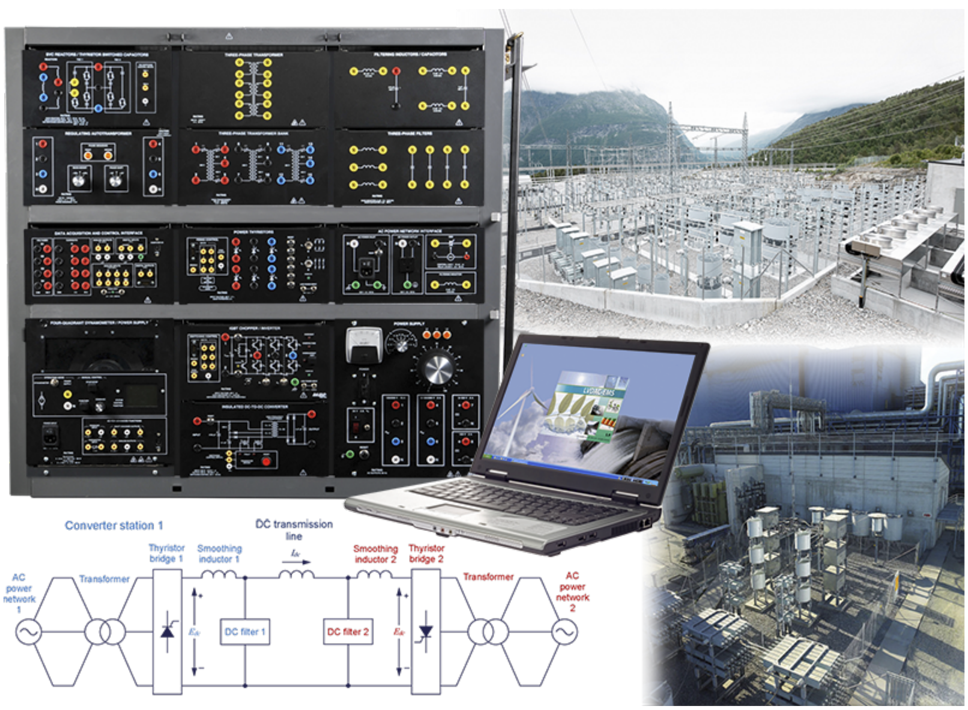
# Smart Grid Technologies Training System
579325 (8010-C0)

**LabVolt Series**

Datasheet




Festo Didactic
en 120 V - 60 Hz
04/2025

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## General Description

The Smart Grid Technologies Training System combines a modular design approach with computer-based data acquisition and control to provide unrivaled training in smart grid technologies. The system features the Four-Quadrant Dynamometer/Power Supply, Model 8960, and the Data Acquisition and Control Interface, Model 9063, two state-of-the-art USB peripherals that greatly enhance the learning experience of students.

Training begins with the Home Energy Production course. This course familiarizes students with the fundamentals of home energy production from renewable resources such as wind and sunlight. It covers both stand-alone home energy production and grid-tied home energy production. The course also explains and demonstrates how home energy production is an important contributor to the implementation of a smart grid. Students then continue with the following three courses dealing with smart grid technologies:

- Static Var Compensator (SVC)

- Static Synchronous Compensator (STATCOM)

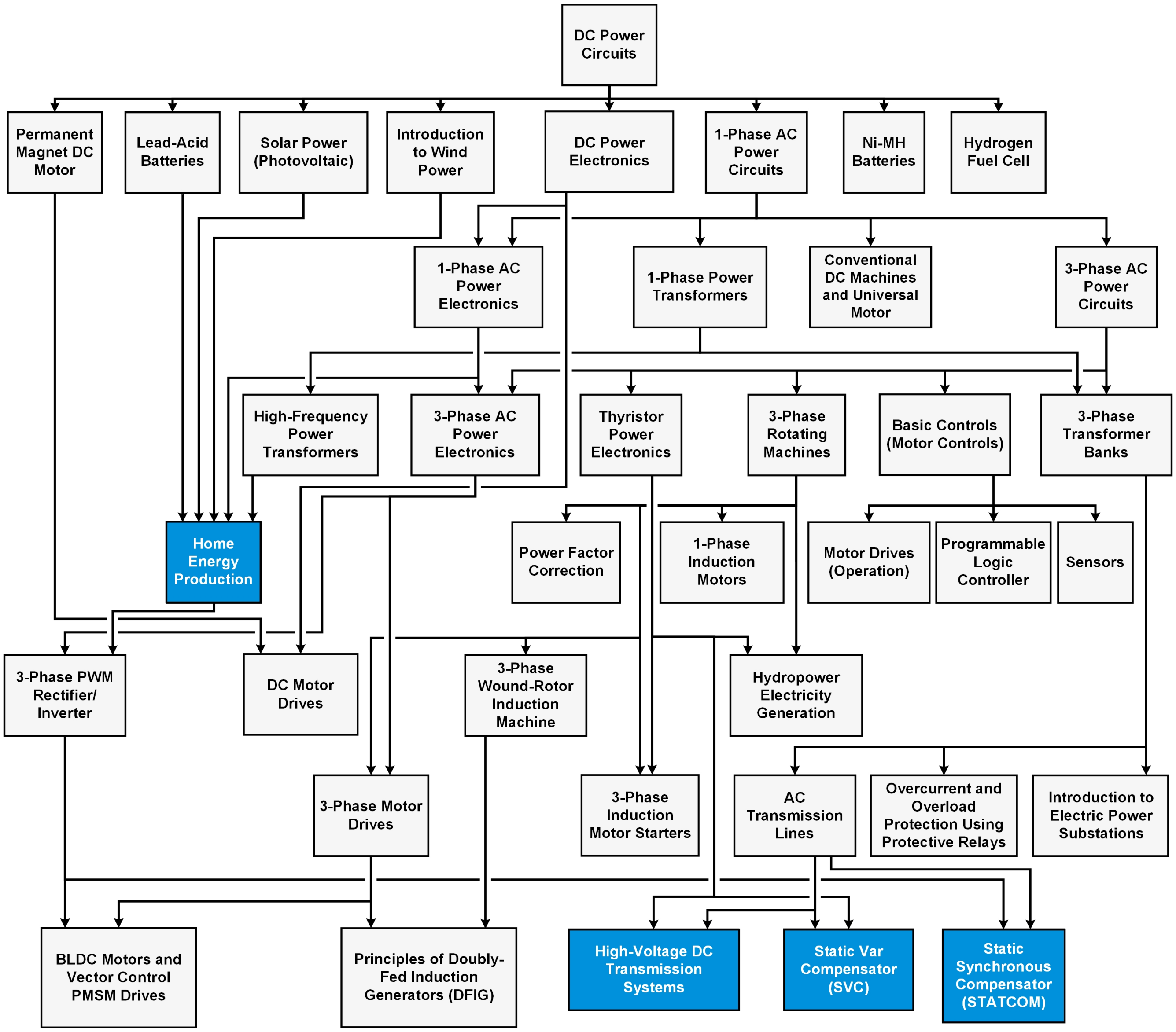
- High-Voltage DC (HVDC) Transmission Systems

These courses introduce students to the fundamentals of SVCs, STATCOMs, and HVDC transmission systems. Students learn that SVCs and STATCOMs, which are examples of flexible ac transmission systems (FACTS), can be used in conjunction with HVDC transmission systems to greatly enhance the controllability and power transfer capability of a power network and are thus essential tools to the implementation of a smart grid. These courses also allow students to experiment with actual SVCs, STATCOMs, and HVDC transmission systems implemented with power electronics modules.

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

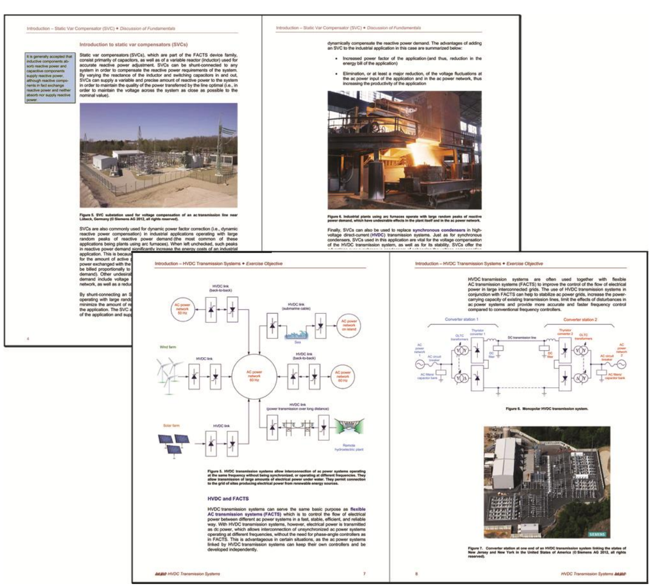
The Electric Power Technology Training Program is highly modular in both courseware and hardware. Because of this, courses and equipment from the program are available as required, either individually or in the context of a specific training system. The program covers several different subjects in the field of electrical energy, such as rotating machines, electrical power transmission, power electronics, home energy production from renewable resources (wind and sunlight), large-scale electricity production from hydropower and wind power, smart-grid technologies (SVC, STATCOM, HVDC transmission, etc.), storage of electrical energy in batteries, and drive systems for small electric vehicles and cars.




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

## Courseware



Each course in the training system includes a full-color student manual providing all the theoretical matter required, guided lab-exercise procedures to be performed with the training equipment, and review questions that test the knowledge gained by the student. Whenever possible, each course is built to bring the student to actual applications as soon as possible. A full-color instructor guide providing all lab results and answers to questions is also included with each course.

## Modular Design Approach

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

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

## Features & Benefits

- The training system teaches the principles behind certain key technologies allowing the implementation of a smart grid. These technologies include home energy production, SVCs, STATCOMs, and HVDC transmission systems.
- Realistic control functions implemented using the Data Acquisition and Control Interface via the LVDAC-EMS software allow the implementation of complex devices such as an SVC and a STATCOM directly in the laboratory.
- The course curriculum of the Electric Power Technology Training Program is highly flexible and allows a multitude of different customized training solutions.
- The courseware includes student manuals and instructor guides with all the theory required to perform the hands-on experiments.
- All workstations, modules, and components are sturdy and protected against electrical damage to ensure a prolonged service life in a demanding environment such as a training laboratory.
- The modular design approach of the training equipment allows a large variety of courses to be performed using a small number of modules, without unnecessary duplication of equipment.
- All electrical components can be interconnected without electric shock hazard since all live parts of the connection leads are concealed and insulated.
- All electrical symbols representing the components used in a laboratory exercise are clearly silk-screened on the front panel of the modules.
- The training system includes two highly versatile USB peripherals:
  - Four-Quadrant Dynamometer/Power Supply, Model 8960-2. This module is used as a solar panel emulator with a large variety of configurable parameters.
  - Data Acquisition and Control Interface, Model 9063. This module gives access to a large variety of computer-based measuring instruments and is used to control the various power electronics devices necessary for home energy production, as well as SVC, STATCOM, and HVDC implantation. All functions are implemented via the LVDAC-EMS software.

- The training system also includes four highly versatile power electronics modules controlled using the Data Acquisition and Control Interface:
  - SVC Reactors/Thyristor Switched Capacitors, Model 8334. This module is used to implement the TCR and TSCs for SVC operation.
  - Insulated DC-to-DC Converter, Model 8835. This module is used to implement a solar/wind power inverter with HF transformer topology.
  - + IGBT Chopper/Inverter, Model 8837-B. This module is used to implement the solar/wind power inverter for home energy production and the three-phase PWM rectifier/inverter for STATCOM operation.
  - Power Thyristors, Model 8841. This module is used to implement the TCR and TSCs for SVC operation and the thyristor converters for HVDC operation.
- Software upgrades for LVDAC-EMS and firmware upgrades for the Four-Quadrant Dynamometer/Power Supply and Data Acquisition and Control Interface are available for download free of charge on the Festo Didactic website.

## List of Equipment

| Qty | Description | Model number |
|---|---|---|
| 1 | Home Energy Production (Student Manual) | 579385 (86361-00) |
| 1 | Home Energy Production (Instructor Guide) | 579387 (86361-10) |
| 1 | Static Var Compensators (SVC) (Student Manual) | 579431 (86370-00) |
| 1 | Static Var Compensators (SVC) (Instructor Guide) | 579432 (86370-10) |
| 1 | Static Synchronous Compensator (STATCOM) (Student Manual) | 579433 (86371-00) |
| 1 | Static Synchronous Compensator (STATCOM) (Instructor Guide) | 579434 (86371-10) |
| 1 | High-Voltage DC Transmission Systems (Student Manual) | 579460 (86380-00) |
| 1 | High-Voltage DC Transmission Systems (Instructor Guide) | 579461 (86380-10) |
| 1 | Tabletop Workstation | 579484 (8134-20) |
| 1 | Resistive Load | 763359 (8311-00) |
| 1 | Inductive Load | 763362 (8321-00) |
| 1 | Filtering Inductors/Capacitors | 579523 (8325-A0) |
| 1 | Three-Phase Filter | 579529 (8326-00) |
| 1 | Line Inductors | 763364 (8326-A0) |
| 2 | Three-Phase Transmission Line | 579535 (8329-00) |
| 1 | Capacitive Load | 763366 (8331-00) |
| 1 | SVC Reactors / Thyristor-Switched Capacitors | 763368 (8334-00) |
| 2 | Three-Phase Transformer Bank | 579559 (8348-40) |
| 2 | Three-Phase Regulating Autotransformer | 763369 (8349-00) |
| 1 | Transformer | 763371 (8353-00) |
| 1 | Three-Phase Transformer | 763373 (8354-00) |
| 1 | AC Power Network Interface | 579581 (8622-00) |
| 1 | Lead-Acid Battery Pack | 579591 (8802-10) |
| 1 | Variable Three-Phase Power Supply | 579603 (8821-20) |
| 1 | Insulated DC-to-DC Converter | 579618 (8835-00) |
| 1 | IGBT Chopper/Inverter | 579623 (8837-B0) |
| 2 | Power Thyristors | 763376 (8841-20) |
| 1 | Connection Lead Set | 579638 (8951-L0) |
| 1 | Connection Lead Set | 579639 (8951-N0) |
| 1 | Four-Quadrant Dynamometer/Power Supply | 579674 (8960-G0) |

| Qty | Description | Model number |
|---|---|---|
| 1 | Data Acquisition and Control Interface | 579677 (9063-00) |
| 1 | Data Acquisition and Control Interface | 579694 (9063-H0) |

## List of Manuals

| Description | Manual number |
|---|---|
| Home Energy Production (Workbook) | 579385 (86361-00) |
| Home Energy Production (Workbook (Instructor)) | 579387 (86361-10) |
| Static Var Compensator (SVC) (Workbook) | 579431 (86370-00) |
| Static Var Compensator (SVC) (Workbook (Instructor)) | 579432 (86370-10) |
| Static Synchronous Compensator (STATCOM) (Workbook) | 579433 (86371-00) |
| Static Synchronous Compensator (STATCOM) (Workbook (Instructor)) | 579434 (86371-10) |
| HVDC Transmission Systems (Workbook) | 579460 (86380-00) |
| HVDC Transmission Systems (Workbook (Instructor)) | 579461 (86380-10) |
| Electric Power Technology Training Equipment (User Guide) | 584778 (38486-E0) |
| Computer-Based Instruments for EMS (User Guide) | 585219 (86718-E0) |

## Table of Contents of the Manual(s)

**Home Energy Production (Workbook) (579385 (86361-00))**

- 1 Stand-Alone Home Energy Production
- 2 Single-Phase Grid-Tied Inverter (PWM Rectifier/Inverter)
- 3 Grid-Tied Home Energy Production Using a Solar or Wind Power Inverter without DC-to-DC Converter
- 4 Grid-Tied Home Energy Production Using a Solar or Wind Power Inverter with DC-to-DC Converter
- 5 Large-Scale Energy Storage: A Step in the Implementation of the Smart Grid

**Static Var Compensator (SVC) (Workbook) (579431 (86370-00))**

- 1 Main Components of a Static Var Compensator (SVC)
- 2 Voltage Compensation of AC Transmission Lines Using an SVC
- 3 Dynamic Power Factor Correction Using an SVC

**Static Synchronous Compensator (STATCOM) (Workbook) (579433 (86371-00))**

- 1 Voltage Compensation of AC Transmission Lines Using a STATCOM
- 2 Dynamic Power Factor Correction Using a STATCOM

**HVDC Transmission Systems (Workbook) (579460 (86380-00))**

- 1 Voltage Regulation and Displacement Power Factor (DPF) in Thyristor Three-Phase Bridges
- 2 Basic Operation of HVDC Transmission Systems
- 3 DC Current Regulation and Power Flow Control in HVDC Transmission Systems
- 4 Commutation Failure at the Inverter Bridge
- 5 Harmonic Reduction using Thyristor 12-Pulse Converters

**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

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

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

## Additional Equipment Required to Perform the Exercises (Purchased separately)

| Qty | Description | Model number |
|---|---|---|
| 1 | Digital Multimeter | 579782 (8946-20) [1] |

## Software

| Qty | Description | Model number |
|---|---|---|
| 1 | SCADA for LVDAC-EMS | 8094377 (8973-00) [2] |
| 1 | Software Development Kit (SDK) | 581459 (9069-90) [3] |

## System Specifications

| Parameter | Value |
|---|---|
| **Sytem 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 |
| **Computer Requirements** | |
| Computer Requirements | A currently available personal computer with USB 2.0 ports, running under one of the following operating systems: Windows® 7 or Windows® 8. |
| **Physical Characteristics** | |
| Intended Location | On a table able to support the weight of the workstation and installed equipment |
| Dimensions (H x W x D) | 900 x 930 x 530 mm (35.4 x 36.6 x 20.9 in) |
| Net Weight | TBE |
| **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) |

[1] The data acquisition already includes this function and many more, but the DC Circuits manual references using multimeters.
[2] Software allowing the monitoring of up to 5 Stations through OPC.
[3] Additional firmware for the Data Acquisition.

