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Electric Power / Controls
0.2 kW

Lab-Volt®

ELECTRICAL ENERGY TRAINING SYSTEMS, SERIES 8010



Shown with optional equipment.

GENERAL DESCRIPTION

The production of energy using renewable natural resources such as wind, sunlight, rain, tides, geothermal heat, etc., has gained much importance in recent years as it is an effective means of reducing greenhouse gas (GHG) emissions. To answer the increasing need for training in the renewable energy field, Lab-Volt has developed the Electrical Energy Training Program, a modular study program for technical institutes, colleges, and universities. The program provides in-depth coverage of a wide variety of topics related to the field of electrical energy such as AC and DC power circuits, power electronics, transformers, transmission lines, rotating machines, etc. This program uses this knowledge to covers also several renewable energy topics such as the large-scale production of electrical energy from hydro power, solar power, and wind power (doubly-fed induction generator [DFIG], synchronous

generator, and asynchronous generator technologies), small-scale production of electrical energy from wind power and solar power, storage of energy in batteries, home energy production, and drive systems for small electric vehicles (e.g., bicycles, scooters, golf carts, fork lifts, etc.) and electric cars.

The Electrical Energy Training Systems, Series 8010, are based on the Lab-Volt Electrical Energy Training Program, each system providing a turn-key solution dealing with different aspects of the wide field of electrical energy. Each system in the 8010 Series is based on the proven Lab-Volt Electromechanical System (EMS), as well as newly-developed, state-of-the-art training equipment. The Electrical Energy Training Program also incorporates knowledge from well established other Lab-Volt training programs, which are:

ELECTRICAL ENERGY TRAINING SYSTEMS SERIES 8010

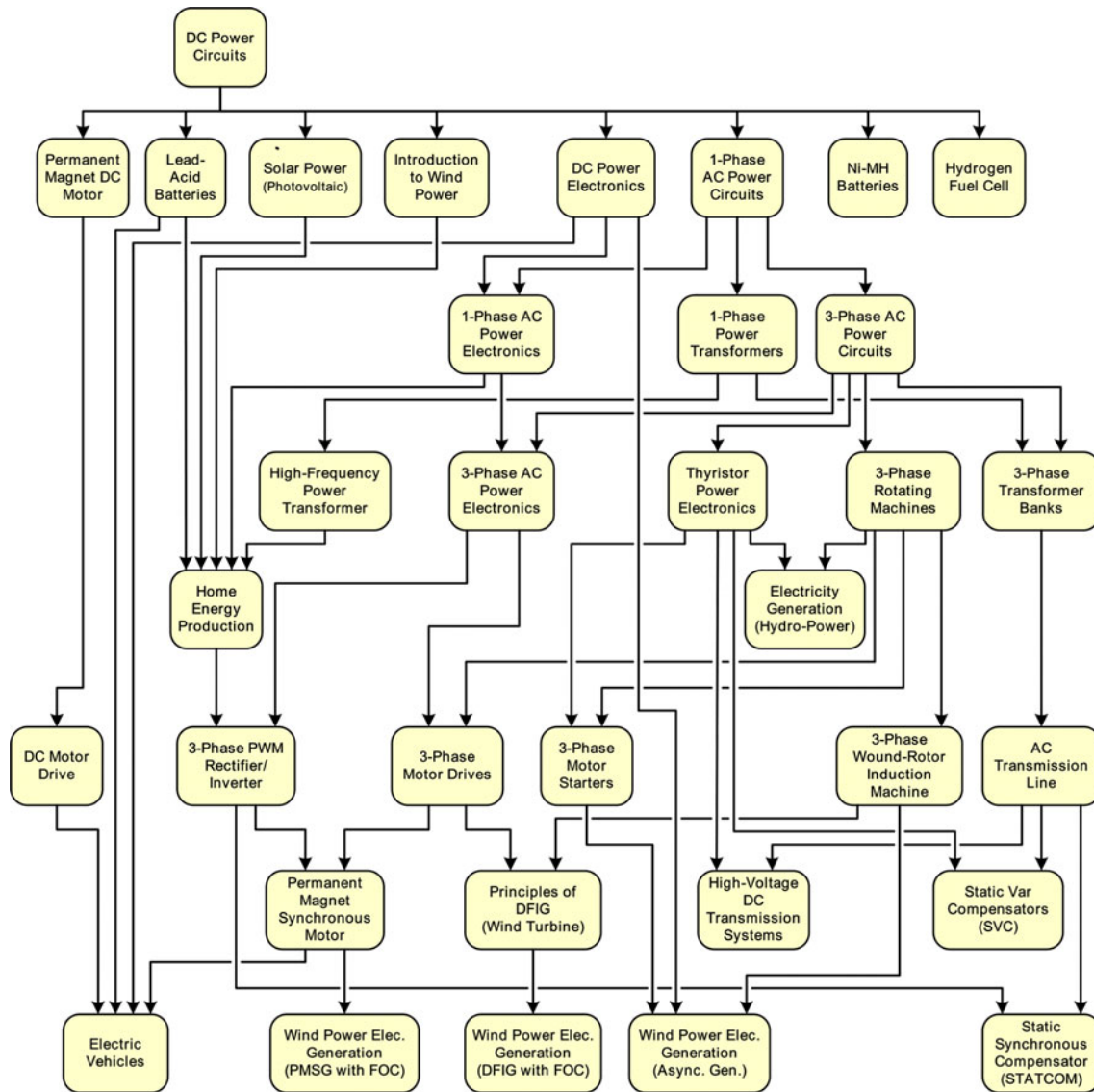
- Electromechanical Training System (Model 8001 and 8006)
- Power Electronics Training System (Model 8032)
- Wind Power Technology (Model 8052)
- Power Transmission Training System (Model 8055)

By incorporating these programs in the Electrical Energy Training Program, Lab-Volt also gives the possibility to create a custom training course using these courses as well as new courses on new technologies.

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LAB-VOLT ELECTRICAL ENERGY TRAINING PROGRAM



The Lab-Volt Electrical Energy Training Program is a modular study program divided into courses, each course dealing with a specific aspect of the new energy domain and fundamental principles of electricity (motor, transformer, DC or AC circuits ...). The program is shown below as a flow chart, each box in the flow chart representing a course. This training program still being under development, the flow chart display what is currently available and the other course which will be available in that program. Refer to the legend below the flow chart for more details.

Each course includes a student manual providing all the theoretical matter required, guided lab-exercise procedures to be performed with Lab-Volt training equipment, and review questions that test the knowledge gained by the student. Whenever possible, each course is built to bring the student to real applications as soon as possible. An instructor guide providing all lab results and answers to questions is also included with each course. Refer to the Course Description section of this data sheet for additional information about each course.

ELECTRICAL ENERGY TRAINING SYSTEMS

Lab-Volt offers a series of Electrical Energy Training Systems that are based on the Electrical Energy Training Program. The following systems are currently available in the 8010 Series:

| SYSTEM NAME | MODEL NUMBER |
|--|---------------------|
| DC and AC Power Circuits Training System | 8010-1 |
| Solar Power Training System | 8010-2 |
| Small-Scale Wind Power Electricity Generation Training System | 8010-3 |
| Lead-Acid Batteries Training System | 8010-4 |
| Basic Renewable Energy Training System | 8010-5 |
| DC Power Electronics Training System | 8010-6 |
| Home Energy Production Training System | 8010-7 |
| Hydrogen Fuel Cell Training System | 8010-8 |
| Electromechanical Training System | 8010-9 |
| <i>This system covers the fundamental subjects of Lab-Volt 0.2 kW Electromechanical Training System (Models 8001 and 8006)</i> | |
| Power Electronics Training System | 8010-A |
| <i>This system covers the fundamental subjects of Lab-Volt 0.2 kW Power Electronics Training System (Model 8032)</i> | |

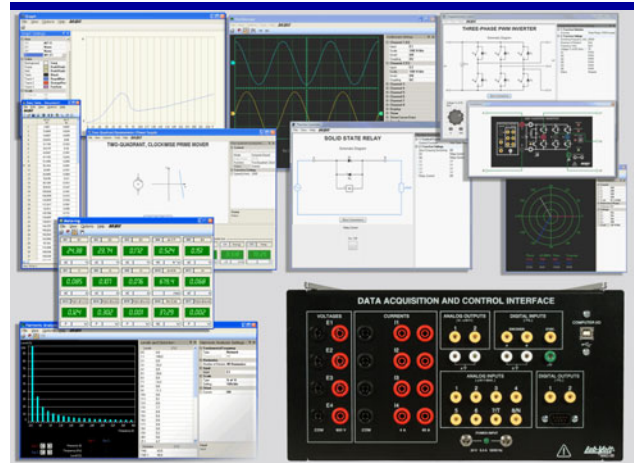
The current systems available covers the basis of the new energy training program as well more low-cost solution to teach fundamental principles of electricity that were taught in other Lab-Volt training systems. Other systems will be added to the 8010 Series as additional courses in the Electrical Energy Training Program become available. Each system in the 8010 Series is a turn-key solution that includes the equipment and courseware material required to perform a different combination of courses in the Electrical Energy Training Program (see table on the

next page). Each system uses the Four-Quadrant Dynamometer/Power Supply, Model 8960, and/or the EMS Data Acquisition and Control Interface (LVDAC-EMS), Model 9063, two state-of-the-art USB peripherals, newly-developed by Lab-Volt, that greatly enhance hands-on learning. Refer to the Lists of Equipment section of this data sheet for the list of equipment included in each training system.

