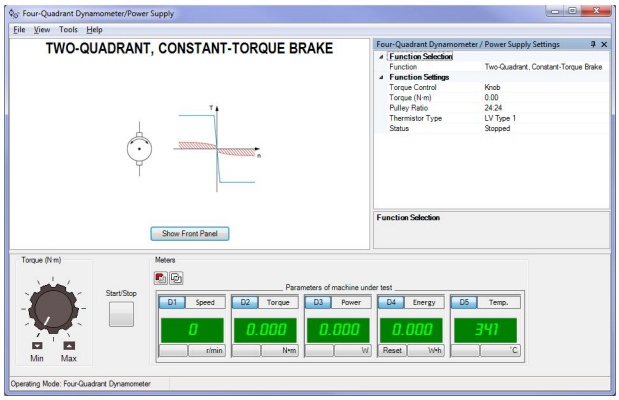
- Positive Voltage Source
- Negative Voltage Source
- 200 V DC Bus

- Positive Current Source
- Negative Current Source
- 50 Hz Power Source
- 60 Hz Power Source
- Lead-Acid Battery Float Charger

Specifications

Parameter	Value
Control Functions	
Control Functions	Two-Quadrant, Constant-Torque Brake
	Clockwise Prime Mover/Brake
	Counterclockwise Prime Mover/Brake
	Clockwise Constant-Speed Prime Mover/Brake
	Counterclockwise Constant-Speed Prime Mover/Brake
	Positive Constant-Torque Prime Mover/Brake
	Negative Constant-Torque Prime Mover/Brake
	Positive Voltage Source
	Negative Voltage Source
	Positive Current Source
	Negative Current Source
	50 Hz Power Source
	60 Hz Power Source
	200 V DC Bus
	Lead-Acid Battery Float Charger
Two-Quadrant, Constant-Torque Brake	
Torque	0-3 N·m (26.55 lbf·in)
Clockwise/Counterclockwise Prime Mover/Brake	
Speed	0-2500 r/min
Clockwise/Counterclockwise Constant-Speed Prime Mover/Brake	
Speed	0-2500 r/min
Positive/Negative Constant-Torque Prime Mover/Brake	
Torque	0-3 N·m (26.55 lbf·in)
Positive/Negative Voltage Source	
Voltage	0 to ±150 V
Positive/Negative Current Source	
Current	0 to ±5 A
50 Hz/60 Hz Power Source	
No-Load Voltage	0-140 V
200 V DC Bus	
Status	On or off
Lead-Acid Battery Float Charger	
Float Voltage	0-150 V

Standard Functions (computer-based control) Set 581437 (8968-20)



The Standard Functions (computer-based control) Set is a package of control functions that can be activated in the Four-Quadrant Dynamometer/ Power Supply, Model 8960-2, enabling the module to perform a wide variety of functions in each of its two operating modes (Dynamometer and Power Supply).

The set allows only computer-based control of the functions. This means that the function performed by the Four-Quadrant Dynamometer/Power Supply is selected, set, and monitored using the LVDAC-EMS software. The following control functions are available in the set:

Dynamometer operating mode

- Two-Quadrant, Constant-Torque Brake
- Clockwise Prime Mover/Brake
- Counterclockwise Prime Mover/Brake
- Clockwise Constant-Speed Prime Mover/Brake
- Counterclockwise Constant-Speed Prime Mover/Brake
- Positive Constant-Torque Prime Mover/Brake
- Negative Constant-Torque Prime Mover/Brake
- Four-Quadrant Constant-Speed Prime Mover/Brake
- Speed Sweep

Power Supply operating mode

- Positive Voltage Source
- Negative Voltage Source
- DC Voltage Source
- Positive Current Source
- Negative Current Source
- DC Current Source
- 50 Hz Power Source
- 60 Hz Power Source
- AC Power Source
- Lead-Acid Battery Float Charger

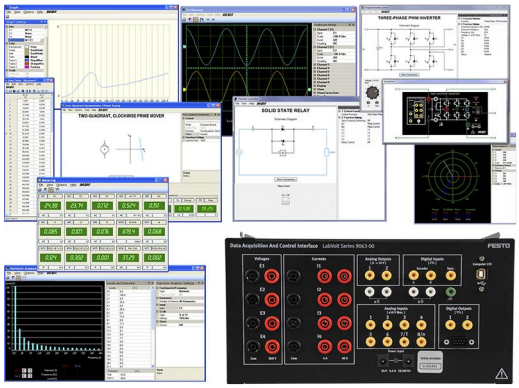
Specifications

Parameter	Value
Control Functions	
Control Functions	Two-Quadrant, Constant-Torque Brake
	Clockwise Prime Mover/Brake
	Counterclockwise Prime Mover/Brake
	Clockwise Constant-Speed Prime Mover/Brake
	Counterclockwise Constant-Speed Prime Mover/Brake