# Equipment Description

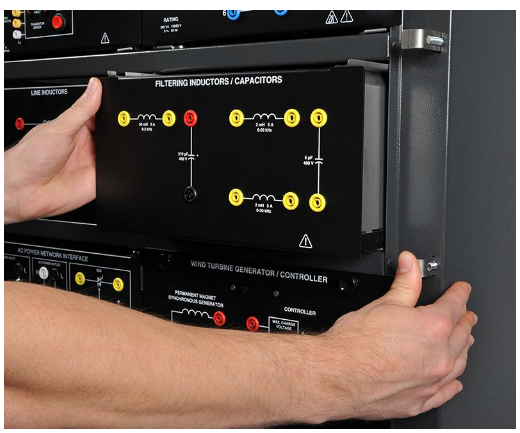
## Tabletop Workstation
## 579484 (8134-20)

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

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.

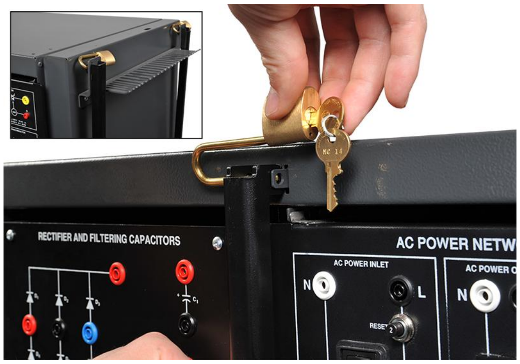
### Module Installation

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

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

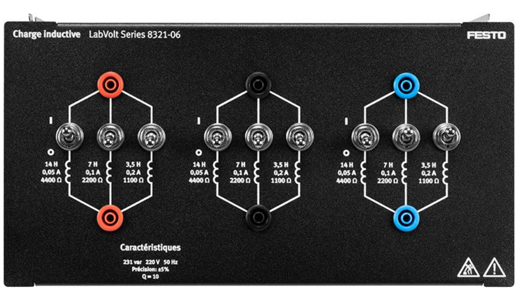
The Resistive Load consists of a module housing nine wire-wound power resistors arranged in three identical banks. Each bank consists of three resistors connected in parallel that can be switched on or off with toggle switches to obtain various resistance values. This allows the total (equivalent) resistance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



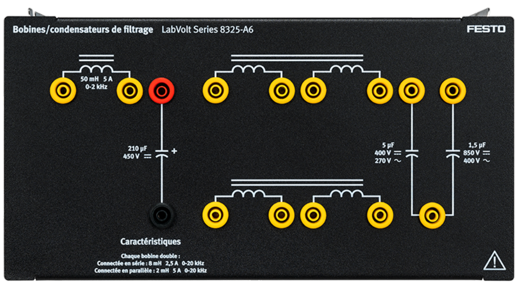

The Inductive Load consists of a module housing nine iron-core power inductors arranged in three identical banks. Each bank consists of three inductors connected in parallel that can be switched on or off with toggle switches to obtain various inductance values. This allows the equivalent inductance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

# Filtering Inductors/Capacitors 579523 (8325-A0)

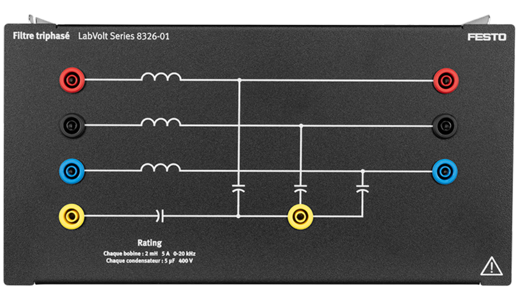



This Filtering Inductors/Capacitors module consists of two separate filters enclosed in a half-size EMS module: a low-frequency filter and a high-frequency filter. The low-frequency filter consists of an inductor and a polarized capacitor, while the high-frequency filter consists of two inductors and a non-polarized capacitor. Internal electrical components are identified on the module front panel. 4 mm banana jacks provide access to the different components in the module.

## Specifications

| Parameter | Value |
|---|---|
| **Low Frequency Filter** | |
| Inductance | 50 mH - 5 A - 0-2 kHz |
| Capacitor (Aluminium Electrolytic) | 210 µF - 450 V |
| **High Frequency Filter** | |
| Inductance (2) | 2 mH - 5 A - 0-20 kHz |
| Capacitor (Metallized Polypropylene) | 5 µF - 400 V |
| Supplementary Capacitor (Met. Prop.) | N/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 | 12.3 kg (27.12 lb) |

# Three-Phase Filter 579529 (8326-00)




The Three-Phase Filters consists of three inductors and four capacitors enclosed in a half-size EMS module. Eight safety banana jacks on the module front panel provide access to the three-phase filter. The module is used to filter three-phase signals in power electronics applications.

## Specifications

| Parameter | Value |
|---|---|
| **Inductors** | |
| Number | 3 |
| Ratings | 2 mH – 5 A – 0-20 kHz |
| **Capacitors** | |
| Number | 4 |
| Type | Metallized polypropylene |
| Ratings | 5 µF – 400 V |
| **Physical Characteristics** | |
| Dimensions (H x W x D) | 154 x 287 x 440 mm (6.1 x 11.3 x 17.3 in) |
| Net Weight | TBE |

# Line Inductors
# 763364 (8326-A0)

The Line Inductors module consists of three separate inductors enclosed in a half-size EMS module to be connected in series in a three-phase circuit. Six safety banana jacks provide individual access to each inductor. The Line Inductors are used to limit the rate of change of line currents in three-phase ac power systems.

## Specifications

| 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 | TBE |
| **Inductors** | |
| Number | 3 |
| Ratings | 25 mH – 1.5 A – 50/60 Hz |

# Three-Phase Transmission Line
# 579535 (8329-00)

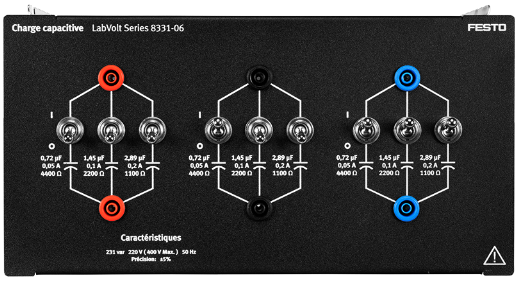
The Three-Phase Transmission Line consists of three iron-core inductors enclosed in a half-size EMS module. The inductors are specifically designed to simulate a high-voltage ac transmission line (typically 315 kV lines). The line impedance can be adjusted to four different values using a selector switch mounted on the front panel. A three-pole switch is used to induce transients by momentarily interrupting the power flow. Both sides (sender and receiver) of the Three-Phase Transmission Line are terminated on the front panel by 4 mm color-coded safety banana jacks.

## Specifications

| Parameter | Value |
|---|---|
| **Ratings** | |
| Line Reactance Settings | 0, 60, 120, and 180 Ω |
| Nominal Line Current | 1 A |
| Line Simulated Lengths | 175, 350 and 525 km (109, 217 and 326 miles) |

| 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 | 8.2 kg (18 lb) |
| Shipping Weight | 9.8 kg (21.6 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) |

## SVC Reactors / Thyristor-Switched Capacitors
## 763368 (8334-00)

The SVC Reactors / Thyristor-Switched Capacitors module consists of a set of three identical inductors to implement thyristor-controlled reactors (TCRs) using the Power Thyristors, Model 8841. The module contains two sets of three identical capacitors with a solid-state relay for each capacitor to implement two thyristor-switched capacitors (TSCs). Eleven safety banana jacks on the module front panel provide access to the TCRs and TSCs. The module also includes two digital inputs (TTL) to control the TSCs using a Data Acquisition and Control Interface, Model 9063.

### Specifications

| Parameter | Value |
|---|---|
| **SVC Reactors** | |
| Quantity | 3 |
| Impedance | 465 Ω |
| Ratings | 120 V - 60 Hz |
| Reactive Power | 31 var |
| **SVC Thyristor-Switched Capacitors** | |
| Quantity | 6 |
| Impedance | 600 Ω |
| Ratings | 120 V - 60 Hz |
| Reactive Power | 24 var |
| Switching Control Inputs | 0/3.5 V (9 mA) and 0/5 V (15 mA) |
| **Physical Characteristics** | |
| Dimensions (H x W x D) | 154 x 287 x 440 mm (6.1 x 11.3 x 17.3 in) |
| Net Weight | TBE |

## Three-Phase Transformer Bank
## 579559 (8348-40)

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

### Specifications

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

| Parameter | Value |
|---|---|
| Net Weight | 13.9 kg (30.6 lb) |

## Three-Phase Regulating Autotransformer 763369 (8349-00)

The Three-Phase Regulating Autotransformer consists of a three-phase autotransformer enclosed in a half-size EMS module. Eight safety banana jacks on the module front panel provide access to both sides of the regulating autotransformer. A buck-boost selector switch can be used to increase or decrease the autotransformer output voltage by 15%. A phase-shift selector switch can be used to set the phase shift produced by the autotransformer output voltage to ±15°. A phase sequence indicator on the module front panel indicates the phase sequence of the voltages across the autotransformer.

### Specifications

| Parameter | Value |
|---|---|
| **Rating** | |
| Line Voltage | 120/208 V |
| Power | 360 VA |
| Line Current | 1 A |
| Buck-Boost Voltage | -15, 0, -15% |
| Phase Shift | -15, 0, -15° |
| Phase Sequence | 1-2-3 |
| **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 | 7.6 kg (16.7 lb) |
| Shipping Weight | 9.2 kg (20.2 lb) |

## Transformer 763371 (8353-00)

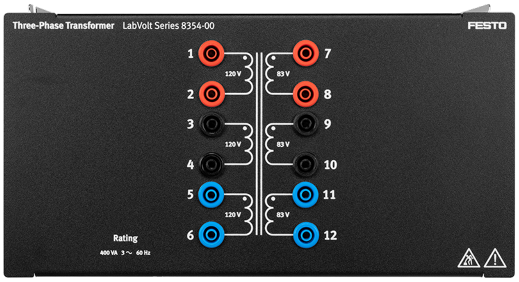
The Transformer consists of a power transformer enclosed in a module. Both the primary and secondary sides of the Transformer are made of two identical separate windings. Banana jacks on the module front panel provide access to each winding, allowing connection in a variety of configurations. The Transformer has a turns ratio of 1:5, when considering the totality of its primary and secondary windings. The Transformer windings are polarized and the polarity of each winding is indicated by a small dot on the module front panel. A thermistor output allows monitoring of transformer temperature to prevent overheating. A typical application of the Transformer is to convert the energy stored in batteries to a suitable voltage level (for example, to the level of the ac power network voltage).

### Specifications

| Parameter | Value |
|---|---|
| **Nominal Power** | 240 VA |
| **Primary Rating (2 windings)** | 24 V AC – 5 A for each winding |
| **Secondary Rating (2 windings)** | 120 V ac – 1 A for each winding |
| **Protection** | 10 kΩ thermistor, type 2 |

| Parameter | Value |
|---|---|
| **Physical Characteristics** | |
| Dimensions (H x W x D) | 154 x 287 x 440 mm (6.1 x 11.3 x 16.1 in) |
| Net Weight | TBE |

## Three-Phase Transformer 763373 (8354-00)




The Three-Phase Transformer is a three-phase power tranformer, made up of a single magnetic core with three branches, enclosed in a half-size EMS module. It is used to adjust the ac power network voltage to a value more suitable for certain power electronics applications. For example, the Three-Phase Transformer is used to adapt the value of the three-phase ac power network voltage to the value of the dc bus voltage in three-phase PWM rectifiers/inverters. Twelve banana jacks on the module front panel provide individual access to each phase of the power transformer, allowing connection in wye or delta configuration.

### Specifications

| Parameter | Value |
|---|---|
| **Rating (Each Phase Winding)** | |
| Primary Voltage | 120 V |
| Secondary Voltage | 83 V |
| Power | 200 VA |
| Primary Current | 1.7 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 | TBE |

## AC Power Network Interface 579581 (8622-00)


The AC Power Network Interface is used to interface the ac power network with EMS modules. It consists of an AC Power Inlet section comprising a C14 power cord inlet with 4 mm color-coded safety sockets for each terminal (line, neutral, and ground). The line is fuse-protected between the inlet and the safety jacks. The module also consists of an AC Power Outlet section comprising a standard ac outlet (country dependent) with direct connections to safety sockets. A solid-state relay used for network disconnection and a filtering inductor are also included in the model to complete the interface with the ac network.

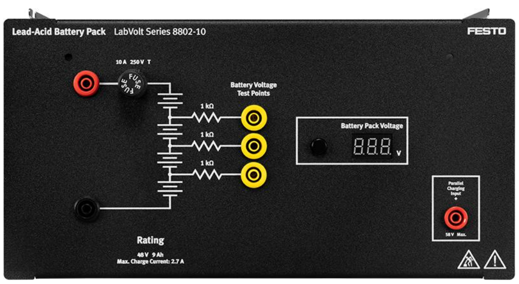
All components of the AC Power Network Interface are industrial components and are mounted in the module to allow visual inspection. Where necessary, these components are protected against overload or short-circuit conditions by thermal-magnetic circuit breakers. The components are terminated on the module faceplate by 4 mm color-coded safety sockets and are identified by schematic symbols, numbered terminal codes, and electrical ratings.