ELECTRICAL ENERGY TRAINING SYSTEMS SERIES 8010



The Four-Quadrant Dynamometer/Power Supply, Model 8960, is a highly versatile USB peripheral designed to be used in the Lab-Volt EMS environment.



The Lab-Volt Data Acquisition and Control Interface, Model 9063, is a highly versatile USB peripheral used for measuring, observing, analyzing, and controlling electrical and mechanical parameters in electric power systems and power electronics circuits.

The following table indicates the combination of courses which can be performed with each training system in the 8010 Series.

| Courseware | | Electrical Energy Training System Model Number | | | | | | | | | |
|--|-------------|--|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| Title | Part Number | 8010-1 | 8010-2 | 8010-3 | 8010-4 | 8010-5 | 8010-6 | 8010-7 | 8010-8 | 8010-9 | 8010-A |
| DC Power Circuits | 86350 | • | • | • | • | • | • | • | | • | |
| Permanent Magnet DC Motor | 86357 | | | | | | | | | • | |
| Lead-Acid Batteries | 86351 | | | | • | • | | • | | | |
| Solar Power (photovoltaic) | 86352 | | • | | | • | | • | | | |
| Introduction to Wind Power | 86353 | | | • | | • | | • | | | |
| DC Power Electronics (diodes, IGBTs, and choppers) | 86356 | | | | | | • | • | | | • |
| Single-Phase AC Power Circuits | 86358 | • | | | | | | • | | • | |
| Ni-MH Batteries | 86354 | | | | | | | | | | |
| Hydrogen Fuel Cell | 86355 | | | | | | | | • | | |
| Single-Phase AC Power Electronics | 86359 | | | | | | | • | | | • |
| Single-Phase Power Transformer | 86377 | | | | | | | • | | • | |
| Three-Phase AC Power Circuits | 86360 | | | | | | | | | • | |
| Electric Vehicles | 86375 | | | | | | | | | | |

| Courseware | | Electrical Energy Training System Model Number | | | | | | | | | |
|---|-------------|--|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| Title | Part Number | 8010-1 | 8010-2 | 8010-3 | 8010-4 | 8010-5 | 8010-6 | 8010-7 | 8010-8 | 8010-9 | 8010-A |
| High-Frequency Power Transformer | 86378 | | | | | | | • | | | |
| Three-Phase AC Power Electronics | 86362 | | | | | | | | | | • |
| Thyristor Power Electronics | 86363 | | | | | | | | | | • |
| Three-Phase Rotating Machines | 86364 | | | | | | | | | • | |
| Three-Phase Transformer Banks | 86379 | | | | | | | | | • | |
| Home Energy Production | 86361 | | | | | | | • | | | |
| Hydro-Power Electricity Generation | 86369 | | | | | | | | | | |
| DC Motor Drive | 88553 | | | | | | | | | | • |
| Three-Phase PWM Rectifier/Inverter | 86366 | | | | | | | | | | |
| Three-Phase Motor Drives | 86368 | | | | | | | | | | • |
| Three-Phase Motor Starters | 88197 | | | | | | | | | | |
| Three-Phase Wound-Rotor Induction Machine | 86367 | | | | | | | | | | |
| AC Transmission Line | 86365 | | | | | | | | | | |
| Principles of DFIG (Wind Turbine) | 86376 | | | | | | | | | | |
| High-Voltage DC Transmission Systems | 86380 | | | | | | | | | | |
| Static Var Compensators (SVC) | 86370 | | | | | | | | | | |
| Wind Power Electricity Generation (PMSG with FOC) | 86372 | | | | | | | | | | |
| Permanent Magnet Synchronous Motor | 86373 | | | | | | | | | | |
| Wind Power Electricity Generation (Async. Gen.) | 86374 | | | | | | | | | | |
| Static Synchronous Compensator (STATCOM) | 86371 | | | | | | | | | | |
| Wind Power Electricity Generation (DFIG with FOC) | 88809 | | | | | | | | | | |

If none of the above Electrical Energy Training Systems meets your specific training needs, please refer to the Custom Training Solutions section of this data sheet to learn how Lab-Volt can provide a training solution adapted to your needs.

ELECTRICAL ENERGY TRAINING SYSTEMS SERIES 8010

LISTS OF EQUIPMENT

This section lists the equipment for each training system in the 8010 series. Some additional equipment, such as a digital multimeter or a host computer, is required to perform the exercises but is not included in the

8010 series training systems, as most school labs are already equipped with such equipment. Optional equipment can be added to certain training systems to enhance the lab exercises.

DC AND AC POWER CIRCUITS TRAINING SYSTEM, MODEL 8010-1

| QTY | DESCRIPTION | ORDERING NUMBER ¹ |
|-----|---|------------------------------|
| 1 | Three-Module Workstation | 8131-00 ² |
| 1 | Resistive Load | 8311-00 ³ |
| 1 | Inductive Load | 8321-00 ⁴ |
| 1 | Capacitive Load | 8331-00 ⁴ |
| 1 | Connection Leads | 8951-L0 |
| 1 | Four-Quadrant Dynamometer/Power Supply | 8960-C0 |
| 1 | Data Acquisition and Control Interface | 9063-B0 |
| 1 | 24-Vac Power Supply | 30004-20 |
| 1 | DC Power Circuits (Student Manual) | 86350-00 |
| 1 | DC Power Circuits (Instructor Guide) | 86350-10 |
| 1 | Single-Phase AC Power Circuits (Student Manual) | 86358-00 |
| 1 | Single-Phase AC Power Circuits (Instructor Guide) | 86358-10 |

ADDITIONAL EQUIPMENT REQUIRED FOR MODEL 8010-1

| QTY | DESCRIPTION | ORDERING NUMBER ¹ |
|-----|--------------------|------------------------------|
| 2 | Digital Multimeter | 8946-20 |
| 1 | Personal Computer | 8990-00 |

SOLAR POWER TRAINING SYSTEM, MODEL 8010-2

| QTY | DESCRIPTION | ORDERING NUMBER ¹ |
|-----|--|------------------------------|
| 1 | Three-Module Workstation | 8131-00 ² |
| 1 | Resistive Load | 8311-00 ³ |
| 1 | Lead-Acid Batteries | 8801-00 |
| 1 | Solar Panel Test Bench | 8805-00 |
| 1 | Monocrystalline Silicon Solar Panel | 8806-00 |
| 1 | Connection Leads | 8951-L0 |
| 1 | Four-Quadrant Dynamometer/Power Supply | 8960-C0 |
| 1 | DC Power Circuits (Student Manual) | 86350-00 |
| 1 | DC Power Circuits (Instructor Guide) | 86350-10 |
| 1 | Solar Power (Student Manual) | 86352-00 |
| 1 | Solar Power (Instructor Guide) | 86352-10 |

¹ The ordering numbers shown apply to the English 120-V version. Other versions are available. Refer to the Ordering Numbers section.

² The Three-Module Workstation, Model 8131, can be replaced with the Mobile Workstation, Model 8110, or the Workstation, Model 8134.

³ In English 220-V and 240-V system versions, the Resistive Load is not voltage dependent and Model 8311-00 needs to be ordered.

⁴ In training systems 8010-15, 8010-16, 8010-17, and 8010-1A, the Inductive Load, Model 8321, and the Capacitive Load, Model 8331, are replaced with the Inductive and Capacitive Loads, Model 8333.

ADDITIONAL EQUIPMENT REQUIRED FOR MODEL 8010-2

| QTY | DESCRIPTION | ORDERING NUMBER ¹ |
|-----|--------------------------|------------------------------|
| 2 | Digital Multimeter | 8946-20 |
| 1 | Heavy-Duty Tripod | 40208-10 |

OPTIONAL EQUIPMENT FOR MODEL 8010-2

| QTY | DESCRIPTION | ORDERING NUMBER ¹ |
|-----|-------------------|------------------------------|
| 1 | Pyranometer | 8989-00 |

SMALL-SCALE WIND POWER ELECTRICITY GENERATION TRAINING SYSTEM, MODEL 8010-3

| QTY | DESCRIPTION | ORDERING NUMBER ¹ |
|-----|---|------------------------------|
| 1 | Three-Module Workstation | 8131-00 ² |
| 1 | Wind Turbine Generator/Controller | 8216-00 |
| 1 | Resistive Load | 8311-00 ³ |
| 1 | Lead-Acid Batteries | 8801-00 |
| 1 | Lead-Acid Battery Pack | 8802-10 |
| 1 | Timing Belt | 8942-00 |
| 1 | Connection Leads | 8951-L0 |
| 1 | Four-Quadrant Dynamometer/Power Supply | 8960-D0 |
| 1 | DC Power Circuits (Student Manual) | 86350-00 |
| 1 | DC Power Circuits (Instructor Guide) | 86350-10 |
| 1 | Introduction to Wind Power (Student Manual) | 86353-00 |
| 1 | Introduction to Wind Power (Instructor Guide) | 86353-10 |

