# 0.2 kW Electromechanical Training Systems
8001

**LabVolt Series**

Datasheet

* The product images shown in this document are for illustration purposes; actual products may vary. Please refer to the Specifications section of each product/item for all details. Festo Didactic reserves the right to change product images and specifications at any time without notice.

Festo Didactic
en 120 V - 60 Hz
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# Table of Contents

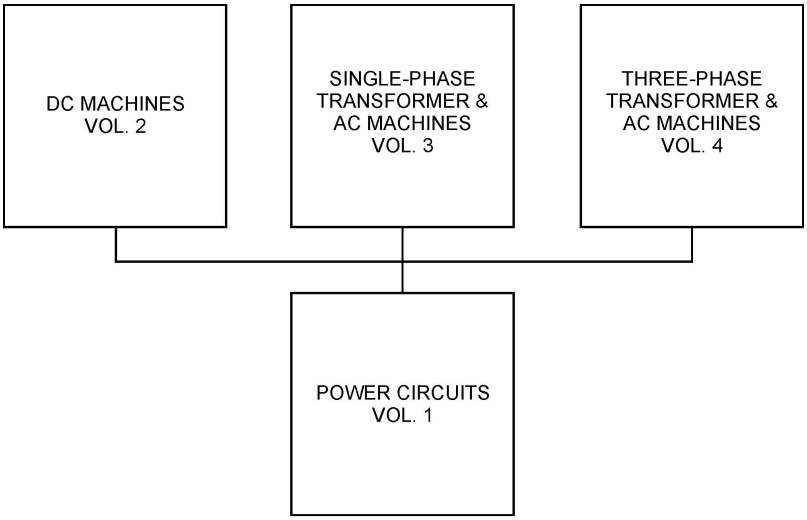
## General Description

The 0.2 kW Electromechanical Training Systems (EMS) are part of a modular instructional program designed to teach electric power technology through laboratory observations. The program, divided in four subsystems, deals with the different techniques associated with the generation and use of electrical energy. The subsystems cover the common machines, and each subsystem is offered with its courseware presented in a student manual.

Each subsystem is available as a package that consists of the equipment necessary to perform the laboratory exercises presented in the correlated student manual.

0.2 kW Electromechanical Training Systems give instructors complete versatility in selecting a program adapted to students' specific career objectives. The EMS System was developed by educators to satisfy educational requirements that include industrial applications of electric power technology. The design objective was to develop a low-power (0.2 kW or ¼ hp) educational system with equipment that operates like industrial equipment.

Through careful attention to engineering detail, the EMS System meets this objective, and in so doing, provides laboratory results that are easy to understand, with data values that are easily observed. The data, when applied to formulas, provides results that verify electrical laws rather than deny them because of large operational tolerance errors.




## Laboratory manuals

Laboratory manuals guide students step-by-step through the experiments and provide the necessary theoretical background to allow students to successfully complete the educational objectives. These manuals contain experiments that correlate with the training equipment for hands-on involvement with the subject matter. The instructor can select the experiments that will satisfy the objectives of technical courses or university programs. The flexibility of the training systems allows students to use their own initiative during the laboratory sessions. Under the direction of an instructor, students can gain the required competencies for successful employment.

## A Modular Approach

The modular approach in designing the training systems allows new equipment to be added to existing EMS laboratories without needless duplication of equipment. There are two standard module sizes: full size, 308 mm (12.1 in) high, and half size, 154 mm (6.1 in) high. All modules can be inserted into a Mobile Workstation, Model 8110. With the exception of rotating machines, all modules have steel face plates. The modules are constructed of heavy-gauge steel, finished in baked enamel. Symbols and diagrams specific to each module are clearly silk-screened on the steel faceplates. Standard, color-coded, 4 mm safety jacks are used to interconnect all system components.

## The Mobile Workstation

The mobile workstation is equipped with four swivel casters. It contains a general storage cabinet, a pull-out work surface, and spaces to insert the modules required for each experiment. Six full-size, or twelve half-size, modules plus three additional half-size modules can be used simultaneously. For applications requiring additional modules, a Three-Module Workstation, Model 8131 can easily be bolted on top of the mobile workstation. The modules are guided into position along stainless steel guide rails and are held securely in place by a holding mechanism. Front-mounted release levers allow easy removal of modules from the workstation. Safety locking devices prevent students from removing modules from the workstation during lab exercises.

## Storage Cabinet

All unused modules can be placed in a Storage Cabinet, Model 8150. Only the necessary modules for a given experiment are placed in the console so that students are not distracted by unused instruments.

## Accessibility

All rotating machines are mounted in standard-size modules. These modules are equipped with a clear plastic faceplate fitted with a chrome-plated piano hinge. The faceplate can be lowered for access to the machine, and when closed, it is secured by two quick-lock fasteners. Each rotating machine is provided with a safety locking device that prevents students from lowering the faceplate during lab exercises.

## Visual Inspection

All rotating machines have open bell housings (front and rear) to permit visual inspection of the internal construction and observation of the machine during operation with the aid of a Stroboscope, Model 8922. Externally mounted components such as centrifugal switches, capacitors, brushes, slip rings, and commutators – in addition to the exposed squirrel cage and wound rotors – permit students to clearly determine component function as well as to understand relative position, turns, and wire sizes of the machinery.

## Machine Features

The shaft of each machine has a concave slotted end to facilitate the use of tachometers, holding brakes, plugging switches, and inertia wheels. A geared pulley is fitted on each machine shaft to mechanically couple machines together using a non-slip timing belt. The Timing Belt, Model 8942, has molded teeth, which mesh with the geared machine pulleys. Tension for the timing belt is provided by the idler-tensioning ball bearings mounted on each machine module.

## Loads

Resistive, inductive, and capacitive load components, housed in separate modules, are designed to provide equal load magnitudes for all three types of loads. The load impedance can be varied in equal steps of unity value by switches provided on all load modules. These characteristics simplify the calculations required in the learning process.

## Metering Modules

The metering modules are designed to cover the complete range of required measurements with a minimum number of meters. The ac ammeter and voltmeter modules each contains three meters for simultaneously measuring all three currents and voltages on a three-phase system. All meters are designed to sustain starting currents even when used on a low range. Wattmeters are internally connected to read power directly when the input is connected to the source and the output to the load. Protection of vulnerable meter components is accomplished without fuses.

## Power Supply

A separate power supply for each workstation provides total control of the necessary power sources. This allows the student maximum use of laboratory equipment and reduces interference with other simultaneous laboratory experiments. The power supply module provides all ac and dc power sources required at each station.

## Speed Measurements

The speed of the machines can be measured with a Hand Tachometer, Model 8920, or an optional Electrical Tachometer, Model 8931, which is easily mounted on the machine.

## Leads

The machines and various components of the system are connected using flexible PVC-insulated connection leads terminated with 4 mm safety plugs. These leads allow safe connection of components without danger of electrical shock, since the live parts of their plugs are concealed and insulated in such a way that they cannot be contacted accidentally. They come in three different lengths, each identified by a distinctive color. A handy rack can be attached to the workstation side for inventory and storage of these leads.

## Features & Benefits

- Sturdy workstations and modules constructed of heavy-gauge steel, finished in baked enamel
- Cutaway bell housings to permit visual inspection of the internal construction and observation of the machine during operation
- The shaft of each machine has a concave and slotted end to facilitate the use of tachometers, holding brakes, plugging switches, or inertia wheels
- Metering modules are designed to cover the complete range of required measurements with a minimum number of meters
- System conception and load components simplify calculations required in the learning process
- Safe: all electrical components can be interconnected without electric shock hazard as all live parts of the plugs are concealed and insulated
- Comprehensive curriculum
- Estimated total program duration: approximately 150 hours

## List of Available Training Systems

| Qty | Description | Model number |
|---|---|---|
| 1 | 0.2 kW Electromechanical Training System – Modular with motor starters | 587243 (8001-10) |
| 1 | 0.2 kW EMS – Power Circuits | 587250 (8001-20) |
| 1 | 0.2 kW EMS – DC Machines | 587257 (8001-30) |
| 1 | 0.2 kW EMS – Single-Phase Transformers and AC Machines | 587264 (8001-40) |
| 1 | 0.2 kW EMS – Three-Phase Transformers and AC Machines | 587271 (8001-50) |
| 1 | 0.2 kW Electromechanical Training System | 587278 (8001-60) |

# Available Training Systems

## 0.2 kW Electromechanical Training System – Modular with motor starters 587243 (8001-10)

The Complete 0.2 kW EMS – Modular training system is complete and supported by student manuals for all four subsystems.

The subsystems – Power Circuits (Vol. 1), DC Machines (Vol. 2), Single-Phase Transformer and AC Machines (Vol. 3), Three-Phase Transformer and AC Machines (Vol. 4) – cover the common machines, and each subsystem is offered with its courseware presented in a student manual. Each subsystem is available as a package that consists of the equipment necessary to perform the laboratory exercises presented in the correlated student manual.

### List of Equipment

| Qty | Description | Model number |
|---|---|---|
| 1 | _____ | 583899 (25986-00) |
| 1 | _____ | 583909 (25987-00) |
| 1 | _____ | 583913 (25988-00) |
| 1 | _____ | 583917 (25989-00) |
| 1 | Investigations in Electric Power Technology (Instructor Guide) _____ | 583921 (25990-01) |
| 1 | Mobile Workstation _____ | 579755 (8110-20) |
| 1 | Storage Shelves _____ | 579756 (8150-10) |
| 1 | DC Motor/Generator _____ | 579759 (8211-00) |
| 1 | Four-Pole Squirrel-Cage Induction Motor _____ | 579491 (8221-00) |
| 1 | Three-Phase Wound-Rotor Induction Machine _____ | 586320 (8231-00) |
| 1 | Synchronous Motor/Generator _____ | 586351 (8241-00) |
| 1 | Capacitor-Start Motor _____ | 579767 (8251-00) |
| 1 | Capacitor-Run Motor _____ | 586390 (8253-00) |
| 1 | Universal Motor _____ | 579774 (8254-00) |
| 1 | Resistive Load _____ | 763359 (8311-00) |
| 1 | Inductive Load _____ | 763362 (8321-00) |
| 1 | Capacitive Load _____ | 763366 (8331-00) |
| 3 | Fully Protected Transformer _____ | 763419 (8341-20) |
| 1 | DC Voltmeter/Ammeter _____ | 581397 (8412-00) |
| 1 | AC Ammeter _____ | 581406 (8425-00) |
| 1 | AC Voltmeter _____ | 581413 (8426-00) |
| 1 | Single-Phase Wattmeter _____ | 586514 (8431-20) |
| 1 | Three-Phase Wattmeter _____ | 586521 (8441-20) |
| 1 | Synchronizing Module _____ | 586738 (8621-00) |
| 1 | Manual DC Motor Starter _____ | 586745 (8631-00) |
| 1 | Synchronous Motor Starter _____ | 586751 (8641-00) |
| 1 | Three-Phase Full-Voltage Starter _____ | 586758 (8651-00) |

| Qty | Description | Model number |
|---|---|---|
| 1 | Three-Phase Rheostat | 586786 (8731-00) |
| 1 | Variable Three-Phase Power Supply | 579603 (8821-20) |
| 1 | Electrodynamometer, Imperial Units | 586856 (8911-00) |
| 1 | Digital Tachometer | 581427 (8920-40) |
| 1 | Timing Belt | 579637 (8942-00) |
| 1 | Digital Multimeter | 579782 (8946-20) |
| 1 | Connection Lead Set | 581428 (8951-00) |
| 1 | Thyristor Speed Controller | 587007 (9017-00) |

## List of Manuals

| Description | Manual number |
|---|---|
| Power Circuits (Workbook) | 583899 (25986-00) |
| DC Machines (Workbook) | 583909 (25987-00) |
| Single-Phase Transformers and AC Machines (Workbook) | 583913 (25988-00) |
| Three-Phase Transformers and AC Machines (Workbook) | 583917 (25989-00) |
| Investigations in Electric Power Technology (Workbook (Instructor)) | 583921 (25990-01) |
| Phase-Shifting with Transformers (Workbook) | 583981 (27082-00) |
| The Wound-Rotor Induction Motor and Applications (Workbook) | 584327 (35064-00) |
| The Capacitor-Run Motor (Workbook) | 584328 (35065-00) |
| Electric Power Technology Training Equipment (User Guide) | 584778 (38486-E0) |

## Table of Contents of the Manual(s)

**Power Circuits (Workbook) (583899 (25986-00))**

- 24 Phase Sequence

**DC Machines (Workbook) (583909 (25987-00))**

- 0 Safety and the Power Supply
- 1 Prime Mover and Torque Measurement
- 2 The Direct Current Motor – Part I
- 3 The Direct Current Motor – Part II
- 4 The DC Shunt Motor
- 5 The DC Series Motor
- 6 The DC Compound Motor
- 7 The DC Separately Excited Shunt Generator
- 8 The DC Self Excited Shunt Generator
- 9 The DC Compound Generator
- 10 DC Motor Starter
- 11 Thyristor Speed Controller
- 12 Thyristor Speed Controller with Regulation

**Single-Phase Transformers and AC Machines (Workbook) (583913 (25988-00))**

- 0 Safety and the Power Supply
- 1 The Single-Phase Transformer
- 2 Transformer Polarity
- 3 Transformer Regulation
- 4 The Autotransformer
- 5 Transformers in Parallel
- 6 The Distribution Transformer
- 7 Prime Mover and Torque Measurement
- 8 The Split-Phase Inductor Motor – Part I
- 9 The Split-Phase Inductor Motor – Part II
- 10 The Split-Phase Inductor Motor – Part III
- 11 The Capacitor-Start Motor
- 12 The Capacitor-Run Motor
- 13 The Universal Motor – Part I
- 14 The Universal Motor – Part II

**Three-Phase Transformers and AC Machines (Workbook) (583917 (25989-00))**

- 0 Safety and the Power Supply
- 1 Three-Phase Transformer Connections
- 2 Prime Mover and Torque Measurement
- 3 The Wound-Rotor Induction Motor – Part I
- 4 The Wound-Rotor Induction Motor – Part II
- 5 The Wound-Rotor Induction Motor – Part III
- 6 The Squirrel-Cage Induction Motor
- 7 The Synchronous Motor – Part I
- 8 The Synchronous Motor – Part II
- 9 The Synchronous Motor – Part III
- 10 The Three-Phase Alternator
- 11 The Alternator Under Load
- 12 Alternator Synchronization
- 13 Alternator Power

- 14 Three-Phase Motor Starter
- 15 Frequency Conversion
- 16 Reactance and Frequency
- 17 Selsyn Control

**Phase-Shifting with Transformers (Workbook) (583981 (27082-00))**

- 1 Phase Shifting with Transformers

**The Wound-Rotor Induction Motor and Applications (Workbook) (584327 (35064-00))**

- 1 The Wound-Rotor Induction Motor – Part I
- 2 The Wound-Rotor Induction Motor – Part II
- 3 The Wound-Rotor Induction Motor – Part III
- 4 Frequency Conversion
- 5 Reactance and Frequency
- 6 Selsyn Control

**The Capacitor-Run Motor (Workbook) (584328 (35065-00))**

- 1 The Capacitor-Run Motor

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

- 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

## Software

| Qty | Description | Model number |
|---|---|---|
| 1 | Complete Function Set | 581435 (8968-00) [1] |
| 1 | Standard Functions (computer-based control) Set | 581437 (8968-20) [2] |
| 1 | Electromechanical Systems Simulation Software (LVSIM®-EMS) - 1 User Online, 1 year | 586971 (8972-00) [3] |
| 1 | Electromechanical Systems Simulation Software (LVSIM®-EMS) - 5 Users Online, 1 year | 586974 (8972-A0) [4] |
| 1 | Electromechanical Systems Simulation Software (LVSIM®-EMS) - 10 Users Online, 1 year | 586977 (8972-B0) [5] |

[1] Additional firmware for the optional Four-Quadrant Dynamometer/Power Supply.

[2] Additional firmware for the optional Four-Quadrant Dynamometer/Power Supply.

[3] Simulation software that covers these topics and more.

[4] Simulation software that covers these topics and more.

[5] Simulation software that covers these topics and more.

| Qty | Description | Model number |
|---|---|---|
| 1 | Electromechanical Systems Simulation Software (LVSIM®-EMS) - 15 Users Online, 1 year | 586980 (8972-C0) [6] |
| 1 | Electromechanical Systems Simulation Software (LVSIM®-EMS) - 20 Users Online, 1 year | 586983 (8972-D0) [7] |
| 1 | Electromechanical Systems Simulation Software (LVSIM®-EMS) - 25 Users Online, 1 year | 586986 (8972-E0) [8] |
| 1 | Electromechanical Systems Simulation Software (LVSIM®-EMS) - 30 Users Online, 1 year | 586989 (8972-F0) [9] |
| 1 | Electromechanical Systems Simulation Software (LVSIM®-EMS) - 35 Users Online, 1 year | 586992 (8972-G0) [10] |
| 1 | Electromechanical Systems Simulation Software (LVSIM®-EMS) - 40 Users Online, 1 year | 586995 (8972-H0) [11] |
| 1 | SCADA for LVDAC-EMS | 8094377 (8973-00) [12] |
| 1 | Complete Function Set | 581451 (9069-00) [13] |
| 1 | Synchroscope Function | 579789 (9069-C0) [14] |

## System Specifications

| Parameter | Value |
|---|---|
| **System Requirements** | |
| Maximum Current | 15 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 |
| **Physical Characteristics** | |
| Intended Location | On the floor (stands on casters) |
| Dimensions (H x W x D) | 900 x 930 x 530 mm (35.4 x 36.6 x 20.9 in) |
| Net Weight | 439 kg (966 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) |

## 0.2 kW EMS – Power Circuits 587250 (8001-20)



The 0.2 kW EMS – Power Circuits training system is supported by the student manual Volume 1: Power Circuits.

[6] Simulation software that covers these topics and more.
[7] Simulation software that covers these topics and more.
[8] Simulation software that covers these topics and more.
[9] Simulation software that covers these topics and more.
[10] Simulation software that covers these topics and more.
[11] Simulation software that covers these topics and more.
[12] Allows monitoring of up to 5 Stations through OPC.
[13] Additional firmware for the optional Data Acquisition.
[14] Additional firmware for the optional Data Acquisition.

## List of Equipment

| Qty | Description | Model number |
|---|---|---|
| 1 | _____ | 583899 (25986-00) |
| 1 | Mobile Workstation _____ | 579755 (8110-20) |
| 1 | Storage Shelves _____ | 579756 (8150-10) |
| 1 | Resistive Load _____ | 763359 (8311-00) |
| 1 | Inductive Load _____ | 763362 (8321-00) |
| 1 | Capacitive Load _____ | 763366 (8331-00) |
| 1 | DC Voltmeter/Ammeter _____ | 581397 (8412-00) |
| 1 | AC Ammeter _____ | 581406 (8425-00) |
| 1 | AC Voltmeter _____ | 581413 (8426-00) |
| 1 | Single-Phase Wattmeter _____ | 586514 (8431-20) |
| 1 | Three-Phase Wattmeter _____ | 586521 (8441-20) |
| 1 | Synchronizing Module _____ | 586738 (8621-00) |
| 1 | Variable Three-Phase Power Supply _____ | 579603 (8821-20) |
| 1 | Digital Multimeter _____ | 579782 (8946-20) |
| 1 | Connection Lead Set _____ | 581428 (8951-00) |

## List of Manuals

| Description | Manual number |
|---|---|
| Power Circuits (Workbook) _____ | 583899 (25986-00) |
| Electric Power Technology Training Equipment (User Guide) _____ | 584778 (38486-E0) |

## Table of Contents of the Manual(s)

**Power Circuits (Workbook) (583899 (25986-00))**

- 22 Three-Phase Watts, Vars, and Volt-Amperes
- 23 Three-Phase Power Measurement
- 24 Phase Sequence

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

- 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

## System Specifications

| Parameter | Value |
|---|---|
| **System Requirements** | |
| Maximum Current | 15 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 |
| **Physical Characteristics** | |
| Intended Location | On the floor (stands on casters) |
| Dimensions (H x W x D) | 900 x 930 x 530 mm (35.4 x 36.6 x 20.9 in) |
| Net Weight | 439 kg (966 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) |

## 0.2 kW EMS – DC Machines 587257 (8001-30)

The 0.2 kW EMS – DC Machines training system is supported by the student manual Volume 2: DC Machines.

## List of Equipment

| Qty | Description | Model number |
|---|---|---|
| 1 | _____ | 583909 (25987-00) |
| 1 | Mobile Workstation _____ | 579755 (8110-20) |
| 1 | Storage Shelves _____ | 579756 (8150-10) |
| 1 | DC Motor/Generator _____ | 579759 (8211-00) |
| 1 | Synchronous Motor/Generator _____ | 586351 (8241-00) |
| 1 | Resistive Load _____ | 763359 (8311-00) |

| Qty | Description | Model number |
|---|---|---|
| 1 | DC Voltmeter/Ammeter | 581397 (8412-00) |
| 1 | AC Ammeter | 581406 (8425-00) |
| 1 | AC Voltmeter | 581413 (8426-00) |
| 1 | Manual DC Motor Starter | 586745 (8631-00) |
| 1 | Variable Three-Phase Power Supply | 579603 (8821-20) |
| 1 | Electrodynamometer, Imperial Units | 586856 (8911-00) |
| 1 | Digital Tachometer | 581427 (8920-40) |
| 1 | Timing Belt | 579637 (8942-00) |
| 1 | Connection Lead Set | 581428 (8951-00) |
| 1 | Thyristor Speed Controller | 587007 (9017-00) |

## List of Manuals

| Description | Manual number |
|---|---|
| DC Machines (Workbook) | 583909 (25987-00) |
| Electric Power Technology Training Equipment (User Guide) | 584778 (38486-E0) |

## Table of Contents of the Manual(s)

### DC Machines (Workbook) (583909 (25987-00))



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



## System Specifications

| Parameter | Value |
|---|---|
| **System Requirements** | |
| Maximum Current | 15 A |
| Typical Current | 1.5 A per student group |

| Parameter | Value |
|---|---|
| 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 |
| **Physical Characteristics** | |
| Intended Location | On the floor (stands on casters) |
| Dimensions (H x W x D) | 900 x 930 x 530 mm (35.4 x 36.6 x 20.9 in) |
| Net Weight | 307 kg (675 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) |

## 0.2 kW EMS – Single-Phase Transformers and AC Machines 587264 (8001-40)

The 0.2 kW EMS – Single-Phase Transformers and AC Machines training system is supported by the student manual Volume 3: Single-Phase Transformers and AC Machines.