### Specifications

| Parameter | Value |
|---|---|
| **AC Power Inlet** | |

| Parameter | Value |
|---|---|
| Rating | 120 V - 2 A - 60 Hz |
| Type | C14 connector |
| Circuit Breaker | 2 A |
| **AC Power Outlet** | |
| Rating | 120 V - 8 A - 60 Hz |
| Type | NEMA 5-15 (type B) |
| **Solid-State Relay** | |
| Coil Rating | 3 to 32 V dc - 15 mA |
| Contact Rating | 24 to 240 V - 8 A - 60 Hz |
| **Filtering Inductor** | 2 mH - 5 A - 0 to 20 kHz |
| **Physical Characteristics** | |
| Dimensions (H x W x D) | 154 x 287 x 440 mm (6.1 x 11.3 x 17.3 in) |
| Net Weight | TBE |

## Lead-Acid Battery Pack
## 579591 (8802-10)

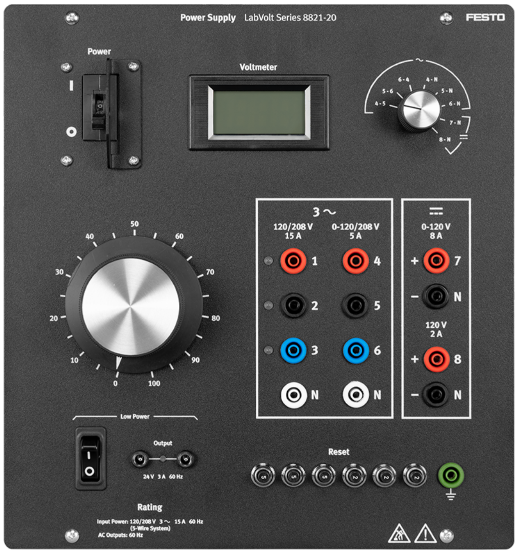



The Lead-Acid Battery Pack is a half-size EMS module housing four 12 V lead-acid batteries connected in series. The Lead-Acid Battery Pack thus provides a fixed dc voltage of 48 V, available at two color-coded safety banana jacks on the module front panel. Three battery voltage test points allow measurement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

## Specifications

| Parameter | Value |
|---|---|
| **Battery Pack** | |
| Type | 4 valve-regulated lead-acid batteries |
| Voltage | 48 V (12 V for each battery) |
| Capacity | 9 Ah |
| Maximum Charge Current | 2.7 A |
| Maximum Discharge Current | 7 A |
| Parallel Charging Input | 58 V maximum |
| **Overcurrent Protection** | |
| Battery Pack Fuse | 10 A |
| Test Point Limiting Resistors (3) | 1 kΩ |
| **Physical Characteristics** | |
| Dimensions (H x W x D) | 154 x 287 x 440 mm (6.1 x 11.3 x 17.3 in) |
| Net Weight | 13.8 kg (30.4 lb) |

## Variable Three-Phase Power Supply 579603 (8821-20)

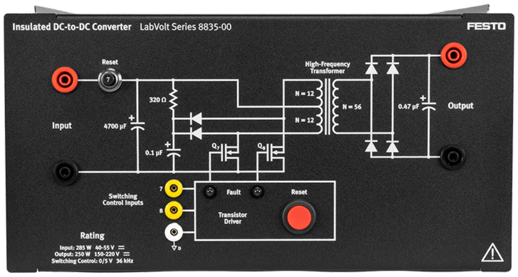


The Power Supply is enclosed in a full-size EMS module. It can be used to power most of the EMS modules of the Electricity and New Energy Training Equipment. This Power Supply provides dc power and ac power, both fixed and variable, single-phase and three-phase. Color-coded safety banana jacks provide 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 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. |

## Insulated DC-to-DC Converter
## 579618 (8835-00)

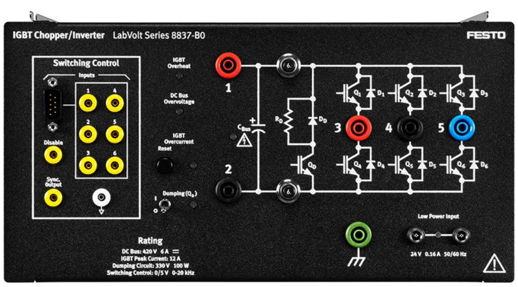



The Insulated DC-to-DC Converter is used to convert a low-voltage dc source, such as the Battery Pack, Model 8802, into a high-voltage dc output suitable for ac conversion. This type of converter (push-pull) can be found in most switched-mode power supplies and commercial inverters. The Insulated DC-to-DC Converter mainly consists of two power MOSFETs and their respective drivers, an high-frequency power transformer and a full-wave diode bridge on the output side. The MOSFETs can be controlled using an external controller or the digital outputs of the Data Acquisition and Control Interface, Model 9063. Internal electrical components are identified on the module front panel by silkscreened symbols and terminated by 4 mm safety banana jacks.

### Specifications

| Parameter | Value |
|---|---|
| **Input** | |
| Rating | 285 W - 40-55 V dc |
| Circuit Breaker | 7 A |
| **Output Rating** | 250 W - 150-220 V dc |
| **Switching Control Inputs** | |
| Quantity | 2 |
| Signal Level | 0-5 V (TTL compatible) |
| Nominal Frequency | 36 kHz |
| Maximum Duty Cycle per signal | 45 % |
| **Physical Characteristics** | |
| Dimensions (H x W x D) | 154 x 287 x 440 mm (6.1 x 11.3 x 17.3 in) |
| Net Weight | TBE |

## IGBT Chopper/Inverter
## 579623 (8837-B0)




The IGBT Chopper/Inverter module consists of seven insulated-gate bipolar transistors (IGBT) mounted in a half-size EMS module. Six IGBTs are used to implement choppers and inverters. These IGBTs are protected against a variety of abnormal operating conditions, such as short-circuits, overvoltage, overcurrent, and overheat. The seventh IGBT and a dumping resistor allow smooth dissipation of excess energy at the dc bus. The dumping circuit can be activated through the use of a toggle switch on the front panel.

The module switching control section allows 0/5 V pulse signals from either the Data Acquisition and Control Interface, Model 9063, the Chopper/Inverter Control Unit, Model 9029, or any compatible 0/5 V control unit, to be applied to the gating circuits of the IGBTs. The signals are input in the IGBT Chopper/Inverter module through a nine-pin connector.

Six miniature banana jacks can be used as test points to monitor the pulse signals using an oscilloscope. These jacks can also be used to inject 0/5 V pulse signals from an alternate control unit, as well as to inhibit each gating circuit. The IGBT Chopper/Inverter module also includes a synchronization output to trigger an oscilloscope when observing the switching control signals, as well as a switching control disable input that allows all six IGBTs in the chopper/inverter section to be switched off.

## Specifications

| Parameter | Value |
|---|---|
| **DC Bus** | |
| Maximum Voltage | 420 V |
| Maximum Current | 6 A |
| Filtering Capacitor | 1360 µF |
| **Protections** | |
| DC Bus Overvoltage | 440 V |
| DC Bus Circuit Breaker | 6 A |
| IGBT Electronic Overcurrent | 12 A |
| IGBT Overheat | About 60ºC |
| **Dumping Circuit** | |
| Voltage Threshold | 330 V |
| Resistor | 100 Ω, 100 W |
| **Switching Control Signals** | |
| Level | 0/5 V |
| High Level Current | about 600 µA |
| Frequency Range | 0-20 kHz |
| Minimum Dead Time | 1.2 µs |
| **Power Requirements** | 24 V, 0.16 A, 50/60 Hz |
| **Accessories** | |
| Accessories | 24 V power cable (1) |
| | 2 mm banana plug test leads (2) |
| | DB9 connector control cable (1) |
| **Physical Characteristics** | |
| Dimensions (H x W x D) | 154 x 287 x 410 mm (6.1 x 11.3 x 16.1 in) |
| Net Weight | 6.8 kg (15 lb) |

## Power Thyristors
## 763376 (8841-20)


The Power Thyristors module consists of six power thyristors (SCRs) mounted in a half-size EMS enclosure. Each individual thyristor is protected against overcurrents and short-circuits. All the anodes and cathodes of the thyristors are terminated on the front panel by color-coded, 4 mm safety banana jacks. To reduce the number of external connections, the most typical thyristor configurations can be achieved through the use of two toggle switches on the front panel.

A firing control section allows six 0-5 V pulse signals from either the Data Acquisition and Control Interface, Model 9063, the Thyristor Firing Unit, Model 9030, or any compatible 0-5 V control unit, to be applied to the gating circuits of the thyristors. The signals are input in the Power Thyristors module through a nine-pin connector.

Six miniature banana jacks in this section are used as test points to monitor the firing control signals using an oscilloscope. They can also be used to inject 0-5 V pulse signals from an alternate firing unit, as well as to inhibit each gating circuit. The Power Thyristors module also includes a synchronization output to trigger an oscilloscope when observing the firing control signals as well as a firing control disable input that prevents all six power thyristors from being fired.

## Specifications

| Parameter | Value |
|---|---|
| **Rating** | |
| Peak Inverse Voltage | 600 V |
| Maximum Current | 2 A |

| Parameter | Value |
|---|---|
| Gate Control Signals | 0-5 V Pulses (TTL compatible) |
| **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 | 5.6 kg (12.35 lb) |

## Connection Lead Set 579638 (8951-L0)

This Connection Lead Set consists of extra-flexible leads terminated with stacking 4 mm safety banana plugs. In addition, the set includes stacking 2 mm banana plug leads of the same length and color.

4mm: 20 x 30 cm yellow, 10 x 60 cm red, 4 x 90 cm blue. 2mm: 4 x 60 cm red.

### Specifications

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

## Connection Lead Set 579639 (8951-N0)

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

579639 (8951-N0):

4mm: 14 x 30 cm yellow, 8 x 60 cm red, 4 x 90 cm blue. 4 x 60 cm 3 phase.

579640 (8951-NA):

4mm: 14 x 30 cm yellow, 8 x 60 cm red, 4 x 90 cm blue. 2mm: 10 x 60 cm red. 4 x 3 phase 60 cm.

### 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) | 14 |
| Red, 60 cm (24 in) | 8 |
| Blue, 90 cm (36 in) | 4 |
| **Three-Phase 4 mm Safety Banana Plug Leads Characteristics** | |
| Cross Section | 1 mm² (1974 cmil) |
| Rated Current | 19 A |
| Rated Voltage | 600 V, CAT II |

| Parameter | Value |
|---|---|
| **Three-Phase 4 mm Safety Banana Plug Leads Quantities** | |
| Red/Black/Blue, 60 cm (24 in) | 4 |

## Four-Quadrant Dynamometer/Power Supply 579674 (8960-G0)

The Four-Quadrant Dynamometer/Power Supply is a highly versatile USB peripheral designed to be used in the Electric Power Technology Training Systems. Two operating modes are available: Dynamometer and Power Supply. A wide variety of user-selectable functions is available in each operating mode.

In the Dynamometer mode, the unit becomes a four-quadrant dynamometer that can act as either a fully configurable brake (i.e., a mechanical load) or a fully configurable prime mover (i.e., a motor drive). In the Power Supply mode, the unit becomes a four-quadrant power supply that can act as a dc voltage source, dc current source, ac power source, etc.

In each operating mode, key parameters related to the selected function are displayed. Speed, torque, mechanical power, and energy are displayed in the Dynamometer mode while voltage, current, electrical power, and energy are displayed in the Power Supply mode. Optional functions, such as a small wind-turbine emulator, an hydraulic turbine emulator, a solar panel emulator, battery chargers, an SDK (Software Development Kit) etc., can be added to the standard functions to further enhance the training possibilities of the Four-Quadrant Dynamometer/Power Supply. Refer to the Optional Equipment section of this data sheet for more information about the optional functions currently available.

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

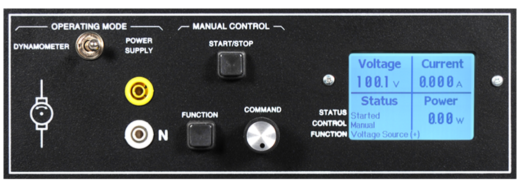
In the Manual control mode, the module operates as a stand-alone unit, and the function performed is selected, set, and monitored using front-panel mounted controls and display. This mode provides access to all basic functions. In the Computer-Based control mode, the function performed by the module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

## Four-Quadrant Dynamometer/Power Supply

The Four-Quadrant Dynamometer/Power Supply mainly consists of a permanent-magnet dc motor, a four-quadrant power supply, and an onboard microcontroller enclosed in a full-size EMS module. A toggle switch on the front panel allows selection of the operating mode (Dynamometer or Power Supply).

In the Dynamometer mode, the unit operates as a four-quadrant dynamometer that can act as either a fully configurable brake (i.e., a mechanical load), a fully configurable prime mover (i.e., a motor drive), a small wind turbine emulator (optional), depending on the control function selected by the user. A pulley on the machine shaft allows mechanical coupling to any EMS rotating machine.

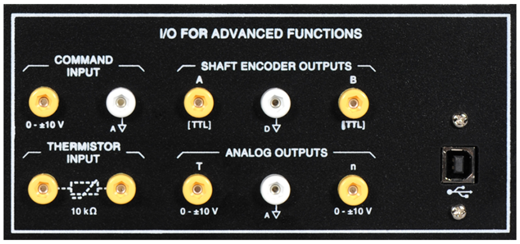
In the Power Supply mode, the four-quadrant power supply operates as a four-quadrant power supply that can act as a dc voltage source, dc current source, ac power source, etc., depending on the control function selected by the user. Two 4 mm safety banana jacks on the front panel provide access to the four-quadrant power supply terminals.




Controls, power supply terminals, and display on the front panel.

In the Manual control mode, two push buttons (FUNCTION and START/STOP), a control knob (COMMAND), and an LCD mounted on the front panel of the module allow the function performed by the unit to be selected, set, and monitored.

The Four-Quadrant Dynamometer/Power Supply is provided with a set of low-level (0 to ±10 V) inputs and outputs for advanced functions. Access to these inputs and outputs is through miniature banana jacks on the front panel.




Low-level inputs and outputs for advanced control functions and USB port connector on the front panel.

The Command Input allows an analog signal to be injected into the module. The voltage of this signal determines the command (e.g., the current command of a DC current source) of the function implemented by the module when the Command Input is selected as the source of command (option available in the Computer-Based control mode). The Thermistor Input allows connection of an external temperature sensor (thermistor) for temperature measurement using the Four-Quadrant Dynamometer/Power Supply. Temperature measurement is required for some advanced functions such as the Ni-MH battery chargers. The Shaft Encoder Outputs provide the digital signals (A-B output type) produced by the shaft encoder mounted on the PM DC motor. Finally, the T and n Analog Outputs provide analog signals proportional to the torque and speed measured at the shaft of the permanent-magnet dc motor. These outputs are designed to be connected to the corresponding inputs on data acquisition modules (Models 9061, 9062, and 9063) for torque and speed measurement using the LVDAC-EMS or LVDAM-EMS software.

A USB port connector mounted on the front panel allows the Four-Quadrant Dynamometer/Power Supply to be connected to a USB port of the computer running the LVDAC-EMS software (USB cable included with the module). A main power connector mounted on the front panel is used to connect the Four-Quadrant Dynamometer/Power Supply to a standard wall receptacle using a conventional line cord (included with the module). All inputs and outputs of the Four-Quadrant Dynamometer/Power Supply are protected against improper connections and overvoltage/overcurrent conditions.

The internal friction of the permanent-magnet dc machine and the friction of the belt coupling are measured after assembly for each Four-Quadrant Dynamometer/Power Supply. The measured friction data is stored in the microcontroller memory and used to compensate the effect of friction in order to achieve accurate torque measurements. An auxiliary function of the Four-Quadrant Dynamometer/Power Supply allows the user to easily recalibrate the friction compensation. Recalibration of the friction compensation is useful to maintain optimal torque measurement accuracy as the internal friction of the machine decreases slightly with usage. The Zero Friction Machine, Model 8969, is required to perform recalibration of the friction compensation.

The optional functions currently available for the Four-Quadrant Dynamometer/Power Supply are described in the Optional Module Functions section of this data sheet. To activate a specific optional function, a license for that function, Model 8968-X, must be ordered for each Four-Quadrant Dynamometer/Power Supply that will be used to perform this function.

## Model Variants

The Four-Quadrant Dynamometer/Power Supply is available in several model variants. Each variant consists of the Four-Quadrant Dynamometer/Power Supply, Model 8960-3, plus a unique combination of functions pre-activated in the module. The model variants currently available are listed in the following table. Other model variants will be added as they become available.

| Control Function Sets | | Model Variants | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Model** | **Name** | **8960-A** | **8960-B** | **8960-C** | **8960-D** | **8960-E** | **8960-F** | **8960-G** |
| 8968-0 | Complete Function Set | ● | | | | | | |
| 8968-1 | Standard Functions (Manual Control) | ● | ● | ● | ● | ● | ● | ● |
| 8968-2 | Standard Functions (Computer-Based Control) | ● | | ● | ● | ● | ● | ● |
| 8968-3 | Turbine Emulator | ● | | | ● | | ● | |
| 8968-4 | Lead-Acid Battery Charger | ● | | | ● | ● | ● | |
| 8968-5 | Ni-MH Battery Charger | ● | | | | | | |
| 8968-6 | Solar Panel Emulator | ● | | | | | ● | ● |
| 8968-7 | Software Development Kit (SDK) | ● | | | | | | |

Model 8960-B is the basic variant of the Four-Quadrant Dynamometer/Power Supply and is designed to operate as a stand-alone unit (no computer required). It includes all standard functions available in the Manual control mode only (Model 8968-1). Model 8960-B is a direct replacement for the older Prime Mover / Dynamometer, Model 8960-1, used in the 0.2 kW Computer-Assisted Electromechanical Training System, Model 8006.

Model 8960-C is a step-up variant that includes all standard functions available in the Manual control mode (Model 8968-1) plus all standard functions available in the Computer-Based control mode (Model 8968-2). Model 8960-C is the minimal variant that allows the addition of optional functions required to perform certain courses in the Electric Power Technology Training Program, Series 8010. For instance, Model 8960-D consists of the Four-Quadrant Dynamometer/Power Supply, Model 8960-C, plus the licenses for the Turbine Emulator, Model 8968-3, and the Lead-Acid Battery Charger, Model 8968-4, which are required to perform several lab exercises in the Basic Renewable Energy Training System, Model 8010-5.

Model 8960-A is the fully equipped variant including all optional functions currently available for the Four-Quadrant Dynamometer/Power Supply.

Four-Quadrant Dynamometer/Power Supply modules with a specific combination of pre-activated optional functions other than those listed above can also be ordered. To order a customized Four-Quadrant Dynamometer/Power Supply, request Model 8960-C and add each desired optional function (8968-X).