Parameter	Value
	Positive Constant-Torque Prime Mover/Brake
	Negative Constant-Torque Prime Mover/Brake
	Four-Quadrant, Constant-Speed Prime Mover/Brake
	Speed Sweep
	Mechanical Load
	Positive Voltage Source
	Negative Voltage Source
	DC Voltage Source
	Positive Current Source
	Negative Current Source
	DC Current Source
	50 Hz Power Source
	60 Hz Power Source
	AC Power Source
	Lead-Acid Battery Float Charger
Two-Quadrant, Constant-Torque Brake	
Torque Control	Software knob, 8960 module knob, or 8960 command input
Torque	0-3 N·m (26.55 lbf·in)
Pulley Ratio	24:24, 24:12, or 24:32
Clockwise/Counterclockwise Prime Mover/Brake	
Speed Control	Software knob, 8960 module knob, or 8960 command input
Speed	0-2500 r/min
Pulley Ratio	24:24, 24:12, or 24:32
Clockwise/Counterclockwise Constant-Speed Prime Mover/Brake	
Speed Control	Software knob, 8960 module knob, or 8960 command input
Speed	0-2500 r/min
Pulley Ratio	24:24, 24:12, or 24:32
Positive/Negative Constant-Torque Prime Mover/Brake	
Torque Control	Software knob, 8960 module knob, or 8960 command input
Torque	0-3 N·m (26.55 lbf·in)
Pulley Ratio	24:24, 24:12, or 24:32
Four-Quadrant, Constant-Speed Prime Mover/Brake	
Speed Control	Software knob, 8960 module knob, or 8960 command input
Speed	0-2500 r/min
Pulley Ratio	24:24, 24:12, or 24:32
Speed Sweep	
Start Speed	-3000 r/min to 3000 r/min
Finish Speed	-3000 r/min to 3000 r/min
Number of Steps	0-50 steps
Step Duration	2-10 s
Record Data to Table	Yes or no
Pulley Ratio	24:24, 24:12, or 24:32
Mechanical Load	
Load Type	Flywheel, fan, grinder, conveyor, calender, crane, user defined
Inertia	0.005-1 kg·m² (0.119-23.73 lb·ft²)
Friction Torque	0.05-3 N·m (0.44-26.55 lbf·in)
Pulley Ratio	24:24, 24:12, or 24:32
Positive/Negative Voltage Source	
Voltage Control	Software knob, 8960 module knob, or 8960 command input
Voltage	0 V to 147 V / -147 V to 0 V
DC Voltage Source	
Voltage Control	Software knob, 8960 module knob, or 8960 command input
Voltage	-147 V to 147 V
Positive/Negative Current Source	
Current Control	Software knob, 8960 module knob, or 8960 command input
Current	0 A to 5 A / -5 A to 0 A
DC Current Source	
Current Control	Software knob, 8960 module knob, or 8960 command input
Current	-5 A to 5 A
50 Hz/60 Hz Power Source	

Parameter	Value
Voltage Control	Software knob, 8960 module knob, or 8960 command input
No-Load Voltage	0-140 V
AC Power Source	
No-Load Voltage	0-140 V
DC Offset Correction	-1000 to 1000
Frequency	10-100 Hz
Lead-Acid Battery Float Charger	
Float Voltage	0-150 V

Data Acquisition and Control Interface 579692 (9063-G0)



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. The LVDAC-EMS software, as well as all available upgrades, is free and can be downloaded anytime on the Festo Didactic website.

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. The user guide provided allows students to quickly become familiar with the instruments and control functions available.

Model 9063-G includes the DACI, Model 9063, with the following function sets activated:

- Computer-Based Instrumentation Function, Model 9069-1
- Synchroscope Function, Model 9069-C

Manual

Description	Manual number
Computer-Based Instruments for EMS (User Guide)	585219 (86718-E0)

Table of Contents of the Manual(s)

Computer-Based Instruments for EMS (User Guide) (585219 (86718-E0))

- 5 Measuring Three-Phase Power Using the Metering Window

Additional Equipment Required to Perform the Exercises

Qty	Description	Model number
1	Personal Computer	579785 (8990-00) [10]
1	24 V AC Power Supply	579696 (30004-20) [11]