### List of Equipment

| Qty | Description | Model number |
|---|---|---|
| 1 | _____ | 583913 (25988-00) |
| 1 | Mobile Workstation _____ | 579755 (8110-20) |
| 1 | Storage Shelves _____ | 579756 (8150-10) |
| 1 | Capacitor-Start Motor _____ | 579767 (8251-00) |
| 1 | Capacitor-Run Motor _____ | 586390 (8253-00) |
| 1 | Universal Motor _____ | 579774 (8254-00) |
| 1 | Resistive Load _____ | 763359 (8311-00) |
| 1 | Inductive Load _____ | 763362 (8321-00) |
| 1 | Capacitive Load _____ | 763366 (8331-00) |
| 2 | Fully Protected Transformer _____ | 763419 (8341-20) |
| 1 | DC Voltmeter/Ammeter _____ | 581397 (8412-00) |
| 1 | AC Ammeter _____ | 581406 (8425-00) |
| 1 | AC Voltmeter _____ | 581413 (8426-00) |
| 1 | Single-Phase Wattmeter _____ | 586514 (8431-20) |
| 1 | Variable Three-Phase Power Supply _____ | 579603 (8821-20) |
| 1 | Electrodynamometer, Imperial Units _____ | 586856 (8911-00) |
| 1 | Digital Tachometer _____ | 581427 (8920-40) |
| 1 | Timing Belt _____ | 579637 (8942-00) |
| 1 | Digital Multimeter _____ | 579782 (8946-20) |
| 1 | Connection Lead Set _____ | 581428 (8951-00) |

## List of Manuals

| Description | Manual number |
|---|---|
| Single-Phase Transformers and AC Machines (Workbook) | 583913 (25988-00) |
| The Capacitor-Run Motor (Workbook) | 584328 (35065-00) |
| Electric Power Technology Training Equipment (User Guide) | 584778 (38486-E0) |

## Table of Contents of the Manual(s)

### Single-Phase Transformers and AC Machines (Workbook) (583913 (25988-00))

- 0 Safety and the Power Supply
- 1 The Single-Phase Transformer
- 2 Transformer Polarity
- 3 Transformer Regulation
- 4 The Autotransformer
- 5 Transformers in Parallel
- 6 The Distribution Transformer
- 7 Prime Mover and Torque Measurement
- 8 The Split-Phase Inductor Motor – Part I
- 9 The Split-Phase Inductor Motor – Part II
- 10 The Split-Phase Inductor Motor – Part III
- 11 The Capacitor-Start Motor
- 12 The Capacitor-Run Motor
- 13 The Universal Motor – Part I
- 14 The Universal Motor – Part II

### The Capacitor-Run Motor (Workbook) (584328 (35065-00))

- 1 The Capacitor-Run Motor

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

- 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

## System Specifications

| Parameter | Value |
|---|---|
| **System Requirements** | |
| Maximum Current | 15 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 |
| **Physical Characteristics** | |
| Intended Location | On the floor (stands on casters) |
| Dimensions (H x W x D) | 900 x 930 x 530 mm (35.4 x 36.6 x 20.9 in) |
| Net Weight | 332 kg (730 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) |

| Parameter | Value |
|---|---|
| Half-Size Dimensions (H x W x D) | 154 x 287 x 440 mm (6.1 x 11.3 x 17.3 in) |

## 0.2 kW EMS – Three-Phase Transformers and AC Machines 587271 (8001-50)

The 0.2 kW EMS – Three-Phase Transformers and AC Machines training system is supported by the student manual Volume 4: Three-Phase Transformers and AC Machines.

### List of Equipment

| Qty | Description | Model number |
|---|---|---|
| 1 | | 583917 (25989-00) |
| 1 | Mobile Workstation | 579755 (8110-20) |
| 1 | Storage Shelves | 579756 (8150-10) |
| 1 | DC Motor/Generator | 579759 (8211-00) |
| 1 | Four-Pole Squirrel-Cage Induction Motor | 579491 (8221-00) |
| 1 | Three-Phase Wound-Rotor Induction Machine | 586320 (8231-00) |
| 1 | Synchronous Motor/Generator | 586351 (8241-00) |
| 1 | Resistive Load | 763359 (8311-00) |
| 1 | Inductive Load | 763362 (8321-00) |
| 1 | Capacitive Load | 763366 (8331-00) |
| 3 | Fully Protected Transformer | 763419 (8341-20) |
| 1 | DC Voltmeter/Ammeter | 581397 (8412-00) |
| 1 | AC Ammeter | 581406 (8425-00) |
| 1 | AC Voltmeter | 581413 (8426-00) |
| 1 | Three-Phase Wattmeter | 586521 (8441-20) |
| 1 | Synchronizing Module | 586738 (8621-00) |
| 1 | Synchronous Motor Starter | 586751 (8641-00) |
| 1 | Three-Phase Full-Voltage Starter | 586758 (8651-00) |
| 1 | Three-Phase Rheostat | 586786 (8731-00) |
| 1 | Variable Three-Phase Power Supply | 579603 (8821-20) |
| 1 | Electrodynamometer, Imperial Units | 586856 (8911-00) |
| 1 | Digital Tachometer | 581427 (8920-40) |
| 1 | Timing Belt | 579637 (8942-00) |
| 1 | Connection Lead Set | 581428 (8951-00) |

### List of Manuals

| Description | Manual number |
|---|---|
| Three-Phase Transformers and AC Machines (Workbook) | 583917 (25989-00) |
| Phase-Shifting with Transformers (Workbook) | 583981 (27082-00) |
| The Wound-Rotor Induction Motor and Applications (Workbook) | 584327 (35064-00) |

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

## Table of Contents of the Manual(s)

**Three-Phase Transformers and AC Machines (Workbook) (583917 (25989-00))**

- 0 Safety and the Power Supply
- 1 Three-Phase Transformer Connections
- 2 Prime Mover and Torque Measurement
- 3 The Wound-Rotor Induction Motor – Part I
- 4 The Wound-Rotor Induction Motor – Part II
- 5 The Wound-Rotor Induction Motor – Part III
- 6 The Squirrel-Cage Induction Motor
- 7 The Synchronous Motor – Part I
- 8 The Synchronous Motor – Part II
- 9 The Synchronous Motor – Part III
- 10 The Three-Phase Alternator
- 11 The Alternator Under Load
- 12 Alternator Synchronization
- 13 Alternator Power
- 14 Three-Phase Motor Starter
- 15 Frequency Conversion
- 16 Reactance and Frequency
- 17 Selsyn Control

**Phase-Shifting with Transformers (Workbook) (583981 (27082-00))**

- 1 Phase Shifting with Transformers

**The Wound-Rotor Induction Motor and Applications (Workbook) (584327 (35064-00))**

- 1 The Wound-Rotor Induction Motor – Part I
- 2 The Wound-Rotor Induction Motor – Part II
- 3 The Wound-Rotor Induction Motor – Part III
- 4 Frequency Conversion
- 5 Reactance and Frequency
- 6 Selsyn Control

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

- 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

## System Specifications

| Parameter | Value |
|---|---|
| **System Requirements** | |
| Maximum Current | 15 A |

| Parameter | Value |
|---|---|
| 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 |
| **Physical Characteristics** | |
| Intended Location | On the floor (stands on casters) |
| Dimensions (H x W x D) | 900 x 930 x 530 mm (35.4 x 36.6 x 20.9 in) |
| Net Weight | 371 kg (816 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) |

## 0.2 kW Electromechanical Training System 587278 (8001-60)

The 0.2 kW Electromechanical Training System (EMS) is a modular instructional program designed to teach electric power technology through laboratory observations.

The training system is supported by a 65-experiment laboratory manual, "Investigations in Electric Power."

### List of Equipment

| Qty | Description | Model number |
|---|---|---|
| 1 | Investigations in Electric Power Technology (Student Manual) | 583758 (11627-00) |
| 1 | Investigations in Electric Power Technology (Instructor Guide) | 583759 (11627-01) |
| 1 | Mobile Workstation | 579755 (8110-20) |
| 1 | Storage Shelves | 579756 (8150-10) |
| 1 | DC Motor/Generator | 579759 (8211-00) |
| 1 | Four-Pole Squirrel-Cage Induction Motor | 579491 (8221-00) |
| 1 | Three-Phase Wound-Rotor Induction Machine | 586320 (8231-00) |
| 1 | Synchronous Motor/Generator | 586351 (8241-00) |
| 1 | Capacitor-Start Motor | 579767 (8251-00) |
| 1 | Capacitor-Run Motor | 586390 (8253-00) |
| 1 | Universal Motor | 579774 (8254-00) |
| 2 | Resistive Load | 763359 (8311-00) |
| 1 | Inductive Load | 763362 (8321-00) |
| 2 | Capacitive Load | 763366 (8331-00) |
| 3 | Fully Protected Transformer | 763419 (8341-20) |
| 1 | DC Voltmeter/Ammeter | 581397 (8412-00) |
| 1 | AC Ammeter | 581406 (8425-00) |
| 1 | AC Voltmeter | 581413 (8426-00) |
| 1 | Single-Phase Wattmeter | 586514 (8431-20) |
| 1 | Three-Phase Wattmeter | 586521 (8441-20) |
| 1 | Synchronizing Module | 586738 (8621-00) |
| 1 | Three-Phase Rheostat | 586786 (8731-00) |
| 1 | Variable Three-Phase Power Supply | 579603 (8821-20) |

| Qty | Description | Model number |
|---|---|---|
| 1 | Electrodynamometer, Imperial Units | 586856 (8911-00) |
| 1 | Digital Tachometer | 581427 (8920-40) |
| 1 | Timing Belt | 579637 (8942-00) |
| 1 | Connection Lead Set | 581428 (8951-00) |
| 1 | Thyristor Speed Controller | 587007 (9017-00) |

## List of Manuals

| Description | Manual number |
|---|---|
| Investigations in Electric Power Technology (Workbook) | 583758 (11627-00) |
| Investigations in Electric Power Technology (Workbook (Instructor)) | 583759 (11627-01) |
| Phase-Shifting with Transformers (Workbook) | 583981 (27082-00) |
| The Wound-Rotor Induction Motor and Applications (Workbook) | 584327 (35064-00) |
| The Capacitor-Run Motor (Workbook) | 584328 (35065-00) |
| Electric Power Technology Training Equipment (User Guide) | 584778 (38486-E0) |

## Table of Contents of the Manual(s)

**Investigations in Electric Power Technology (Workbook) (583758 (11627-00))**

- 30 The DC Series Generator
- 31 The Split-Phase Inductor Motor – Part I
- 32 The Split-Phase Inductor Motor – Part II
- 33 The Split-Phase Inductor Motor – Part III
- 34 The Capacitor-Start Motor
- 35 The Capacitor-Run Motor
- 36 The Universal Motor – Part I
- 37 The Universal Motor – Part II
- 38 The Repulsion Start-Induction Run Motor (optional)
- 39 The Single-Phase Transformer
- 40 Transformer Polarity
- 41 Transformer Regulation
- 42 The Autotransformer
- 43 Transformers in Parallel
- 44 The Distribution Transformer
- 45 Three-Phase Circuits
- 46 Three-Phase Watts, Vars, and Volt-Amperes
- 47 Three-Phase Power Measurement
- 48 Three-Phase Transformer Connections
- 49 The Wound-Rotor Induction Motor – Part I
- 50 The Wound-Rotor Induction Motor – Part II
- 51 The Wound-Rotor Induction Motor – Part III
- 52 The Squirrel-Cage Induction Motor
- 53 The Synchronous Motor – Part I
- 54 The Synchronous Motor – Part II
- 55 The Synchronous Motor – Part III
- 56 The Three-Phase Alternator
- 57 The Alternator Under Load
- 58 Alternator Synchronization
- 59 Alternator Power
- 60 Phase Sequence
- 61 Frequency Conversion
- 62 Reactance and Frequency
- 63 Three-Phase to Two-Phase Conversion
- 64 Selsyn Control
- 65 Thyristor Speed Controllers
- 66 Thyristor Speed Controllers with Regulation

**Phase-Shifting with Transformers (Workbook) (583981 (27082-00))**

- 1 Phase Shifting with Transformers

**The Wound-Rotor Induction Motor and Applications (Workbook) (584327 (35064-00))**

- 1 The Wound-Rotor Induction Motor – Part I
- 2 The Wound-Rotor Induction Motor – Part II
- 3 The Wound-Rotor Induction Motor – Part III
- 4 Frequency Conversion
- 5 Reactance and Frequency
- 6 Selsyn Control

**The Capacitor-Run Motor (Workbook) (584328 (35065-00))**

- 1 The Capacitor-Run Motor

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

- 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

## Software

| Qty | Description | Model number |
|---|---|---|
| 1 | Complete Function Set | 581435 (8968-00) [15] |
| 1 | Standard Functions (computer-based control) Set | 581437 (8968-20) [16] |
| 1 | Electromechanical Systems Simulation Software (LVSIM®-EMS) - 1 User Online, 1 year | 586971 (8972-00) [17] |
| 1 | Electromechanical Systems Simulation Software (LVSIM®-EMS) - 5 Users Online, 1 year | 586974 (8972-A0) [18] |
| 1 | Electromechanical Systems Simulation Software (LVSIM®-EMS) - 10 Users Online, 1 year | 586977 (8972-B0) [19] |
| 1 | Electromechanical Systems Simulation Software (LVSIM®-EMS) - 15 Users Online, 1 year | 586980 (8972-C0) [20] |
| 1 | Electromechanical Systems Simulation Software (LVSIM®-EMS) - 20 Users Online, 1 year | 586983 (8972-D0) [21] |
| 1 | Electromechanical Systems Simulation Software (LVSIM®-EMS) - 25 Users Online, 1 year | 586986 (8972-E0) [22] |
| 1 | Electromechanical Systems Simulation Software (LVSIM®-EMS) - 30 Users Online, 1 year | 586989 (8972-F0) [23] |
| 1 | Electromechanical Systems Simulation Software (LVSIM®-EMS) - 35 Users Online, 1 year | 586992 (8972-G0) [24] |
| 1 | Electromechanical Systems Simulation Software (LVSIM®-EMS) - 40 Users Online, 1 year | 586995 (8972-H0) [25] |
| 1 | SCADA for LVDAC-EMS | 8094377 (8973-00) [26] |
| 1 | Complete Function Set | 581451 (9069-00) [27] |
| 1 | Synchroscope Function | 579789 (9069-C0) [28] |

## System Specifications

| Parameter | Value |
|---|---|
| **System Requirements** | |
| Maximum Current | 15 A |

[15] Additional firmware for the optional Four-Quadrant Dynamometer/Power Supply.
[16] Additional firmware for the optional Four-Quadrant Dynamometer/Power Supply.
[17] Simulation software that covers these topics and more.
[18] Simulation software that covers these topics and more.
[19] Simulation software that covers these topics and more.
[20] Simulation software that covers these topics and more.
[21] Simulation software that covers these topics and more.
[22] Simulation software that covers these topics and more.
[23] Simulation software that covers these topics and more.
[24] Simulation software that covers these topics and more.
[25] Simulation software that covers these topics and more.
[26] Allows monitoring of up to 5 Stations through OPC.
[27] Additional firmware for the optional Data Acquisition.
[28] Additional firmware for the optional Data Acquisition.

| Parameter | Value |
|---|---|
| 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 |
| **Physical Characteristics** | |
| Intended Location | On the floor (stands on casters) |
| Dimensions (H x W x D) | 900 x 930 x 530 mm (35.4 x 36.6 x 20.9 in) |
| Net Weight | 440 kg (970 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

## Mobile Workstation 579755 (8110-20)

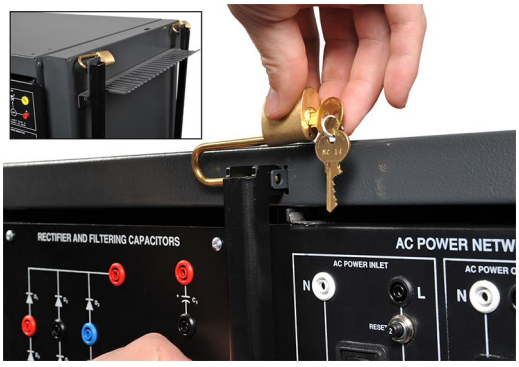
The Mobile Workstation is a ready-for-use workstation that consists of two fully assembled modules: a Workstation mounted on a Mobile Storage Cabinet. Four rubber-tire swivel casters allow easy movement of the workstation in the laboratory classroom. The lower portion of the workstation serves as a storage 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))**

- 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

## 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) |

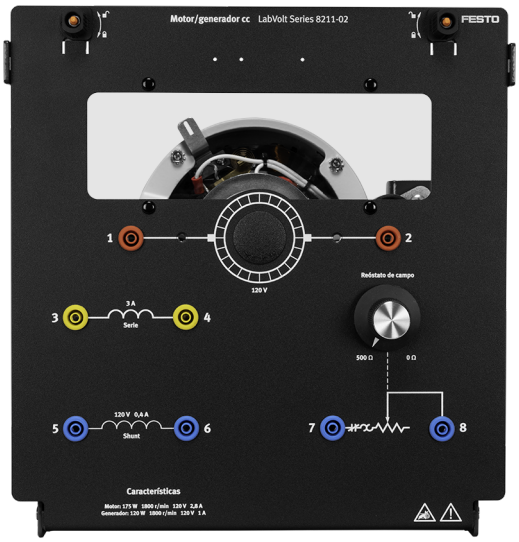
## Storage Shelves 579756 (8150-10)

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.

## 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 510 mm (78 x 48.2 x 20.1 in) |
| Net Weight | TBE |

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



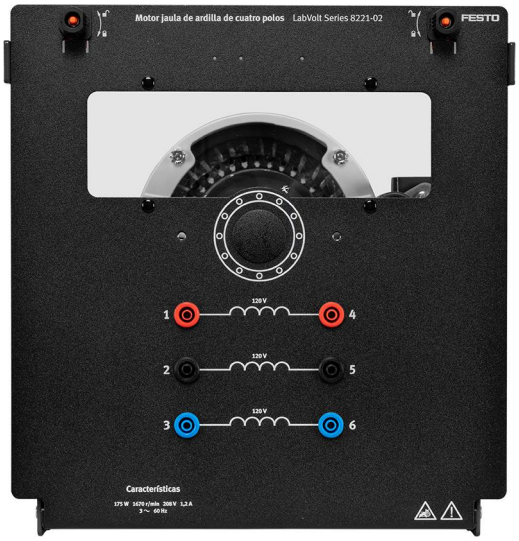

The DC Motor/Generator is a dc machine mounted in a full-size EMS module. It can operate independently as a dc motor or a dc generator. The armature, shunt field, and series field windings are terminated separately on the faceplate to permit long and short shunt as well as cumulatively and differentially 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 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) |

## Four-Pole Squirrel-Cage Induction Motor 579491 (8221-00)



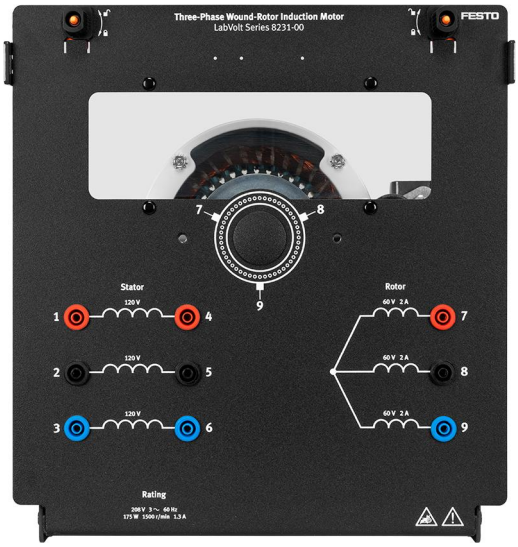

The Four-Pole Squirrel-Cage Induction Motor is a 0.2 kW squirrel-cage induction machine mounted in a full-size EMS module. The machine stator windings are independently connected (six jacks), allowing connection in either wye or delta configuration. Connections to the machine are made through color-coded safety banana jacks located on the front panel on the module.

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

## Specifications

| Parameter | Value |
|---|---|
| **Ratings** | |
| Stator Voltage | 120/208 V, 60 Hz, 3-phase |
| Mechanical Power | 175 W |
| Nominal Speed | 1670 r/min |
| Nominal Current | 1.2 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 | 13.5 kg (29.7 lb) |

## Three-Phase Wound-Rotor Induction Machine 586320 (8231-00)




The Three-Phase Wound-Rotor Induction Machine is a rotating machine mounted in a full-size EMS module. Each phase of the stator windings is independently terminated and identified on the faceplate to permit operation in either delta or star (wye) configuration. The rotor windings are brought out to the faceplate via external slip rings and brushes. This machine can be used as a wound-rotor induction motor, phase shifter, single-phase variable coupling transformer, three-phase transformer, selsyn control, frequency converter or asynchronous induction generator. The speed of the machine can be controlled through the use of the Three-Phase Rheostat.