## LVDAC-EMS Software

The LVDAC-EMS software is a freeware which can be downloaded from website www.labvolt.com. It is a user-friendly tool that facilitates the use of the various functions which can be implemented with USB peripherals such as the Four-Quadrant Dynamometer/Power Supply, Model 8960-3, and the Data Acquisition and Control Interface, Model 9063.

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

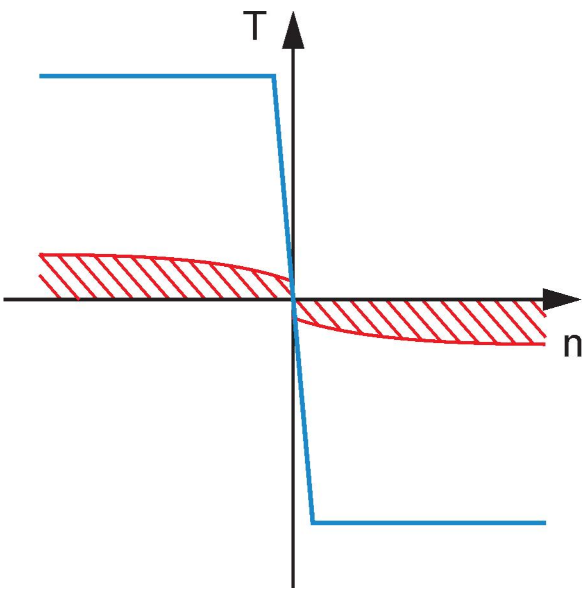
Using LVDAC-EMS with the Four-Quadrant Dynamometer/Power Supply provides access to the basic functions available in the Manual control mode plus a broad selection of advanced functions not available in the Manual control mode. Furthermore, extra information is provided for each control function. All parameters related to the function performed by the Four-Quadrant Dynamometer/Power Supply can be monitored using the computer-based instruments in LVDAC-EMS and exported to the LVDAC-EMS Data Table and Graph tool for further analysis.

## Module Functions

The Four-Quadrant Dynamometer/Power Supply can perform a wide variety of functions in each of the two operating modes (Dynamometer and Power Supply). The standard functions available in each operating mode are described below. A table at the end of this section lists the standard functions available in each of the two control modes (Manual and Computer-Based).

## Function Description (Dynamometer Operating Mode)

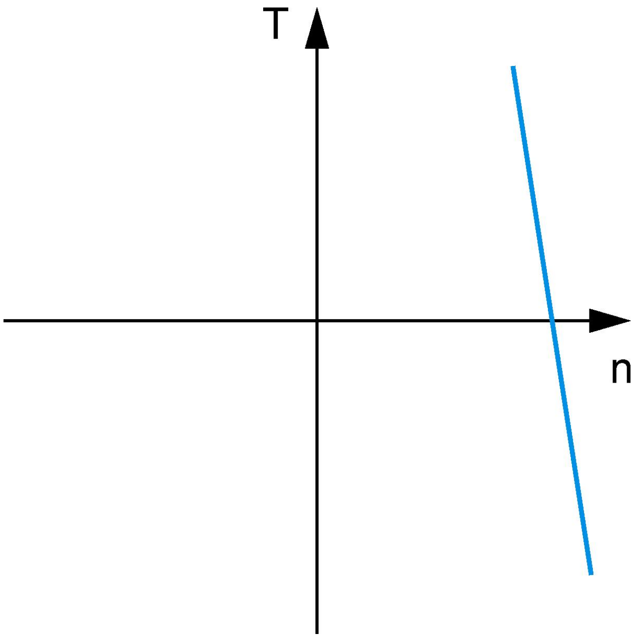
### Two-Quadrant, Constant-Torque Brake




This function makes the permanent-magnet dc machine operate as a generator to produce a constant opposition to the rotation of the machine coupled to the Four-Quadrant Dynamometer/Power Supply (i.e., the machine under test). Closed-loop control is used to maintain the opposition torque constant when the rotation speed changes. A torque command entered by the user determines the value (magnitude) of the torque opposing rotation of the machine under test. The function indicates the speed, torque, mechanical power, and energy measured at the shaft of the machine under test. The function can also indicate the machine temperature when the temperature sensor of the machine under test (if so equipped) is connected to the Thermistor Input of the Four-Quadrant Dynamometer/Power Supply.

### Clockwise Prime Mover/Brake

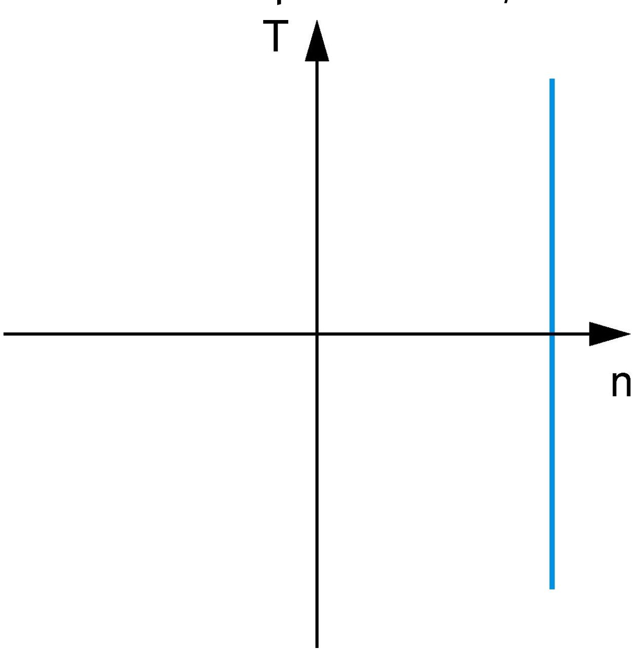



This function uses the permanent-magnet dc machine to make the machine coupled to the Four-Quadrant Dynamometer/Power Supply (i.e., the machine under test) rotate clockwise at a certain speed. A speed command entered by the user determines the no-load rotation speed of the machine under test. The function indicates the speed, torque, mechanical power, and energy measured at the shaft of the machine under test. The function can also indicate the machine temperature when the temperature sensor of the machine under test (if so equipped) is connected to the Thermistor Input of the Four-Quadrant Dynamometer/Power Supply. This function is well suited for the study of AC generator synchronization.

### Counterclockwise Prime Mover/Brake

Same as the Clockwise Prime Mover/Brake function except for the direction of rotation.

### Clockwise Constant-Speed Prime Mover/Brake

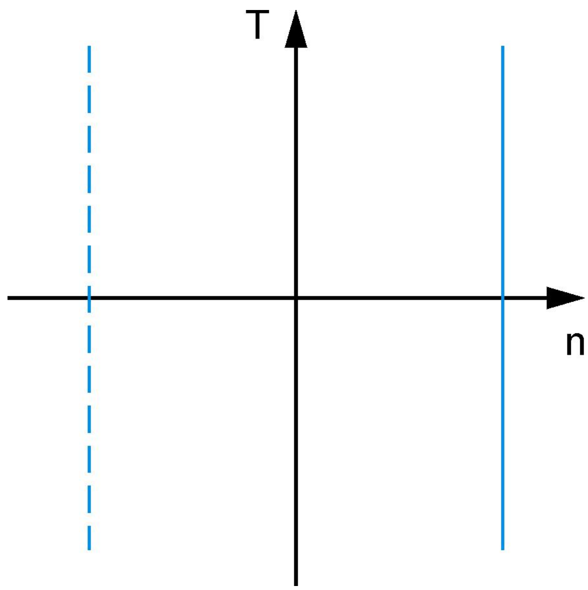



This function uses the permanent-magnet dc machine to make the machine coupled to the Four-Quadrant Dynamometer/Power Supply (i.e., the machine under test) rotate clockwise at a fixed speed. Closed-loop control is used to maintain the rotation speed constant under varying load conditions. A speed command entered by the user determines the rotation speed of the machine under test. The function indicates the speed, torque, mechanical power, and energy measured at the shaft of the machine under test. The function can also indicate the machine temperature when the temperature sensor of the machine under test (if so equipped) is connected to the Thermistor Input of the Four-Quadrant Dynamometer/Power Supply.

### Counterclockwise Constant-Speed Prime

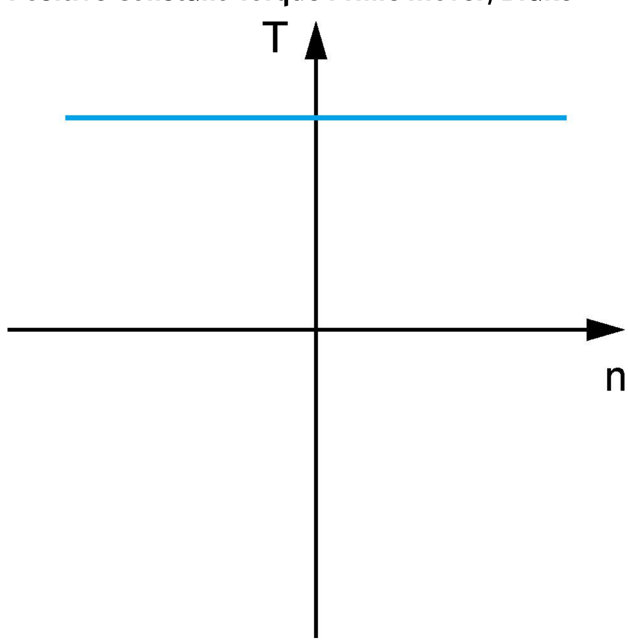
Mover/Brake Same as the Clockwise Constant-Speed Prime Mover/Brake except for the direction of rotation.

### Four-Quadrant, Constant-Speed Prime Mover/Brake




This function uses the permanent-magnet dc machine to make the machine coupled to the Four-Quadrant Dynamometer/Power Supply (i.e., the machine under test) rotate at a fixed rotation speed. Closed-loop control is used to maintain the rotation speed constant under varying load conditions. A speed command entered by the user determines the value (direction and magnitude) of the speed at which the machine under test rotates. The function indicates the speed, torque, mechanical power, and energy measured at the shaft of the machine under test. The function can also indicate the machine temperature when the temperature sensor of the machine under test (if so equipped) is connected to the Thermistor Input of the Four-Quadrant Dynamometer/Power Supply.

### Positive Constant-Torque Prime Mover/Brake



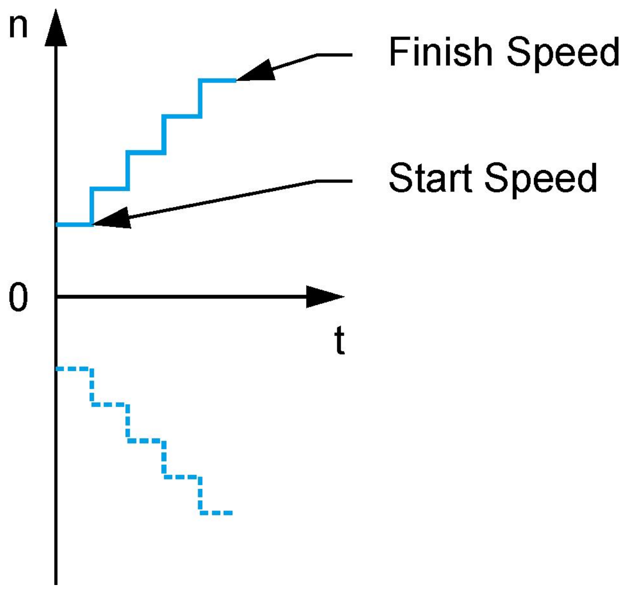

This function uses the permanent-magnet dc machine to apply a positive (i.e., applied in clockwise direction) constant torque to the machine coupled to the Four-Quadrant Dynamometer/Power Supply (i.e., the machine under test). Closed-loop control is used to maintain the torque constant as the rotation speed changes, no matter the machine under test operates as a motor or a brake (i.e., a generator). A torque command entered by the user determines the torque applied to the machine under test. The function indicates the speed, torque, mechanical power, and energy measured at the shaft of the machine under test. The function can also indicate the machine temperature when the temperature sensor of the machine under test (if so equipped) is connected to the Thermistor Input of the Four-Quadrant Dynamometer/Power Supply.

### Negative Constant-Torque Prime Mover/Brake

Same as the Positive Constant-Torque Prime Mover/Brake except that the torque is negative (i.e., applied in counterclockwise direction).

### Mechanical Load

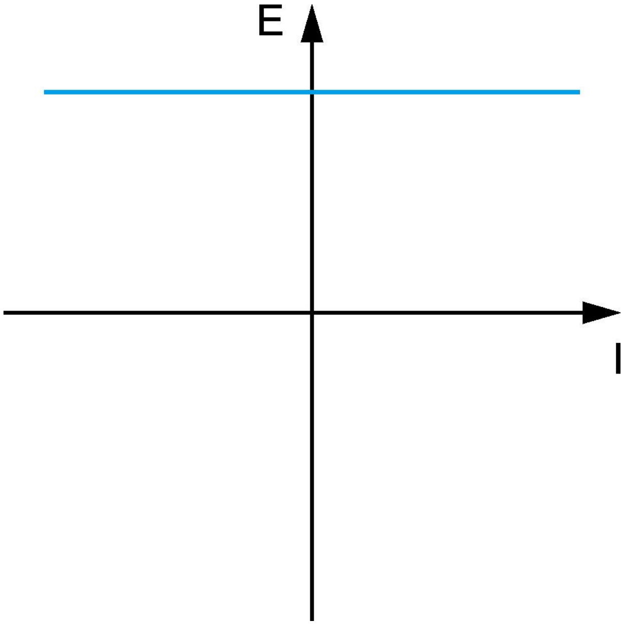
### Speed Sweep




This function uses the permanent-magnet dc machine to make the machine coupled to the Four-Quadrant Dynamometer/Power Supply (i.e., the machine under test) rotate at various speeds within a specific range, in a certain number of steps and in a certain time interval. Closed-loop control is used to ensure accurate speed sweep. The speed sweep performed is defined entirely by the user with only four parameters (start speed, end speed, number of steps, and step duration). The function indicates the speed, torque, mechanical power, and energy measured at the shaft of the machine under test. The function can also indicate the machine temperature when the temperature sensor of the machine under test (if so equipped) is connected to the Thermistor Input of the Four-Quadrant Dynamometer/Power Supply. The Speed Sweep function is useful to measure how parameters related to the machine under test vary as a function of the rotation speed. The parameters measured throughout the speed sweep can be recorded to a data table automatically.

### Function Description (Power Supply Operating Mode)

**Positive Voltage Source**

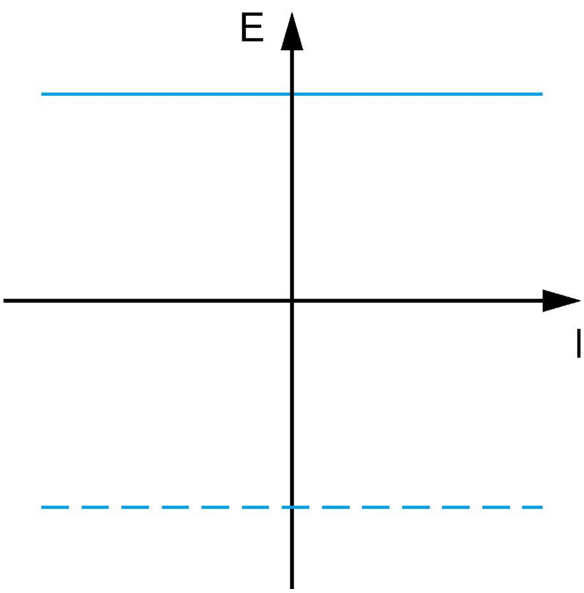



This function uses the four-quadrant power supply to implement a DC voltage source having a positive polarity. The source can either source or sink current (two-quadrant operation). A voltage command entered by the user determines the value of the source voltage. The function indicates the voltage, current, electrical power, and energy at the source output. The function can also indicate circuit temperature (e.g., battery temperature) when a temperature sensor is connected to the Thermistor Input of the Four-Quadrant Dynamometer/Power Supply.

**Negative Voltage Source**

Same as the Positive Voltage Source function except for the polarity.