Specifications

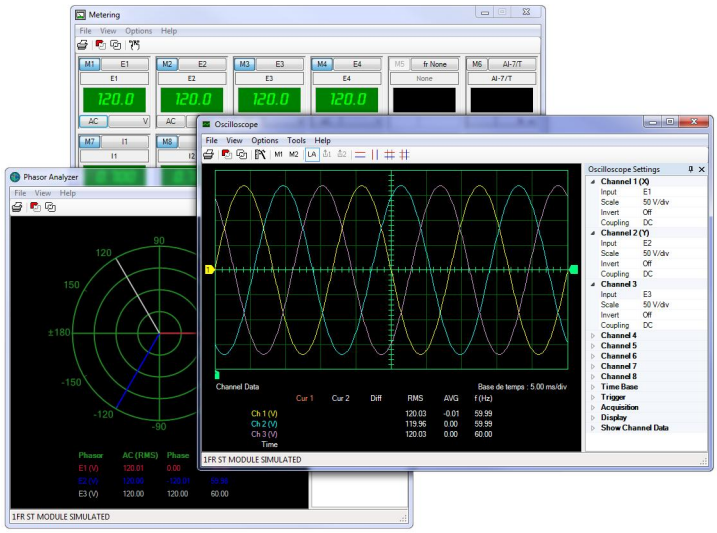
Parameter	Value
Insulated Voltage Inputs (4)	
Range (Low / High Scales)	-80 to +80 V / -800 to + 800 V (user-selectable through software)
Impedance (Low / High Scales)	326.6 kΩ / 3.25 MΩ
Bandwidth	DC to 65 kHz (-3 dB)
Accuracy	1% (dc to 10 kHz)
Insulation	800 V
Measurement Category	CAT II (283 V ac/400 V dc versus ground)
Insulated Current Inputs (4)	
Range (Low / High Scales)	-4 to +4 A / -40 to + 40 A (25 A rms)
Impedance (Low / High Scales)	5 mΩ / 50 mΩ
Bandwidth	DC to 65 kHz (-3 dB)
Accuracy	1% (dc to 10 kHz)
Insulation	800 V
Measurement Category	CAT II (283 V ac/400 V dc versus ground)
Analog Inputs (8)	
Voltage Range	-10 to +10 V
Impedance	› 10 MΩ
Bandwidth	DC to 125 kHz
Measured Parameters	User-selectable through software
Parameter-to-Voltage Ratio	User-determined through software
A/D Converter for Insulated and Analog Inputs (16)	
Type	Successive approximation
Resolution	12 bits
Integral Non-Linearity	≤ ±1.5 LSB
Differential Non-Linearity	≤ ±1 LSB
Maximum Sampling Rate	600 ksamples/s (one channel)
FIFO Buffer Size	16 ksamples
Analog Outputs (2)	
Voltage Range (2)	-10 to +10 V
Operational Load Impedance	› 600 Ω
D/A Converter for Analog Outputs (2)	
Type	Resistor string
Resolution	12 bits
Integral Non-Linearity	≤ ±8 LSB
Differential Non-Linearity	-0.5 to +0.7 LSB
Digital Inputs (3)	
Types	Encoder (2), synchronization (1)
Signal Level	0-5 V (TTL compatible)
Maximum Input Frequency	50 kHz
Impedance	5 kΩ
Digital Outputs (9)	
Types	Control (6 on a DB9 connector and 2 on 2 mm banana jacks), synchronization (1 on a DB9 connector)
Signal Level	0-5 V (TTL compatible)

[10] Refer to the Computer Requirements in the System Specifications section of this datasheet if the computer is to be provided by the end-user. Only one computer is required per station. This model is available in multiple voltage- and frequency dependent variants. Contact a Festo representative to obtain the correct part number.

[11] Required if power is not supplied by the Power Supply, Model 8821-2. This model is available in multiple voltage- and frequency dependent variants. Contact a Festo representative to obtain the correct part number.

Parameter	Value
Maximum Output Frequency	20 kHz (software-limited)
Impedance	200 Ω
Control Functions	
Activated Sets	Computer-Based Instrumentation Function, Model 9069-1
	Synchroscope Function, Model 9069-C
Computer I/O Interface	USB 2.0 full speed via type-B receptacle
Power Requirements	24 V - 0.4 A - 50/60 Hz
Accessories	
Included Accessories	2 m USB interconnection cable (1)
	24 V power cable (1)
	2 mm banana plug test leads (3)
	DB9 connector control cable (1)
Physical Characteristics	
Dimensions (H x W x D)	154 x 287 x 410 mm (6.1 x 11.3 x 16.1 in)
Net Weight	3.9 kg (8.6 lb)

Computer-Based Instrumentation Function Set 581452 (9069-10)



The Computer-Based Instrumentation Function Set, Model 9069-1, includes the following computer-based instruments:

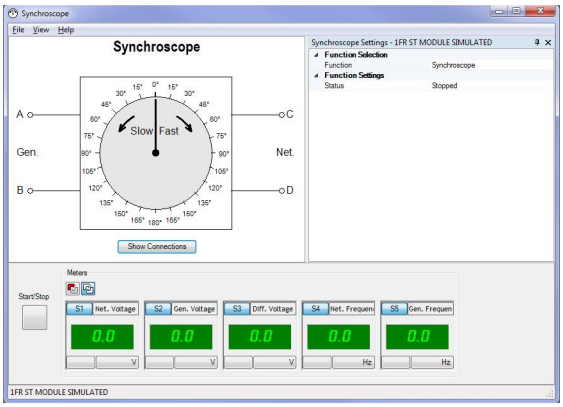
- Metering
- Data Table and Graph
- Oscilloscope
- Phasor Analyzer
- Harmonic Analyzer

Specifications

Parameter	Value
Metering	
Number of Meters	18
Sampling Window	266.7 ms or user adjusted through software (11.4-819 ms)
Sampling Frequency (each meter)	7.68 kHz or user adjusted through software (2.5-179.2 kHz)
Display Type	Digital or analog, user selectable through software
Oscilloscope	
Number of Channels	8
Vertical Sensitivity	2-500 V/div.
Time Base	0.0001-10 s/div.
Sampling Window	20 x selected time base (software triggering) / 10 x selected time base (hardware triggering)
Sampling Frequency	512 samples per measured parameter per horizontal sweep, up to a maximum of 512 kHz
Phasor Analyzer	
Voltage Sensitivity	2-200 V/div.
Current Sensitivity	0.1-5 A/div.
Sampling Window	2-409 ms
Sampling Frequency (Each Phasor)	5-102.4 kHz
Harmonic Analyzer	
Fundamental-Frequency Range	1-1400 Hz
Number of Harmonic Components	5 to 40, user selectable through software

Parameter	Value
Vertical Scale (Relative Scale)	0.1-10%/div.
Vertical Scale (Absolute Scale)	0.1-50 V/div., 0.01-10 A/div.
Sampling Window	10 ms to 1 s
Sampling Frequency	16-102 kHz

Synchroscope Function 579789 (9069-C0)



The Synchroscope Function is used for the synchronization of synchronous generators. This function emulates the operation of an actual synchroscope by showing on-screen the dial indicating the phase angle difference between the generator voltage and the network voltage. In addition, the Synchroscope Function includes meters displaying various parameters important to generator synchronization (e.g., network voltage and frequency, generator voltage and frequency, voltage difference).