This version has a 2:1 turn ratio on the rotor, which is optimized for using with a rotor rheostat. There is also a different version that has a higher turn ratio on the rotor, to be used as a DFIG.

## List of Manuals

| Description | Manual number |
|---|---|
| Phase-Shifting with Transformers (Workbook) | 583981 (27082-00) |
| The Wound-Rotor Induction Motor and Applications (Workbook) | 584327 (35064-00) |

## Table of Contents of the Manual(s)

### Phase-Shifting with Transformers (Workbook) (583981 (27082-00))

- 1 Phase Shifting with Transformers

### The Wound-Rotor Induction Motor and Applications (Workbook) (584327 (35064-00))

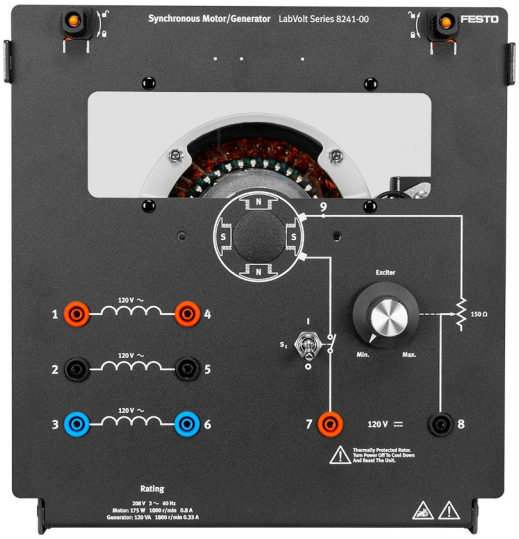
- 1 The Wound-Rotor Induction Motor – Part I
- 2 The Wound-Rotor Induction Motor – Part II
- 3 The Wound-Rotor Induction Motor – Part III
- 4 Frequency Conversion
- 5 Reactance and Frequency
- 6 Selsyn Control

## Specifications

| Parameter | Value |
|---|---|
| **Power Requirement** | 120/208 V |

| Parameter | Value |
|---|---|
| **Rating** | |
| Output Power | 175 W |
| Stator Voltage | 120/208 V, 3-phase |
| Rotor Voltage | 60/104 V, 3-phase |
| Full-Load Speed | 1500 r/min |
| Full-Load Current | 1.3 A |
| **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 | 14 kg (30.8 lb) |

## Synchronous Motor/Generator 586351 (8241-00)




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.

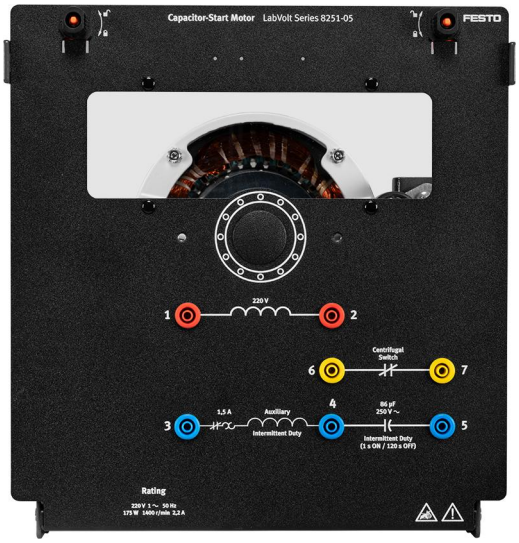
Connections to the machine are made through color-coded safety banana jacks located on the front panel of the module. This front panel can be opened to install a Timing Belt on the pulley of the machine shaft. This permits mechanical coupling of the machine to the dynamometer or prime mover.

Note that the coupling can only be done on the right side of the machine. If you require a coupling on the left side, please contact your sales representative.

### Specifications

| Parameter | Value |
|---|---|
| **Motor** | |
| Stator Voltage | 120/208 V, 60 Hz, 3-phase |
| Rotor Voltage | 120 V dc |
| Output Power | 175 W |
| Synchronous Speed | 1800 r/min |
| Full-Load Current | 0.8 A |
| **Generator** | |
| Stator Voltage | 120/208 V, 60 Hz, 3-phase |
| Rotor Voltage | 120 V dc |
| Output Power | 120 VA |
| Synchronous Speed | 1800 r/min |
| Nominal Output Current | 0.33 A |
| **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 | 14 kg (30.8 lb) |

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

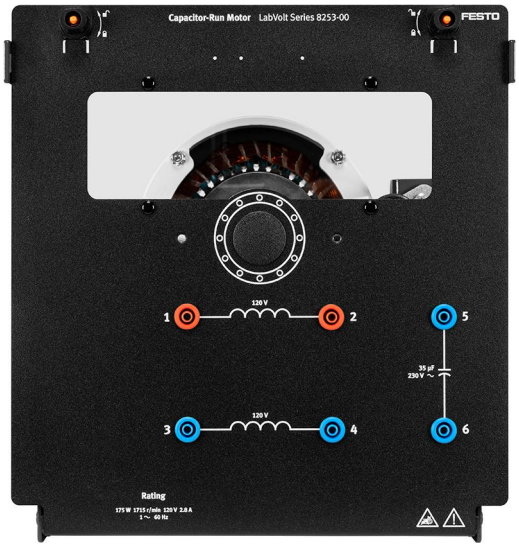



The Capacitor-Start Motor is a 0.2 kW capacitor-start machine mounted in a full-size EMS module. The centrifugal switch and contact points of the machine are mounted externally to allow students to examine their construction and observe their operation. The switch, the starting auxiliary winding, and 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) |

## Capacitor-Run Motor 586390 (8253-00)




The Capacitor-Run Motor is fitted with a running capacitor and running windings that are independently terminated and identified on the faceplate to facilitate experimentation of various machine connections, including operation from a two-phase source of power. The design of the machine has been optimized so that it operates like a two-phase motor at full load when connected to a single-phase source.

## Manual

| Description | Manual number |
|---|---|
| The Capacitor-Run Motor (Workbook) | 584328 (35065-00) |

## Table of Contents of the Manual(s)

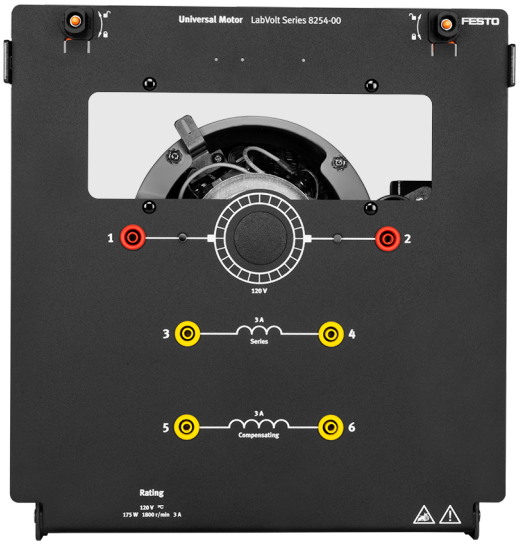
### The Capacitor-Run Motor (Workbook) (584328 (35065-00))

- 1 The Capacitor-Run Motor

## Specifications

| Parameter | Value |
|---|---|
| **Rating** | |
| Line Voltage | 120 V |
| Output Power | 175 W |
| Full Load Speed | 1715 r/min |
| Full Load Current | 2.8 A |
| **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 | 13.6 kg (29.9 lb) |

# Universal Motor 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) |

## Resistive Load
## 763359 (8311-00)

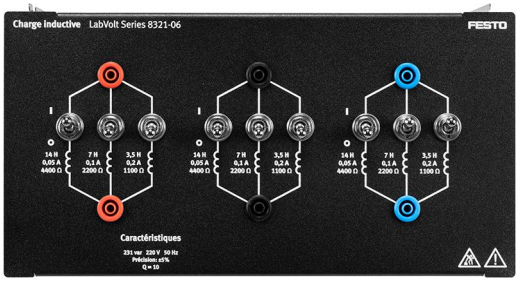
The Resistive Load consists of a module housing nine wire-wound power resistors arranged in three identical banks. Each bank consists of three resistors connected in parallel that can be switched on or off with toggle switches to obtain various resistance values. This allows the total (equivalent) resistance 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 loads 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)



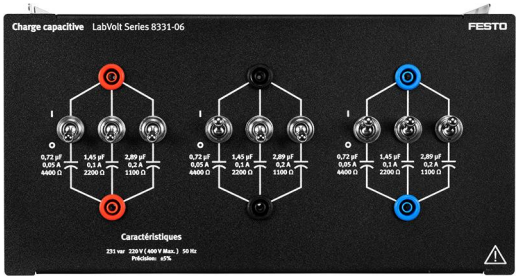

The Inductive Load consists of a module housing nine iron-core power inductors arranged in three identical banks. Each bank consists of three inductors connected in parallel that can be switched on or off with toggle switches to obtain various inductance values. This allows the equivalent inductance 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 loads 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.

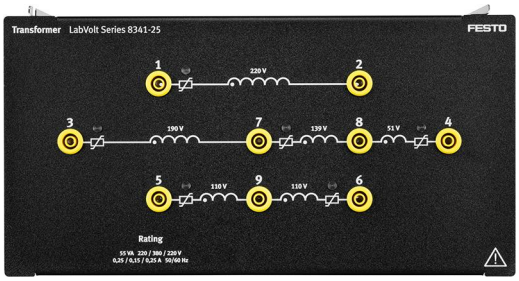
A permanently connected discharge resistor reduces the voltage across the terminals of each bank of capacitors to 5% of the applied voltage within 25 seconds after the load is disconnected from the supply. The Capacitive Load may be used with both dc and ac power.

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 loads 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 |
| 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) |

## Fully Protected Transformer 763419 (8341-20)




The Fully Protected Transformer is fitted with three discrete windings. Any winding can be used as either a primary or a secondary, which increases the number of laboratory applications. Due to its numerous taps, the Fully Protected Transformer can be used with many different input and output voltages. For this reason, it can be used for impedance matching and other transformer experimentations. By using multiple Fully Protected Transformers, students can explore transformer phasing, distribution transformers, open- and closed-delta transformer configurations, delta-wye, wye-delta, wye-wye, and delta-delta connections. Other specialized transformer connections, such as Scott (three-phase to two-phase), three-phase to six-phase, and zig-zag connections are also possible. Furthermore, resettable fuses are used to protect the windings.

The Fully Protected Transformer is mounted in a half-size EMS module. The primaries and secondaries are terminated on the module faceplate to 4 mm color-coded safety sockets and are identified by schematic symbol, terminal number, voltage and current.

### Specifications

| Parameter | Value |
|---|---|
| **Rating (Coil 1)** | |
| Voltage | 120 V ac |
| Current | 0.5 A |
| **Rating (Coil 2)** | |
| Voltage | 208 V ac |
| Current | 0.3 A |
| Taps | 50% and 86.6% |
| **Rating (Coil 3)** | |
| Voltage | 120 V ac |
| Current | 0.5 A |
| Tap | 50% |
| **Circuit-Protection Type** | 6 resettable fuses |
| **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 | 6.5 kg (14.3 lb) |

## DC Voltmeter/Ammeter 581397 (8412-00)


The DC Voltmeter/Ammeter module is an EMS metering module. It is fitted with one dc voltmeter, one dc milliammeter, and one dc ammeter. Meter ranges and scalar values of each instrument have been carefully selected for compatibility and are appropriate for the electrical values to be measured. All meter readings are direct indications and do not require the indicated value to be mentally multiplied by a constant.

All meters are diode-protected against burnout, should the students miswire a meter by range or function. This permits the greatest latitude of student involvement without fear of damaging equipment. All meters are terminated by 4 mm color-coded safety sockets.

## Specifications

| Parameter | Value |
|---|---|
| **Voltmeter Ranges** | |
| Low | 0-20 V |
| High | 200 V |
| **Milliammeter Range** | 0-500 mA |
| **Ammeter Ranges** | |
| Low | 0-2.5 A |
| High | 5 A |
| **Accuracy** | 2% |
| **Type of Instrument** | Panel meter - 65 mm (2.5 in) |
| **Type of Movement** | d'Arsonval |
| **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 | 3.5 kg (7.7 lb) |
| Shipping Weight | 5.1 kg (11.2 lb) |

# AC Ammeter
# 581406 (8425-00)


The AC Ammeter module is fitted with three separate multi-range ac ammeters for simultaneous measurement of three-phase currents. Two of the three meters have identical ranges while the third instrument has one additional higher range for measurement of the starting current of single-phase motors. Meter ranges and scalar values of each instrument have been carefully selected for compatibility and are appropriate for the electrical values to be measured. All meter readings are direct indications and do not require the indicated value to be mentally multiplied by a constant.

All meters are diode-protected against burnout, should the students miswire a meter by range or function. This permits the greatest latitude of student involvement without fear of damaging equipment. All meters are terminated by 4 mm color-coded safety sockets.

## Specifications

| Parameter | Value |
|---|---|
| **Ammeter Ranges** | |
| High (Two Meters) | 0-0.5 A / 2.5 A / 8 A |
| Low (One Meter) | 0-0.5 A / 2.5 A / 8 A / 25 A |
| **Accuracy** | 3% |
| **Type of Instrument** | Panel meter - 65 mm (2.5 in) |
| **Type of Movement** | Moving vane and current transformer |
| **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 | 4.8 kg (10.6 lb) |
| Shipping Weight | 6.4 kg (14.1 lb) |

## AC Voltmeter
## 581413 (8426-00)

The AC Voltmeter module is fitted with three separate multi-range ac voltmeters for simultaneous measurement of three-phase voltages. Meter ranges and scalar values of each instrument have been carefully selected for compatibility and are appropriate for the electrical values to be measured. All meter readings are direct indications and do not require the indicated value to be mentally multiplied by a constant.

All meters are diode-protected against burnout, should the students miswire a meter by range or function. This permits the greatest latitude of student involvement without fear of damaging equipment. All meters are terminated by 4 mm color-coded safety sockets.

### Specifications

| Parameter | Value |
|---|---|
| **Voltmeter Ranges** | |
| Low | 0-100 V ac |
| High | 250 V ac |
| **Accuracy** | 2% |
| **Type of Instrument** | Panel meter - 65 mm (2.5 in) |
| **Type of Movement** | d'Arsonval, 1000 Ω/V, and rectifier current |
| **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) |

## Single-Phase Wattmeter
## 586514 (8431-20)

The Single-Phase Wattmeter is used to indicate active power in single-phase circuits. Its electronic design uses voltage and current sensors to sample line voltage and current. Voltage and current circuits are internally connected so that students only have to connect the “line” and “load” terminals of the module.

### Specifications

| Parameter | Value |
|---|---|
| **Rating** | |
| Range | 0-750 W |
| Maximum Voltage | 150 V |
| Maximum Current | 10 A |
| **AC Power Input** | 24 V |
| **Accuracy** | 2% |
| **Type of Instrument** | Panel Type – 100 mm (4 in) |
| **Type of Movement** | d'Arsonval |

| Parameter | Value |
|---|---|
| **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 | Net: 3.6 kg (7.9 lb) |

## Three-Phase Wattmeter 586521 (8441-20)


The Three-Phase Wattmeter module is fitted with two separate wattmeters, each of which is equipped with a polarity switch. Its electronic design uses voltage and current sensors to sample line voltage and current. Voltage and current circuits are internally connected so that students only have to connect the “line” and “load” terminals of the module. The three-phase active power is the algebraic sum of the two meter indications. When used independently, each meter will indicate active power in single-phase circuits.

### Specifications

| Parameter | Value |
|---|---|
| **Rating** | |
| Range (2 Meters) | 0-300 W |
| Maximum Voltage | 300 V |
| Maximum Current | 2 A |
| **AC Power Input** | 24 V |
| **Accuracy** | 2% |
| **Type of Instrument** | Panel Type – 100 mm (4 in) |
| **Type of Movement** | d'Arsonval |
| **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 | 3.9 kg (8.6 lb) |

## Synchronizing Module 586738 (8621-00)


The Synchronizing Module is a power control device enclosed in a half-size EMS module. The Synchronizing Module is mainly used to synchronize two ac generators. It can also be used to determine the phase sequence in three-phase circuits. The synchronizing Module has three indicator lamps indicating the relative voltage difference between two circuits. The brightness of the indicator lamps increases with the voltage difference between the two circuits. The Synchronizing Module has a three-phase switch mounted on the module front panel. This three-phase switch is a triple-pole, single-throw switch. Each phase leg of the three-phase switch is protected against overcurrents and short-circuits by a thermal-magnetic circuit breaker.

### Specifications

| Parameter | Value |
|---|---|
| **Rating** | |
| Each Phase | 240 V – 2 A ac |
| Light Bulbs | 130 V – 2.6 W – BA9S |
| Circuit Breakers | 2 A |

| 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 | 3.6 kg (7.9 lb) |

## Manual DC Motor Starter 586745 (8631-00)

The Manual DC Motor Starter can be wired as either a three or four point dc starter to be used in conjunction with the DC Motor/Generator, Model 8211. The module has a fitted, manually operated handle for variable resistance starting. When it is in the full-run position, the handle is held in place by an electromagnet. In the event of field loss, the holding electromagnet is de-energized and the starting handle is returned to the off position by a stiff spring.

### Specifications

| Parameter | Value |
|---|---|
| **Rating** | |
| Motor Power | 0.2 kW |
| Line Voltage | 120 V dc |
| Armature Starting Current | 3 A |
| Full Load Current | 3 A |
| Maximum Field Current | 0.4 A |
| **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 | 5.9 kg (13 lb) |
| Shipping Weight | 7.5 kg (16.5 lb) |

## Synchronous Motor Starter 586751 (8641-00)

The Synchronous Motor Starter is designed to start the Three-Phase Synchronous Motor/Generator directly from the ac power network. The module consists of a three-pole magnetic contactor and a built-in dc power source which applies dc voltage to the field winding when the rotor speed reaches approximately 90% of the machine synchronous speed. A pilot lamp indicates that the motor is synchronized with the ac power network when dc voltage is applied to the machine. Industrial push-button controls are mounted on the front panel of the module. The I button must be depressed and held until the Motor Synchronized indicator lights up (releasing the I push-button before the machine is synchronized prevents three-phase ac current from flowing into the synchronous machine). The Synchronous Motor Starter contains an overload protection to prevent damage to the machine. Connections are made through 4 mm color-coded jacks.

## Specifications

| Parameter | Value |
|---|---|
| **Rating** | |
| Motor Power | 0.2 kW |
| Line Voltage | 208 V ac, 3-Phase |
| Full Load Current | 1 A |
| Maximum Field Current | 0.8 A |
| **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 | 5.8 kg (12.8 lb) |
| Shipping Weight | 7.4 kg (16.3 lb) |

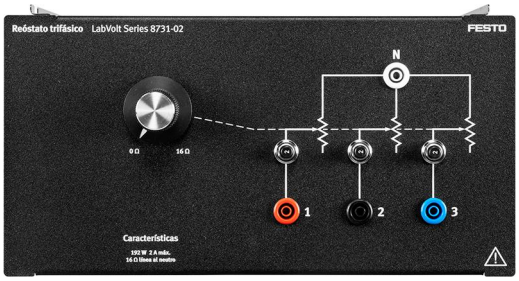
## Three-Phase Full-Voltage Starter 586758 (8651-00)

The Three-Phase Full-Voltage Starter is designed to start the Four-Pole Squirrel-Cage Induction Motor and Three-Phase Wound-Rotor Induction Motor directly from the ac power network. The module consists of a three-pole magnetic contactor with a variable overload relay. The components are interconnected to the line and load terminals. A power-on pilot lamp and I and O push-buttons are also mounted on the module faceplate. The auxiliary contacts of the main contactor can be accessed for use as an interlock in control circuits. Connections are made through 4 mm color-coded jacks.

## Specifications

| Parameter | Value |
|---|---|
| **Rating** | |
| Motor Power | 0.2 kW |
| Line Voltage | 208 V ac, 3-Phase |
| Full Load Current | 1.1 A |
| Reduced Voltage Starting Time | 20 s |
| **Physical Characteristics** | |
| Dimensions (H x W x D) | 156 x 287 x 440 mm (6.1 x 11.3 x 17.3 in) |
| Net Weight | 4.4 kg (9.7 lb) |
| Shipping Weight | 6 kg (13.2 lb) |

## Three-Phase Rheostat 586786 (8731-00)



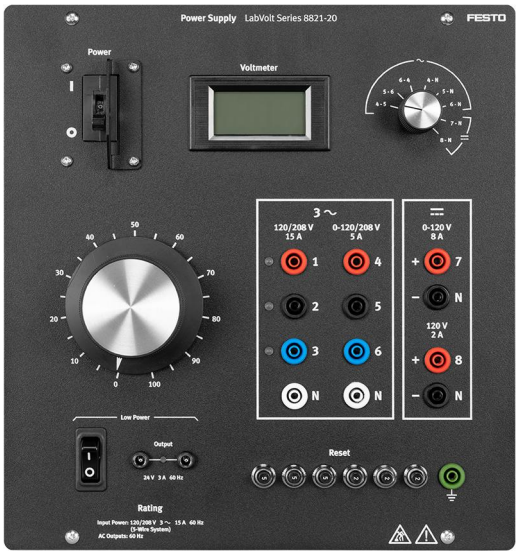

The Three-Phase Rheostat module consists of three rheostats mounted on a common shaft directly controlled by a single knob on the module faceplate. The rheostats are electrically interconnected in a four-wire wye configuration and each leg is protected from over-current conditions by a thermal-magnetic circuit breaker.

The module is mainly used for speed control of a Three-Phase Wound-Rotor Induction Motor., Model 8231. This module can also be used for other applications where a variable power resistor is needed.