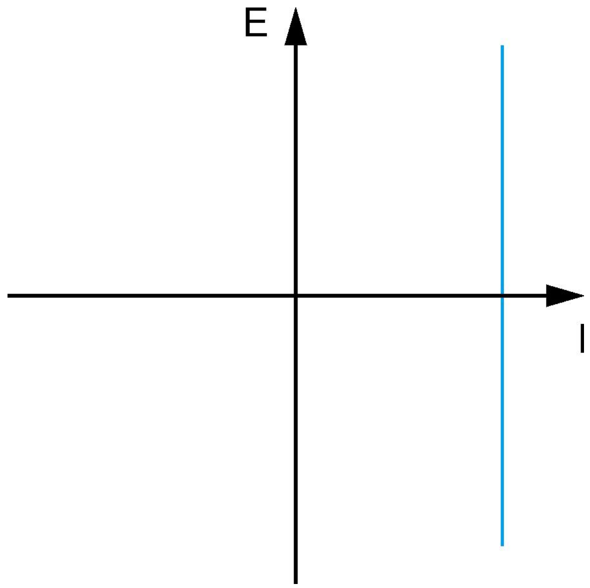
**DC Voltage Source**




This function uses the four-quadrant power supply to implement a DC voltage source having either positive or negative polarity. The source can either source or sink current no matter if the source voltage polarity is positive or negative (four-quadrant operation). A voltage command entered by the user determines the polarity and value of the source voltage. The function indicates the voltage, current, electrical power, and energy at the source output. The function can also indicate circuit temperature (e.g., battery temperature) when a temperature sensor is connected to the Thermistor Input of the Four-Quadrant Dynamometer/Power Supply.

### Positive Current Source

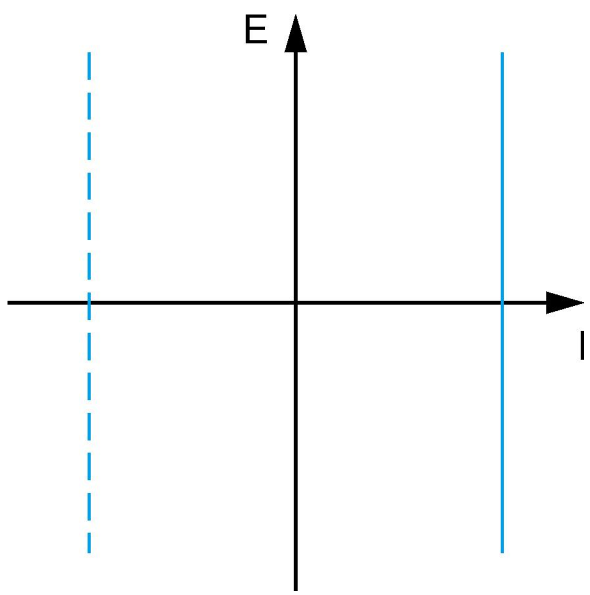



This function uses the four-quadrant power supply to implement a DC current source that sources current at its output. The polarity of the voltage across the source can be either positive or negative (two-quadrant operation). A current command entered by the user determines the value of the source current. The function indicates the voltage, current, electrical power, and energy at the source output. The function can also indicate circuit temperature (e.g., battery temperature) when a temperature sensor is connected to the Thermistor Input of the Four-Quadrant Dynamometer/Power Supply.

### Negative Current Source

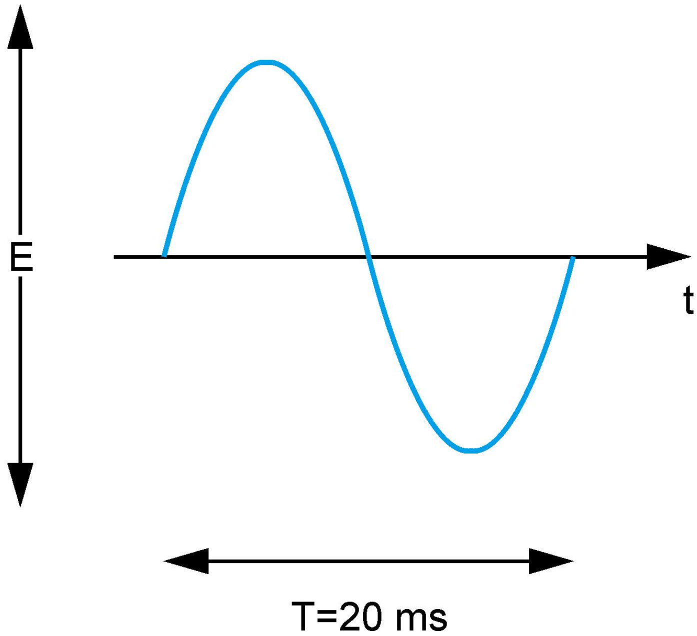
Same as the Positive Current Source function except for the direction of current flow.

### DC Current Source



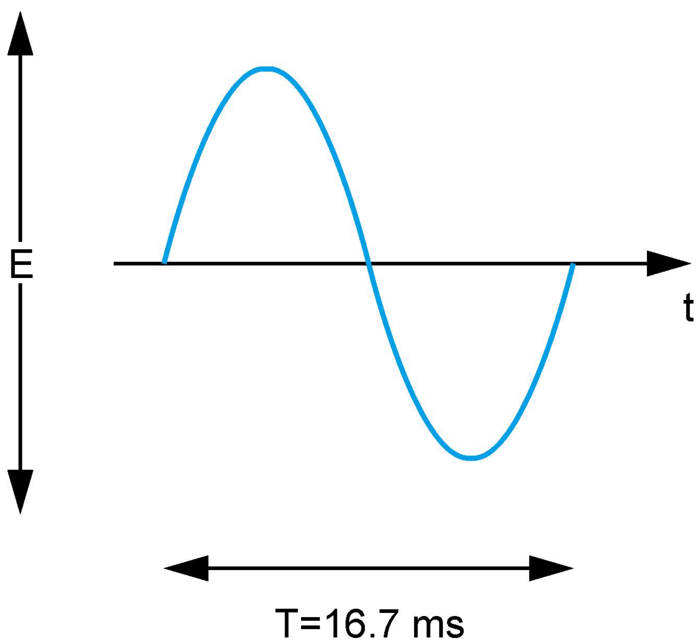

This function uses the four-quadrant power supply to implement a DC current source that either sources current (positive polarity) or sinks current (negative polarity) at its output. The polarity of the voltage across the source can be either positive or negative no matter the direction of the source current (four-quadrant operation). A current command entered by the user determines the direction (polarity) and value of the source current. The function indicates the voltage, current, electrical power, and energy at the source output. The function can also indicate circuit temperature (e.g., battery temperature) when a temperature sensor is connected to the Thermistor Input of the Four-Quadrant Dynamometer/Power Supply.

**50 Hz Power Source**



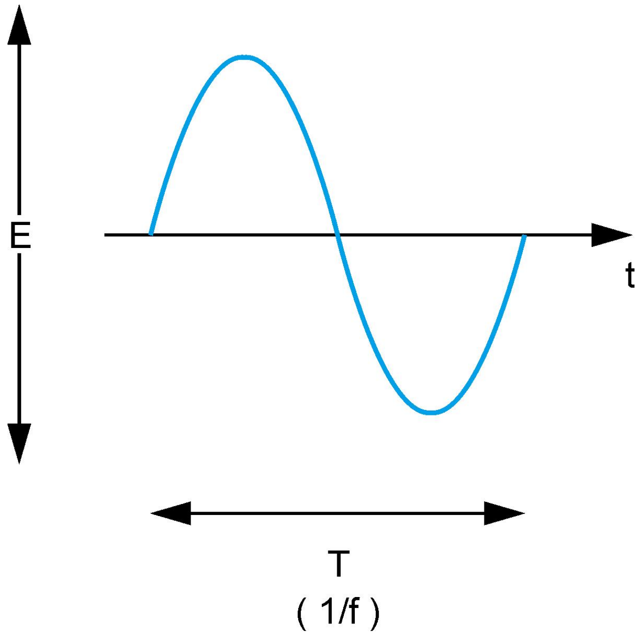

This function uses the four-quadrant power supply to implement a non-regulated variable-voltage 50 Hz power source. A voltage command entered by the user determines the rms value of the "no-load" source voltage. The source can either source or sink current no matter if the source voltage polarity (instantaneous) is positive or negative (four-quadrant operation). The function indicates the circuit temperature (e.g., transformer core temperature) when a temperature sensor is connected to the Thermistor Input of the Four-Quadrant Dynamometer/Power Supply.

**60 Hz Power Source**



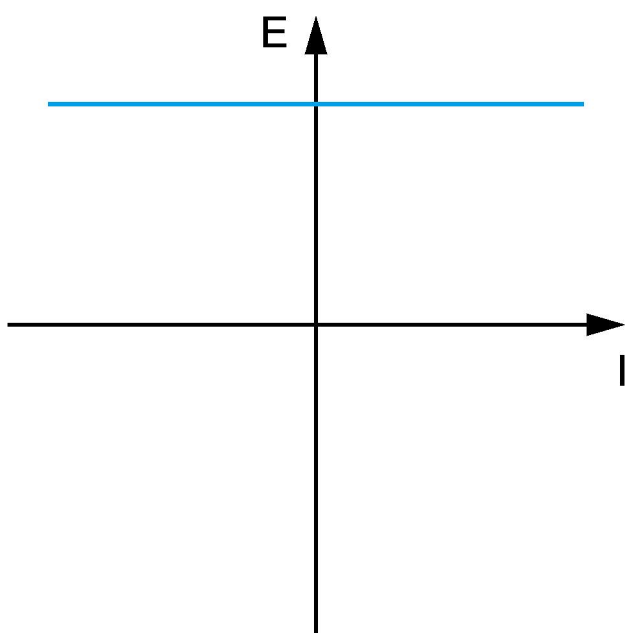

Same as the 50 Hz Power Source function except for the frequency.

**AC Power Source**



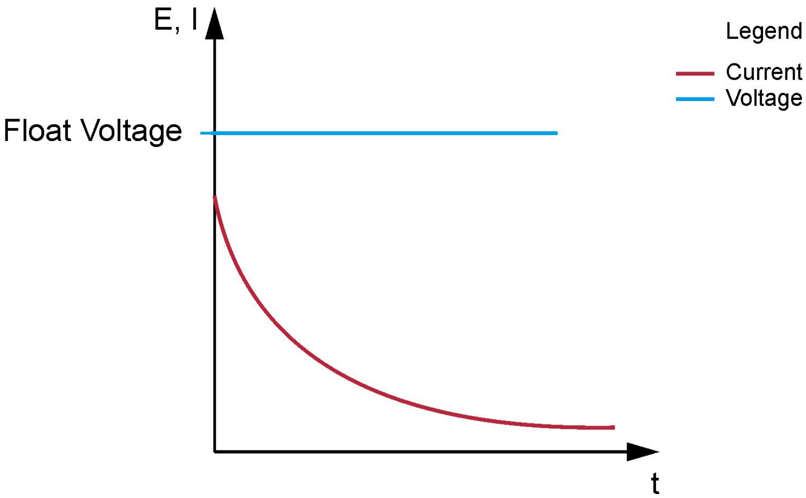

This function uses the four-quadrant power supply to implement a non-regulated variable-voltage, variable-frequency AC power source. The source can either source or sink current no matter if the source voltage polarity (instantaneous) is positive or negative (four-quadrant operation). Voltage and frequency commands entered by the user determine the rms value and frequency of the "no-load" source voltage. The function indicates the circuit temperature (e.g., transformer core temperature) when a temperature sensor is connected to the Thermistor Input of the Four-Quadrant Dynamometer/Power Supply.

**200 V DC Bus**




This function uses the four-quadrant power supply to implement a fixed-voltage dc bus of 200 V. The dc bus can either source or sink current (two-quadrant operation). The function indicates the voltage, current, and power at the source output.

### Lead-Acid Battery Float Charger




This function uses the four-quadrant power supply to implement a lead-acid battery float charger. This charger applies a constant voltage to the battery. The user only has to specify the battery float charging voltage. The function indicates the voltage, current, and electrical power at the charger output. The Lead-Acid Battery Float Charger function is well suited to charge several lead-acid batteries connected in parallel overnight so they are ready for next-day lab sessions.

| Control Functions | Control Mode | |
|---|---|---|
| | Manual (Stand-Alone) | Computer-Based (LVDAC-EMS) |
| **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 | | ● |
| Mechanical Load | | ● |
| 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 | | ● |
| 200 V DC Bus | ● | ● |
| Lead-Acid Battery Float Charger | ● | ● |

Standard control functions available in Power Supply mode.

## Optional Module Functions

The Four-Quadrant Dynamometer/Power Supply can perform a wide variety of functions in each of the two operating modes (Dynamometer and Power Supply). The optional functions currently available in each operating mode are described below. The license (Model 8968-X) required to activate each optional function is also indicated. A table at the end of this section lists the optional functions available. All optional functions can be accessed through the computer-based control mode only.

This emulator enables the study of synchronous generation in small and large-scale hydraulic installations. The license for the Turbine Emulator, Model 8968-3, is required to activate the function in the Four-Quadrant Dynamometer/Power Supply.

## Optional Function Description (Dynamometer Operating Mode)

### Small Wind-Turbine Emulator, Model 8968-3

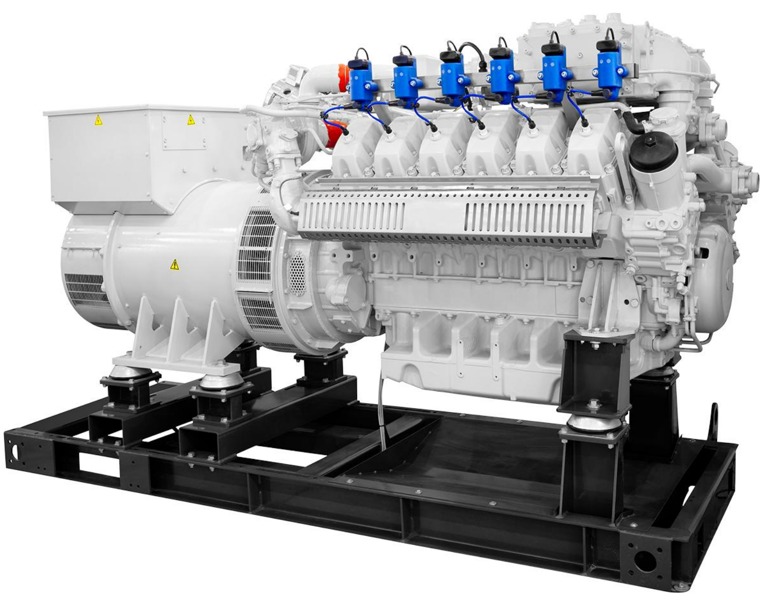
This function uses the permanent-magnet dc machine to faithfully reproduce the effect of wind on the bladed rotor of a small-scale wind turbine (3 blade rotor, fixed pitch, 1.15 m [46 in] diameter). The torque-speed characteristic at the shaft of the machine coupled to the Four-Quadrant Dynamometer/Power Supply (e.g., the wind turbine generator in the Wind Turbine Generator/Controller, Model 8216) is the same as the one that is obtained when wind blows at a certain speed on the rotor of the actual wind turbine. The user has control over the windspeed and air density. The function indicates the speed, torque, mechanical power, and energy measured at the shaft of the wind turbine generator. The function can also indicate the generator temperature when the temperature sensor of the wind turbine generator under test (if so equipped) is connected to the Thermistor Input of the Four-Quadrant Dynamometer/Power Supply. The Small Wind-Turbine Emulator function makes the study of wind turbine generator operation independent of weather conditions (you do not have to wait for wind) and much safer as there is no rotating bladed rotor (a potential cause of injuries). The license for the Turbine Emulator, Model 8968-3, is required to activate the function in the Four-Quadrant Dynamometer/Power Supply.

### Hydraulic Turbine Emulator, Model 8968-3

This function uses the permanent-magnet dc machine to recreate the behavior of a hydraulic turbine with a synchronous generator. The torque-speed characteristics at the shaft of the machine coupled to the Four-Quadrant Dynamometer/Power Supply (e.g. the Synchronous Generator, Model 8241) is the same as that of a Francis-type hydraulic turbine. The user has control over the vane angle (manually or through the module analog input), the vane variation speed, and the inertia.

This emulator enables the study of synchronous generation in small and large-scale hydraulic installations. The license for the Turbine Emulator, Model 8968-3, is required to activate the function in the Four-Quadrant Dynamometer/Power Supply.

### Engine Emulator, Model 8968-3

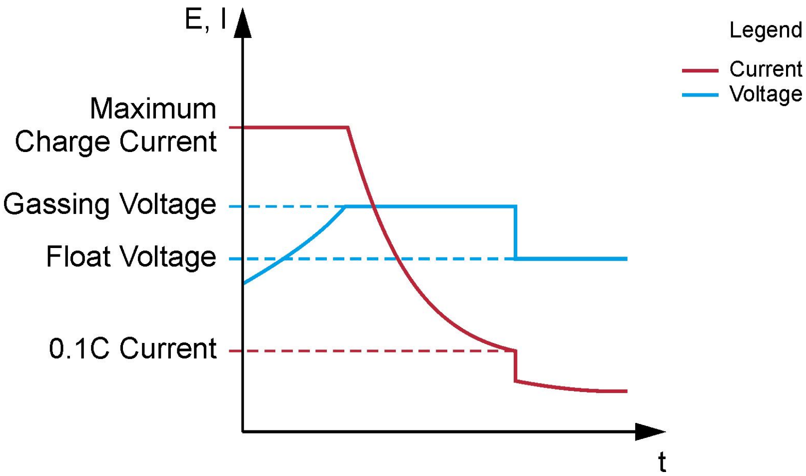


This function uses the four-quadrant dynamometer to recreate the behavior of an engine (such as a diesel-powered engine) with a synchronous generator. The torque-speed characteristics at the shaft of the machine coupled to the Four-Quadrant Dynamometer/ Power Supply (e.g. the Synchronous Generator, Model 8241) is the same as that of the selected engine type. The user has control over parameters relevant to the engine type, such as the fuel rack position in a diesel engine.