Specifications

Parameter	Value
Monitored Values (in Addition to Phase Difference Dial)	
Monitored Values (in Addition to Phase Difference Dial)	Network voltage
	Network frequency
	Generator voltage
	Generator frequency
	Voltage difference

24 V AC Power Supply 579696 (30004-20)

The 24 V AC Power Supply is used to power specific modules of the Electric Power Technology Training Systems, such as the Data Acquisition and Control Interface, the IGBT Chopper/ Inverter, and the Power Thyristors.

Specifications

Parameter	Value
Power Requirements	
Maximum Current	0.75 A
AC Power Network Installation	120 V – 50/60 Hz, must include live, neutral, and ground wires

Parameter	Value
Power Outputs	
Fixed, Single-Phase AC	24 V – 2,5 A

Optional Equipment Description

Mobile Workstation (Optional) 579755 (8110-20)

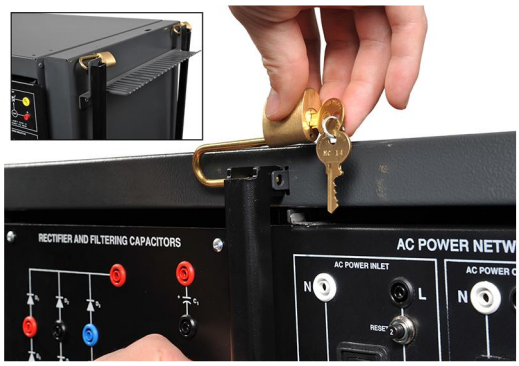
The Mobile Workstation is a ready-for-use workstation that consists of two fully assembled modules: a Workstation, Model 8134-2, mounted on a Mobile Storage Cabinet, Model 89117-1. Four rubber-tire swivel casters allow easy movement of the workstation in the laboratory classroom. The lower portion of the workstation serves as a storage cabinet with two hinged panels and a lock handle. Immediately above the storage cabinet is a pullout work surface with a scuff- and burn-resistant laminate finish. The upper portion of the workstation consists of three rows of compartments designed to house EMS modules. Two of these rows have full-height compartments while the other row has half-height compartments. Each row of full-height compartments can accommodate up to three full-size EMS modules or six half-size EMS modules, whereas the row of half-height compartments can accommodate up to three half-size EMS modules.

Module Installation

The EMS modules are guided into position along stainless steel guide rails. Separators between each bay of the workstation ensure perfect alignment of the EMS modules and allow their easy insertion in the workstation. A holding mechanism ensures that each EMS module stays in place once it is installed in a compartment of the workstation. Front-mounted push levers allow all EMS modules on a single row to be released for easy removal.

Safety Padlock Bars

Two safety padlock bars on the front of the workstation prevent students from removing EMS modules during laboratory exercises. The bars can be removed and locked to the side of the workstation when the safety lock is not necessary.



Additional Information

Six holes in the rear panel of the workstation allow connection to a power supply, as well as the connection of 2 kW machines to their interconnection modules. Assembly of the workstation before painting ensures that each EMS module in the workstation is correctly grounded.

Manual

Description	Manual number
Electric Power Technology Training Equipment (User Guide)	584778 (38486-E0)

Table of Contents of the Manual(s)

Electric Power Technology Training Equipment (User Guide) (584778 (38486-E0))

Optional Equipment

Qty	Description	Model number
1	Industrial Controls Single-Rail Workstation	581243 (3105-A0) [12]
1	Industrial Controls Double-Rail Workstation	585964 (3105-B0) [13]

[12] This add-on workstation allows modules from the Industrial Controls Training Systems, Models 8036, to be installed in the EMS workstation. Refer to the 8036 datasheet for more information.

[13] This add-on workstation allows modules from the Industrial Controls Training Systems, Models 8036, to be installed in the EMS workstation. Refer to the 8036 datasheet for more information.

Qty	Description	Model number
1	All-in-One Touch Screen Computer (including Monitor Stand with Articulating Arm)	8108708 (8990-A0)
1	External Shelf for the Mobile Workstation	581465 (36653-00) [14]
1	Mounting Stand with Articulating Arm	8108710 (36653-A0)

Specifications

Parameter	Value
Physical Characteristics	
Intended Location	On the floor (stands on casters)
Dimensions (H x W x D)	1660 x 935 x 665 mm (65.4 x 36.8 x 26.2 in)
Net Weight	77.1 kg (170 lb)

Storage Shelves (Optional) 579756 (8150-10)

The Storage Shelves module contains five shelves, each of which can accommodate four full-size EMS modules or eight half-size EMS modules. Stainless steel rails guide the modules on the storage shelves and protect them against wear. The Storage Shelves module requires assembly. A diagram is provided to facilitate assembly. Note that this model cannot stand by itself and must be attached to a wall.