## Specifications

| Parameter | Value |
|---|---|
| **Rating** | |
| Resistance (line-neutral) | 16 Ω |
| Total Power | 192 W |
| Maximum Current (per phase) | 2 A |
| **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 | 4.9 kg (10.8 lb) |
| Shipping Weight | 6.5 kg (14.3 lb) |

## Variable Three-Phase Power Supply 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 (three-phase half-wave rectified without filtering capacitor) |
| Fixed DC | 120 V – 2 A (three-phase half-wave rectified with 94µF capacitor) |
| Low Power AC | 24 V – 3 A - 60 Hz |
| **Included Accessories** | |
| | 3 m (10 ft) AC power cord (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 |

| Parameter | Value |
|---|---|
| | 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. |

## Electrodynamometer, Imperial Units 586856 (8911-00)


The Electrodynamometer is made of a squirrel-cage rotor fitted in a dc-excited stator. Mechanical loading is achieved by increasing the stator field current, which generates eddy currents in the driven rotor. The stator is trunnion-mounted on ball bearings and rotates against a helicoidal spring to oppose braking torque.

The front-end bell is provided with a circular scale that indicates the torque developed. The circular scale is graduated in Imperial units (lbf·in). A damper lever is located underneath the dynamometer to prevent oscillation if the power supply is applied while the dynamometer is turning. To measure the torque, this lever can be pushed to adjust and read the torque. The Electrodynamometer is electrically powered from standard fixed ac line supply.

The Electrodynamometer can be coupled to a 0.2 kW drive motor through the use of the Timing Belt, Model 8942. The faceplate can be lowered to provide access to the inside for coupling the Electrodynamometer to the drive motor. When closed, the faceplate is secured by two quick-lock fasteners.

A variant of the model expressing values in the International System of Units (SI) is also available (see Model 8911-1).

### Specifications

| Parameter | Value |
|---|---|
| **Rating** | |
| Torque Range (8911) | -3 to +27 lbf·in |
| Speed | 250 to 3000 r/min |
| Accuracy | 2% |
| Input Voltage | 120 V – AC |
| Input Current | 2 A |
| **Physical Characteristics** | |
| Dimensions (H x W x D) | 308 x 291 x 490 mm (12.1 x 11.5 x 19.3 in) |
| Net Weight | 17.4 kg (38.3 lb) |

## Digital Tachometer
## 581427 (8920-40)

The Digital Tachometer indicates motor rotation speed either in a clockwise or counterclockwise direction. The measured speed is automatically indicated on a five-digit display and is updated every second to enable measurement of acceleration and deceleration.

Coupling to the shaft of a motor is accomplished through a rubber tip attached to the Digital Tachometer. The optical sensor can also be used with a reflective tape to read motor speed. Designed to fit comfortably in either the right or left hand, the tachometer is constructed to withstand years of rugged use.

### Specifications

| Parameter | Value |
|---|---|
| **Direction of Rotation** | CW and CCW |
| **Speed Range** | 0.5-19 999 r/min (Contact Tacho) / 5-99999 r/min (Photo Tacho) |
| **Accuracy** | 0.05% + 1 digit |
| **Resolution (up to 999.9 r/min)** | 0.1 r/min |
| **Resolution (1000 r/min and above)** | 1 r/min |
| **Sampling Time** | 1 s (for speeds › 60 r/min) |
| **Display** | 5 digits |
| **Memory Hold Time** | 5 minutes after measurement |
| **Power** | Four 1.5 V AA cells |
| **Accessories Included** | Rubber contact tip, rubber contact ring, instruction manual, storage case, reflective tape, and batteries |
| **Physical Characteristics** | |
| Dimensions (H x W x D) | 80 x 250 x 120 mm (3.1 x 9.8 x 4.7 in) |
| Net Weight | 0.61 kg (1.34 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) |

## Digital Multimeter
## 579782 (8946-20)


The Digital Multimeter consists of an Extech EX350 Digital Multimeter. 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) |

## Connection Lead Set
## 581428 (8951-00)

This Connection Lead Set consists of extra-flexible leads terminated with stacking 4 mm safety banana plugs. The leads are supplied in different lengths and are color-coded according to length.

4mm: 10 x 30 cm yellow, 15 x 60 cm red, 6 x 90 cm blue.

### 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) | 10 |
| Red, 60 cm (24 in) | 15 |
| Blue, 90 cm (36 in) | 6 |

## Thyristor Speed Controller 587007 (9017-00)


The Thyristor Speed Controller is designed to control the speed of the DC Motor/Generator in both the open-loop and closed-loop modes of control.

The Thyristor Speed Controller module contains a thyristor single-phase bridge rectifier installed in a full-height EMS module. Speed control of the dc motor is achieved by varying the firing angle of the thyristors. In the open-loop mode of control, the firing angle is set manually using a potentiometer, while, in the closed-loop mode, it is set by a controller which compares the motor armature voltage to a voltage reference set by the user. The mode of control is selectable using a toggle switch. Other parameters that can be controlled using the Thyristor Speed Controller include ramp control, IR compensation, and current limit. These controls are accessible directly on the faceplate of the module.

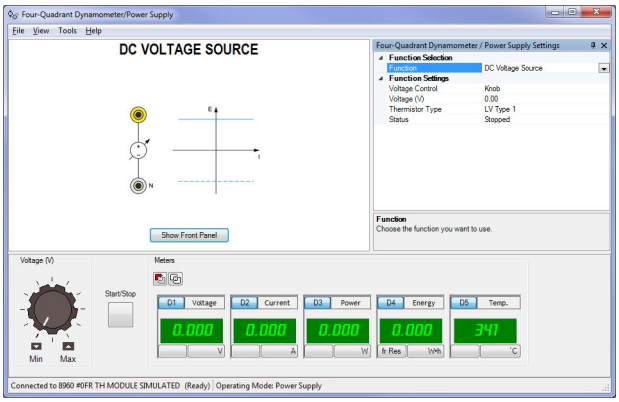
Schematic symbols and their electrical interconnections are silk-screened on the faceplate of the module. Components are terminated by 4 mm color-coded safety sockets where student access is required.

### Specifications

| Parameter | Value |
|---|---|
| **Power Requirements** | 120-240 V – 5 A – 50/60 Hz |
| **Variable DC Bus** | |
| Voltage | 0-100 V |
| Current | 3 A |
| **Fixed DC Bus** | |
| Voltage | 100 V |
| Current | 1 A |
| **Physical Characteristics** | |
| Dimensions (H × W × D) | 308 × 287 × 450 mm (12.1 x 11.3 x 17.7 in) |
| Net Weight | 5 kg (2.2 lb) |

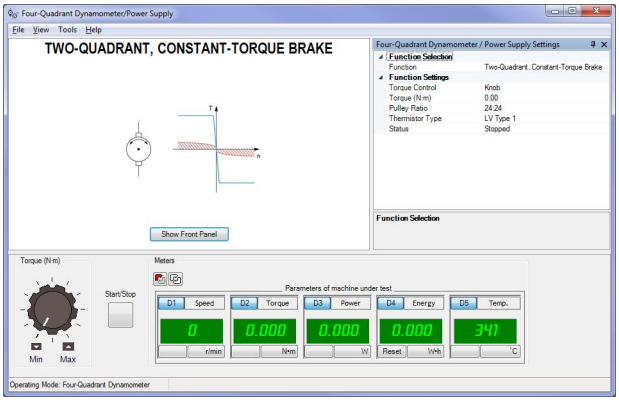
# Optional Equipment Description

## Complete Function Set (Optional) 581435 (8968-00)




This Model activates all currently available control function sets for the Four-Quadrant Dynamometer/ Power Supply, Model 8960-3. See individual control functions sets, Model 8968-X, for more information on the included functions.

## Standard Functions (computer-based control) Set (Optional) 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, 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

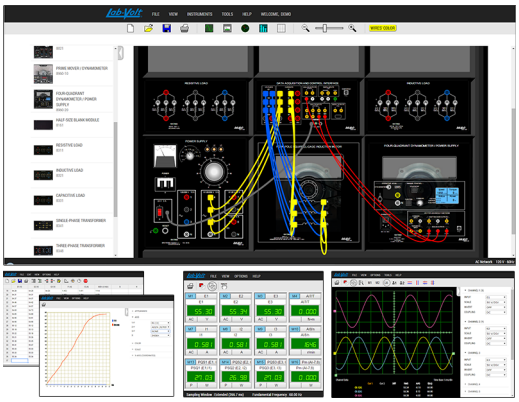
### Specifications

| Parameter | Value |
|---|---|
| **Control Functions** | |
| Control Functions | Two-Quadrant, Constant-Torque Brake |

| Parameter | Value |
|---|---|
| | 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 |
| | 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** | |

| Parameter | Value |
|---|---|
| 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** | |
| 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 |

## Electromechanical Systems Simulation Software (LVSIM®-EMS) - 1 User Online, 1 year (Optional) 586971 (8972-00)



The Electromechanical Systems Simulation Software (LVSIM®-EMS) is a simulation software that covers the same courseware as the following systems:

Computer-Assisted 0.2 kW Electromechanical Training System, Model 8006-1
DC and AC Power Circuits Training System, Model 8010-1
Electromechanical Training System, Model 8010-9
AC Power Transmission Training System, Model 8010-B

All workbooks parts of the systems above are available in the navigation menu of LVSIM-EMS for online consultation. To obtain the printing rights, Campus Licenses for each are available and must be ordered separately.

With LVSIM-EMS, all the standard EMS laboratory equipment is replaced by images of the actual EMS modules that students can manipulate on the computer screen. Students can identify and set up equipment for a given exercise, make the necessary connections between the virtual EMS modules, and verify the connections made without the need for actual EMS equipment.

Sophisticated mathematical models fully simulate the electrical and mechanical characteristics of all the actual EMS modules: power supplies, motors, generators, transformers, electrical and mechanical loads, etc. All modules simulated in the LVSIM-EMS software feature the same front panel information as the actual EMS modules. Short-circuit connections in the virtual equipment setup cause the virtual circuit-breaker protection to trip. This trip condition is clearly indicated on the virtual EMS modules.

Used either as a complement to the actual EMS laboratory equipment, or as a stand-alone product, LVSIM-EMS is a cost-effective tool that enables students to perform the same exercises as in the courseware of the above-mentioned training systems. When used as a stand-alone package, the LVSIM-EMS software allows students to perform hands-on activities related to electrical power and machines, including active, reactive, and apparent power, phasors, ac/dc motors and generators, three-phase circuits, and transformers.

LVSIM-EMS is a web-browser based application **available in three different configurations.** The simulation software can either be installed locally on a Windows® personal computer (local version), on a Windows server (network version), or accessed directly online through the labvolt.com website at lvsim.labvolt.com (online

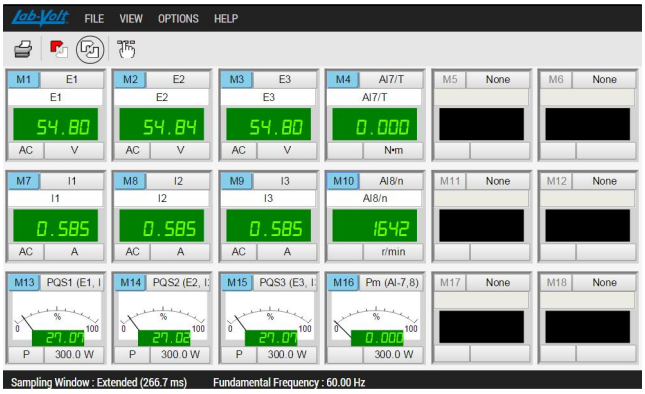
version). Both network and local versions are delivered with perpetual license for the current version. The online version is delivered as a annual license with possibility to expand for more years.

Please visit https://lvsim.labvolt.com and try the online version!

## Virtual Instrumentation

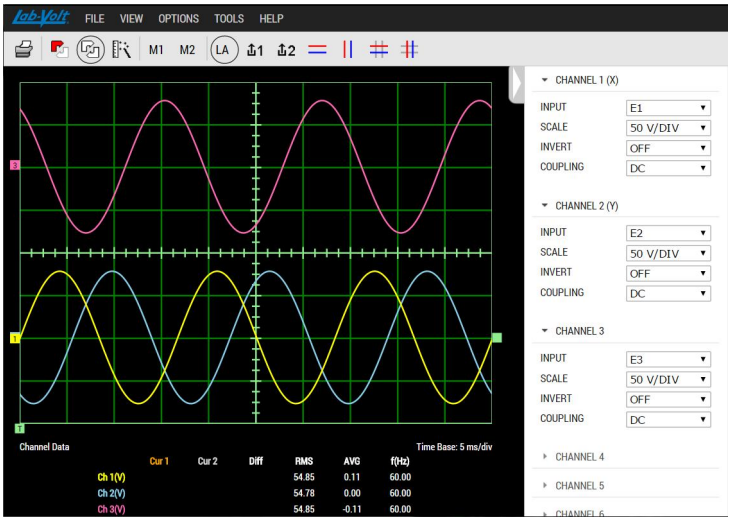
LVSIM-EMS comprises a set of conventional and specialized instruments that can be used for measuring, observing, and analyzing electrical and mechanical parameters in electric power systems and power electronic circuits. Each instrument appears as a window on the computer screen. The conventional instruments include ac/dc voltmeters and ammeters, power meters, and an eight-channel oscilloscope. The specialized instruments include a six-channel phasor analyzer, a harmonic analyzer, torque, speed, and mechanical power meters, and user-programmable meters. The software is also provided with data-recording and graph-plotting capabilities. The various instruments are briefly described in the next section of this datasheet.

## Metering Window



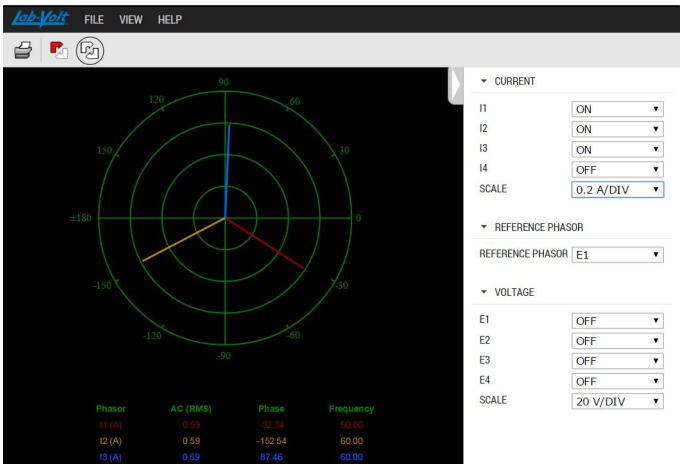

The Metering window displays up to eighteen meters, which can be configured individually for measuring ac/dc voltage and current, electrical power (active, reactive, and apparent), torque, speed, mechanical power, etc. The voltage and current meters have several modes of operation that allow measurement of the mean (dc) value, RMS value, crest factor, RMS value of a particular harmonic (up to the 15th value), RMS value of the harmonics, and total harmonic distortion (THD). Six of the eighteen meters are user-programmable and give access to a larger variety of functions for measurement of power factor, efficiency, impedance, frequency, energy, phase shift, etc. The layout of the meters in the Metering window is user-customizable.

## Oscilloscope




The Oscilloscope displays up to eight waveforms simultaneously, each of a different color for easy identification. Each channel has independent vertical controls similar to those found on conventional oscilloscopes. An automatic scale-setting function allows the sensitivity of each channel to be set automatically according to the magnitude of the observed parameter. The time base and trigger controls are similar to those found on most oscilloscopes. The RMS value, average value, and frequency of each observed parameters can be displayed in the Oscilloscope window. Two vertical cursors can be activated to perform precise measurements at particular points on the displayed waveforms. The Oscilloscope toolbar includes two memory buttons for saving displayed waveforms.

## Phasor Analyzer

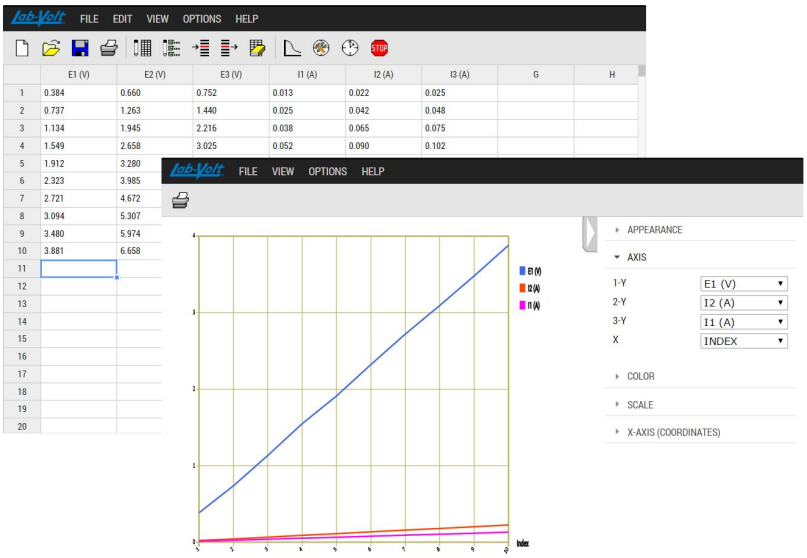



The Phasor Analyzer displays the phasors related to the measured voltages and currents. The amplitude and phase angle of each voltage and current is clearly represented by the orientation and length of their corresponding phasors, allowing easy comparison between the displayed parameters. This produces a unique and dynamic display of the voltages and currents in a circuit (especially in three-phase circuits) that cannot be obtained with conventional instruments. The RMS value, phase angle, and frequency of the voltage or current related to each phasor is displayed in the Phasor Analyzer window.

## Harmonic Analyzer


The Harmonic Analyzer allows observation and analysis of the harmonic components in the measured voltages and currents. The fundamental frequency can be manually set to the ac power network frequency or automatically set to the frequency of the fundamental component of the selected voltage or current. The harmonic components of the selected voltage or current can be displayed using a vertical scale graduated in either absolute or relative values. A group of data displays in the Harmonic Analyzer indicates the values of the dc component of the selected voltage or current, as well as the total harmonic distortion (THD). Vertical and horizontal cursors can be displayed to perform precise measurements at particular points on the display. Since the equipment simulated by LVSIM-EMS produces only dc and sinusoidal ac signals (without harmonics), the Harmonic Analyzer, which is intended for use with devices that produce harmonics, is not often used with LVSIM-EMS.

## Data Table and Graph Windows




The values indicated by the various meters in the Metering window, as well as values measured by the other instruments, can be recorded in the Data Table window with a click of the mouse. The values recorded in the Data Table can be saved to a file (ASCII-formatted file). The recorded data can also be used to plot graphs by selecting which parameter(s) to plot in the Graph window. This allows lab results to be plotted quickly and easily. More sophisticated graphs can be created by exporting the contents of the Data Table window to any spreadsheet program, such as Microsoft Excel®, directly through the Windows Clipboard.

## Software Protection and Licensing

The local and network version provides a perpetual licence and the online access version provides a annual licence (additional years can be purchased when ordering).

The local and network version of LVSIM-EMS are copy-protected by means of a hardlock security device. When LVSIM-EMS detects the security device, students have complete access to all measuring functions of the virtual instruments and other protected features of LVSIM-EMS, as well as to the student manuals included with the simulation software. Note that students are allowed to copy the software onto their personal computer to allow them to prepare laboratories in advance.

Two different security devices are available for LVSIM-EMS: a single-user hardlock key, which can be inserted in the USB port of the user's computer, and a multiple-user hardlock key, which can be inserted in the USB port of the network server or any computer in the same network. Once the hardlock key is active on the network, the other computer will see the available licences. Alternately, the multiple-user hardlock key can be inserted in a USB port inside the server using a circuit board with edge-type connector (provided with the key) that can be installed in a PCI expansion slot of the server.

The multiple-user hardlock key can be installed in servers running under one of the following Microsoft® operating systems: Windows 7, Windows 8, Windows 10, Windows 2008 Server, and Windows 2013 Server. As its name indicates, the multiple-user hardlock key allows several users of a network to run LVSIM-EMS simultaneously. Different versions of LVSIM-EMS are available, each allowing a particular number of users.

## Online Edition

The online version of LVSIM-EMS is accessible directly via the internet, and requires no software installation nor any update since the latest version of the software is always available. The online version of LVSIM-EMS also includes a demo mode that allows students to prepare laboratories in advance by familiarizing with the equipment and connections. The demo mode does not require any login.