This emulator enables the study of various engine types in the production of electricity. The license for the Turbine Emulator, Model 8968-3, is required to activate the function in the Four-Quadrant Dynamometer/Power Supply.

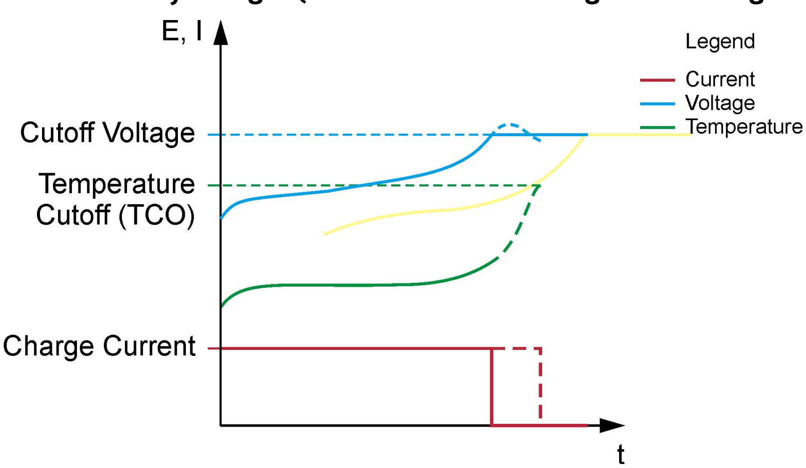
### Optional Function Description (Power Supply Operating Mode)

**Lead-Acid Battery Charger (Fast), Model 8968-4**



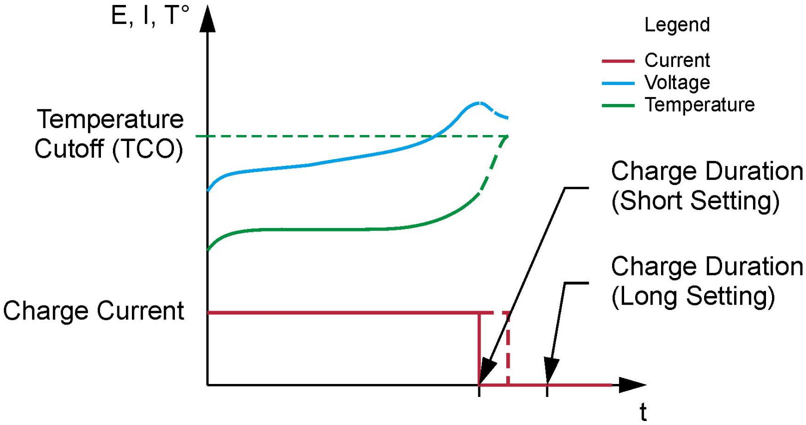

This function uses the four-quadrant power supply to implement a battery charger that is able to rapidly charge lead-acid batteries of various capacities (typically in less than two hours). A three-step charge algorithm is used. Battery charging starts with a constant current corresponding to the battery maximum charge current until the battery gassing voltage is reached. At this point, battery charging continues with a constant voltage (close to gassing voltage) until the charge current decreases to 0.1 C. Then, constant-voltage charging continues but at a lower voltage (float charging voltage). The user has to specify the following four battery characteristics for the charger to achieve proper charge control: maximum charge current, gassing voltage, 0.1C current (10% of battery capacity), and float charging voltage. The function indicates the voltage, current, electrical power, and energy at the charger output. The function can also indicate battery temperature when the temperature sensor of the battery (if so equipped) is connected to the Thermistor Input of the Four-Quadrant Dynamometer/Power Supply. The function can also indicate battery temperature when the temperature sensor of the battery (if so equipped) is connected to the Thermistor Input of the Four-Quadrant Dynamometer/Power Supply. The license for the Lead-Acid Battery Charger, Model 8968-4, is required to activate the Lead-Acid Battery Charger (Fast) function in the Four-Quadrant Dynamometer/Power Supply.

**Ni-MH Battery Charger (Constant-Current Charge with Voltage Cutoff and TCO), Model 8968-5**



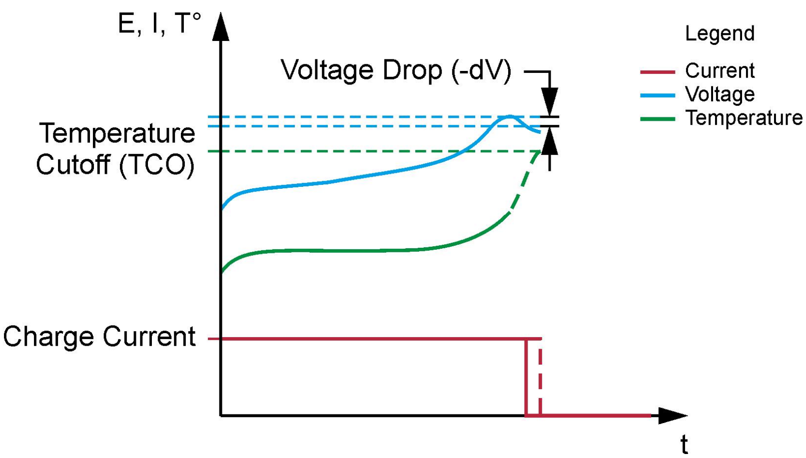

This function uses the four-quadrant power supply to implement a basic Ni-MH battery charger. This charger forces a constant charge (current value of 0.1C or less) in the battery until the battery voltage reaches a certain value at which the charge terminates. The charger also monitors the battery temperature during charge. Battery charging is terminated immediately when the battery temperature reaches a specific cutoff temperature. The user has to specify the charge current, cutoff voltage, and cutoff temperature for the charger to achieve proper charge control. The function indicates the voltage, current, electrical power, and energy at the charger output as well as the battery temperature. This method of charging Ni-MH batteries is the slowest one but requires less surveillance. The license for the Ni-MH Battery Chargers, Model 8968-5, is required to activate the Ni-MH Battery Charger (Constant-Current Charge with Voltage Cutoff and TCO) function in the Four-Quadrant Dynamometer/Power Supply.

### Ni-MH Battery Charger (Constant-Current Timed Charge with TCO), Model 8968-5



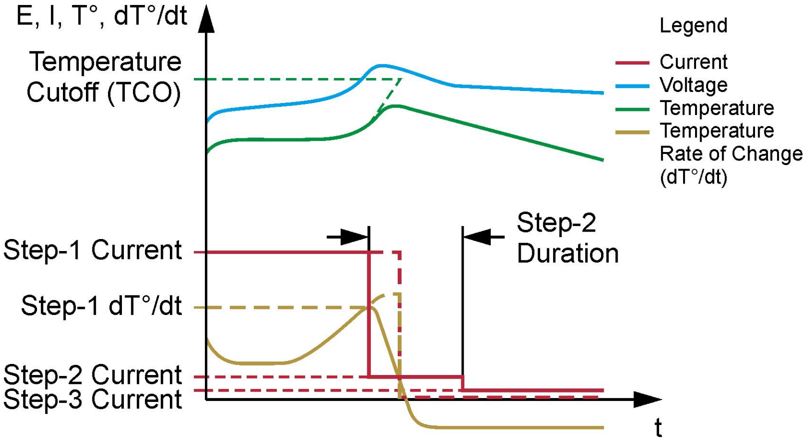

This function uses the four-quadrant power supply to implement a time-controlled Ni-MH battery charger. This charger forces a constant charge current in the battery during a specific period of time and then turns off. The charger also monitors the battery temperature during charge. Battery charging is terminated immediately when the battery temperature reaches a specific cutoff temperature. The user has to specify the charge current, charge duration, and cutoff temperature for the charger to achieve proper charge control. The function indicates the voltage, current, electrical power, and energy at the charger output as well as the battery temperature. The license for the Ni-MH Battery Chargers, Model 8968-5, is required to activate the Ni-MH Battery Charger (Constant-Current Timed Charge with TCO) function in the Four-Quadrant Dynamometer/Power Supply.

### Ni-MH Battery Charger (Constant-Current Charge with -dV and TCO), Model 8968-5



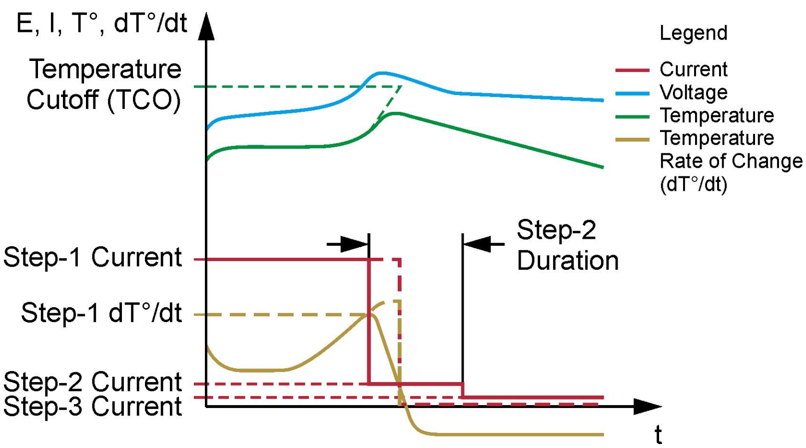

This function uses the four-quadrant power supply to implement an advanced Ni-MH battery charger. This charger forces a constant charge current in the battery until the battery voltage, which increases steadily from the beginning of charge, reaches a plateau and decreases by a certain amount (-dV), at which point the charge terminates. The charger also monitors the battery temperature during charge. Battery charging is terminated immediately when the battery temperature reaches a specific cutoff temperature. The user has to specify the charge current, voltage drop (-dV), and cutoff temperature for the charger to achieve proper charge control. The function indicates the voltage, current, electrical power, and energy at the charger output as well as the battery temperature. The license for the Ni-MH Battery Chargers, Model 8968-5, is required to activate the Ni-MH Battery Charger (Constant-Current Charge with -dV and TCO) function in the Four-Quadrant Dynamometer/Power Supply.

### Ni-MH Battery Charger (Constant-Current Charge with dT°/dt and TCO), Model 8968-5



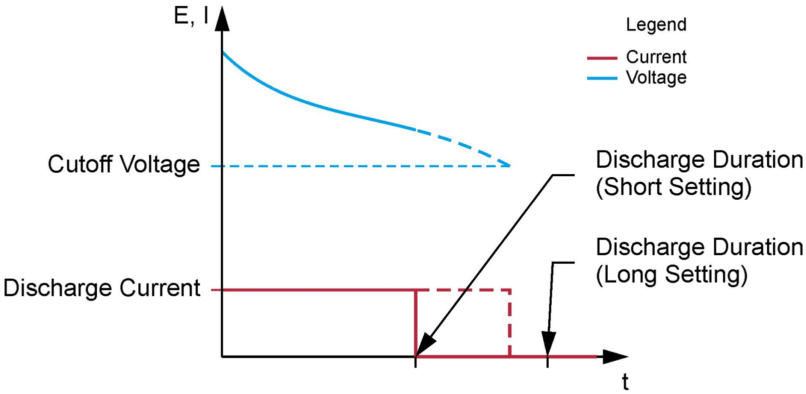

This function uses the four-quadrant power supply to implement an advanced Ni-MH battery charger. This charger monitors the battery temperature and forces a constant charge current in the battery until the rate of increase of the battery temperature (dT°/dt) reaches a specific value, at which point the charge terminates. Battery charging can also terminate when the battery temperature reaches a specific cutoff temperature. The user has to specify the charge current, maximum rate of temperature increase (dT°/dt), and cutoff temperature for the charger to achieve proper charge control. The function indicates the voltage, current, electrical power, and energy at the charger output as well as the battery temperature. The license for the Ni-MH Battery Chargers, Model 8968-5, is required to activate the Ni-MH Battery Charger (Constant-Current Charge with dT°/dt and TCO) function in the Four-Quadrant Dynamometer/Power Supply.

### Ni-MH Battery Charger (three-step Charge with TCO), Model 8968-5



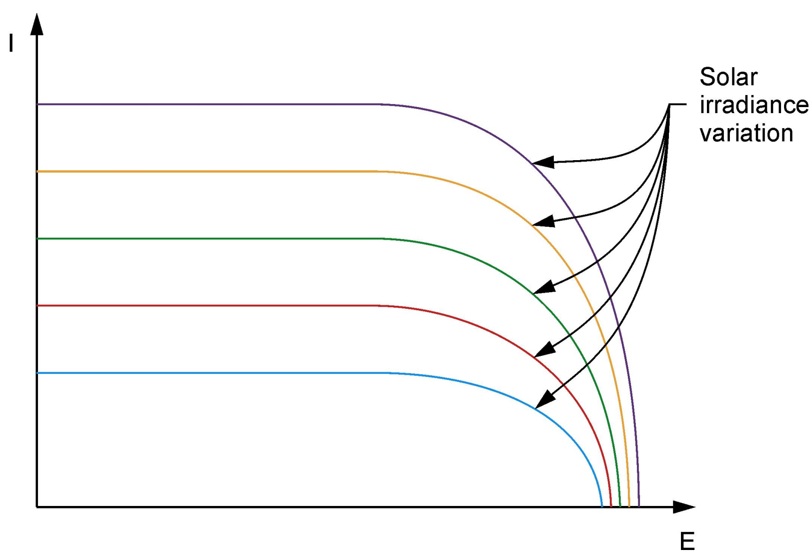

This function uses the four-quadrant power supply to implement a fast Ni-MH battery charger (three-step charge algorithm). Battery charging begins by forcing a constant charge current (about 1C) in the battery until the rate of increase of the battery temperature (dT°/dt) reaches a specific value. At this point, the charger enters the second phase of the charge process and continues battery charging with a constant current having a lower value (about 0.1 C) for a specific period. After this period, battery charging continues with a constant current of very low value (about 0.03 C). The charger monitors the battery temperature during charge. Battery charging can also terminate when the battery temperature reaches a specific cutoff temperature. The user has to specify the following parameters for the charger to achieve proper charge control: charge current for each of the three phases of the charging process, maximum rate of temperature increase (dT°/dt) used during the first phase of charge, duration of the second phase of charge, and cutoff temperature. The function indicates the voltage, current, electrical power, and energy at the charger output as well as the battery temperature. The license for the Ni-MH Battery Chargers, Model 8968-5, is required to activate the Ni-MH Battery Charger (3-Step Charge with TCO) function in the Four-Quadrant Dynamometer/Power Supply.

### Battery Discharger (Constant-Current Timed Discharge with Voltage Cutoff), Model 8968-4 or Model 8968-5




This function uses the four-quadrant power supply to sink a constant current from a battery, thereby discharging the battery at a specific rate, during a specific period. The discharger also monitors the battery voltage during discharge. Battery discharging terminates immediately when the battery voltage decreases to a specific cutoff voltage. The user has to specify the discharge current, discharge duration, and cutoff voltage for the discharger to achieve proper discharge control. The function indicates the voltage, current, electrical power, and energy at the discharger output. The function can also indicate battery temperature when the temperature sensor of the battery (if so equipped) is connected to the Thermistor Input of the Four-Quadrant Dynamometer/Power Supply. The Battery Discharger function is perfectly suited to measure discharge characteristics of batteries at various rates as well as to bring a battery to a specific depth of discharge before a battery charging experiment. The license for the Lead-Acid Battery Charger, Model 8968-4, or the license for the Ni-MH Battery Chargers, Model 8968-5, is required to activate the Battery Discharger (Constant-Current Timed Discharge with Voltage Cutoff) function in the Four-Quadrant Dynamometer/Power Supply.

### Solar Panel Emulator, Model 8968-6




This function uses the four-quadrant power supply to emulate a solar panel consisting of an array of photovoltaic (PV) modules. The current-voltage characteristic of each PV module emulated is the same as that of the PV module used in the Monocrystalline Silicon Solar Panel, Model 8806. The function allows the user to determine the size of the PV module array emulated, by selecting the number of PV modules connected in series and in parallel. A sliding control in the Solar Panel Emulator interface provides the user full control of solar irradiance. The function indicates the voltage, current, power, and energy provided by the Solar Panel Emulator. The function can also indicate temperature when a temperature sensor is connected to the Thermistor Input of the Four-Quadrant Dynamometer/Power Supply. The Solar Panel Emulator function makes the study of electricity production using solar panels independent of weather conditions (you do not have to wait for sunny periods). The license for the Solar Panel Emulator, Model 8968-6, is required to activate the function in the Four-Quadrant Dynamometer/Power Supply.