ADDITIONAL EQUIPMENT REQUIRED FOR MODEL 8010-3

| QTY | DESCRIPTION | ORDERING NUMBER ¹ |
|-----|--------------------------|------------------------------|
| 2 | Digital Multimeter | 8946-20 |
| 1 | Personal Computer | 8990-00 |

OPTIONAL EQUIPMENT FOR MODEL 8010-3

| QTY | DESCRIPTION | ORDERING NUMBER ¹ |
|-----|---|------------------------------|
| 1 | Wind Turbine Demonstrator | 8216-D0 |
| 1 | Magnetic Field Strength Indicator | 86618-00 |
| 1 | Wind Turbine Rotor | 86630-00 |

LEAD-ACID BATTERIES TRAINING SYSTEM, MODEL 8010-4

| QTY | DESCRIPTION | ORDERING NUMBER ¹ |
|-----|--|------------------------------|
| 1 | Three-Module Workstation | 8131-00 ² |
| 1 | Resistive Load | 8311-00 ³ |
| 1 | Lead-Acid Batteries | 8801-00 |
| 1 | Connection Leads | 8951-L0 |
| 1 | Four-Quadrant Dynamometer/Power Supply | 8960-E0 |
| 1 | DC Power Circuits (Student Manual) | 86350-00 |
| 1 | DC Power Circuits (Instructor Guide) | 86350-10 |
| 1 | Lead-Acid Batteries (Student Manual) | 86351-00 |
| 1 | Lead-Acid Batteries (Instructor Guide) | 86351-10 |

ADDITIONAL EQUIPMENT REQUIRED FOR MODEL 8010-4

| QTY | DESCRIPTION | ORDERING NUMBER ¹ |
|-----|--------------------------|------------------------------|
| 1 | Digital Multimeter | 8946-20 |
| 1 | Personal Computer | 8990-00 |

ELECTRICAL ENERGY TRAINING SYSTEMS SERIES 8010

BASIC RENEWABLE ENERGY TRAINING SYSTEM, MODEL 8010-5

| QTY | DESCRIPTION | ORDERING NUMBER ¹ |
|-----|---|------------------------------|
| 1 | Three-Module Workstation | 8131-00 ² |
| 1 | Wind Turbine Generator/Controller | 8216-00 |
| 1 | Resistive Load | 8311-00 ³ |
| 1 | Lead-Acid Batteries | 8801-00 |
| 1 | Lead-Acid Battery Pack | 8802-10 |
| 1 | Solar Panel Test Bench | 8805-00 |
| 1 | Monocrystalline Silicon Solar Panel | 8806-00 |
| 1 | Timing Belt | 8942-00 |
| 1 | Connection Leads | 8951-L0 |
| 1 | Four-Quadrant Dynamometer/Power Supply | 8960-D0 |
| 1 | DC Power Circuits (Student Manual) | 86350-00 |
| 1 | DC Power Circuits (Instructor Guide) | 86350-10 |
| 1 | Lead-Acid Batteries (Student Manual) | 86351-00 |
| 1 | Lead-Acid Batteries (Instructor Guide) | 86351-10 |
| 1 | Solar Power (Student Manual) | 86352-00 |
| 1 | Solar Power (Instructor Guide) | 86352-10 |
| 1 | Introduction to Wind Power (Student Manual) | 86353-00 |
| 1 | Introduction to Wind Power (Instructor Guide) | 86353-10 |

ADDITIONAL EQUIPMENT REQUIRED FOR MODEL 8010-5

| QTY | DESCRIPTION | ORDERING NUMBER ¹ |
|-----|------------------------------|------------------------------|
| 2 | Digital Multimeter | 8946-20 |
| 1 | Personal Computer | 8990-00 |
| 1 | Heavy-Duty Tripod | 40208-10 |

OPTIONAL EQUIPMENT FOR MODEL 8010-5

| QTY | DESCRIPTION | ORDERING NUMBER ¹ |
|-----|---|------------------------------|
| 1 | Wind Turbine Demonstrator | 8216-D0 |
| 1 | Pyranometer | 8989-00 |
| 1 | Magnetic Field Strength Indicator | 86618-00 |
| 1 | Wind Turbine Rotor | 86630-00 |

DC POWER ELECTRONICS TRAINING SYSTEM, MODEL 8010-6

| QTY | DESCRIPTION | ORDERING NUMBER ¹ |
|-----|---|------------------------------|
| 1 | Three-Module Workstation | 8131-00 ² |
| 1 | Resistive Load | 8311-00 ³ |
| 1 | Filtering Inductors/Capacitors | 8325-A0 |
| 1 | Lead-Acid Battery Pack | 8802-10 |
| 1 | IGBT Chopper/Inverter | 8837-B0 |
| 1 | Connection Leads | 8951-L0 |
| 1 | Four-Quadrant Dynamometer/Power Supply | 8960-E0 |
| 1 | Data Acquisition and Control Interface | 9063-C0 |
| 1 | 24-Vac Power Supply | 30004-20 |
| 1 | DC Power Circuits (Student Manual) | 86350-00 |
| 1 | DC Power Circuits (Instructor Guide) | 86350-10 |
| 1 | DC Power Electronics (Student Manual) | 86356-00 |
| 1 | DC Power Electronics (Instructor Guide) | 86356-10 |

ADDITIONAL EQUIPMENT REQUIRED FOR MODEL 8010-6

| QTY | DESCRIPTION | ORDERING NUMBER ¹ |
|-----|--------------------|------------------------------|
| 2 | Digital Multimeter | 8946-20 |
| 1 | Personal Computer | 8990-00 |

HOME ENERGY PRODUCTION TRAINING SYSTEM, MODEL 8010-7

| QTY | DESCRIPTION | ORDERING NUMBER ¹ |
|-----|--|------------------------------|
| 1 | Workstation | 8134-00 ⁵ |
| 1 | Wind Turbine Generator/Controller | 8216-00 |
| 1 | Resistive Load | 8311-00 ⁶ |
| 1 | Inductive Load | 8321-00 ⁷ |
| 1 | Filtering Inductors/Capacitors | 8325-A0 |
| 1 | Capacitive Load | 8331-00 ⁷ |
| 1 | Transformer | 8353-00 |
| 1 | AC Power Network Interface | 8622-00 |
| 1 | Lead-Acid Batteries | 8801-00 |
| 1 | Lead-Acid Battery Pack | 8802-10 |
| 1 | Solar Panel Test Bench | 8805-00 |
| 1 | Monocrystalline Silicon Solar Panel | 8806-00 |
| 1 | Insulated DC-to-DC Converter | 8835-00 |
| 1 | IGBT Chopper/Inverter | 8837-B0 |
| 1 | Rectifier and Filtering Capacitors | 8842-A0 |
| 1 | Timing Belt | 8942-00 |
| 1 | Connection Leads | 8951-L0 |
| 1 | Four-Quadrant Dynamometer/Power Supply | 8960-F0 |
| 1 | Data Acquisition and Control Interface | 9063-E0 |
| 1 | 24-Vac Power Supply | 30004-20 |
| 1 | DC Power Circuits (Student Manual) | 86350-00 |
| 1 | DC Power Circuits (Instructor Guide) | 86350-10 |
| 1 | Lead-Acid Batteries (Student Manual) | 86351-00 |
| 1 | Lead-Acid Batteries (Instructor Guide) | 86351-10 |
| 1 | Solar Power (Student Manual) | 86352-00 |
| 1 | Solar Power (Instructor Guide) | 86352-10 |
| 1 | Introduction to Wind Power (Student Manual) | 86353-00 |
| 1 | Introduction to Wind Power (Instructor Guide) | 86353-10 |
| 1 | DC Power Electronics (Student Manual) | 86356-00 |
| 1 | DC Power Electronics (Instructor Guide) | 86356-10 |
| 1 | Single-Phase AC Power Circuits (Student Manual) | 86358-00 |
| 1 | Single-Phase AC Power Circuits (Instructor Guide) | 86358-10 |
| 1 | Single-Phase AC Power Electronics (Student Manual) | 86359-00 |
| 1 | Single-Phase AC Power Electronics (Instructor Guide) | 86359-10 |
| 1 | Home Energy Production (Student Manual) | 86361-00 |
| 1 | Home Energy Production (Instructor Guide) | 86361-10 |
| 1 | Single-Phase Power Transformer (Student Manual) | 86377-00 |
| 1 | Single-Phase Power Transformer (Instructor Guide) | 86377-10 |
| 1 | High-Frequency Power Transformer (Student Manual) | 86378-00 |
| 1 | High-Frequency Power Transformer (Instructor Guide) | 86378-10 |

⁵ The Workstation, Model 8134, can be replaced with the Mobile Workstation, Model 8110.

⁶ In training systems 8010-75, 8010-76, 8010-77, and 8010-7A, two different Resistive Load module must be ordered. One voltage-dependent Resistive Load, Model 8311-05 (-06, -07 or -0A), and one non-voltage-dependent Resistive Load, Model 8311-00 (-01, -02 or -A0).