Optional Equipment

Qty	Description	Model number
1	Dust Cover for Model 8150	587006 (8992-00)

Specifications

Parameter	Value
Physical Characteristics	
Intended Location	On the floor and attached to a wall
Dimensions (H x W x D)	1980 x 1225 x 480 mm (78 x 48.2 x 18.9 in)
Net Weight	TBE

[14] Extra shelf to be mounted on side of the Mobile Workstation.

Full-Size Blank EMS Module (Optional)
579757 (8160-00)

The Full-Size Blank EMS Module is used to fill unused locations in a workstation, preventing students from accessing electrical or moving parts inside the other modules. Combined with the use of safety bars to prevent students from removing modules, blank EMS modules ensure student safety during lab exercises.

Specifications

Parameter	Value
Physical Characteristics	
Dimensions (H x W x D)	308 x 287 x 415 mm (12.1 x 11.3 x 16.3 in)
Net Weight	TBE

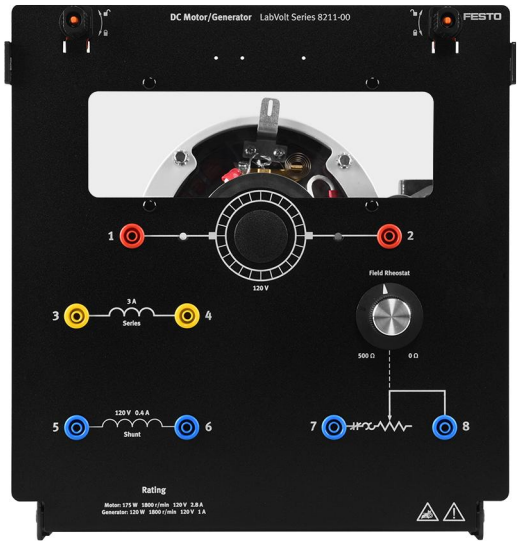
Half-Size Blank EMS Module (Optional)
579758 (8161-00)

The Half-Size Blank EMS Module is used to fill unused locations in a workstation, preventing students from accessing electrical or moving parts inside the other modules. Combined with the use of safety bars to prevent students from removing modules, blank EMS modules ensure student safety during lab exercises.

Specifications

Parameter	Value
Physical Characteristics	
Dimensions (H x W x D)	154 x 287 x 410 mm (6.1 x 11.3 x 16.1 in)
Net Weight	TBE

DC Motor/Generator (Optional) 579759 (8211-00)



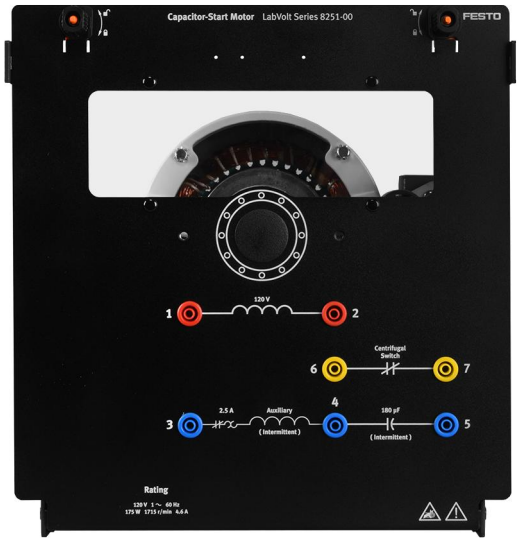
The DC Motor/Generator is a dc machine mounted in a full-size EMS module. It can operate independently as a dc motor or a dc generator. The armature, shunt field, and series field windings are terminated separately on the faceplate to permit long and short shunt as well as cumulatively and differentially compounded motor and generator connections. This machine is fitted with exposed movable brushes to allow students to study the effect of armature reaction and commutation while the machine is operating under load.

An independent, circuit-breaker protected, shunt-field rheostat is mounted on the faceplate for motor speed control or generator output voltage adjustment. The speed of the DC Motor/Generator can be controlled using the Thyristor Speed Controller, Model 9017, in both the open-loop and closed-loop modes of control.

Specifications

Parameter	Value
Rating	
Motor Output Power	175 W
Generator Output Power	120 W
Armature Voltage	120 V dc
Shunt Field Voltage	120 V dc
Full-Load Speed	1800 r/min
Full-Load Motor Current	2.8 A
Full-Load Generator Current	1 A
Physical Characteristics	
Dimensions (H x W x D)	308 x 287 x 445 mm (12.1 x 11.3 x 17.5 in)
Net Weight	14.1 kg (31 lb)

Capacitor-Start Motor (Optional)
579767 (8251-00)