## Software Development Kit (SDK), Model 8968-70

The Software Development Kit offers the possibility to control the Four-Quadrant Dynamometer/Power Supply, Model 8960-3, with third-party rapid prototyping software like Mathworks® MATLAB, National Instruments® LabVIEW or other programming tools that support Microsoft® .NET Framework 3.5. The functions available in the Software Development Kit allow control of the Four-Quadrant Dynamometer/Power Supply in both the Dynamometer and Power Supply operating modes.

The SDK includes DLL files to communicate with the Four-Quadrant Dynamometer/Power Supply, functions documentation, MATLAB (2010 or later) and LabVIEW (2009 or later) example programs.

Available functions in the Dynamometer Operating Mode:

- Two-Quadrant, Constant Torque Brake
- CW and CCW, Prime Mover/Brake
- CW and CCW, Constant-Speed Prime Mover/Brake
- Positive and Negative, Constant-Torque Prime Mover/Brake
- Four-Quadrant, Constant-Speed Prime Mover/Brake

Available functions in the Power Supply Operating Mode:

- Voltage Control
- Current Control
- AC Power Source

Important note: A Software Development Kit must be ordered for each Four-Quadrant Dynamometer/Power Supply, Model 8960-3, to unlock the SDK features.

| Optional Control Functions | Control Mode | |
|---|---|---|
| | Manual (Stand-Alone) | Computer-Based (LVDAC-EMS) |
| **Dynamometer Operating Mode** | | |
| Small Wind-Turbine Emulator | | X |
| Hydraulic and Diesel Turbine Emulators | | X |
| **Power Supply Operating Mode** | | |
| Lead-Acid Battery Charger (Fast) | | X |
| Ni-MH Battery Charger (Constant-Current Charge with Voltage Cutoff and TCO) | | X |
| Ni-MH Battery Charger (Constant-Current Timed Charge with TCO) | | X |
| Ni-MH Battery Charger (Constant-Current Charge with -ΔV and TCO) | | X |
| Ni-MH Battery Charger (Constant-Current Charge with ΔT°/Δt and TCO) | | X |
| Ni-MH Battery Charger (Three-Step Charge with TCO) | | X |
| Battery Discharger (Constant-Current Timed Discharge with Voltage Cutoff) | | X |
| Solar Panel Emulator | | X |

Optional module functions available in each control mode.

## Topic Coverage

- Speed and Torque
- Voltage and Current
- Mechanical and Electrical Power
- Energy

## Features & Benefits

- State-of-the-art, multipurpose device combining power supply, prime mover, dynamometer, metering and emulator properties
- USB port computer-based mode allows the user to completely control every function directly from the computer
- Supports learning of electromechanical and renewable energy
- Can be connected with other EMS equipment to enhance the training possibilities

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

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

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

Dynamometer operating mode

- Two-Quadrant, Constant-Torque Brake

- Clockwise Prime Mover/Brake

- Counterclockwise Prime Mover/Brake

- Clockwise Constant-Speed Prime Mover/Brake

- Counterclockwise Constant-Speed Prime Mover/Brake

- Positive Constant-Torque Prime Mover/Brake

- Negative Constant-Torque Prime Mover/Brake

Power Supply operating mode

- Positive Voltage Source

- Negative Voltage Source

- 200 V DC Bus

- Positive Current Source

- Negative Current Source

- 50 Hz Power Source

- 60 Hz Power Source

- Lead-Acid Battery Float Charger

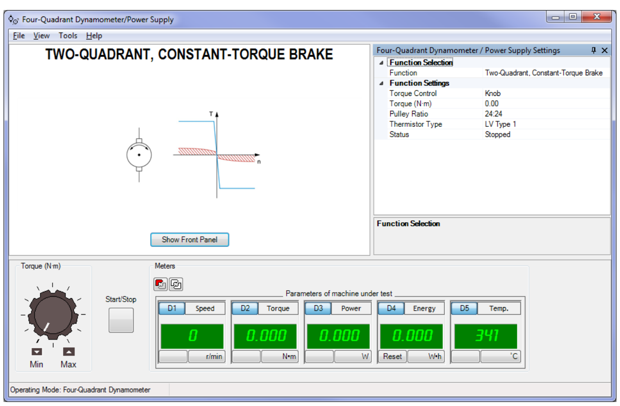
## Specifications

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

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

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




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

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

Dynamometer operating mode

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

- Positive Constant-Torque Prime Mover/Brake

- Negative Constant-Torque Prime Mover/Brake

- Four-Quadrant Constant-Speed Prime Mover/Brake

- Speed Sweep

Power Supply operating mode

- Positive Voltage Source

- Negative Voltage Source

- DC Voltage Source

- Positive Current Source

- Negative Current Source

- DC Current Source

- 50 Hz Power Source

- 60 Hz Power Source

- AC Power Source

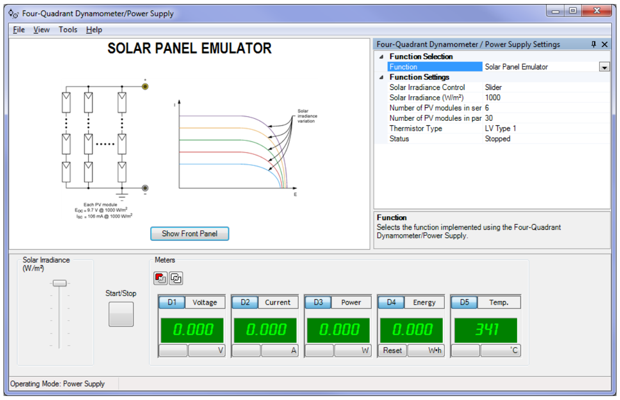
- Lead-Acid Battery Float Charger

## Specifications

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

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

## Solar Panel Emulator Function Set
## 581440 (8968-60)




The Solar Panel Emulator Function Set is a function that can be activated in the Four-Quadrant Dynamometer/ Power Supply enabling the module to emulate a solar panel.

The Solar Panel Emulator control function is only available in computer-based mode. This means that the function performed by the Four-Quadrant Dynamometer/Power Supply is selected, set, and monitored using the LVDAC-EMS software. The function emulates a solar panel consisting of an array of photovoltaic (PV) modules. The current-voltage characteristic of each PV module emulated is the same as that of the PV module used in the Monocrystalline Silicon Solar Panel. The function allows the user to determine the size of the PV module array emulated, by selecting the number of PV modules connected in series and in parallel. A sliding control in the Solar Panel Emulator interface provides the user full control of solar irradiance.

### Specifications

| Parameter | Value |
|---|---|
| **Control Functions** | Solar Panel Emulator |
| **Solar Panel Emulator** | |
| Solar Irradiance Control | Software slider or 8960 command input |
| Solar Irradiance | 1-1000 W/m² |
| Number of PV Modules in Series | 1-7 modules |
| Number of PV Modules in Parallel | 5-45 modules |

## Data Acquisition and Control Interface
## 579677 (9063-00)

The Data Acquisition and Control Interface (DACI) is a versatile USB peripheral used for measuring, observing, analyzing, and controlling electrical and mechanical parameters in electric power systems and power electronics circuits. For these purposes, a set of computer-based instruments as well as a variety of control functions are available for the DACI. These instruments and control functions are accessed through the LVDAC-EMS software. The LVDAC-EMS software, as well as all available upgrades, is free and can be downloaded anytime on the Festo Didactic website.

Together, the DACI and the LVDAC-EMS software allow training in various areas such as electric power technology, ac/dc machines, renewable energy, transmission lines, and power electronics using modern and versatile measuring instruments and control functions. LVDAC-EMS also offers the possibility to use pre-built SCADA interfaces for several applications to ease the view and understanding of the process taking place. The user guide provided allows students to quickly become familiar with the instruments and control functions available.

Model 9063-0 includes only the DACI, Model 9063, with no control function set activated. This enables the user to customize the DACI by individually picking the computer-based instruments and control function sets that he wants to activate in the DACI.

Alternately, variant 9063-0 is also used in several courses as an extension module. This means that it is used in conjunction to another DACI in which particular control function sets are activated. Both DACIs are connected to a single computer running LVDAC-EMS. When used in such a way, variant 9063-0 shares all control function sets activated in the other DACI. For example, if the Computer-Based Instrumentation Function, Model 9069-1, and the Three-Phase PWM Rectifier/Inverter Control Function Set, Model 9069-5, are activated in the other DACI, these function sets will also be available in variant 9063-0. This enables the user to perform courses requiring the use of more than one DACI without having to activate the same control function sets in all DACIs.

## Manual

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

## Table of Contents of the Manual(s)

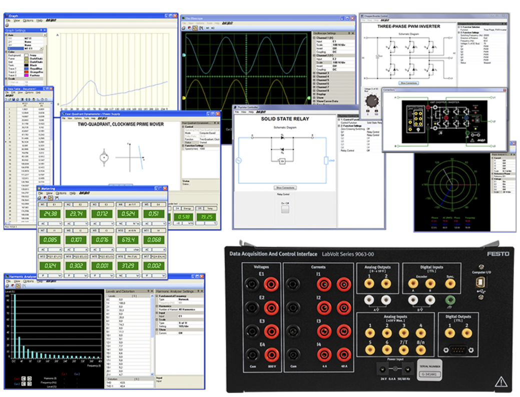
### Computer-Based Instruments for EMS (User Guide) (585219 (86718-E0))

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

## Additional Equipment Required to Perform the Exercises (Purchased separately)

| Qty | Description | Model number |
|---|---|---|
| 1 | Personal Computer | 579785 (8990-00) [4] |

## Data Acquisition and Control Interface 579694 (9063-H0)



The Data Acquisition and Control Interface (DACI) is a versatile USB peripheral used for measuring, observing, analyzing, and controlling electrical and mechanical parameters in electric power systems and power electronics circuits. For these purposes, a set of computer-based instruments as well as a variety of control functions are available for the DACI. These instruments and control functions are accessed through the LVDAC-EMS software. The LVDAC-EMS software, as well as all available upgrades, is free and can be downloaded anytime on the Festo Didactic website.

Together, the DACI and the LVDAC-EMS software allow training in various areas such as electric power technology, ac/dc machines, renewable energy, transmission lines, and power electronics using modern and versatile measuring

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

instruments and control functions. LVDAC-EMS also offers the possibility to use pre-built SCADA interfaces for several applications to ease the view and understanding of the process taking place. The user guide provided allows students to quickly become familiar with the instruments and control functions available.

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

- Computer-Based Instrumentation Function, Model 9069-1
- Thyristor Control Function Set, Model 9069-3
- Home Energy Production Control Function Set, Model 9069-4
- HVDC Transmission System Control Function Set, Model 9069-7
- SVC Control Function Set, Model 9069-8
- STATCOM Control Function Set, Model 9069-B

## Manual

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

## Table of Contents of the Manual(s)

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


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


## Additional Equipment Required to Perform the Exercises (Purchased separately)

| Qty | Description | Model number |
|---|---|---|
| 1 | Personal Computer | 579785 (8990-00) [5] |
| 1 | AC 24 V Wall Mount Power Supply | 579696 (30004-20) [6] |

## Specifications

| Parameter | Value |
|---|---|
| **Insulated Voltage Inputs (4)** | |
| Range (Low / High Scales) | -80 to +80 V / -800 to + 800 V (user-selectable through software) |
| Impedance (Low / High Scales) | 326.6 kΩ / 3.25 MΩ |
| Bandwidth | DC to 65 kHz (-3 dB) |
| Accuracy | 1% (dc to 10 kHz) |
| Insulation | 800 V |
| Measurement Category | CAT II (283 V ac/400 V dc versus ground) |
| **Insulated Current Inputs (4)** | |
| Range (Low / High Scales) | -4 to +4 A / -40 to + 40 A (25 A rms) |
| Impedance (Low / High Scales) | 5 mΩ / 50 mΩ |
| Bandwidth | DC to 65 kHz (-3 dB) |

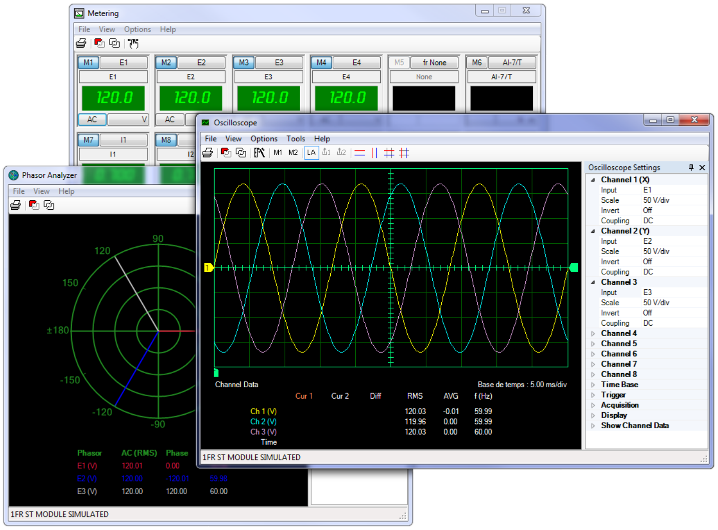
[5] Refer to the Computer Requirements in the System Specifications section of this datasheet if the computer is to be provided by the end-user. Only one computer is required per station. This model is available in multiple voltage- and frequency dependent variants. Contact a Festo representative to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

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

| Parameter | Value |
|---|---|
| Accuracy | 1% (dc to 10 kHz) |
| Insulation | 800 V |
| Measurement Category | CAT II (283 V ac/400 V dc versus ground) |
| **Analog Inputs (8)** | |
| Voltage Range | -10 to +10 V |
| Impedance | > 10 MΩ |
| Bandwidth | DC to 125 kHz |
| Measured Parameters | User-selectable through software |
| Parameter-to-Voltage Ratio | User-determined through software |
| **A/D Converter for Insulated and Analog Inputs (16)** | |
| Type | Successive approximation |
| Resolution | 12 bits |
| Integral Non-Linearity | ≤ ±1.5 LSB |
| Differential Non-Linearity | ≤ ±1 LSB |
| Maximum Sampling Rate | 600 ksamples/s (one channel) |
| FIFO Buffer Size | 16 ksamples |
| **Analog Outputs (2)** | |
| Voltage Range (2) | -10 to +10 V |
| Operational Load Impedance | > 600 Ω |
| **D/A Converter for Analog Outputs (2)** | |
| Type | Resistor string |
| Resolution | 12 bits |
| Integral Non-Linearity | ≤ ±8 LSB |
| Differential Non-Linearity | -0.5 to +0.7 LSB |
| **Digital Inputs (3)** | |
| Types | Encoder (2), synchronization (1) |
| Signal Level | 0-5 V (TTL compatible) |
| Maximum Input Frequency | 50 kHz |
| Impedance | 5 kΩ |
| **Digital Outputs (9)** | |
| Types | Control (6 on a DB9 connector and 2 on 2 mm banana jacks), synchronization (1 on a DB9 connector) |
| Signal Level | 0-5 V (TTL compatible) |
| Maximum Output Frequency | 20 kHz (software-limited) |
| Impedance | 200 Ω |
| **Control Functions** | |
| Activated Sets | Computer-Based Instrumentation Function, Model 9069-1 |
| | Thyristor Control Function Set, Model 9069-3 |
| | Home Energy Production Control Function Set, Model 9069-4 |
| | HVDC Transmission System Control Function Set, Model 9069-7 |
| | SVC Control Function Set, Model 9069-8 |
| | STATCOM Control Function Set, Model 9069-B |
| **Computer I/O Interface** | USB 2.0 full speed via type-B receptacle |
| **Power Requirements** | 24 V - 0.4 A - 50/60 Hz |
| **Accessories** | |
| Included Accessories | 2 m USB interconnection cable (1) |
| | 24 V power cable (1) |
| | 2 mm banana plug test leads (3) |
| | DB9 connector control cable (1) |
| **Physical Characteristics** | |
| Dimensions (H x W x D) | 154 x 287 x 410 mm (6.1 x 11.3 x 16.1 in) |
| Net Weight | 3.9 kg (8.6 lb) |