⁷ In training systems 8010-75, 8010-76, 8010-77, and 8010-7A, the Inductive Load, Model 8321, and the Capacitive Load, Model 8331, are replaced with the Inductive and Capacitive Loads, Model 8333 and 8311-05 (-06, -07 or -0A).

ELECTRICAL ENERGY TRAINING SYSTEMS SERIES 8010

ADDITIONAL EQUIPMENT REQUIRED FOR MODEL 8010-7

| QTY | DESCRIPTION | ORDERING NUMBER ¹ |
|-----|--------------------------|------------------------------|
| 2 | Digital Multimeter | 8946-20 |
| 1 | Personal Computer | 8990-00 |
| 1 | Heavy-Duty Tripod | 40208-10 |

OPTIONAL EQUIPMENT FOR MODEL 8010-7

| QTY | DESCRIPTION | ORDERING NUMBER ¹ |
|-----|---|------------------------------|
| 1 | Wind Turbine Demonstrator | 8216-D0 |
| 1 | Pyranometer | 8989-00 |
| 1 | Magnetic Field Strength Indicator | 86618-00 |
| 1 | Wind Turbine Rotor | 86630-00 |

HYDROGEN FUEL CELL TRAINING SYSTEM, MODEL 8010-8

| QTY | DESCRIPTION | ORDERING NUMBER ¹ |
|-----|---|------------------------------|
| 1 | Three-Module Workstation | 8131-00 ² |
| 1 | Traffic Lights | 8380-00 |
| 1 | Electronic Load | 8381-00 |
| 1 | Hydrogen Fuel Cell | 8803-00 |
| 1 | Hydrogen Fuel Cell - Student Manual | 86355-00 |
| 1 | Hydrogen Fuel Cell - Instructor Guide | 86355-10 |
| 1 | Hydrogen Fuel Cell - User Guide | 86355-E0 |
| 1 | Hydrogen Storage Canister | 87948-00 |

OPTIONAL EQUIPMENT FOR MODEL 8010-8

| QTY | DESCRIPTION | ORDERING NUMBER ¹ |
|-----|--------------------------|------------------------------|
| 1 | Hydrogen Generator | 8894-00 |

ELECTROMECHANICAL TRAINING SYSTEM, MODEL 8010-9

| QTY | DESCRIPTION | ORDERING NUMBER ¹ |
|-----|---|------------------------------|
| 1 | Workstation | 8134-20 ⁵ |
| 1 | Permanent Magnet DC Motor | 8213-00 |
| 1 | Three-Phase Induction Machine | 8221-B0 |
| 1 | Three-Phase Synchronous Motor/Generator | 8241-00 |
| 1 | Resistive Load | 8311-00 ⁸ |
| 1 | Inductive Load | 8321-00 ⁹ |
| 1 | Capacitive Load | 8331-00 ⁹ |
| 1 | Three-Phase Transformer Bank | 8348-40 |
| 1 | Single-Phase Transformer | 8353-00 |
| 1 | Lead-Acid Battery Pack | 8802-10 |
| 1 | Power Supply | 8823-00 |
| 1 | Timing Belt | 8942-00 |
| 1 | Connection Leads | 8951-L0 |
| 1 | Four-Quadrant Dynamometer/Power Supply | 8960-C0 |
| 1 | Data Acquisition and Control Interface | 9063-B0 |
| 1 | 24-Vac Power Supply | 30004-20 |
| 1 | DC Power Circuits - Student Manual | 86350-00 |

⁸ In training systems 8010-95 (-96, -97 and -9A), and 8010-A5 (-A6, -A7 and -AA), two different Resistive Load module must be ordered. One voltage-dependent Resistive Load, Model 8311-05 (-06, -07 or -0A), and one non-voltage-dependent Resistive Load, Model 8311-00 (-01, -02 or -A0).

⁹ In training systems 8010-95 (-96, -97 and -9A), the Inductive and Capacitive Loads, Model 8333, must be added.

ELECTROMECHANICAL TRAINING SYSTEM, MODEL 8010-9 (cont'd)

| QTY | DESCRIPTION | ORDERING NUMBER ¹ |
|-----|---|------------------------------|
| 1 | DC Power Circuits - Instructor Guide | 86350-10 |
| 1 | Permanent Magnet DC Motor - Student Manual | 86357-00 |
| 1 | Permanent Magnet DC Motor - Instructor Guide | 86357-10 |
| 1 | Single-Phase AC Power Circuits - Student Manual | 86358-00 |
| 1 | Single-Phase AC Power Circuits - Instructor Guide | 86358-10 |
| 1 | Three-Phase AC Power Circuits - Student Manual | 86360-00 |
| 1 | Three-Phase AC Power Circuits - Instructor Guide | 86360-10 |
| 1 | Three-Phase Rotating Machines - Student Manual | 86364-00 |
| 1 | Three-Phase Rotating Machines - Instructor Guide | 86364-10 |
| 1 | Single-Phase Power Transformer - Student Manual | 86377-00 |
| 1 | Single-Phase Power Transformer - Instructor Guide | 86377-10 |
| 1 | Three-Phase Transformer Banks - Student Manual | 86379-00 |
| 1 | Three-Phase Transformer Banks - Instructor Guide | 86379-10 |

ADDITIONAL EQUIPMENT REQUIRED FOR MODEL 8010-9

| QTY | DESCRIPTION | ORDERING NUMBER ¹ |
|-----|--------------------|------------------------------|
| 2 | Digital Multimeter | 8946-20 |
| 1 | Personal Computer | 8990-00 |

POWER ELECTRONICS TRAINING SYSTEM, MODEL 8010-A

| QTY | DESCRIPTION | ORDERING NUMBER ¹ |
|-----|--|------------------------------|
| 1 | Workstation | 8134-20 ⁵ |
| 1 | Three-Phase Induction Machine | 8221-B0 |
| 1 | Resistive Load | 8311-00 ⁸ |
| 1 | Filtering Inductors/Capacitors | 8325-A0 |
| 1 | Three-Phase Filters | 8326-00 |
| 1 | Capacitive Load | 8331-00 |
| 1 | Three-Phase Transformer Bank | 8348-40 |
| 1 | Single-Phase Transformer | 8353-00 |
| 1 | Lead-Acid Battery Pack | 8802-10 |
| 1 | Power Supply | 8823-00 |
| 1 | IGBT Chopper/Inverter | 8837-B0 |
| 1 | Power Thyristors | 8841-20 |
| 1 | Rectifier and Filtering Capacitors | 8842-A0 |
| 1 | Connection Leads | 8951-L0 |
| 1 | Four-Quadrant Dynamometer/Power Supply | 8960-E0 |
| 1 | Data Acquisition and Control Interface | 9063-D0 |
| 1 | 24-Vac Power Supply | 30004-20 |
| 3 | Safety Banana Plug Leads (Yellow, 30 cm) | 30011-04 |
| 1 | DC Power Electronics - Student Manual | 86356-00 |
| 1 | DC Power Electronics - Instructor Guide | 86356-10 |
| 1 | Single-Phase AC Power Electronics - Student Manual | 86359-00 |
| 1 | Single-Phase AC Power Electronics - Instructor Guide | 86359-10 |
| 1 | Three-Phase AC Power Electronics - Student Manual | 86362-00 |
| 1 | Three-Phase AC Power Electronics - Instructor Guide | 86362-10 |
| 1 | Thyristor Power Electronics - Student Manual | 86363-00 |
| 1 | Thyristor Power Electronics - Instructor Guide | 86363-10 |
| 1 | Three-Phase Motor Drives - Student Manual | 86368-00 |
| 1 | Three-Phase Motor Drives - Instructor Guide | 86368-10 |

ELECTRICAL ENERGY TRAINING SYSTEMS SERIES 8010

ADDITIONAL EQUIPMENT REQUIRED FOR MODEL 8010-A

| QTY | DESCRIPTION | ORDERING NUMBER ¹ |
|-----|--------------------------|------------------------------|
| 1 | Digital Multimeter | 8946-20 |
| 1 | Personal Computer | 8990-00 |

OPTIONAL EQUIPMENT FOR MODEL 8010-A

| QTY | DESCRIPTION | ORDERING NUMBER ¹ |
|-----|----------------------------------|------------------------------|
| 1 | AC Power Network Interface | 8622-00 |
| 1 | Solar Panel Test Bench | 8805-00 |

CUSTOM TRAINING SOLUTIONS

The modularity of the Lab-Volt Electrical Energy Training Program allows you to build your own training solution in renewable energy by selecting courses in the program that correspond to your specific needs. To build a custom training solution, refer to the Course Description section of this data sheet to see the topic coverage and prerequisites of each course in the Electrical Energy Training Program, then select the courses that meet your specific training needs. The Lab-Volt sales representative can easily determine the exact list of equipment required to perform the lab exercises associated with your selection of courses. A few examples of custom solutions for specific training needs are shown below.