## Computer Requirements

Local and Network Versions:

- One (1) USB 2.0 port for the security dongle, Microsoft Windows 10 operating system recommended (compatible with Windows 7 and 8), basic dual core CPU, Google Chrome web browser installed (for better experience)

Online Version:

- Microsoft Windows 10 operating system recommended (compatible with Windows 7 and 8 but not fully compatible with mobile devices), basic dual core CPU, internet access (bandwidth usage of 50 KB/s maximum), Google Chrome web browser installed (for better experience)

## List of Manuals

| Description | Manual number |
|---|---|
| Electromechanical Systems Simulation Software (User Guide) | 583879 (20858-E0) |
| Computer-Based Instruments for EMS (User Guide) | 584396 (36221-E0) |

## Table of Contents of the Manual(s)

**Electromechanical Systems Simulation Software (User Guide) (583879 (20858-E0))**

- 1 Overview of LVSIM-EMS
- 2 Installing the Security Device
- 3 Installing and Running LVSIM-EMS

**Computer-Based Instruments for EMS (User Guide) (584396 (36221-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

## Topic Coverage

- Fundamentals for Electric Power Technology
- Alternating Current
- Capacitors in AC Circuits
- Inductors in AC Circuits
- Power, Phasors, and Impedance in AC Circuits
- Three-Phase Circuits
- Special Transformer Connections
- Single- and three-Phase Transformers
- Fundamentals for Rotating Machines
- DC Motors and Generators
- Special Characteristics of DC Motors
- AC Induction and Synchronous Motors
- Three-Phase Synchronous Generators

## Features & Benefits

- Replicates the Electromechanical Training System, enabling students to perform actual experiments using virtual equipment
  - Install, move, and remove EMS modules in and from the workstation
  - Modify module connections at any time and change the color of wires
  - Install a timing belt between two EMS machines
  - Verify module connections using a tool that highlights all wires connected to a same circuit point
  - Perform measurements of voltage, current, power, speed, torque, impedance, resistance, reactance, and frequency and display the values on digital or analog meters
  - Record measurements in a data table and plot graphs using the recorded data
  - Display waveforms on a multi-channel oscilloscope and ac voltages and currents as phasors
- Students prepare for laboratories in advance using virtual equipment, thereby decreasing the time they require to perform the exercises using actual equipment
- Decreases the quantity of actual equipment required per student
- Allows students to practice with EMS equipment operation and connection at home on a personal computer

## Specifications

| Parameter | Value |
|---|---|
| **Computer Requirements** | |

| Parameter | Value |
|---|---|
| Local and Network versions | One (1) USB 2.0 port for the security dongle, Microsoft Windows 10 operating system recommended (compatible with Windows 7 and 8), basic dual core CPU, Google Chrome web browser installed (for better experience) |
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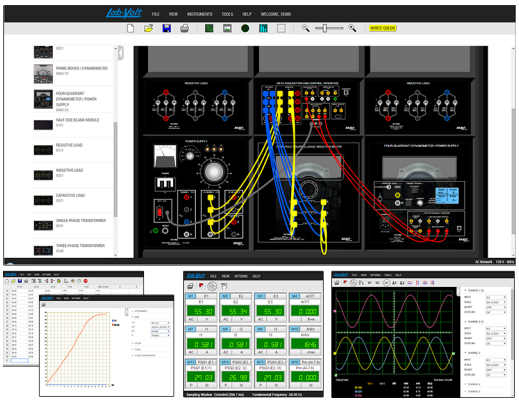
## Electromechanical Systems Simulation Software (LVSIM®-EMS) - 5 Users Online, 1 year (Optional) 586974 (8972-A0)



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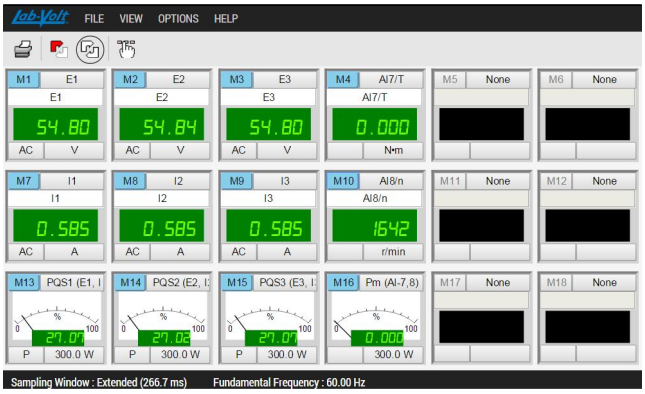
## Metering Window

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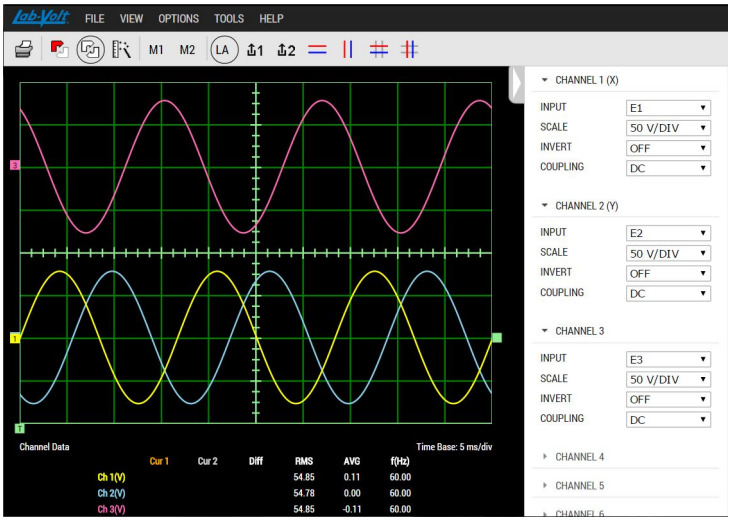
## Oscilloscope

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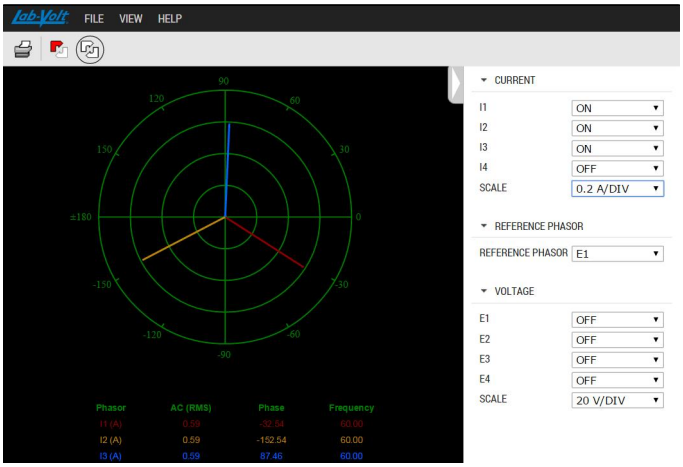
## Phasor Analyzer

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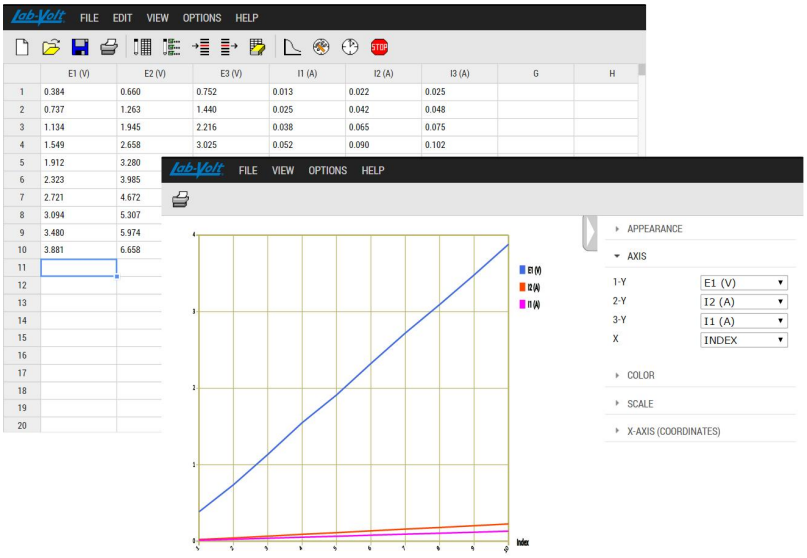
## Data Table and Graph Windows




The values indicated by the various meters in the Metering window, as well as values measured by the other instruments, can be recorded in the Data Table window with a click of the mouse. The values recorded in the Data Table can be saved to a file (ASCII-formatted file). The recorded data can also be used to plot graphs by selecting which parameter(s) to plot in the Graph window. This allows lab results to be plotted quickly and easily. More sophisticated graphs can be created by exporting the contents of the Data Table window to any spreadsheet program, such as Microsoft Excel®, directly through the Windows Clipboard.

## Software Protection and Licensing

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The local and network version of LVSIM-EMS are copy-protected by means of a hardlock security device. When LVSIM-EMS detects the security device, students have complete access to all measuring functions of the virtual instruments and other protected features of LVSIM-EMS, as well as to the student manuals included with the simulation software. Note that students are allowed to copy the software onto their personal computer to allow them to prepare laboratories in advance.

Two different security devices are available for LVSIM-EMS: a single-user hardlock key, which can be inserted in the USB port of the user's computer, and a multiple-user hardlock key, which can be inserted in the USB port of the network server or any computer in the same network. Once the hardlock key is active on the network, the other computer will see the available licences. Alternately, the multiple-user hardlock key can be inserted in a USB port inside the server using a circuit board with edge-type connector (provided with the key) that can be installed in a PCI expansion slot of the server.

The multiple-user hardlock key can be installed in servers running under one of the following Microsoft® operating systems: Windows 7, Windows 8, Windows 10, Windows 2008 Server, and Windows 2013 Server. As its name indicates, the multiple-user hardlock key allows several users of a network to run LVSIM-EMS simultaneously. Different versions of LVSIM-EMS are available, each allowing a particular number of users.

## Online Edition

The online version of LVSIM-EMS is accessible directly via the internet, and requires no software installation nor any update since the latest version of the software is always available. The online version of LVSIM-EMS also includes a demo mode that allows students to prepare laboratories in advance by familiarizing with the equipment and connections. The demo mode does not require any login.

## Computer Requirements

Local and Network Versions:

- One (1) USB 2.0 port for the security dongle, Microsoft Windows 10 operating system recommended (compatible with Windows 7 and 8), basic dual core CPU, Google Chrome web browser installed (for better experience)

Online Version:

- Microsoft Windows 10 operating system recommended (compatible with Windows 7 and 8 but not fully compatible with mobile devices), basic dual core CPU, internet access (bandwidth usage of 50 KB/s maximum), Google Chrome web browser installed (for better experience)

## List of Manuals

| Description | Manual number |
|---|---|
| Electromechanical Systems Simulation Software (User Guide) | 583879 (20858-E0) |
| Computer-Based Instruments for EMS (User Guide) | 584396 (36221-E0) |

## Table of Contents of the Manual(s)

**Electromechanical Systems Simulation Software (User Guide) (583879 (20858-E0))**



**Computer-Based Instruments for EMS (User Guide) (584396 (36221-E0))**



## Topic Coverage

- Fundamentals for Electric Power Technology
- Alternating Current
- Capacitors in AC Circuits
- Inductors in AC Circuits
- Power, Phasors, and Impedance in AC Circuits
- Three-Phase Circuits
- Special Transformer Connections
- Single- and three-Phase Transformers
- Fundamentals for Rotating Machines
- DC Motors and Generators
- Special Characteristics of DC Motors
- AC Induction and Synchronous Motors
- Three-Phase Synchronous Generators

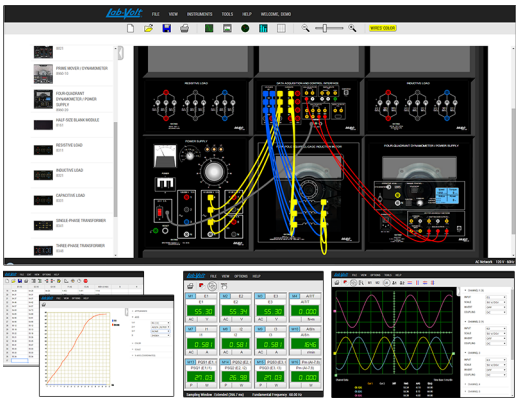
## Features & Benefits

- Replicates the Electromechanical Training System, enabling students to perform actual experiments using virtual equipment
  - Install, move, and remove EMS modules in and from the workstation
  - Modify module connections at any time and change the color of wires
  - Install a timing belt between two EMS machines
  - Verify module connections using a tool that highlights all wires connected to a same circuit point
  - Perform measurements of voltage, current, power, speed, torque, impedance, resistance, reactance, and frequency and display the values on digital or analog meters
  - Record measurements in a data table and plot graphs using the recorded data
  - Display waveforms on a multi-channel oscilloscope and ac voltages and currents as phasors
- Students prepare for laboratories in advance using virtual equipment, thereby decreasing the time they require to perform the exercises using actual equipment
- Decreases the quantity of actual equipment required per student
- Allows students to practice with EMS equipment operation and connection at home on a personal computer

## Specifications

| Parameter | Value |
|---|---|
| **Computer Requirements** | |
| Local and Network versions | One (1) USB 2.0 port for the security dongle, Microsoft Windows 10 operating system recommended (compatible with Windows 7 and 8), basic dual core CPU, Google Chrome web browser installed (for better experience) |
| Online version | Microsoft Windows 10 operating system recommended (compatible with Windows 7 and 8 but not fully compatible with mobile devices), basic dual core CPU, internet access (bandwidth usage of 50 KB/s maximum), Google Chrome web browser installed (for better experience) |

## Electromechanical Systems Simulation Software (LVSIM®-EMS) - 10 Users Online, 1 year (Optional)
## 586977 (8972-B0)



The Electromechanical Systems Simulation Software (LVSIM®-EMS) is a simulation software that covers the same courseware as the following systems:

Computer-Assisted 0.2 kW Electromechanical Training System, Model 8006-1
DC and AC Power Circuits Training System, Model 8010-1
Electromechanical Training System, Model 8010-9
AC Power Transmission Training System, Model 8010-B

All workbooks parts of the systems above are available in the navigation menu of LVSIM-EMS for online consultation. To obtain the printing rights, Campus Licenses for each are available and must be ordered separately.

With LVSIM-EMS, all the standard EMS laboratory equipment is replaced by images of the actual EMS modules that students can manipulate on the computer screen. Students can identify and set up equipment for a given exercise, make the necessary connections between the virtual EMS modules, and verify the connections made without the need for actual EMS equipment.

Sophisticated mathematical models fully simulate the electrical and mechanical characteristics of all the actual EMS modules: power supplies, motors, generators, transformers, electrical and mechanical loads, etc. All

modules simulated in the LVSIM-EMS software feature the same front panel information as the actual EMS modules. Short-circuit connections in the virtual equipment setup cause the virtual circuit-breaker protection to trip. This trip condition is clearly indicated on the virtual EMS modules.

Used either as a complement to the actual EMS laboratory equipment, or as a stand-alone product, LVSIM-EMS is a cost-effective tool that enables students to perform the same exercises as in the courseware of the above-mentioned training systems. When used as a stand-alone package, the LVSIM-EMS software allows students to perform hands-on activities related to electrical power and machines, including active, reactive, and apparent power, phasors, ac/dc motors and generators, three-phase circuits, and transformers.

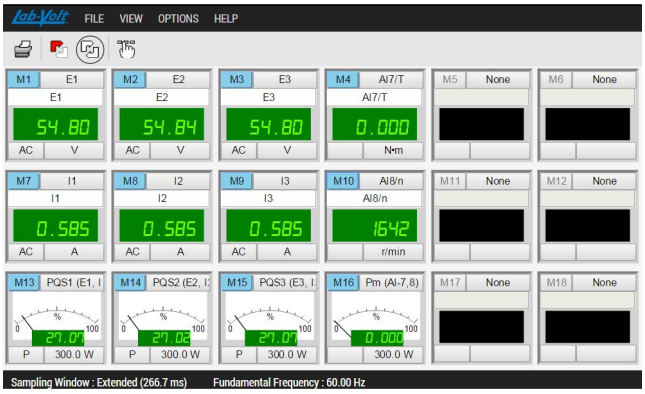
LVSIM-EMS is a web-browser based application **available in three different configurations.** The simulation software can either be installed locally on a Windows® personal computer (local version), on a Windows server (network version), or accessed directly online through the labvolt.com website at lvsim.labvolt.com (online version). Both network and local versions are delivered with perpetual license for the current version. The online version is delivered as a annual license with possibility to expand for more years.

Please visit https://lvsim.labvolt.com and try the online version!

## Virtual Instrumentation

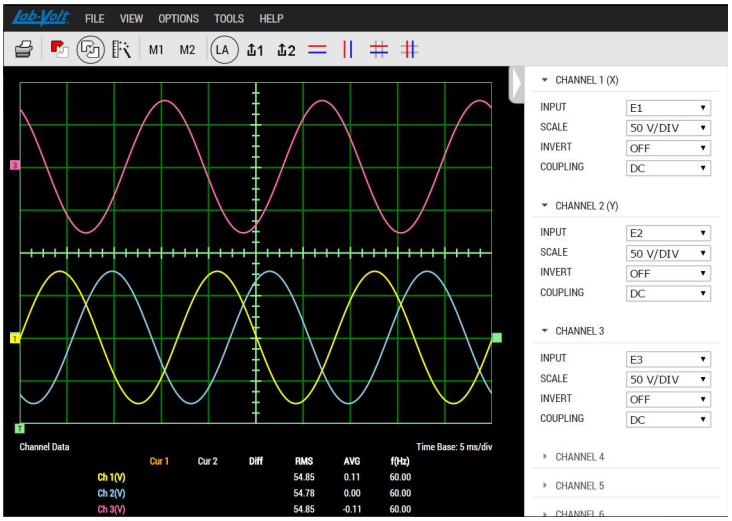
LVSIM-EMS comprises a set of conventional and specialized instruments that can be used for measuring, observing, and analyzing electrical and mechanical parameters in electric power systems and power electronic circuits. Each instrument appears as a window on the computer screen. The conventional instruments include ac/dc voltmeters and ammeters, power meters, and an eight-channel oscilloscope. The specialized instruments include a six-channel phasor analyzer, a harmonic analyzer, torque, speed, and mechanical power meters, and user-programmable meters. The software is also provided with data-recording and graph-plotting capabilities. The various instruments are briefly described in the next section of this datasheet.

## Metering Window



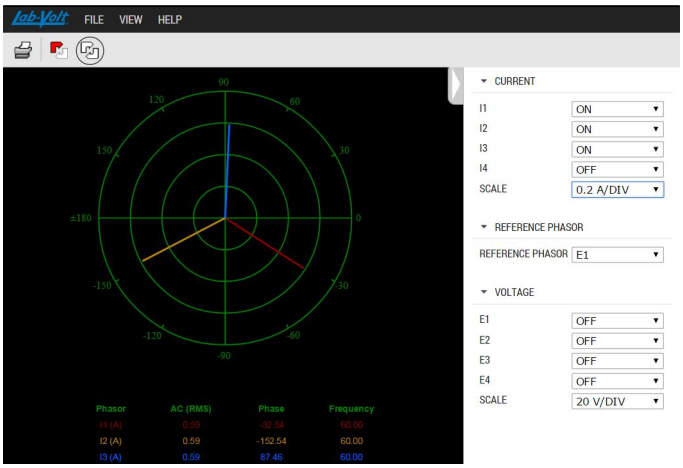

The Metering window displays up to eighteen meters, which can be configured individually for measuring ac/dc voltage and current, electrical power (active, reactive, and apparent), torque, speed, mechanical power, etc. The voltage and current meters have several modes of operation that allow measurement of the mean (dc) value, RMS value, crest factor, RMS value of a particular harmonic (up to the 15th value), RMS value of the harmonics, and total harmonic distortion (THD). Six of the eighteen meters are user-programmable and give access to a larger variety of functions for measurement of power factor, efficiency, impedance, frequency, energy, phase shift, etc. The layout of the meters in the Metering window is user-customizable.

## Oscilloscope




The Oscilloscope displays up to eight waveforms simultaneously, each of a different color for easy identification. Each channel has independent vertical controls similar to those found on conventional oscilloscopes. An automatic scale-setting function allows the sensitivity of each channel to be set automatically according to the magnitude of the observed parameter. The time base and trigger controls are similar to those found on most oscilloscopes. The RMS value, average value, and frequency of each observed parameters can be displayed in the Oscilloscope window. Two vertical cursors can be activated to perform precise measurements at particular points on the displayed waveforms. The Oscilloscope toolbar includes two memory buttons for saving displayed waveforms.

## Phasor Analyzer

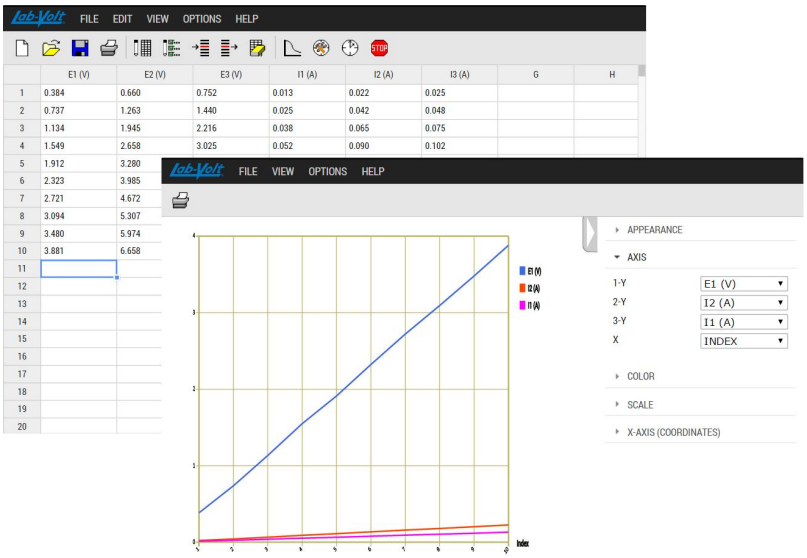



The Phasor Analyzer displays the phasors related to the measured voltages and currents. The amplitude and phase angle of each voltage and current is clearly represented by the orientation and length of their corresponding phasors, allowing easy comparison between the displayed parameters. This produces a unique and dynamic display of the voltages and currents in a circuit (especially in three-phase circuits) that cannot be obtained with conventional instruments. The RMS value, phase angle, and frequency of the voltage or current related to each phasor is displayed in the Phasor Analyzer window.

## Harmonic Analyzer


The Harmonic Analyzer allows observation and analysis of the harmonic components in the measured voltages and currents. The fundamental frequency can be manually set to the ac power network frequency or automatically set to the frequency of the fundamental component of the selected voltage or current. The harmonic components of the selected voltage or current can be displayed using a vertical scale graduated in either absolute or relative values. A group of data displays in the Harmonic Analyzer indicates the values of the dc component of the selected voltage or current, as well as the total harmonic distortion (THD). Vertical and horizontal cursors can be displayed to perform precise measurements at particular points on the display. Since the equipment simulated by LVSIM-EMS produces only dc and sinusoidal ac signals (without harmonics), the Harmonic Analyzer, which is intended for use with devices that produce harmonics, is not often used with LVSIM-EMS.