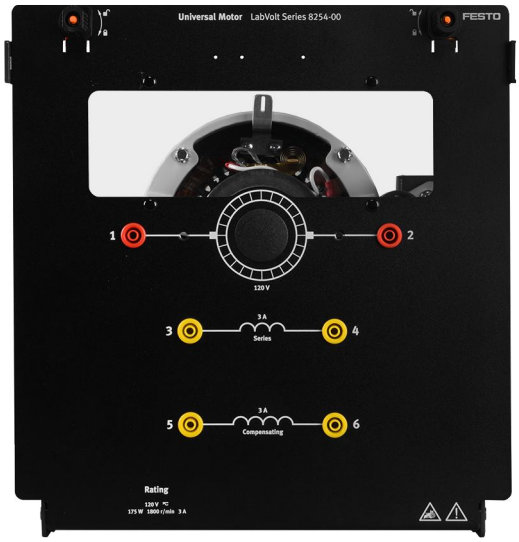


The Capacitor-Start Motor is a 0.2 kW capacitor-start machine mounted in a full-size EMS module. The centrifugal switch and contact points of the machine are mounted externally to allow students to examine their construction and observe their operation. The switch, the starting auxiliary winding, and the main running winding are all independently terminated and identified on the faceplate to facilitate experimentation of various machine connections, including open- and short-circuit fault conditions. The starting winding is circuit breaker protected against overloads. Because of the open bell housing construction, students can compare the relative size, position, and turns of the starting winding and the main running winding. An externally mounted starting capacitor is also independently terminated and identified on the faceplate to permit experimentation as a split-phase or a capacitor-start single-phase induction motor.

Specifications

Parameter	Value
Rating	
Line Voltage	120 V
Mechanical Power	175 W
Full-Load Speed	1715 r/min
Full-Load Current	4.6 A
Physical Characteristics	
Dimensions (H x W x D)	308 x 287 x 420 mm (12.1 x 11.3 x 16.5 in)
Net Weight	13.8 kg (30.4 lb)

Universal Motor (Optional)
579774 (8254-00)

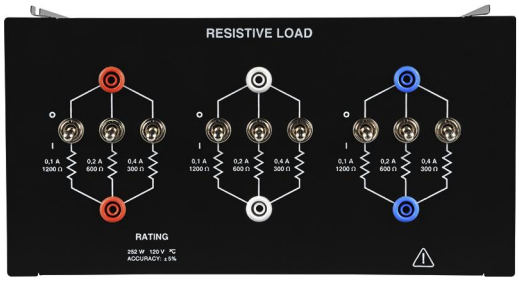


The Universal Motor is a 0.2 kW universal machine mounted in a full-size EMS module. Its commutator bars and adjustable brushes are exposed to allow students to study the effect of armature reactions and commutation while the machine is running under load. The armature winding, the series field winding, and the compensation winding are terminated independently on the module front panel by 4 mm color-coded banana jacks. Students can observe the effects of both inductive and conductive compensation on motor speed and torque for both ac and dc input voltage sources.

Specifications

Parameter	Value
Rating	
Voltage	120 V ac/dc
Mechanical Power	175 W
Full-Load Speed	1800 r/min
Full-Load Current	3 A
Physical Characteristics	
Dimensions (H x W x D)	308 x 287 x 420 mm (12.1 x 11.3 x 16.5 in)
Net Weight	14.4 kg (31.7 lb)

Low-Voltage Resistive Load (Optional)
763361 (8311-A0)



The Resistive Load, Model 8311-A0, is similar to and shares the same specifications as the Resistive Load, Model 8311-00 (120/208 V – 60 Hz). However, the color of the banana jacks and the arrangement of the load element switches are identical to those of a Resistive Load, Model 8311-0A (240/415 V – 50 Hz).

Power Supply (Optional)
579603 (8821-20)

The Power Supply is enclosed in a full-size EMS module. It can be used to power most of the EMS modules of the Electricity and New Energy Training Equipment. This Power Supply provides dc power and ac power, both fixed and variable, single-phase and three-phase. Color-coded safety banana jacks provide access to all the power sources in the Power Supply. All these power sources can be used simultaneously, provided that the total current drawn does not exceed the maximum current rating. A built-in voltmeter with selector switch and liquid crystal display (LCD) indicates the voltage provided by any of the power sources. The input and outputs of the Power Supply are protected by independent circuit breakers.

Specifications

Parameter	Value
Module Requirements	
AC Power Network Installation	3 phases (120/208 V – 60 Hz), star (wye) configuration including neutral and ground wires, protected by a 20 A circuit breaker
AC Power Network Connector	NEMA L21-20
Maximum Current	15 A
Outputs (*see note)	
Three-Phase Fixed AC	120/208 V – 15 A - 60 Hz
Three-Phase Variable AC	0-120/208 V – 5 A - 60 Hz
Variable DC	0-120 V – 8 A
Fixed DC	120 V – 2 A
Low Power AC	24 V – 3 A - 60 Hz
Included Accessories	
	3 m (10 ft) ac power cord (1)
	NEMA L21-20 wall connector with wall plate (1)
	Padlock (1)
Physical Characteristics	
Dimensions (H x W x D)	308 x 287 x 495 mm (12.1 x 11.3 x 19.5 in)
Net Weight	18.4 kg (40.5 lb)
***Note**	The Power Supply cannot supply all the amounts of current indicated by the current ratings on its front panel at the same time. The current indicated for the fixed ac three-phase output section can only be obtained if no current is drawn from any other section, because this section is protected by the main circuit breaker common to every section. If currents flow in other sections, the available current for the fixed ac three-phase output section decreases. The variable ac output section and the variable dc output section are protected by a common set of circuit breakers placed after the fixed ac three-phase output section, which means that the current capacity has to be shared between the two sections. For instance, if current of the variable dc output section is at 70% of its nominal value, current drawn from the variable ac output section should not exceed 30% of its nominal value. The fixed dc output section is also protected by circuit breakers placed after the fixed ac three-phase output section.