Example 1 – Training solution dealing with Electric Vehicles

- Course selection:
- DC Power Circuits
 - Lead-Acid Batteries
 - Permanent Magnet DC Motor
 - DC Power Electronics
 - DC Motor Drive*
 - Electric Vehicles*

Example 2 – Training solution dealing with Single-Phase AC Power Electronics

- Course selection:
- DC Power Circuits
 - DC Power Electronics
 - Single-Phase AC Power Circuits
 - Single-Phase AC Power Electronics

Example 3 – Training solution dealing with Hydro-Power Electricity Generation

- Course selection:
- DC Power Circuits
 - Single-Phase AC Power Circuits
 - Three-Phase AC Power Circuits
 - Three-Phase Rotating Machines
 - Thyristor Power Electronics
 - Hydro-Power Electricity Generation*

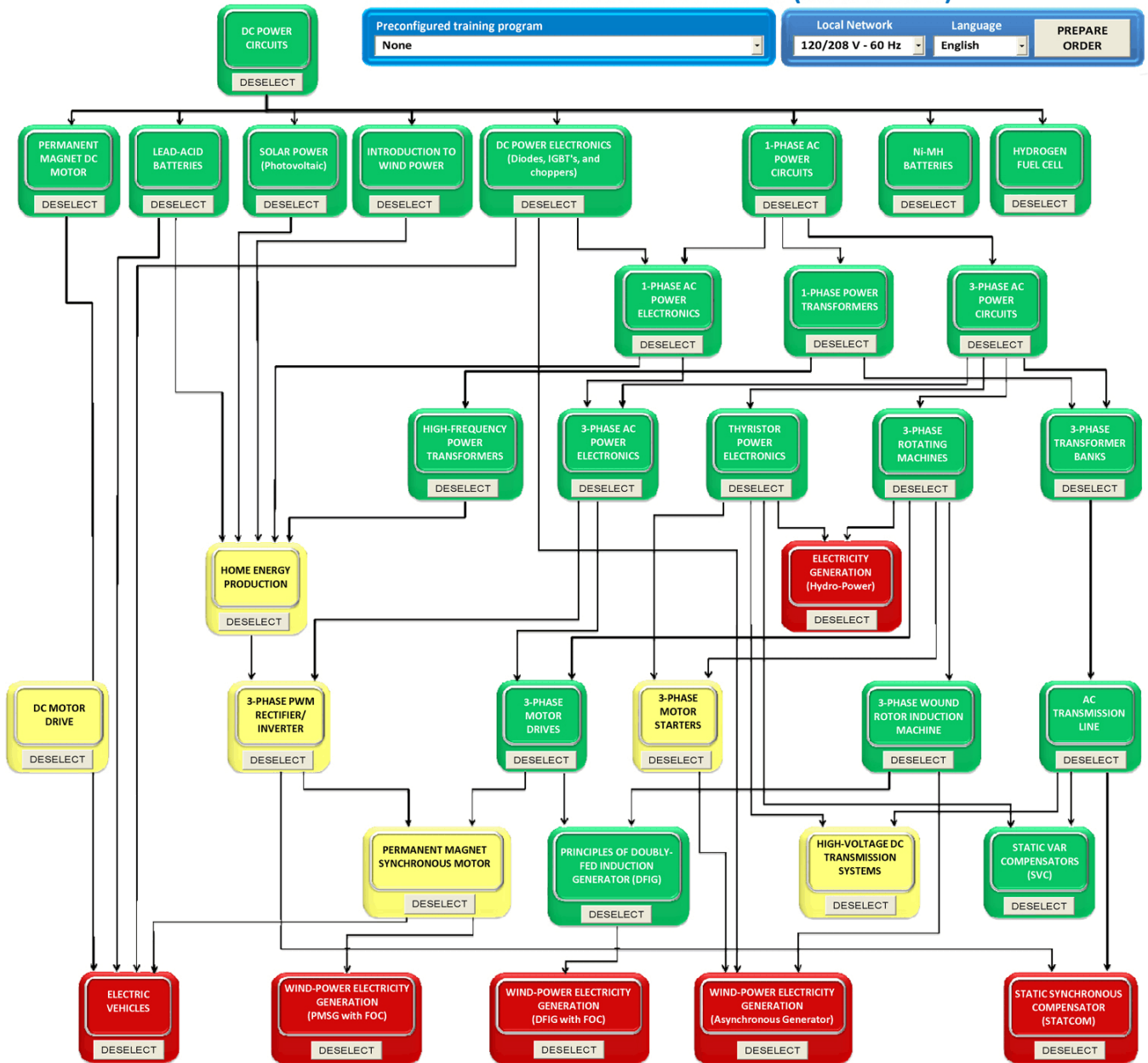
Example 4 – Training solution dealing with Large-Scale Wind Power Electricity Generation

- Course selection:
- DC Power Circuits
 - DC Power Electronics
 - Single-Phase AC Power Circuits
 - Single-Phase AC Power Electronics
 - Three-Phase AC Power Circuits
 - Three-Phase Rotating Machines
 - Three-Phase AC Power Electronics
 - Wind Power Electricity Generation (async. gen.)*
 - Wind Power Electricity Generation (PMSG with FOC)*
 - Principles of DFIG
 - Wind Power Electricity Generation (DFIG with FOC)

* **Note:** Equipment and courses may still be under development. Contact your Lab-Volt sales representative for more information.

CUSTOM TRAINING SOLUTIONS BUILDER

NEW ENERGY TRAINING PROGRAM (8010 SERIES)



- Note:**
- Green Boxes: Complete course available
 - Yellow Boxes: Hardware is available, Courseware still under development
 - Red Boxes: Hardware and Courseware still under development

ELECTRICAL ENERGY TRAINING SYSTEMS SERIES 8010

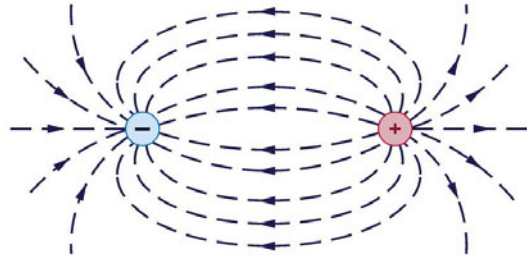
COURSE DESCRIPTION

The Lab-Volt Electrical Energy Training Program consists of a wide selection of courses which are listed below.

- DC Power Circuits
- Permanent Magnet DC Motor
- Lead-Acid Batteries
- Solar Power (photovoltaic)
- Introduction to Wind Power
- DC Power Electronics
- Single-Phase AC Power Circuits
- Ni-MH Batteries
- Hydrogen Fuel Cell
- Single-Phase AC Power Electronics
- Single-Phase Power Transformer
- Three-Phase AC Power Circuits
- DC Motor Drives*
- High-Frequency Power Transformer
- Three-Phase AC Power Electronics
- Thyristor Power Electronics
- Three-Phase Rotating Machines
- Three-Phase Transformer Banks
- Home Energy Production*
- Hydro-Power Electricity Generation*
- Three-Phase PWM Rectifier/Inverter*
- Three-Phase Motor Drives
- Three-Phase Motor Starters*
- Three-Phase Wound-Rotor Induction Machine
- AC Transmission Line
- Permanent Magnet Synchronous Motor *
- Principles of DFIG
- High-Voltage DC Transmission Systems*
- Static VAR Compensators (SVC)
- Electrical Vehicles *
- Wind Power Electricity Generation (PMSG with FOC)*
- Wind Power Electricity Generation (DFIG with FOC)*
- Wind Power Electricity Generation (Async. Gen.)*
- Static Synchronous Compensator (STATCOM)*

The remainder of this section briefly describes each course and provides the topic coverage and prerequisites for each course.

DC Power Circuits (86350)



The DC Power Circuits course introduces the student to the fundamentals of electricity such as the direct current (DC), DC voltage, resistance, Ohm's Law, etc.

Topic Coverage (4 exercises)

- Voltage, Current, Ohm's Law
- Equivalent Resistance
- Power in DC Circuits
- Series and Parallel Circuits

Prerequisites

- None

Permanent Magnet DC Motor (86357)

The Permanent Magnet DC Motor course covers the operating characteristics of a permanent magnet DC motor. In this course, students will learn the motor characteristics when used as a motor or as a generator.

Topic Coverage (3 exercises)

- Prime Mover and Brake Operation
- Operation as a Generator
- Operation as a Motor

Prerequisites

- DC Power Circuits

* **Note:** Course may still be under development (topic coverage subject to change). Contact your Lab-Volt sales representative for more information.

Lead-Acid Batteries (86351)



The Lead-Acid Batteries course explains how a lead-acid battery produces electricity from a chemical reaction. The course familiarizes the student with the charge and discharge characteristics of lead-acid batteries. The student also learns the various methods of charging lead-acid batteries.

Topic Coverage (4 exercises)

- Battery Fundamentals
- Discharge Characteristics
- Battery Charging Fundamentals
- Battery Charging Methods

Prerequisites

- DC Power Circuits

Solar Power (86352)



The Solar Power course familiarizes the student with the production of electricity using photovoltaic (PV) solar panels. The course begins by introducing the diode, the basic semiconductor component in PV solar panels. The student then learns how a solar panel produces electricity from solar power as well as how to store this electric energy in batteries to ensure electric power is available during cloudy periods. The student also learns how to connect PV panels in series and in parallel to increase the voltage and current produced, respectively. Finally, the student learns how to set the orientation of solar panels so the maximum amount of energy is produced.