## Data Table and Graph Windows




The values indicated by the various meters in the Metering window, as well as values measured by the other instruments, can be recorded in the Data Table window with a click of the mouse. The values recorded in the Data Table can be saved to a file (ASCII-formatted file). The recorded data can also be used to plot graphs by selecting which parameter(s) to plot in the Graph window. This allows lab results to be plotted quickly and easily. More sophisticated graphs can be created by exporting the contents of the Data Table window to any spreadsheet program, such as Microsoft Excel®, directly through the Windows Clipboard.

## Software Protection and Licensing

The local and network version provides a perpetual licence and the online access version provides a annual licence (additional years can be purchased when ordering).

The local and network version of LVSIM-EMS are copy-protected by means of a hardlock security device. When LVSIM-EMS detects the security device, students have complete access to all measuring functions of the virtual instruments and other protected features of LVSIM-EMS, as well as to the student manuals included with the simulation software. Note that students are allowed to copy the software onto their personal computer to allow them to prepare laboratories in advance.

Two different security devices are available for LVSIM-EMS: a single-user hardlock key, which can be inserted in the USB port of the user's computer, and a multiple-user hardlock key, which can be inserted in the USB port of the network server or any computer in the same network. Once the hardlock key is active on the network, the other computer will see the available licences. Alternately, the multiple-user hardlock key can be inserted in a USB port inside the server using a circuit board with edge-type connector (provided with the key) that can be installed in a PCI expansion slot of the server.

The multiple-user hardlock key can be installed in servers running under one of the following Microsoft® operating systems: Windows 7, Windows 8, Windows 10, Windows 2008 Server, and Windows 2013 Server. As its name indicates, the multiple-user hardlock key allows several users of a network to run LVSIM-EMS simultaneously. Different versions of LVSIM-EMS are available, each allowing a particular number of users.

## Online Edition

The online version of LVSIM-EMS is accessible directly via the internet, and requires no software installation nor any update since the latest version of the software is always available. The online version of LVSIM-EMS also includes a demo mode that allows students to prepare laboratories in advance by familiarizing with the equipment and connections. The demo mode does not require any login.

## Computer Requirements

Local and Network Versions:

- One (1) USB 2.0 port for the security dongle, Microsoft Windows 10 operating system recommended (compatible with Windows 7 and 8), basic dual core CPU, Google Chrome web browser installed (for better experience)

Online Version:

- Microsoft Windows 10 operating system recommended (compatible with Windows 7 and 8 but not fully compatible with mobile devices), basic dual core CPU, internet access (bandwidth usage of 50 KB/s maximum), Google Chrome web browser installed (for better experience)

## List of Manuals

| Description | Manual number |
|---|---|
| Electromechanical Systems Simulation Software (User Guide) | 583879 (20858-E0) |
| Computer-Based Instruments for EMS (User Guide) | 584396 (36221-E0) |

## Table of Contents of the Manual(s)

**Electromechanical Systems Simulation Software (User Guide) (583879 (20858-E0))**

- 1 Overview of LVSIM-EMS
- 2 Installing the Security Device
- 3 Installing and Running LVSIM-EMS

**Computer-Based Instruments for EMS (User Guide) (584396 (36221-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

## Topic Coverage

- Fundamentals for Electric Power Technology
- Alternating Current
- Capacitors in AC Circuits
- Inductors in AC Circuits
- Power, Phasors, and Impedance in AC Circuits
- Three-Phase Circuits
- Special Transformer Connections
- Single- and three-Phase Transformers
- Fundamentals for Rotating Machines
- DC Motors and Generators
- Special Characteristics of DC Motors
- AC Induction and Synchronous Motors
- Three-Phase Synchronous Generators

## Features & Benefits

- Replicates the Electromechanical Training System, enabling students to perform actual experiments using virtual equipment
  - Install, move, and remove EMS modules in and from the workstation
  - Modify module connections at any time and change the color of wires
  - Install a timing belt between two EMS machines
  - Verify module connections using a tool that highlights all wires connected to a same circuit point
  - Perform measurements of voltage, current, power, speed, torque, impedance, resistance, reactance, and frequency and display the values on digital or analog meters
  - Record measurements in a data table and plot graphs using the recorded data
  - Display waveforms on a multi-channel oscilloscope and ac voltages and currents as phasors
- Students prepare for laboratories in advance using virtual equipment, thereby decreasing the time they require to perform the exercises using actual equipment
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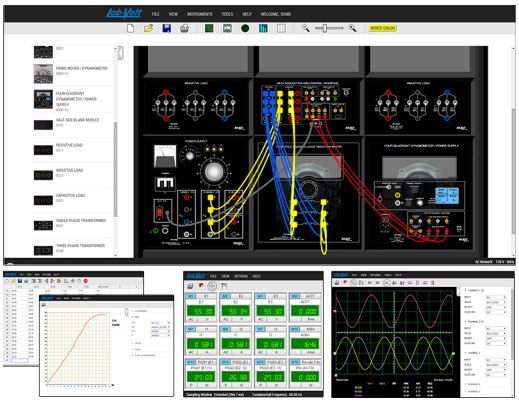
- Allows students to practice with EMS equipment operation and connection at home on a personal computer

## Specifications

| Parameter | Value |
|---|---|
| **Computer Requirements** | |

| Parameter | Value |
|---|---|
| Local and Network versions | One (1) USB 2.0 port for the security dongle, Microsoft Windows 10 operating system recommended (compatible with Windows 7 and 8), basic dual core CPU, Google Chrome web browser installed (for better experience) |
| Online version | Microsoft Windows 10 operating system recommended (compatible with Windows 7 and 8 but not fully compatible with mobile devices), basic dual core CPU, internet access (bandwidth usage of 50 KB/s maximum), Google Chrome web browser installed (for better experience) |

## Electromechanical Systems Simulation Software (LVSIM®-EMS) - 15 Users Online, 1 year (Optional)
## 586980 (8972-C0)



The Electromechanical Systems Simulation Software (LVSIM®-EMS) is a simulation software that covers the same courseware as the following systems:

Computer-Assisted 0.2 kW Electromechanical Training System, Model 8006-1
DC and AC Power Circuits Training System, Model 8010-1
Electromechanical Training System, Model 8010-9
AC Power Transmission Training System, Model 8010-B

All workbooks parts of the systems above are available in the navigation menu of LVSIM-EMS for online consultation. To obtain the printing rights, Campus Licenses for each are available and must be ordered separately.

With LVSIM-EMS, all the standard EMS laboratory equipment is replaced by images of the actual EMS modules that students can manipulate on the computer screen. Students can identify and set up equipment for a given exercise, make the necessary connections between the virtual EMS modules, and verify the connections made without the need for actual EMS equipment.

Sophisticated mathematical models fully simulate the electrical and mechanical characteristics of all the actual EMS modules: power supplies, motors, generators, transformers, electrical and mechanical loads, etc. All modules simulated in the LVSIM-EMS software feature the same front panel information as the actual EMS modules. Short-circuit connections in the virtual equipment setup cause the virtual circuit-breaker protection to trip. This trip condition is clearly indicated on the virtual EMS modules.

Used either as a complement to the actual EMS laboratory equipment, or as a stand-alone product, LVSIM-EMS is a cost-effective tool that enables students to perform the same exercises as in the courseware of the above-mentioned training systems. When used as a stand-alone package, the LVSIM-EMS software allows students to perform hands-on activities related to electrical power and machines, including active, reactive, and apparent power, phasors, ac/dc motors and generators, three-phase circuits, and transformers.

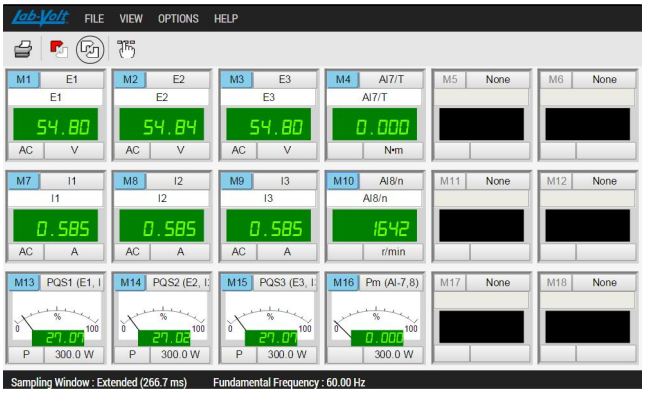
LVSIM-EMS is a web-browser based application **available in three different configurations.** The simulation software can either be installed locally on a Windows® personal computer (local version), on a Windows server (network version), or accessed directly online through the labvolt.com website at lvsim.labvolt.com (online version). Both network and local versions are delivered with perpetual license for the current version. The online version is delivered as a annual license with possibility to expand for more years.

Please visit https://lvsim.labvolt.com and try the online version!

## Virtual Instrumentation

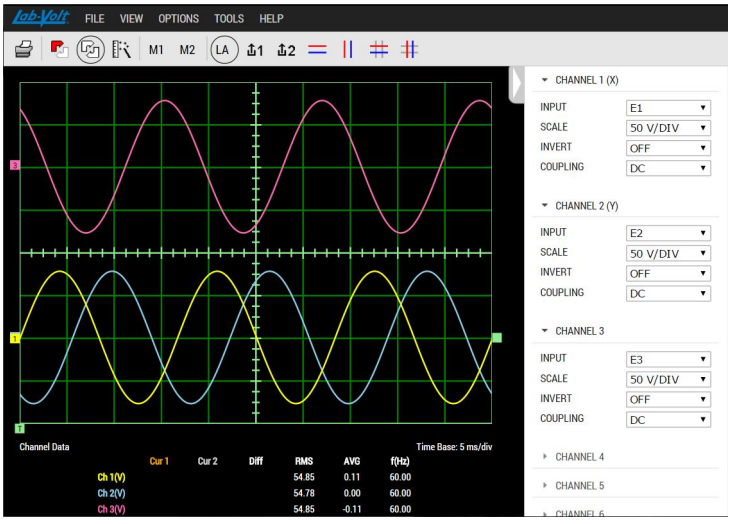
LVSIM-EMS comprises a set of conventional and specialized instruments that can be used for measuring, observing, and analyzing electrical and mechanical parameters in electric power systems and power electronic circuits. Each instrument appears as a window on the computer screen. The conventional instruments include ac/dc voltmeters and ammeters, power meters, and an eight-channel oscilloscope. The specialized instruments include a six-channel phasor analyzer, a harmonic analyzer, torque, speed, and mechanical power meters, and user-programmable meters. The software is also provided with data-recording and graph-plotting capabilities. The various instruments are briefly described in the next section of this datasheet.

## Metering Window



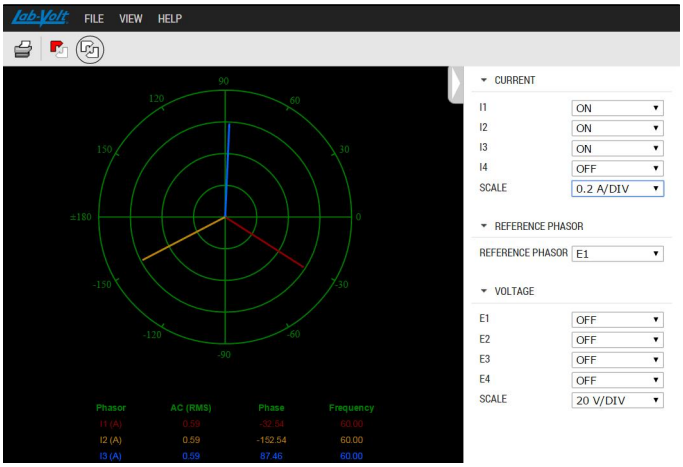

The Metering window displays up to eighteen meters, which can be configured individually for measuring ac/dc voltage and current, electrical power (active, reactive, and apparent), torque, speed, mechanical power, etc. The voltage and current meters have several modes of operation that allow measurement of the mean (dc) value, RMS value, crest factor, RMS value of a particular harmonic (up to the 15th value), RMS value of the harmonics, and total harmonic distortion (THD). Six of the eighteen meters are user-programmable and give access to a larger variety of functions for measurement of power factor, efficiency, impedance, frequency, energy, phase shift, etc. The layout of the meters in the Metering window is user-customizable.

## Oscilloscope




The Oscilloscope displays up to eight waveforms simultaneously, each of a different color for easy identification. Each channel has independent vertical controls similar to those found on conventional oscilloscopes. An automatic scale-setting function allows the sensitivity of each channel to be set automatically according to the magnitude of the observed parameter. The time base and trigger controls are similar to those found on most oscilloscopes. The RMS value, average value, and frequency of each observed parameters can be displayed in the Oscilloscope window. Two vertical cursors can be activated to perform precise measurements at particular points on the displayed waveforms. The Oscilloscope toolbar includes two memory buttons for saving displayed waveforms.

## Phasor Analyzer




The Phasor Analyzer displays the phasors related to the measured voltages and currents. The amplitude and phase angle of each voltage and current is clearly represented by the orientation and length of their corresponding phasors, allowing easy comparison between the displayed parameters. This produces a unique and dynamic display of the voltages and currents in a circuit (especially in three-phase circuits) that cannot be obtained with conventional instruments. The RMS value, phase angle, and frequency of the voltage or current related to each phasor is displayed in the Phasor Analyzer window.

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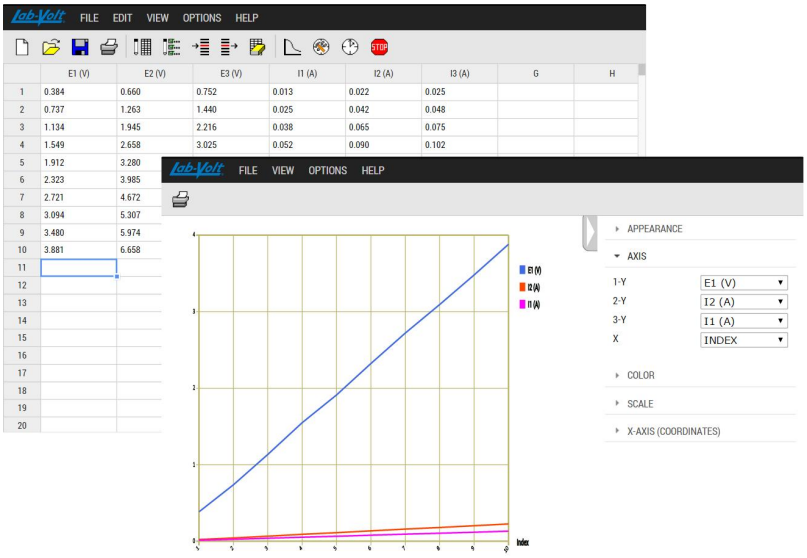
## Data Table and Graph Windows




The values indicated by the various meters in the Metering window, as well as values measured by the other instruments, can be recorded in the Data Table window with a click of the mouse. The values recorded in the Data Table can be saved to a file (ASCII-formatted file). The recorded data can also be used to plot graphs by selecting which parameter(s) to plot in the Graph window. This allows lab results to be plotted quickly and easily. More sophisticated graphs can be created by exporting the contents of the Data Table window to any spreadsheet program, such as Microsoft Excel®, directly through the Windows Clipboard.

## Software Protection and Licensing

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- One (1) USB 2.0 port for the security dongle, Microsoft Windows 10 operating system recommended (compatible with Windows 7 and 8), basic dual core CPU, Google Chrome web browser installed (for better experience)

Online Version:

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## List of Manuals

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|---|---|
| Electromechanical Systems Simulation Software (User Guide) | 583879 (20858-E0) |
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## Table of Contents of the Manual(s)

**Electromechanical Systems Simulation Software (User Guide) (583879 (20858-E0))**



**Computer-Based Instruments for EMS (User Guide) (584396 (36221-E0))**



## Topic Coverage

- Fundamentals for Electric Power Technology
- Alternating Current
- Capacitors in AC Circuits
- Inductors in AC Circuits
- Power, Phasors, and Impedance in AC Circuits
- Three-Phase Circuits
- Special Transformer Connections
- Single- and three-Phase Transformers
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  - Display waveforms on a multi-channel oscilloscope and ac voltages and currents as phasors
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- Decreases the quantity of actual equipment required per student
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| Parameter | Value |
|---|---|
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| Local and Network versions | One (1) USB 2.0 port for the security dongle, Microsoft Windows 10 operating system recommended (compatible with Windows 7 and 8), basic dual core CPU, Google Chrome web browser installed (for better experience) |
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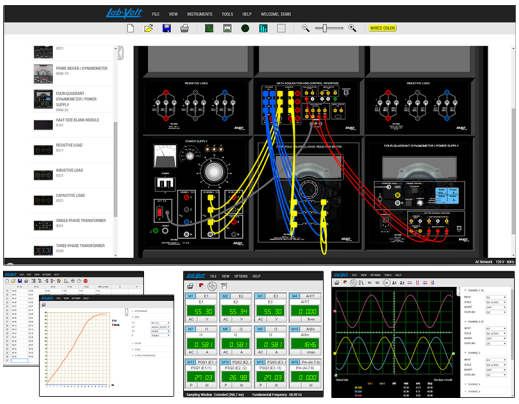
## Electromechanical Systems Simulation Software (LVSIM®-EMS) - 20 Users Online, 1 year (Optional)
## 586983 (8972-D0)



The Electromechanical Systems Simulation Software (LVSIM®-EMS) is a simulation software that covers the same courseware as the following systems:

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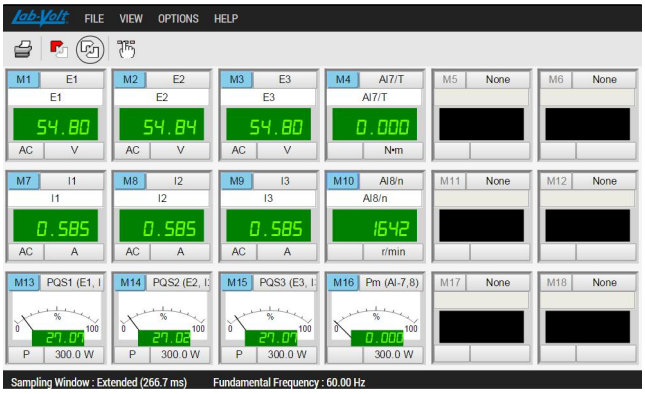


The Metering window displays up to eighteen meters, which can be configured individually for measuring ac/dc voltage and current, electrical power (active, reactive, and apparent), torque, speed, mechanical power, etc. The voltage and current meters have several modes of operation that allow measurement of the mean (dc) value, RMS value, crest factor, RMS value of a particular harmonic (up to the 15th value), RMS value of the harmonics, and total harmonic distortion (THD). Six of the eighteen meters are user-programmable and give access to a larger variety of functions for measurement of power factor, efficiency, impedance, frequency, energy, phase shift, etc. The layout of the meters in the Metering window is user-customizable.

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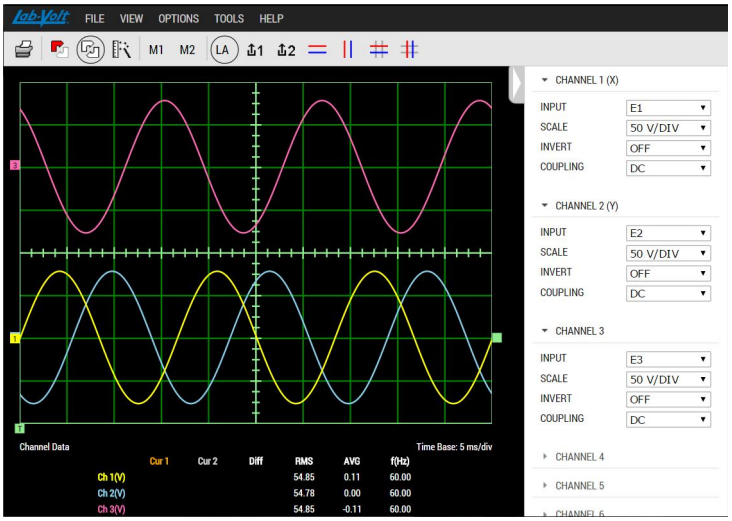


The Oscilloscope displays up to eight waveforms simultaneously, each of a different color for easy identification. Each channel has independent vertical controls similar to those found on conventional oscilloscopes. An automatic scale-setting function allows the sensitivity of each channel to be set automatically according to the magnitude of the observed parameter. The time base and trigger controls are similar to those found on most oscilloscopes. The RMS value, average value, and frequency of each observed parameters can be displayed in the Oscilloscope window. Two vertical cursors can be activated to perform precise measurements at particular points on the displayed waveforms. The Oscilloscope toolbar includes two memory buttons for saving displayed waveforms.