Digital Multimeter (Optional)
579782 (8946-20)

The Digital Multimeter consists of an Amprobe AM-510 Tool Kit Digital Multimeter with Battery Test. It is ideal to perform voltage, current, and resistance measurements in exercises.

Specifications

Parameter	Value
Voltage	
Ranges	0-600 V ac/dc
Current	
Range	0-10 A ac/dc
Resistance	
Range	0-40 MΩ
Physical Characteristics	
Dimensions (H x W x D)	182 x 90 x 45 mm (7.17 x 3.54 x 1.77 in)
Net Weight	354 g (0.78 lb)

Multimeters Module (Optional)
586888 (8946-A0)

The Multimeters Module, Model 8946-A, consists of three Digital Multimeters, Model 8946-2, installed on the front panel of a half-size module. This allows the Multimeters Module to be inserted in a Workstation, just like any other module.

Specifications

Parameter	Value
Multimeters	
Quantity	3
Voltage Range	0-600 V dc and ac
Current Range	0-10 A dc
Resistance Range	0-20 MΩ
Physical Characteristics	
Dimensions (H x W x D)	154 x 287 x 440 mm (6.1 x 11.3 x 17.3 in)
Net Weight	TBE

Personal Computer (Optional)
579785 (8990-00)

The Personal Computer consists of a desktop computer running under Windows® 10. A monitor, keyboard, and mouse are included.

Specifications

Parameter	Value
Power Requirements	
Current	2 A
Service Installation	Standard single-phase ac outlet

Electromechanical Training System (Manuals on CD-ROM) (Optional)
579707 (86357-A0)

List of Manuals

Description	Manual number
Power Factor Correction (Student Manual)	590283 (20116-00)
Power Factor Correction (Instructor Guide)	590284 (20116-10)
Power Factor Correction (Instructor Guide)	590285 (20116-15)
Power Factor Correction (Instructor Guide)	590286 (20116-1A)
Power Factor Correction (Instructor Guide)	590287 (20116-1E)
Electric Power Technology Training Equipment (User Guide)	591259 (38486-E0)
Equipos del Sistema didáctico en tecnología de la energía eléctrica (User Guide)	591260 (38486-E2)
DC Power Circuits (Student Manual)	591809 (86350-00)
Circuitos cc (Student Manual)	591810 (86350-02)
Circuitos de Potência de CC (Student Manual)	591811 (86350-04)
DC Power Circuits (Instructor Guide)	591812 (86350-10)
Circuitos cc (Instructor Guide)	591813 (86350-12)
Circuitos de Potência de CC (Instructor Guide)	591814 (86350-14)
Permanent Magnet DC Machine (Student Manual)	591842 (86357-00)
Máquina cc de imán permanente (Student Manual)	591843 (86357-02)
Máquina de CC de Imã Permanente (Student Manual)	591844 (86357-04)
Permanent Magnet DC Machine (Instructor Guide)	591845 (86357-10)
Máquina cc de imán permanente (Instructor Guide)	591846 (86357-12)
Máquina de CC de Imã Permanente (Instructor Guide)	591847 (86357-14)
Single-Phase AC Power Circuits (Student Manual)	591848 (86358-00)
Circuitos ca monofásicos (Student Manual)	591849 (86358-02)
Single-Phase AC Power Circuits (Instructor Guide)	591850 (86358-10)
Circuitos ca monofásicos (Instructor Guide)	591851 (86358-12)
Three-Phase AC Power Circuits (Student Manual)	591858 (86360-00)
Circuitos ca trifásicos (Student Manual)	591859 (86360-02)
Circuitos de Potência de CA Trifásicos (Student Manual)	591860 (86360-04)
Three-Phase AC Power Circuits (Instructor Guide)	591861 (86360-10)
Circuitos ca trifásicos (Instructor Guide)	591862 (86360-12)
Circuitos de Potência de CA Trifásicos (Instructor Guide)	591863 (86360-14)
Three-Phase AC Power Circuits (Instructor Guide)	591864 (86360-15)
Circuitos de Potência de CA Trifásicos (Instructor Guide)	591865 (86360-19)
Three-Phase AC Power Circuits (Instructor Guide)	591866 (86360-1A)
Three-Phase AC Power Circuits (Instructor Guide)	591867 (86360-1E)
Three-Phase Rotating Machines (Student Manual)	591903 (86364-00)
Máquinas rotatorias trifásicas (Student Manual)	591904 (86364-02)
Three-Phase Rotating Machines (Instructor Guide)	591905 (86364-10)
Máquinas rotatorias trifásicas (Instructor Guide)	591906 (86364-12)
Three-Phase Rotating Machines (Instructor Guide)	591907 (86364-15)
Máquinas rotatorias trifásicas (Instructor Guide)	591908 (86364-17)
Three-Phase Rotating Machines (Instructor Guide)	591909 (86364-1A)
Three-Phase Rotating Machines (Instructor Guide)	591910 (86364-1E)
Máquinas rotatorias trifásicas (Instructor Guide)	591911 (86364-1F)
Single-Phase Power Transformers (Student Manual)	591954 (86377-00)
Transformadores de potencia monofásicos (Student Manual)	591955 (86377-02)
Single-Phase Power Transformers (Instructor Guide)	591956 (86377-10)
Transformadores de potencia monofásicos (Instructor Guide)	591957 (86377-12)
Three-Phase Transformer Banks (Student Manual)	591967 (86379-00)
Bancos trifásicos de transformadores (Student Manual)	591968 (86379-02)