Topic Coverage (7 exercises)

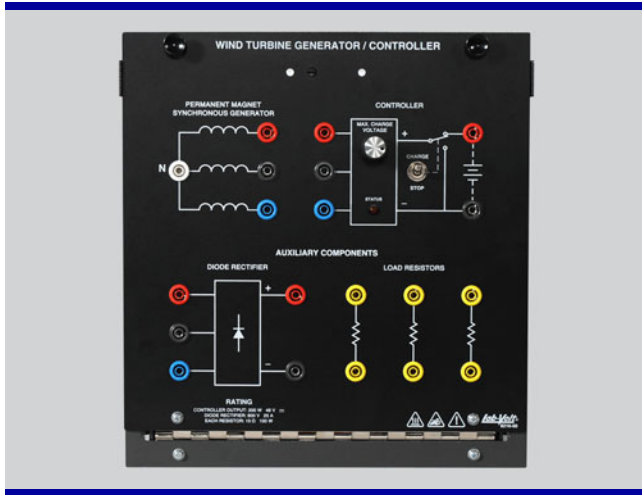
- The Diode
- The Solar Panel (Photovoltaic Panel)
- Effect of Temperature on Solar Panel Performance
- Storing Energy from Solar Panels into Batteries
- Effect of Shading on Solar Panel Operation
- Solar Panel Orientation (optional)
- Solar Panel Performance versus Insolation (optional)

Prerequisites

- DC Power Circuits

ELECTRICAL ENERGY TRAINING SYSTEMS SERIES 8010

Introduction to Wind Power (86353)



The Introduction to Wind Power course familiarizes the student with the small-scale production of electricity using a fixed-pitch, direct-drive wind turbine. The student learns how a wind turbine produces electricity from wind power as well as how to store this electric energy in batteries to ensure electric power is available when there is no wind or during low wind periods.

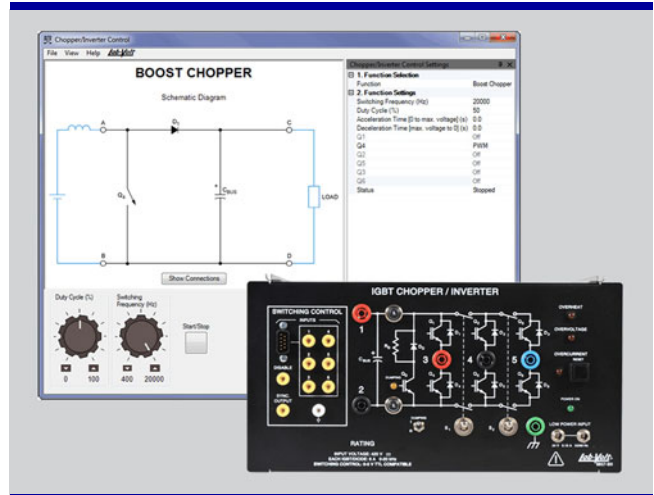
Topic Coverage (4 exercises)

- Voltage-Speed Characteristic of a Wind Turbine Generator
- Torque-Current Characteristic of a Wind Turbine Generator
- Power versus Wind Speed
- Storing Energy from a Wind Turbine into Batteries

Prerequisites

- DC Power Circuits

DC Power Electronics (86356)



The DC Power Electronics course introduces the student to power electronic components and circuits (choppers) required to manage DC power, such as the DC power stored in batteries or produced from wind power or solar power. The course first presents the diode and the switching transistor, the two main semiconductor components used in power electronics. Through the remainder of the course, the student becomes familiar with the main types of choppers, is introduced to high-speed power switching (voltage-type and current-type circuits, free-wheeling diodes, etc), learns how to control ripple in choppers, and discovers how to build a battery charger using a buck chopper.

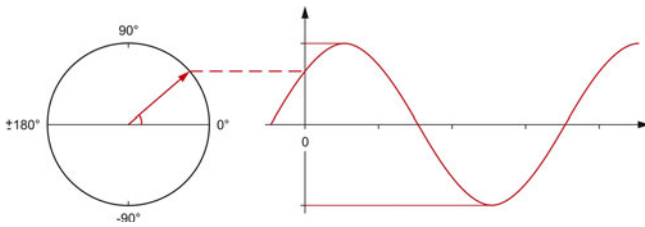
Topic Coverage (8 exercises)

- The Diode and the Switching Transistor
- The Buck Chopper
- Introduction to High-Speed Power Switching
- Ripple in Choppers
- The Lead-Acid Battery Charger
- The Boost Chopper
- The Buck/Boost Chopper
- The Four-Quadrant Chopper

Prerequisites

- DC Power Circuits

Single-Phase AC Power Circuits (86358)



The Single-Phase AC Power Circuits course first introduces the student to the fundamentals of alternating current (AC) such as the sine wave, period and frequency, phase angle and phase shift, instantaneous and average power, etc. The student then becomes familiar with the inductor and capacitor. The course continues with more advanced topics such as the impedance, active power, reactive power, apparent power, and power triangle. The course concludes by teaching the student how to solve AC power circuits using the impedance calculation method or the power triangle method.

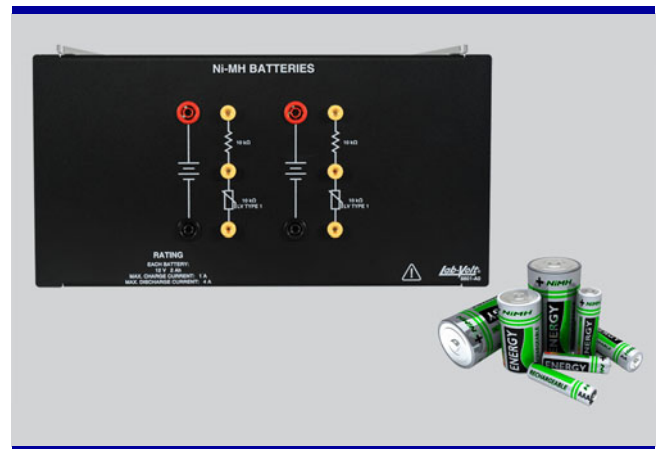
Topic Coverage (10 exercises)

- The Sine Wave
- Phase Angle and Phase Shift
- Instantaneous Power and Average Power
- Inductive Reactance
- Capacitive Reactance
- Impedance
- Active and Reactive Power
- Apparent Power and the Power Triangle
- Solving Simple AC Circuits using Circuit Impedance Calculation
- Solving AC Circuits Using the Power Triangle Method

Prerequisites

- DC Power Circuits

Ni-MH Batteries (86354)



The Ni-MH Batteries course explains how a nickel-metal hydride (Ni-MH) battery produces electricity from a chemical reaction. The course familiarizes the student with the charge and discharge characteristics of Ni-MH batteries. The student also learns the various methods of charging Ni-MH batteries, with emphasis on the various methods of terminating the charge (temperature cutoff, voltage drop, and rate of temperature increase).

Topic Coverage (4 exercises)

- Battery Fundamentals
- Battery Capacity Versus Discharge Rate
- Battery Charging Fundamentals
- Battery Charging Methods

Prerequisites

- DC Power Circuits

ELECTRICAL ENERGY TRAINING SYSTEMS SERIES 8010

Hydrogen Fuel Cell (86355)



The Hydrogen Fuel Cell course teaches foundational engineering principles of fuel cell systems. The course covers the structure and functioning principles, the thermodynamics theory, and the different characteristics of a real 50 W fuel cell system. Through numerous experiments, the students will also learn about the safety aspects of this type of technology.

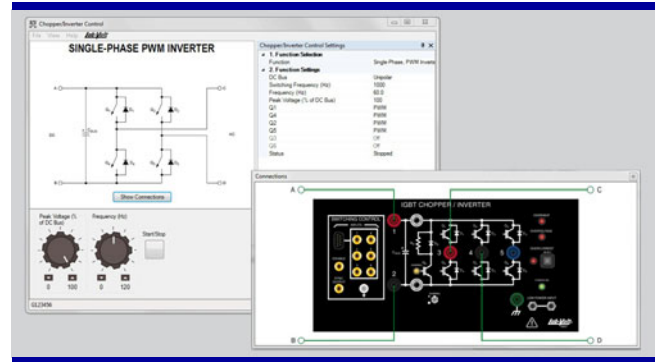
Topic Coverage (9 exercises)

- The Basic Functions of the Fuel Cell System
- The Characteristic Curve of a Fuel Cell
- Parameters Influencing the Characteristic Curve
- Determination of the Hydrogen Current Curve
- Efficiency of the Fuel Cell Stack
- Set-up of a Fuel Cell Power Supply
- Efficiency of a Fuel Cell Power Supply
- Fuel Cell Application I: Remote Traffic Light
- Fuel Cell Application II: Fuel Cell Car

Prerequisites

- DC Power Circuits

Single-Phase AC Power Electronics (86359)



The Single-Phase AC Power Electronics course introduces the student to power electronic circuits (rectifiers and inverters) used to perform AC/DC power conversion in single-phase circuits. The course begins with the study of single-phase diode rectifiers. The student then becomes familiar with the operation of the single-phase inverter and the single-phase PWM rectifier. The course concludes with the study of power flow in a single-phase PWM rectifier.