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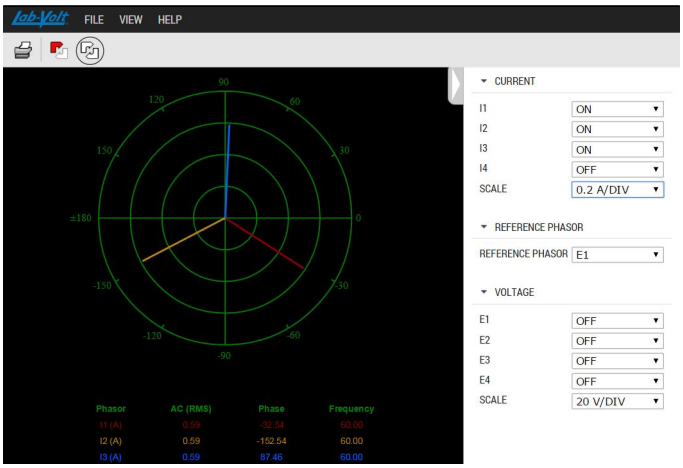
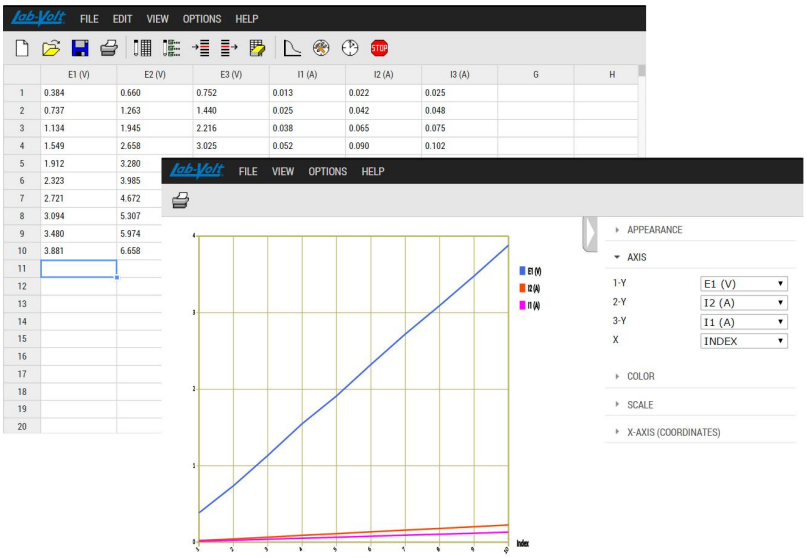



The Phasor Analyzer displays the phasors related to the measured voltages and currents. The amplitude and phase angle of each voltage and current is clearly represented by the orientation and length of their corresponding phasors, allowing easy comparison between the displayed parameters. This produces a unique and dynamic display of the voltages and currents in a circuit (especially in three-phase circuits) that cannot be obtained with conventional instruments. The RMS value, phase angle, and frequency of the voltage or current related to each phasor is displayed in the Phasor Analyzer window.

## Harmonic Analyzer


The Harmonic Analyzer allows observation and analysis of the harmonic components in the measured voltages and currents. The fundamental frequency can be manually set to the ac power network frequency or automatically set to the frequency of the fundamental component of the selected voltage or current. The harmonic components of the selected voltage or current can be displayed using a vertical scale graduated in either absolute or relative values. A group of data displays in the Harmonic Analyzer indicates the values of the dc component of the selected voltage or current, as well as the total harmonic distortion (THD). Vertical and horizontal cursors can be displayed to perform precise measurements at particular points on the display. Since the equipment simulated by LVSIM-EMS produces only dc and sinusoidal ac signals (without harmonics), the Harmonic Analyzer, which is intended for use with devices that produce harmonics, is not often used with LVSIM-EMS.

## Data Table and Graph Windows




The values indicated by the various meters in the Metering window, as well as values measured by the other instruments, can be recorded in the Data Table window with a click of the mouse. The values recorded in the Data Table can be saved to a file (ASCII-formatted file). The recorded data can also be used to plot graphs by selecting which parameter(s) to plot in the Graph window. This allows lab results to be plotted quickly and easily. More sophisticated graphs can be created by exporting the contents of the Data Table window to any spreadsheet program, such as Microsoft Excel®, directly through the Windows Clipboard.

## Software Protection and Licensing

The local and network version provides a perpetual licence and the online access version provides a annual licence (additional years can be purchased when ordering).

The local and network version of LVSIM-EMS are copy-protected by means of a hardlock security device. When LVSIM-EMS detects the security device, students have complete access to all measuring functions of the virtual instruments and other protected features of LVSIM-EMS, as well as to the student manuals included with the simulation software. Note that students are allowed to copy the software onto their personal computer to allow them to prepare laboratories in advance.

Two different security devices are available for LVSIM-EMS: a single-user hardlock key, which can be inserted in the USB port of the user's computer, and a multiple-user hardlock key, which can be inserted in the USB port of the network server or any computer in the same network. Once the hardlock key is active on the network, the other computer will see the available licences. Alternately, the multiple-user hardlock key can be inserted in a USB port inside the server using a circuit board with edge-type connector (provided with the key) that can be installed in a PCI expansion slot of the server.

The multiple-user hardlock key can be installed in servers running under one of the following Microsoft® operating systems: Windows 7, Windows 8, Windows 10, Windows 2008 Server, and Windows 2013 Server. As its name indicates, the multiple-user hardlock key allows several users of a network to run LVSIM-EMS simultaneously. Different versions of LVSIM-EMS are available, each allowing a particular number of users.

## Online Edition

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## Computer Requirements

Local and Network Versions:

- One (1) USB 2.0 port for the security dongle, Microsoft Windows 10 operating system recommended (compatible with Windows 7 and 8), basic dual core CPU, Google Chrome web browser installed (for better experience)

Online Version:

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## List of Manuals

| Description | Manual number |
|---|---|
| Electromechanical Systems Simulation Software (User Guide) | 583879 (20858-E0) |
| Computer-Based Instruments for EMS (User Guide) | 584396 (36221-E0) |

## Table of Contents of the Manual(s)

**Electromechanical Systems Simulation Software (User Guide) (583879 (20858-E0))**

- 1 Overview of LVSIM-EMS
- 2 Installing the Security Device
- 3 Installing and Running LVSIM-EMS

**Computer-Based Instruments for EMS (User Guide) (584396 (36221-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

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- Fundamentals for Electric Power Technology
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- Capacitors in AC Circuits
- Inductors in AC Circuits
- Power, Phasors, and Impedance in AC Circuits
- Three-Phase Circuits
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- Fundamentals for Rotating Machines
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- Special Characteristics of DC Motors
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## Features & Benefits

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  - Install a timing belt between two EMS machines
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  - Perform measurements of voltage, current, power, speed, torque, impedance, resistance, reactance, and frequency and display the values on digital or analog meters
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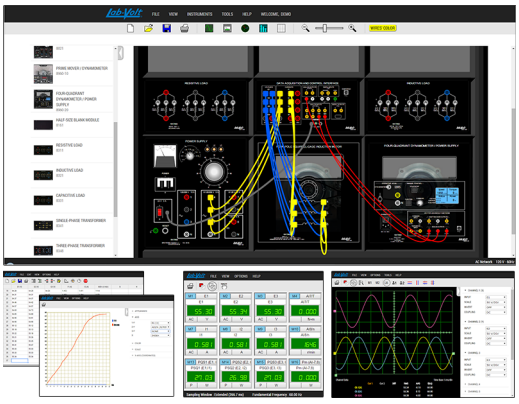
## Electromechanical Systems Simulation Software (LVSIM®-EMS) - 25 Users Online, 1 year (Optional)
## 586986 (8972-E0)



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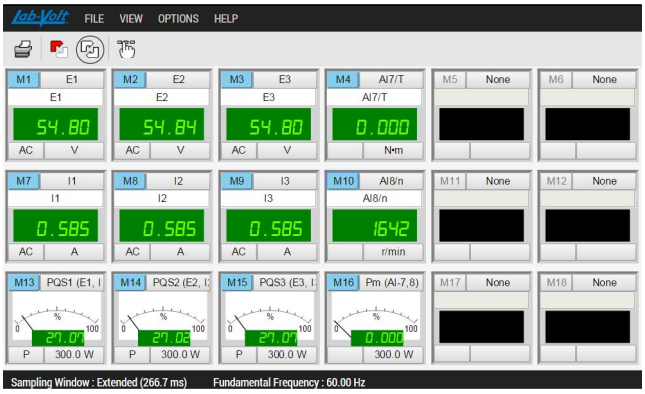


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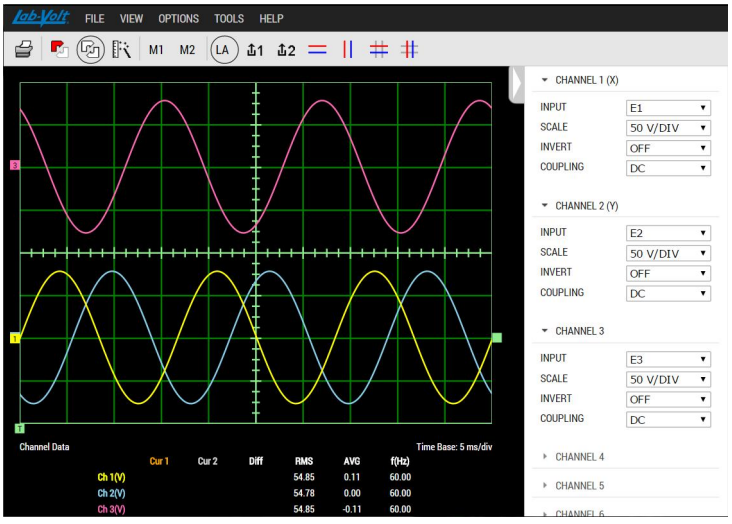


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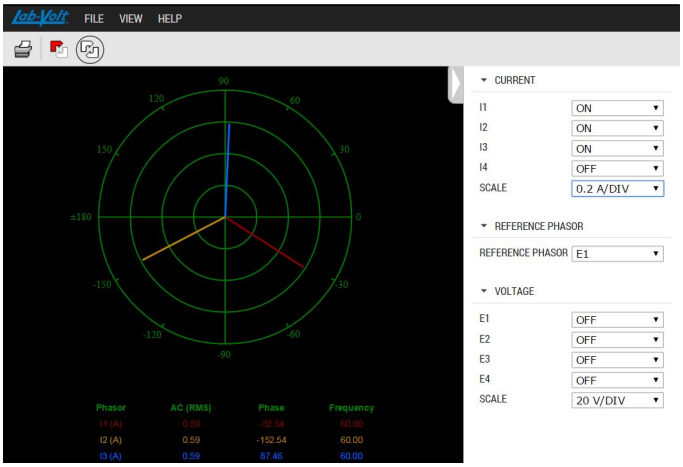


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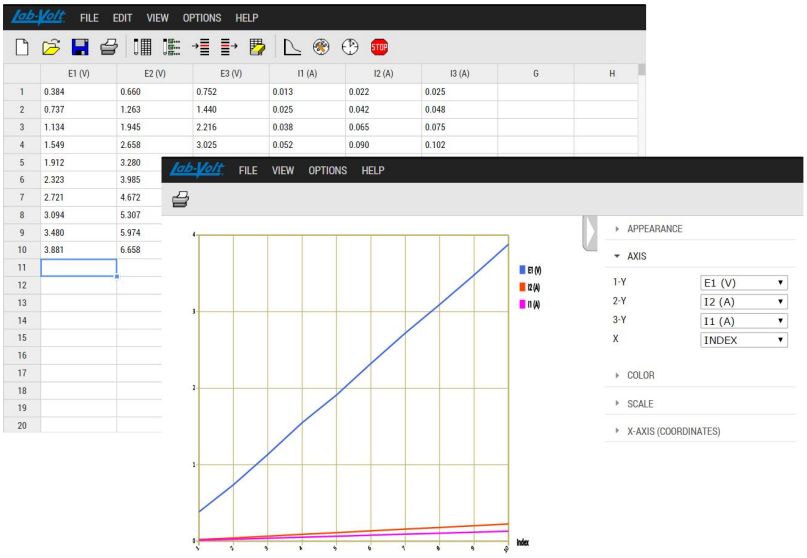


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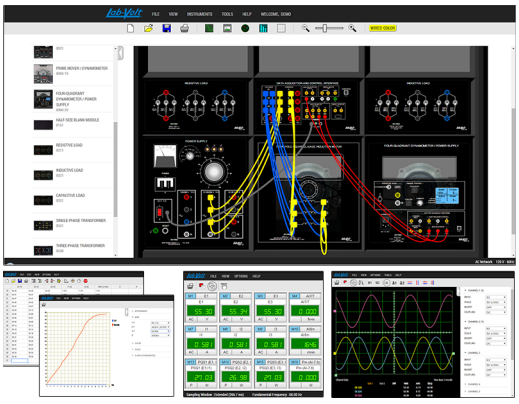
## Electromechanical Systems Simulation Software (LVSIM®-EMS) - 30 Users Online, 1 year (Optional)
## 586989 (8972-F0)



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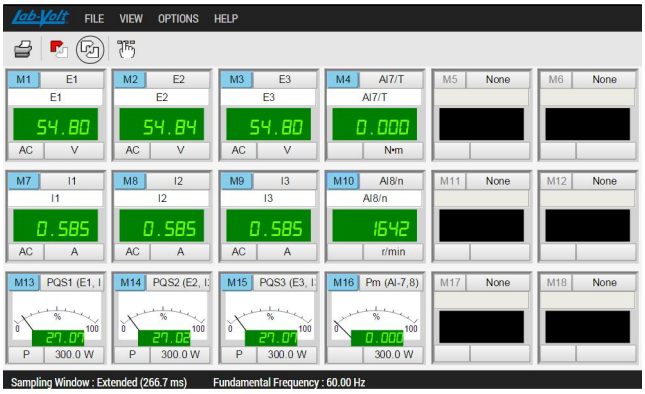


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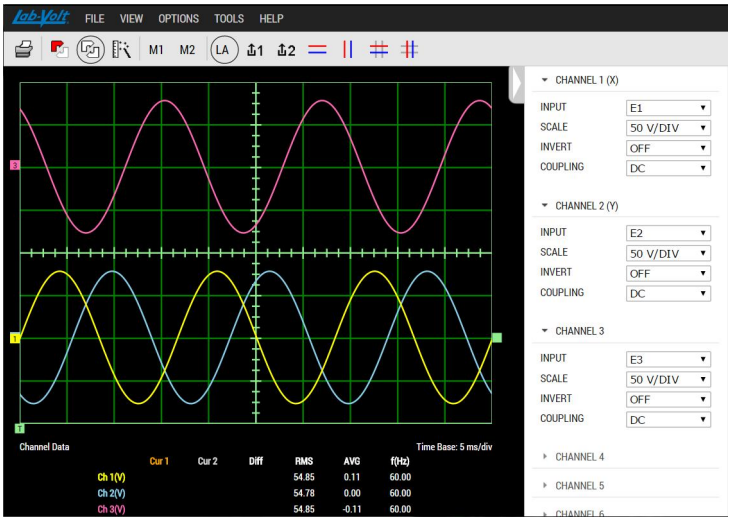
## Oscilloscope

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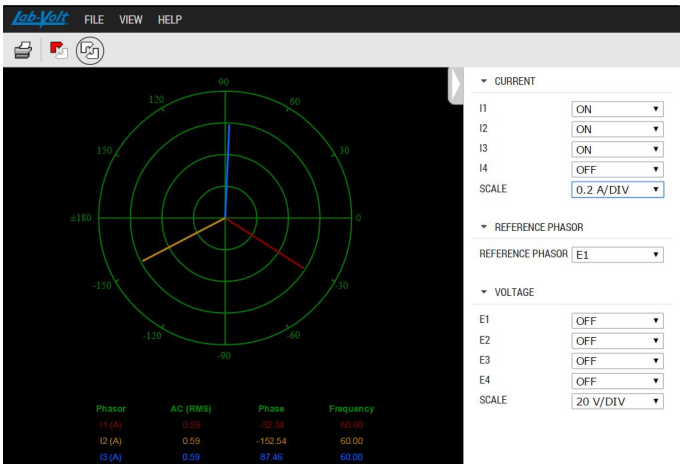
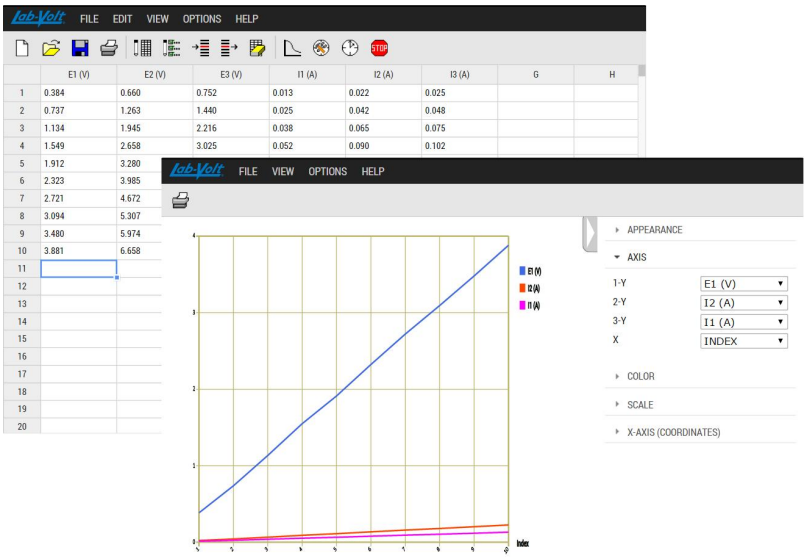



The Phasor Analyzer displays the phasors related to the measured voltages and currents. The amplitude and phase angle of each voltage and current is clearly represented by the orientation and length of their corresponding phasors, allowing easy comparison between the displayed parameters. This produces a unique and dynamic display of the voltages and currents in a circuit (especially in three-phase circuits) that cannot be obtained with conventional instruments. The RMS value, phase angle, and frequency of the voltage or current related to each phasor is displayed in the Phasor Analyzer window.

## Harmonic Analyzer


The Harmonic Analyzer allows observation and analysis of the harmonic components in the measured voltages and currents. The fundamental frequency can be manually set to the ac power network frequency or automatically set to the frequency of the fundamental component of the selected voltage or current. The harmonic components of the selected voltage or current can be displayed using a vertical scale graduated in either absolute or relative values. A group of data displays in the Harmonic Analyzer indicates the values of the dc component of the selected voltage or current, as well as the total harmonic distortion (THD). Vertical and horizontal cursors can be displayed to perform precise measurements at particular points on the display. Since the equipment simulated by LVSIM-EMS produces only dc and sinusoidal ac signals (without harmonics), the Harmonic Analyzer, which is intended for use with devices that produce harmonics, is not often used with LVSIM-EMS.

## Data Table and Graph Windows




The values indicated by the various meters in the Metering window, as well as values measured by the other instruments, can be recorded in the Data Table window with a click of the mouse. The values recorded in the Data Table can be saved to a file (ASCII-formatted file). The recorded data can also be used to plot graphs by selecting which parameter(s) to plot in the Graph window. This allows lab results to be plotted quickly and easily. More sophisticated graphs can be created by exporting the contents of the Data Table window to any spreadsheet program, such as Microsoft Excel®, directly through the Windows Clipboard.

## Software Protection and Licensing

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The local and network version of LVSIM-EMS are copy-protected by means of a hardlock security device. When LVSIM-EMS detects the security device, students have complete access to all measuring functions of the virtual instruments and other protected features of LVSIM-EMS, as well as to the student manuals included with the simulation software. Note that students are allowed to copy the software onto their personal computer to allow them to prepare laboratories in advance.

Two different security devices are available for LVSIM-EMS: a single-user hardlock key, which can be inserted in the USB port of the user's computer, and a multiple-user hardlock key, which can be inserted in the USB port of the network server or any computer in the same network. Once the hardlock key is active on the network, the other computer will see the available licences. Alternately, the multiple-user hardlock key can be inserted in a USB port inside the server using a circuit board with edge-type connector (provided with the key) that can be installed in a PCI expansion slot of the server.

The multiple-user hardlock key can be installed in servers running under one of the following Microsoft® operating systems: Windows 7, Windows 8, Windows 10, Windows 2008 Server, and Windows 2013 Server. As its name indicates, the multiple-user hardlock key allows several users of a network to run LVSIM-EMS simultaneously. Different versions of LVSIM-EMS are available, each allowing a particular number of users.

## Online Edition

The online version of LVSIM-EMS is accessible directly via the internet, and requires no software installation nor any update since the latest version of the software is always available. The online version of LVSIM-EMS also includes a demo mode that allows students to prepare laboratories in advance by familiarizing with the equipment and connections. The demo mode does not require any login.

## Computer Requirements

Local and Network Versions:

- One (1) USB 2.0 port for the security dongle, Microsoft Windows 10 operating system recommended (compatible with Windows 7 and 8), basic dual core CPU, Google Chrome web browser installed (for better experience)

Online Version:

- Microsoft Windows 10 operating system recommended (compatible with Windows 7 and 8 but not fully compatible with mobile devices), basic dual core CPU, internet access (bandwidth usage of 50 KB/s maximum), Google Chrome web browser installed (for better experience)

## List of Manuals

| Description | Manual number |
|---|---|
| Electromechanical Systems Simulation Software (User Guide) | 583879 (20858-E0) |
| Computer-Based Instruments for EMS (User Guide) | 584396 (36221-E0) |

## Table of Contents of the Manual(s)

**Electromechanical Systems Simulation Software (User Guide) (583879 (20858-E0))**

- 1 Overview of LVSIM-EMS
- 2 Installing the Security Device
- 3 Installing and Running LVSIM-EMS

**Computer-Based Instruments for EMS (User Guide) (584396 (36221-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

## Topic Coverage

- Fundamentals for Electric Power Technology
- Alternating Current
- Capacitors in AC Circuits
- Inductors in AC Circuits
- Power, Phasors, and Impedance in AC Circuits
- Three-Phase Circuits
- Special Transformer Connections
- Single- and three-Phase Transformers
- Fundamentals for Rotating Machines
- DC Motors and Generators
- Special Characteristics of DC Motors
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- Three-Phase Synchronous Generators

## Features & Benefits

- Replicates the Electromechanical Training System, enabling students to perform actual experiments using virtual equipment
  - Install, move, and remove EMS modules in and from the workstation
  - Modify module connections at any time and change the color of wires
  - Install a timing belt between two EMS machines
  - Verify module connections using a tool that highlights all wires connected to a same circuit point
  - Perform measurements of voltage, current, power, speed, torque, impedance, resistance, reactance, and frequency and display the values on digital or analog meters
  - Record measurements in a data table and plot graphs using the recorded data
  - Display waveforms on a multi-channel oscilloscope and ac voltages and currents as phasors
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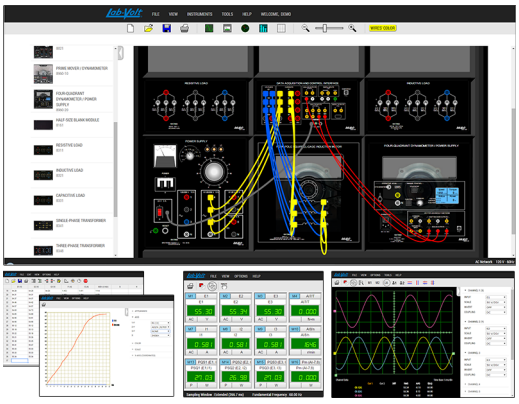
## Electromechanical Systems Simulation Software (LVSIM®-EMS) - 35 Users Online, 1 year (Optional)
## 586992 (8972-G0)



The Electromechanical Systems Simulation Software (LVSIM®-EMS) is a simulation software that covers the same courseware as the following systems:

Computer-Assisted 0.2 kW Electromechanical Training System, Model 8006-1
DC and AC Power Circuits Training System, Model 8010-1
Electromechanical Training System, Model 8010-9
AC Power Transmission Training System, Model 8010-B

All workbooks parts of the systems above are available in the navigation menu of LVSIM-EMS for online consultation. To obtain the printing rights, Campus Licenses for each are available and must be ordered separately.