Description	Manual number
Bancos de Transformadores Trifásicos (Instructor Guide)	591975 (86379-19)
Three-Phase Transformer Banks (Instructor Guide)	591976 (86379-1A)
Three-Phase Transformer Banks (Instructor Guide)	591977 (86379-1E)
Bancos trifásicos de transformadores (Instructor Guide)	591978 (86379-1F)
Computer-Based Instruments for EMS (User Guide)	592016 (86718-E0)
Instrumentos para EMS computarizados (User Guide)	592018 (86718-E2)
Conventional DC Machines and Universal Motor (Student Manual)	592168 (88943-00)
Máquinas cc convencionales y motor universal (Student Manual)	592169 (88943-02)
Conventional DC Machines and Universal Motor (Instructor Guide)	592170 (88943-10)
Máquinas cc convencionales y motor universal (Instructor Guide)	592171 (88943-12)
Conventional DC Machines and Universal Motor (Instructor Guide)	592172 (88943-15)
Máquinas cc convencionales y motor universal (Instructor Guide)	592173 (88943-17)
Conventional DC Machines and Universal Motor (Instructor Guide)	592174 (88943-1A)
Conventional DC Machines and Universal Motor (Instructor Guide)	592175 (88943-1E)
Máquinas cc convencionales y motor universal (Instructor Guide)	592176 (88943-1F)
Single-Phase Induction Motors (Student Manual)	592177 (88944-00)
Motores de inducción monofásicos (Student Manual)	592178 (88944-02)
Single-Phase Induction Motors (Instructor Guide)	592179 (88944-10)
Motores de inducción monofásicos (Instructor Guide)	592180 (88944-12)
Single-Phase Induction Motors (Instructor Guide)	592181 (88944-15)
Motores de inducción monofásicos (Instructor Guide)	592182 (88944-17)
Single-Phase Induction Motors (Instructor Guide)	592183 (88944-1A)
Single-Phase Induction Motors (Instructor Guide)	592184 (88944-1E)
Motores de inducción monofásicos (Instructor Guide)	592185 (88944-1F)
DC Power Circuits (Student Manual)	594401 (86350-0C)
DC Power Circuits (Instructor Guide)	594402 (86350-1C)
Single-Phase AC Power Circuits (Student Manual)	594403 (86358-0C)
Single-Phase AC Power Circuits (Instructor Guide)	594404 (86358-1C)
Three-Phase AC Power Circuits (Student Manual)	594405 (86360-0C)
Three-Phase AC Power Circuits (Instructor Guide)	594406 (86360-1C)
Circuitos ca trifásicos (Instructor Guide)	594407 (86360-1F)
Circuitos ca trifásicos (Instructor Guide)	594408 (86360-17)
Máquinas Rotativas Trifásicas (Student Manual)	594413 (86364-04)
Máquinas Rotativas Trifásicas (Job Sheets - Student)	594414 (86364-14)
Single-Phase Power Transformers (Student Manual)	594445 (86377-0C)
Single-Phase Power Transformers (Instructor Guide)	594446 (86377-1C)
Three-Phase Transformer Banks (Instructor Guide)	594448 (86379-1C)
Corrección del factor de potencia (Student Manual)	595688 (20116-02)
Corrección del factor de potencia (Instructor Guide)	595689 (20116-1F)
Corrección del factor de potencia (Instructor Guide)	595690 (20116-12)
Corrección del factor de potencia (Instructor Guide)	595691 (20116-17)
Transformateurs de puissance monophasés (Instructor Guide)	8108882 (86377-11)
Transformateurs de puissance monophasés (Student Manual)	8108884 (86377-01)
Transformateurs de puissance monophasés (Instructor Guide)	8108886 (86377-1H)
Transformateurs de puissance monophasés (Student Manual)	8108888 (86377-0H)
Banque triphasées de transformateurs (Instructor Guide)	8114282 (86379-11)
Banque triphasées de transformateurs (Student Manual)	8114284 (86379-01)
Banque triphasées de transformateurs (Instructor Guide)	8114286 (86379-16)

Description	Manual number
Machines tournantes triphasées (Student Manual)	8116687 (86364-01)
Machines tournantes triphasées (Instructor Guide)	8116689 (86364-16)
Power Factor Correction (Instructor Guide)	8123643 (20116-1C)
Power Factor Correction (Student Manual)	8123645 (20116-0C)

Table of Contents of the Manual(s)

Power Factor Correction (Student Manual) (590283 (20116-00))

Reflecting the commitment of Festo Didactic to high quality standards in product, design, development, production, installation, and service, our manufacturing and distribution facility has received the ISO 9001 certification.

Festo Didactic SE

Rechbergstrasse 3
73770 Denkendorf
Germany

P. +49(0)711/3467-0
F. +49(0)711/347-54-88500

Festo Didactic Inc.

607 Industrial Way West
Eatontown, NJ 07724
United States

P. +1-732-938-2000
F. +1-732-774-8573

Festo Didactic Ltée/Ltd

675 rue du Carbone
Québec QC G2N 2K7
Canada

P. +1-418-849-1000
F. +1-418-849-1666

www.labvolt.com

www.festo-didactic.com