Topic Coverage (2 exercises)

- Power Diode Single-Phase Rectifiers
- The Single-Phase PWM Inverter

Prerequisites

- DC Power Circuits
- DC Power Electronics
- Single-Phase AC Power Circuits

Single-Phase Power Transformers (86377)



The Single-Phase Power Transformers course covers, through theory and demonstrations, the operating characteristics of single-phase power transformers. Through measurements, students will learn the important characteristics of a power transformer, such as the turns ratio, voltage and current ratios, winding polarity, voltage regulation, power losses, and transformer ratings.

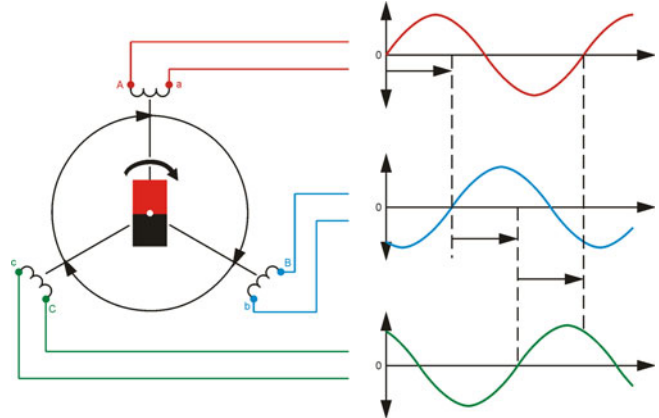
Topic Coverage (6 exercises)

- Voltage and Current Ratios
- Transformer Winding Polarity and Interconnection
- Transformer Losses, Efficiency, and Regulation
- Transformer Rating
- Effect of Frequency on Transformer Rating
- The Autotransformer

Prerequisites

- DC Power Circuits
- Single-Phase AC Power Circuits

Three-Phase AC Power Circuits (86360)



The Three-Phase AC Power Circuit course familiarizes the student with three-phase power systems. The course first introduces the student to the fundamentals of three-phase power systems such as the wye (star) and delta configurations, phase and line voltages, phase and line currents, phase balance, etc. The student then learns how to measure power in three-phase circuits using the two-wattmeter method as well as how to determine the power factor. Finally, the student learns what the phase sequence is and how to determine the phase sequence of a three-phase power system.

Topic Coverage (3 exercises)

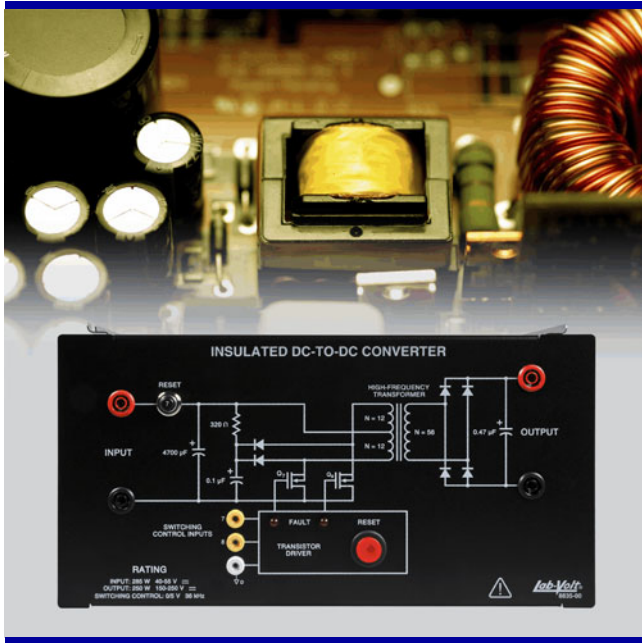
- Three-Phase Circuits
- Three-Phase Power Measurement
- Phase Sequence

Prerequisites

- DC Power Circuits
- Single-Phase AC Power Circuits

ELECTRICAL ENERGY TRAINING SYSTEMS SERIES 8010

High-Frequency Power Transformer (86378)



The High-Frequency Power Transformer course demonstrates how high-frequency switching can be used to increase the power handling capability of power transformers. This type of power transformer is commonly used to perform DC-to-DC conversion in grid-tied inverters used for home energy production.

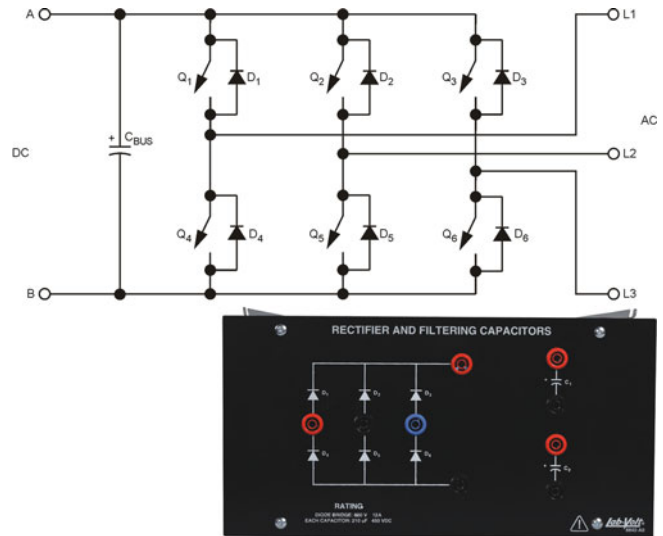
Topic Coverage (1 exercise)

- High-Frequency Power Transformer Operation

Prerequisites

- DC Power Circuits
- Single-Phase AC Power Circuits
- Single-Phase Power Transformer

Three-Phase Power Electronics (86362)



The Three-Phase Power Electronics course introduces the student to power electronic circuits (rectifiers and inverters) used to perform AC/DC power conversion in three-phase circuits. The course begins with the study of three-phase diode rectifiers. The student then becomes familiar with the operation of the single-phase inverter built with a dual-polarity DC bus. The course continues with the operation of the three-phase inverter built with a single-polarity or dual-polarity DC bus. The course concludes with the study of the three-phase PWM rectifier. The 180° modulation and pulse-width modulation (PWM) techniques are introduced during the study of the inverters and PWM rectifier.

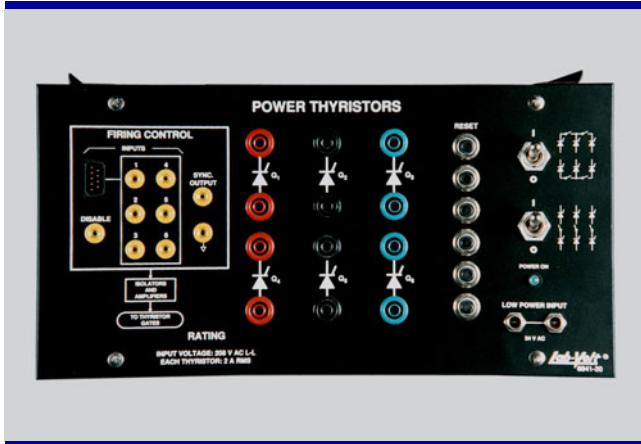
Topic Coverage (3 exercises)

- Power Diode Three-Phase Rectifiers
- The Single-Phase PWM Inverter with Dual-Polarity DC Bus
- The Three-Phase PWM Inverter

Prerequisites

- DC Power Circuits
- DC Power Electronics
- Single-Phase AC Power Circuits
- Single-Phase AC Power Electronics
- Three-Phase AC Power Circuits

Thyristor Power Electronics (86363)



The Thyristor Power Electronics course introduces the student to the power electronic component (thyristor) and circuits (rectifiers) used to control very large amounts of DC power, as in the excitation circuit of synchronous generators in a hydro-power electricity plant. The course first presents the thyristor, the main semiconductor component used to control large amounts of DC power. The student is then introduced to AC phase control. Through the remainder of the course, the student becomes familiar with the single-phase and three-phase thyristor bridges, in both the rectifier and inverter modes.