With LVSIM-EMS, all the standard EMS laboratory equipment is replaced by images of the actual EMS modules that students can manipulate on the computer screen. Students can identify and set up equipment for a given exercise, make the necessary connections between the virtual EMS modules, and verify the connections made without the need for actual EMS equipment.

Sophisticated mathematical models fully simulate the electrical and mechanical characteristics of all the actual EMS modules: power supplies, motors, generators, transformers, electrical and mechanical loads, etc. All modules simulated in the LVSIM-EMS software feature the same front panel information as the actual EMS modules. Short-circuit connections in the virtual equipment setup cause the virtual circuit-breaker protection to trip. This trip condition is clearly indicated on the virtual EMS modules.

Used either as a complement to the actual EMS laboratory equipment, or as a stand-alone product, LVSIM-EMS is a cost-effective tool that enables students to perform the same exercises as in the courseware of the above-mentioned training systems. When used as a stand-alone package, the LVSIM-EMS software allows students to perform hands-on activities related to electrical power and machines, including active, reactive, and apparent power, phasors, ac/dc motors and generators, three-phase circuits, and transformers.

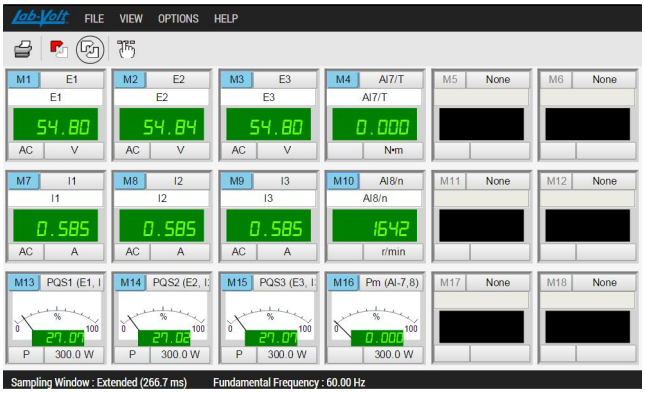
LVSIM-EMS is a web-browser based application **available in three different configurations.** The simulation software can either be installed locally on a Windows® personal computer (local version), on a Windows server (network version), or accessed directly online through the labvolt.com website at lvsim.labvolt.com (online version). Both network and local versions are delivered with perpetual license for the current version. The online version is delivered as a annual license with possibility to expand for more years.

Please visit https://lvsim.labvolt.com and try the online version!

## Virtual Instrumentation

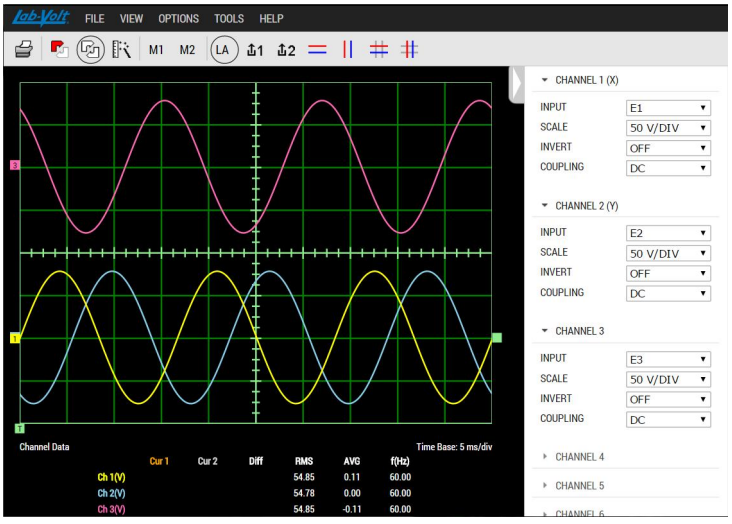
LVSIM-EMS comprises a set of conventional and specialized instruments that can be used for measuring, observing, and analyzing electrical and mechanical parameters in electric power systems and power electronic circuits. Each instrument appears as a window on the computer screen. The conventional instruments include ac/dc voltmeters and ammeters, power meters, and an eight-channel oscilloscope. The specialized instruments include a six-channel phasor analyzer, a harmonic analyzer, torque, speed, and mechanical power meters, and user-programmable meters. The software is also provided with data-recording and graph-plotting capabilities. The various instruments are briefly described in the next section of this datasheet.

## Metering Window



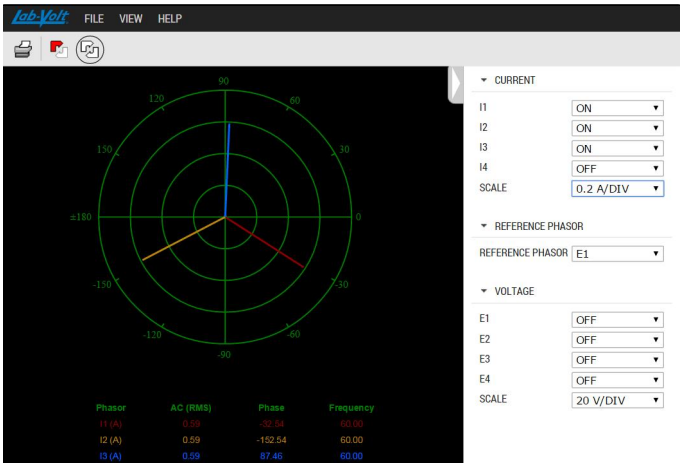

The Metering window displays up to eighteen meters, which can be configured individually for measuring ac/dc voltage and current, electrical power (active, reactive, and apparent), torque, speed, mechanical power, etc. The voltage and current meters have several modes of operation that allow measurement of the mean (dc) value, RMS value, crest factor, RMS value of a particular harmonic (up to the 15th value), RMS value of the harmonics, and total harmonic distortion (THD). Six of the eighteen meters are user-programmable and give access to a larger variety of functions for measurement of power factor, efficiency, impedance, frequency, energy, phase shift, etc. The layout of the meters in the Metering window is user-customizable.

## Oscilloscope




The Oscilloscope displays up to eight waveforms simultaneously, each of a different color for easy identification. Each channel has independent vertical controls similar to those found on conventional oscilloscopes. An automatic scale-setting function allows the sensitivity of each channel to be set automatically according to the magnitude of the observed parameter. The time base and trigger controls are similar to those found on most oscilloscopes. The RMS value, average value, and frequency of each observed parameters can be displayed in the Oscilloscope window. Two vertical cursors can be activated to perform precise measurements at particular points on the displayed waveforms. The Oscilloscope toolbar includes two memory buttons for saving displayed waveforms.

## Phasor Analyzer

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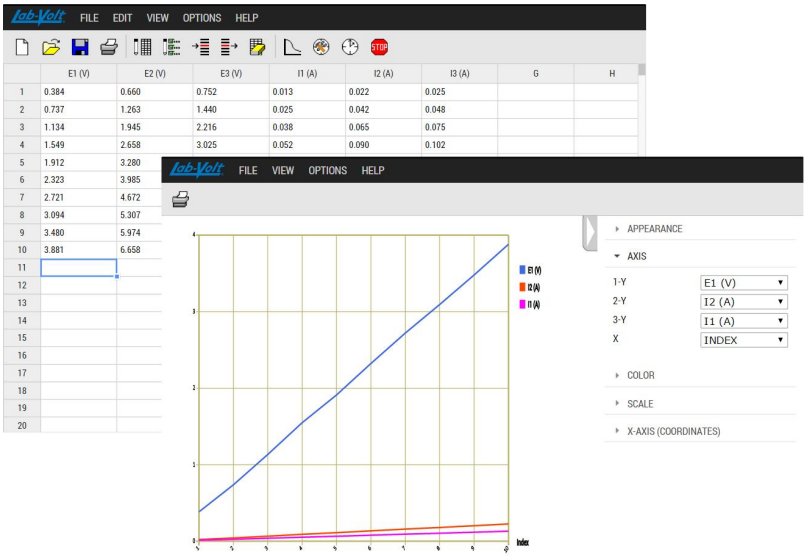
## Data Table and Graph Windows




The values indicated by the various meters in the Metering window, as well as values measured by the other instruments, can be recorded in the Data Table window with a click of the mouse. The values recorded in the Data Table can be saved to a file (ASCII-formatted file). The recorded data can also be used to plot graphs by selecting which parameter(s) to plot in the Graph window. This allows lab results to be plotted quickly and easily. More sophisticated graphs can be created by exporting the contents of the Data Table window to any spreadsheet program, such as Microsoft Excel®, directly through the Windows Clipboard.

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## List of Manuals

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## Table of Contents of the Manual(s)

**Electromechanical Systems Simulation Software (User Guide) (583879 (20858-E0))**



**Computer-Based Instruments for EMS (User Guide) (584396 (36221-E0))**



## Topic Coverage

- Fundamentals for Electric Power Technology
- Alternating Current
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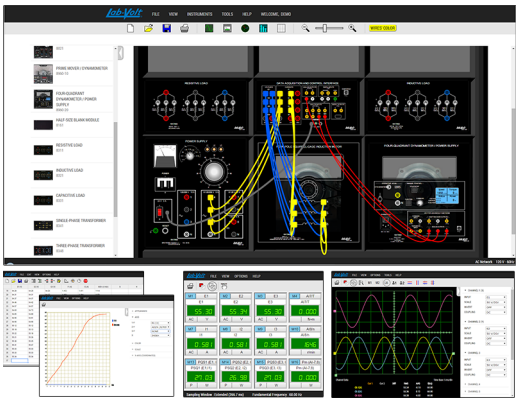
## Electromechanical Systems Simulation Software (LVSIM®-EMS) - 40 Users Online, 1 year (Optional)
## 586995 (8972-H0)



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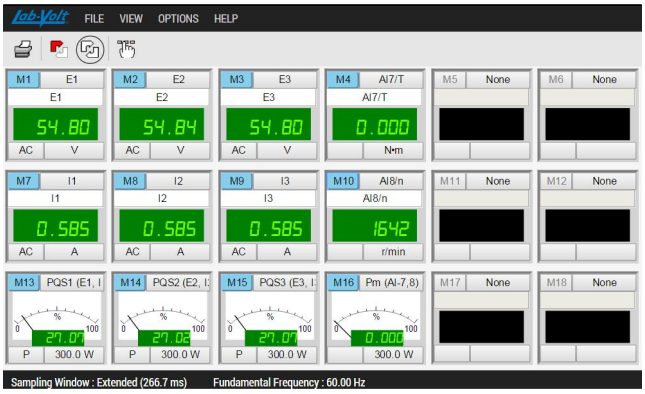


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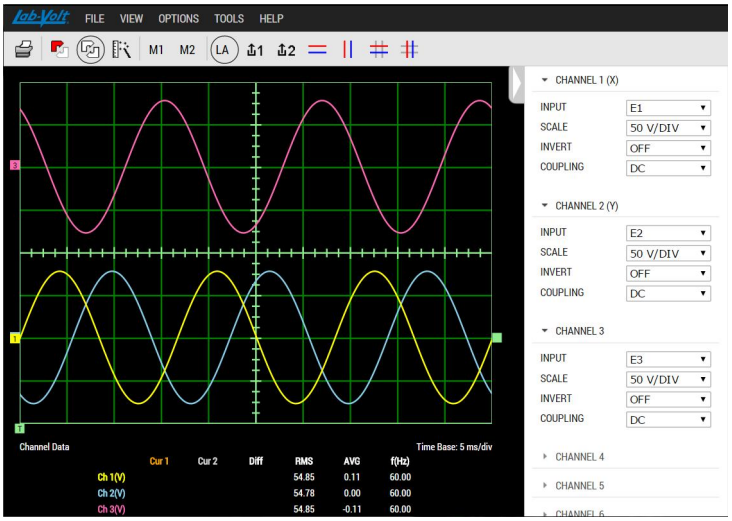
## Oscilloscope

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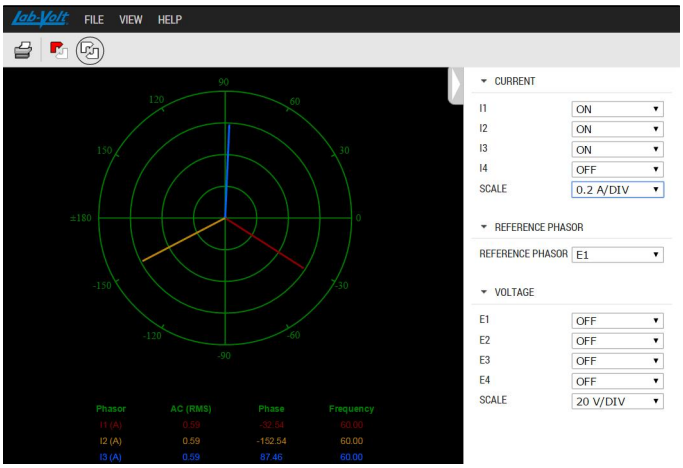


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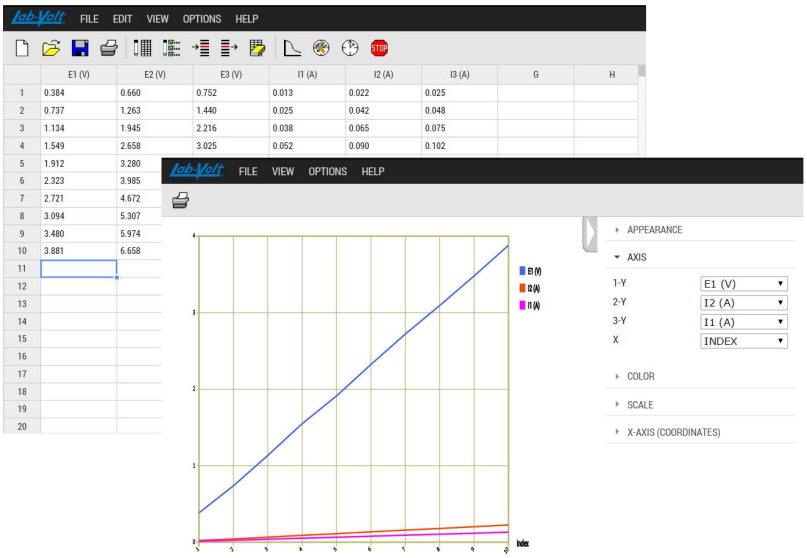


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- 1 Overview of LVSIM-EMS
- 2 Installing the Security Device
- 3 Installing and Running LVSIM-EMS

**Computer-Based Instruments for EMS (User Guide) (584396 (36221-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

## Topic Coverage

- Fundamentals for Electric Power Technology
- Alternating Current
- Capacitors in AC Circuits
- Inductors in AC Circuits
- Power, Phasors, and Impedance in AC Circuits
- Three-Phase Circuits
- Special Transformer Connections
- Single- and three-Phase Transformers
- Fundamentals for Rotating Machines
- DC Motors and Generators
- Special Characteristics of DC Motors
- AC Induction and Synchronous Motors
- Three-Phase Synchronous Generators

## Features & Benefits

- Replicates the Electromechanical Training System, enabling students to perform actual experiments using virtual equipment
  - Install, move, and remove EMS modules in and from the workstation
  - Modify module connections at any time and change the color of wires
  - Install a timing belt between two EMS machines
  - Verify module connections using a tool that highlights all wires connected to a same circuit point
  - Perform measurements of voltage, current, power, speed, torque, impedance, resistance, reactance, and frequency and display the values on digital or analog meters
  - Record measurements in a data table and plot graphs using the recorded data
  - Display waveforms on a multi-channel oscilloscope and ac voltages and currents as phasors
- Students prepare for laboratories in advance using virtual equipment, thereby decreasing the time they require to perform the exercises using actual equipment
- Decreases the quantity of actual equipment required per student
- Allows students to practice with EMS equipment operation and connection at home on a personal computer

## Specifications

| Parameter | Value |
|---|---|
| **Computer Requirements** | |

| Parameter | Value |
|---|---|
| Local and Network versions | One (1) USB 2.0 port for the security dongle, Microsoft Windows 10 operating system recommended (compatible with Windows 7 and 8), basic dual core CPU, Google Chrome web browser installed (for better experience) |
| Online version | Microsoft Windows 10 operating system recommended (compatible with Windows 7 and 8 but not fully compatible with mobile devices), basic dual core CPU, internet access (bandwidth usage of 50 KB/s maximum), Google Chrome web browser installed (for better experience) |

## SCADA for LVDAC-EMS (Optional) 8094377 (8973-00)

Education in electrical engineering at Festo Didactic is largely based on our unique electric power technology training platform, which combines hardware, software, and courseware to allow study of electrical energy.

At the heart of the systems are the data acquisition and control interface (DACI) and the four-quadrant dynamometer/power supply. When used in combination with LVDAC-EMS software program, students have access to a complete set of computer-based instruments to measure, observe, analyze, and control electrical and mechanical parameters of a workstation on their computers.

Our state-of-the-art training platform has just been enhanced through the integration of a new SCADA-EMS feature, a software program designed to run in combination with LVDAC-EMS. SCADA-EMS transforms LVDAC-EMS and the workstation's computer into a local workstation that can be monitored and controlled over a local network from a supervisory computer. Using the OPC Server protocol, SCADA-EMS enables users to design their own interface by calling the different applications running on the local workstations.

SCADA-EMS enhances LVDAC-EMS by adding several new features. You will be able to:

- Collect data from local workstations.

- Observe and control one or more stations from one or more supervisory stations.

- Remotely control several applications in your lab.

- Use a workstation in a different room to make real demonstrations over the network in your classroom without having to bring your workstation to class.

- Introduce students to the fundamentals of SCADA in a smart grid context.

- Recreate a complete grid with several different applications running.

The SCADA-EMS software program can be downloaded from our website. This locked version can be unlocked by a USB dongle. A dongle unlocks five workstations; order as many dongles as required.

Before ordering the dongles, please install:

- LVDAC-EMS (version 3.19 or later) on all your workstation computers.

- SCADA-EMS (1.01 or later) on the workstation computers you want to use to build up your SCADA application.

Contact your sales representative about order details and options.

## LVDAC-EMS

The LVDAC-EMS software is a freeware which can be downloaded anytime from the Festo Didactic website (www.labvolt.com). The LVDAC-EMS software is a user-friendly tool that facilitates the use of the various functions which can be implemented with USB peripherals such as the Data Acquisition and Control Interface (DACI), LabVolt Series 9063, and the Four-Quadrant Dynamometer / Power Supply, LabVolt Series 8960.

The LVDAC-EMS software also includes a firmware update for the DACI. When a DACI is connected to a newer version of LVDAC-EMS, the user can easily update the module using a simple update wizard.

## LVDAC-EMS Functions

The functions that are currently available for the DACI, Model 9063, are described below. All functions can be activated in any DACI by purchasing a license for that specific function and then performing the upgrade procedure on the DACI. New functions will be added to this datasheet as they become available.

### Instrumentation Functions

The instrumentation functions of LVDAC-EMS replace a multitude of actual data acquisition devices (e.g., voltmeters, ammeters, oscilloscopes, synchroscopes) with a series of computer-based instruments that display the data measured by the DACI.

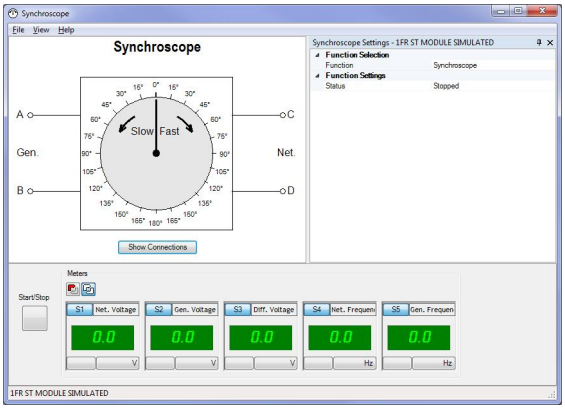
### Features & Benefits

- Monitor and control several workstations from one (or more) supervisory computer(s)
- Use OPC server protocol to communicate between the different workstations
- Include your own pictures and schematics
- Introduce SCADA in existing EMS laboratories

## Complete Function Set (Optional) 581451 (9069-00)

This Model activates all currently available control function sets for the Data Acquisition and Control Interface, Model 9063. See individual control functions sets, Models 9069-X, for more information on the included functions.

## Synchroscope Function (Optional) 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 |

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.



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