# Acquisition functions
# 581452 (9069-10)




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

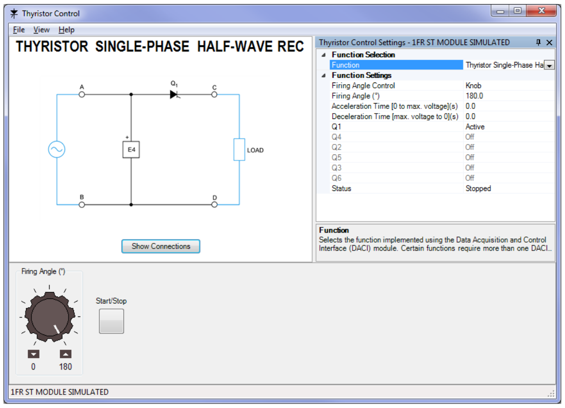
- Metering
- Data Table and Graph
- Oscilloscope
- Phasor Analyzer
- Harmonic Analyzer

## Specifications

| Parameter | Value |
|---|---|
| **Metering** | |
| Number of Meters | 18 |
| Sampling Window | 266.7 ms or user adjusted through software (11.4-819 ms) |
| Sampling Frequency (each meter) | 7.68 kHz or user adjusted through software (2.5-179.2 kHz) |
| Display Type | Digital or analog, user selectable through software |
| **Oscilloscope** | |
| Number of Channels | 8 |
| Vertical Sensitivity | 2-500 V/div. |
| Time Base | 0.0001-10 s/div. |
| Sampling Window | 20 x selected time base (software triggering) / 10 x selected time base (hardware triggering) |
| Sampling Frequency | 512 samples per measured parameter per horizontal sweep, up to a maximum of 512 kHz |
| **Phasor Analyzer** | |
| Voltage Sensitivity | 2-200 V/div. |
| Current Sensitivity | 0.1-5 A/div. |
| Sampling Window | 2-409 ms |
| Sampling Frequency (Each Phasor) | 5-102.4 kHz |
| **Harmonic Analyzer** | |
| Fundamental-Frequency Range | 1-1400 Hz |
| Number of Harmonic Components | 5 to 40, user selectable through software |
| Vertical Scale (Relative Scale) | 0.1-10%/div. |
| Vertical Scale (Absolute Scale) | 0.1-50 V/div., 0.01-10 A/div. |
| Sampling Window | 10 ms to 1 s |
| Sampling Frequency | 16-102 kHz |

## Thyristor Control Function Set 581454 (9069-30)



The Thyristor Control Function Set enables the following thyristor-based devices to be implemented using the Data Acquisition and Control Interface, and the Power Thyristors:

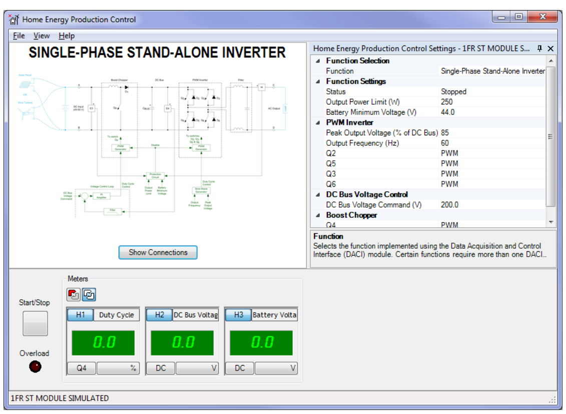
- Thyristor Single-Phase Half-Wave Rectifier
- Thyristor Single-Phase Bridge
- Thyristor Three-Phase Bridge
- Thyristor Three-Phase Bridge with Feedback
- Solid-State Relay
- Thyristor Single-Phase AC Power Control
- Thyristor Three-Phase AC Power Control
- Direct-On-Line Starter
- Soft Starter

## Specifications

| Parameter | Value |
|---|---|
| **Control Functions** | |
| Control Functions | Thyristor Single-Phase Half-Wave Rectifier |
| | Thyristor Single-Phase Bridge |
| | Thyristor Three-Phase Bridge |
| | Thyristor Three-Phase Bridge with Feedback |
| | Solid-State Relay |
| | Thyristor Single-Phase AC Power Control |
| | Thyristor Three-Phase AC Power Control |
| | Direct-On-Line Starter |
| | Soft Starter |
| **Thyristor Single-Phase Half-Wave Rectifier, Thyristor Single-Phase Bridge, Thyristor Three-Phase Bridge** | |
| Firing Angle Control | Knob or analog input on the DACI |
| Firing Angle | 0-180° |
| Acceleration Time (0 to Max. Voltage) | 0-100 s |
| Deceleration Time (Max. Voltage to 0) | 0-100 s |
| Thyristors Q1 to Q6 | Active, on, or off (certain thyristors are unavailable depending on the selected thyristor control function) |
| **Thyristor Three-Phase Bridge with Feedback** | |
| Command Input | On or off |
| Command | Knob or analog input on the DACI |
| Inverter Limit | 100-180° |
| Arc-Cosine | On or off |
| Feedback Input | Voltage, rms voltage, current, speed, power, or low-power analog signal |
| Feedback Range (Voltage Input Only) | 80-800 V |
| Current Feedback Range (Current Input Only) | 0.4-4 A |
| Speed Feedback Range (Speed Input Only) | 250-2500 r/min |
| Analog Feedback Range (Analog Input Only) | 1-10 V |
| Power Feedback Range (Power Input Only) | 32-3200 W |
| Feedback Filter Cutoff Frequency | 10-180 Hz |
| Acceleration Time (0 to 100%) | 0-100 s |
| Deceleration Time (100% to 0) | 0-100 s |
| Thyristors Q1 to Q6 | Active, on, or off |

| Parameter | Value |
|---|---|
| **Solid-State Relay** | |
| Zero-Voltage Switching | On or off |
| Relay Control | Open or close |
| Thyristors Q1 to Q6 | Active, on, or off (certain thyristors are unavailable) |
| **Thyristor Single-Phase AC Power Control** | |
| Control Mode | Phase control, synchronous burst fire control, or asynchronous burst fire control |
| Firing Angle Control | Knob or analog input on the DACI |
| Firing Angle | 0-180° |
| Thyristors Q1 to Q6 | Active, on, or off (certain thyristors are unavailable) |
| **Thyristor Three-Phase AC Power Control** | |
| Load Configuration | 3 wires star (3S), 3 wires delta (3D), 4 wires star (4S), or 6 wires delta (6D) |
| Control Mode | Phase control or synchronous burst fire control (certain control modes are unavailable depending on the selected thyristor control function) |
| Firing Angle Control | Knob or analog input on the DACI |
| Acceleration Time (0 to Max. Voltage) | 0-100 s |
| Deceleration Time (Max. Voltage to 0) | 0-100 s |
| Thyristors Q1 to Q6 | Active, on, or off |
| **Direct-On-Line Starter** | |
| Motor Full-Load Current | 0.4-2 A |
| Overload | On or off |
| Overload Class | 5, 10, 15, 20, 25, 30, 35, or 40 |
| **Soft Starter** | |
| Mode | Soft Start or current-limit start |
| Motor Full-Load Current | 0.4-2 A |
| Initial Torque | 15%, 25%, 35%, or 65% of LRT |
| Start Time | 2-200 s |
| Kick-Start Time | 0 s, 0.5 s, 1 s, or 1.5 s |
| Soft Stop | 0, 1, 2, or 3 times the start time |
| Overload | On or off |
| Overload Class | 5, 10, 15, 20, 25, 30, 35, or 40 |

## Home Energy Production Control Function Set 581455 (9069-40)




The Home Energy Production Control Function Set enables the following devices required for home energy production to be implemented using the Data Acquisition and Control Interface, the IGBT Chopper/Inverter, and the Insulated DC-to-DC Converter:

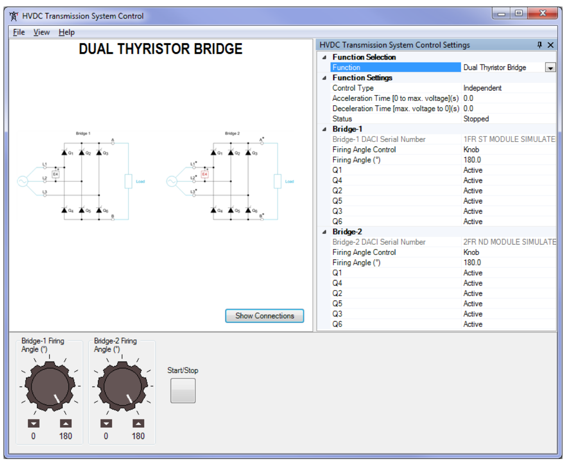
- Single-Phase Stand-Alone Inverter
- Single-Phase Grid-Tied Inverter
- Solar Power Inverter (LF Transformer)
- Solar/Wind Power Inverter (HF Transformer)

## Specifications

| Parameter | Value |
|---|---|
| **Control Functions** | |
| Control Functions | Single-Phase Stand-Alone Inverter |
| | Single-Phase Grid-Tied Inverter |
| | Single-Phase Grid-Tied Inverter (LF Transformer) |
| | Solar/Wind Power Inverter (HF Transformer) |
| **Single-Phase Stand-Alone Inverter Function** | |
| Output Power Limit | 50-250 W |

| Parameter | Value |
|---|---|
| Battery Minimum Voltage | 35-55 V |
| PWM Inverter Peak Output Voltage | 50-95% of dc bus voltage |
| PWM Inverter Output Frequency | 50 or 60 Hz |
| DC Bus Voltage Command | 100-400 V |
| **Single-Phase Grid-Tied Inverter Function** | |
| Active Current Command | -2 to 2 A |
| Reactive Current Command | -2 to 2 A |
| DC Bus Voltage Command | 100-400 V |
| **Solar Power Inverter (LF Transformer)** | |
| MPP Tracker | On or off |
| Active Current Command | -10 A to 10 A (only available when the MPP Tracker parameter is switched to Off) |
| Reactive Current Command | -10 A to 10 A |
| **Solar/Wind Power Inverter (HF Transformer)** | |
| MPP Tracker Type | Solar panel or wind turbine |

## High-Voltage DC (HVDC) Transmission System Control Function Set 579790 (9069-70)



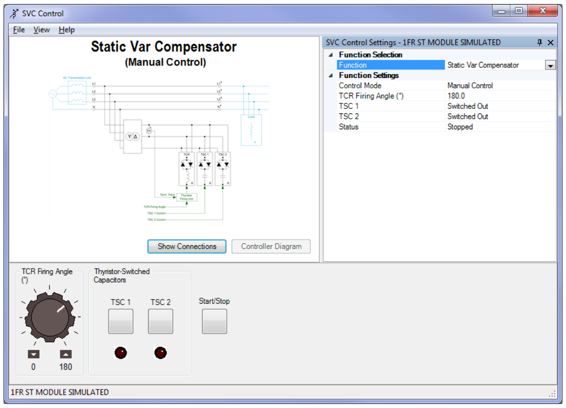

The High-Voltage DC (HVDC) Transmission System Control Function Set enables the following devices required for the study of HVDCs to be implemented using two Data Acquisition and Control Interface, and two Power Thyristors:

- Dual Thyristor Bridge
- Monopolar HVDC Transmission System
- 12-Pulse Converter

## Specifications

| Parameter | Value |
|---|---|
| **Control Functions** | |
| Control Functions | Dual Thyristor Bridge |
| | Monopolar HVDC Transmission System |
| | 12-Pulse Converter |
| **Dual Thyristor Bridge** | |
| Control Type | Independent, common (α,α), or common (α,ß) |
| Acceleration Time (0 to Max. Voltage) | 0-100 s |
| Deceleration Time (Max. Voltage to 0) | 0-100 s |
| Firing Angle Control (for Each Bridge) | Knob or analog input on the DACI |
| Firing Angle (for Each Bridge) | 0-180° |
| **Monopolar HVDC Transmission System** | |
| Control Type | Independent, linked (rectifier = bridge 1), or linked (rectifier = bridge 2) |
| Command Input (for Each Bridge) | Knob or analog input on the DACI |
| Current Command (for Each Bridge) | 0-2 A |
| Inverter Limit (for Each Bridge) | 90-180° |
| Arc-Cosine (for Each Bridge) | On of off |
| Feedback Filter Cutoff Frequency (for Each Bridge) | 10-180 Hz |
| **12-Pulse Converter** | |
| Firing Angle | 0-180° |
| Acceleration Time (0 to Max. Voltage) | 0-100 s |
| Deceleration Time (Max. Voltage to 0) | 0-100 s |

## Static Var Compensator (SVC) Control Function Set
## 581458 (9069-80)



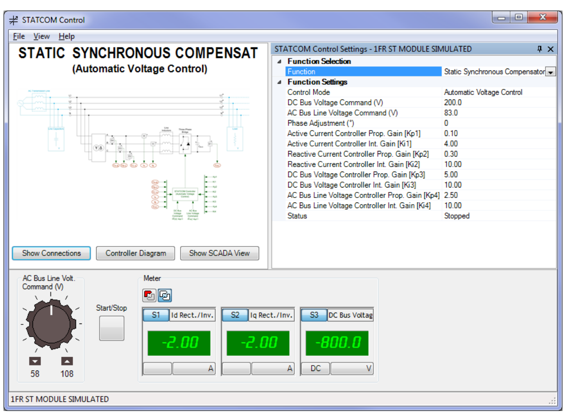

The Static Var Compensator (SVC) Control Function Set enables the following devices required for the study of SVCs to be implemented using the Data Acquisition and Control Interface, and the Power Thyristors:

- Static Var Compensator (Manual Control)
- Static Var Compensator (Automatic Voltage Control)
- Static Var Compensator (Automatic Reactive Power Control)

### Specifications

| Parameter | Value |
|---|---|
| **Control Modes** | |
| Control Modes | Manual control |
| | Automatic voltage control |
| | Automatic reactive power control |
| **Manual Control** | |
| TCR Firing Angle | 0-180° |
| TSC 1 and TSC 2 | Switched in or switched out |
| **Automatic Voltage Control** | |
| Line Voltage Command | 90-150 V |
| **Automatic Reactive Power Control** | |
| Phase Adjustment | -90° to 90° |

## Static Synchronous Compensator (STATCOM) Control Function Set
## 581460 (9069-B0)




The Static Synchronous Compensator (STATCOM) Control Function Set enables the following devices required for the study of STATCOMs to be implemented using the Data Acquisition and Control Interface, and the IGBT Chopper/Inverter:

- Static Synchronous Compensator (Automatic Voltage Control)
- Static Synchronous Compensator (Automatic Reactive Power Control)

### Specifications

| Parameter | Value |
|---|---|
| **Control Modes** | |
| Control Modes | Automatic Voltage Control |
| | Automatic Reactive Power Control |
| **Automatic Voltage Control** | |
| DC Bus Voltage Command | 150-250 V |
| AC Bus Line Voltage Command | 58-108 V |

| Parameter | Value |
|---|---|
| Phase Adjustment | -90° to 90° |
| **Automatic Reactive Power Control** | |
| DC Bus Voltage Command | 150-250 V |
| Phase Adjustment | -90 to 90° |

# Optional Equipment Description

## Digital Multimeter (Optional)
## 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) |

## 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

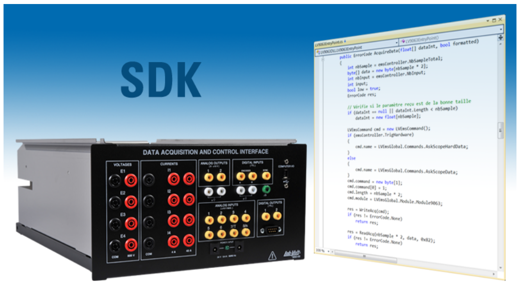
The instrumentation functions of LVDAC-EMS replace a multitude of actual data acquisition devices (e.g., voltmeters, ammeters, oscilloscopes, synchroscopes) with a series of computer-based instruments that display the data measured by the DACI.

## 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

## Software Development Kit (SDK) (Optional)
## 581459 (9069-90)




The DACI SDK (Software Development Kit) offers the possibility to control various inputs and outputs of the Data Acquisition and Control Interface using third-party rapid prototyping software like Mathworks® MATLAB, National Instruments® LabVIEW, Microsoft Visual Studio and other programming tools that support Microsoft® .NET Framework 4.0. The SDK gives users the possibility to build their own advanced functions using the Data Acquisition and Control Interface.

The SDK includes the following:

- DLL files for communication with the DACI

- Documentation related to the functions

- MATLAB (2010 or later), LabVIEW (2009 or later) and Visual Studio C# (2012 or later) example programs

- Binaries from the C# example. This application can be used to verify that your PC configuration is compatible with the SDK.

The following functions are available using the SDK:

- Acquisition through the voltage and current inputs

- Acquisition through the encoder inputs

- Acquisition through the analog inputs

- Control of the digital outputs

- Control of the analog outputs

Important Notice: One DACI SDK (Software Development Kit) must be ordered for each Data Acquisition and Control Interface to unlock the SDK features.

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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