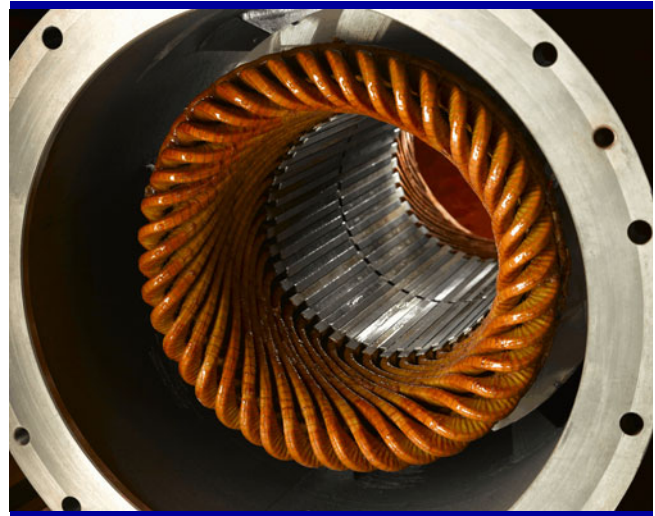
Topic Coverage (7 exercises)

- Power Diode Single-Phase Rectifiers
- Power Diode Three-Phase Rectifiers
- The Power Thyristors
- The Solid State Relay
- Single-Phase AC Power Control
- Three-Phase AC Power Control
- Thyristor Three-Phase Rectifier/Inverter

Prerequisites

- DC Power Circuits
- Single-Phase AC Power Circuits
- Three-Phase AC Power Circuits

Three-Phase Rotating Machines (86364)



The Three-Phase Rotating Machines course familiarizes the student with the various three-phase machines used for large-scale production of electricity from wind power and hydro power. The course begins with fundamentals of rotating machines such as the torque, rotation speed, direction of rotation, motor power, power losses in motor, motor efficiency, etc. The student then studies the operation of the following three-phase machines: squirrel-cage induction machine, and synchronous machine.

Topic Coverage (8 exercises)

- Prime Mover and Brake Operation
- The Three-Phase Squirrel Cage Induction Motor
- Eddy-Current Brake and Asynchronous Generator
- The Three-Phase Synchronous Motor
- Synchronous Motor Pull-Out Torque
- The Three-Phase Synchronous Generator No-Load Operation
- The Three-Phase Synchronous Generator Voltage-Regulation Characteristics
- Manual Generator Synchronization

Prerequisites

- DC Power Circuits
- Single-Phase AC Power Circuits
- Three-Phase AC Power Circuits

ELECTRICAL ENERGY TRAINING SYSTEMS SERIES 8010

Three-Phase Transformer Banks (86379)



The Three-Phase Transformer Banks course covers the operating characteristics of three-phase transformer banks. The course covers the winding connection (wye and delta configurations) and shows how to ensure proper phase relationships between the phase windings.

Topic Coverage (1 exercise)

- Three-Phase Transformer Configurations

Prerequisites

- DC Power Circuits
- Single-Phase AC Power Circuits
- Single-Phase Power Transformer
- Three-Phase AC Power Circuits

Home Energy Production* (86361)



The Home Energy Production course explains how to produce AC power from DC power produced using renewable natural resources (e.g., wind, sunlight, etc) and stored in batteries. The course first shows how to produce AC power for local use (typically at remote sites) from DC power stored in batteries. Then, the student learns how to produce AC power from renewable resources and feed to the local AC power network.

Topic Coverage (5 exercises)

- Home Energy Production using a Stand-Alone Inverter
- The Single-Phase Grid-Tied Inverter (Single-Phase PWM Rectifier/Inverter)
- Home Energy Production using a Grid-Tied Inverter
- Home Energy Production with a Grid-Tied Inverter and an LF Power Transformer
- Home Energy Production with a Grid-Tied Inverter and an Insulated DC-to-DC Converter

Prerequisites

- DC Power Circuits
- Lead-Acid Batteries
- Solar Power (photovoltaic)
- Introduction to Wind Power
- DC Power Electronics
- Single-Phase AC Power Circuits
- Single-Phase AC Power Electronics
- Single-Phase Power Transformer
- High-Frequency Power Transformer

* **Note:** Course may still be under development (topic coverage subject to change). Contact your Lab-Volt sales representative for more information.

Hydro-Power Electricity Generation* (86369)



The Hydro-Power Electricity Generation course examines the large-scale production of electricity from hydro power using a synchronous generator, a proven technology long used worldwide by power utilities. The course first introduces the student to the configuration of a typical hydro-power plant. The student then learns how to adjust the voltage and frequency of the synchronous generator in a hydro-power plant. The course concludes with a study of the automatic voltage and frequency regulation systems used in a hydro-power plant.

Topic Coverage (5 exercises)

- Generator Frequency and Voltage Control Principles
- Generator Synchronization
- Generator Operation with Speed and Voltage Regulation
- Generator Speed and Voltage Regulation with Droop
- Generator Parallel Operation and Load Sharing (Optional)

Prerequisites

- DC Power Circuits
- Single-Phase AC Power Circuits
- Three-Phase AC Power Circuits
- Thyristor Power Electronics
- Three-Phase Rotating Machines

DC Motor Drive* (88553)

The DC Motor Drive course familiarizes the student with the use of DC variable speed drive. Through the curriculum, students will learn the basic power electronics components and concepts used in DC motor drive. They will be able to demonstrate their utilization to control the speed of a DC motor.

Topic Coverage (4 exercises)

- The Buck Chopper Drive
- The Buck-Boost Chopper Drive
- The Four-Quadrant Chopper Drive
- DC Motor Control using Speed and Current Feedback

Prerequisites

- DC Power Circuits
- Permanent Magnet DC Motor

Three-Phase PWM Rectifier/Inverter* (86366)

The Three-Phase PWM Rectifier/Inverter course teaches the operation and characteristics of a Three-Phase Pulse Width Modulation (PWM) system with a rectifier section and an inverter section. Using Three-Phase Power Electronics knowledge previously learned, students will go further in using power electronics devices to transfer power back and forth at different voltage levels (AC or DC).

Topic Coverage (1 exercise)

- Operation of a Three-Phase PWM Rectifier/Inverter

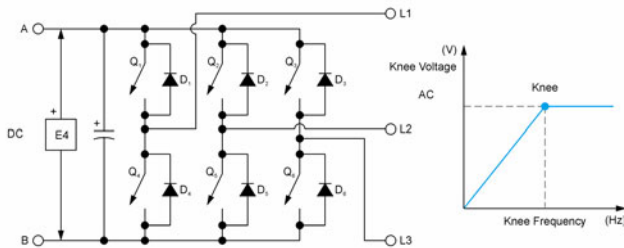
Prerequisites

- DC Power Circuits
- Lead-Acid Batteries
- Solar Power (photovoltaic)
- Introduction to Wind Power
- DC Power Electronics
- Single-Phase AC Power Circuits
- Single-Phase AC Power Electronics
- Single-Phase Power Transformer
- Three-Phase AC Power Circuits
- High-Frequency Power Transformer
- Three-Phase AC Power Electronics
- Home Energy Production*

* **Note:** Course may still be under development (topic coverage subject to change). Contact your Lab-Volt sales representative for more information.

ELECTRICAL ENERGY TRAINING SYSTEMS SERIES 8010

Three-Phase Motor Drives (86368)



The Three-Phase Motor Drives course teaches the fundamentals principles and operating characteristics of three-phase motor drives. The induction motor is a rugged, low maintenance and low cost type of motor, making it attractive for industrial applications. To control the rotational speed of an induction motor, a motor drive using variable frequency and voltage is necessary.

Topic Coverage (2 exercises)

- Three-Phase, Variable-Frequency Induction-Motor Drive
- Three-Phase, Variable-Frequency Induction-Motor Drive with Constant V/f ratio

Prerequisites

- DC Power Circuits
- DC Power Electronics
- Single-Phase AC Power Circuits
- Single-Phase AC Power Electronics
- Three-Phase AC Power Circuits
- Three-Phase AC Power Electronics
- Three-Phase Rotating Machines

Three-Phase Motor Starters* (88197)

The Three-Phase Motor Starters course demonstrates how using a three-phase motor starter to help start a motor allows the motor to start smoothly by avoiding inrush currents and is a better option than connecting a motor directly to a three-phase power source.

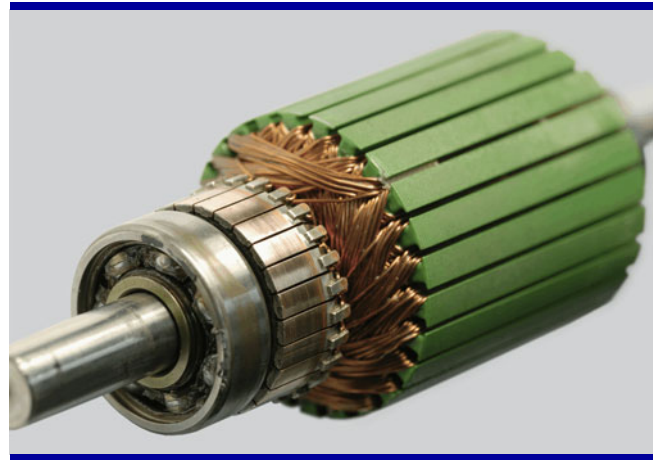
Topic Coverage (2 exercises)

- Direct On-Line Starters
- Soft Starters

Prerequisites

- DC Power Circuits
- Single-Phase AC Power Circuits
- Three-Phase AC Power Circuits
- Thyristor Power Electronics
- Three-Phase Rotating Machines

Three-Phase Wound-Rotor Induction Machine (86367)



The Three-Phase Wound-Rotor Induction Machine course describes the operation of three-phase wound-rotor induction machines. The students will learn the effects of varying the rotor resistor to reduce starting current and increase the machine starting torque. They will also learn how to vary the operating speed of this type of motor.

Topic Coverage (2 exercises)

- Wound-Rotor Induction Motor with Short-Circuited Rotor
- Wound-Rotor Induction Motor with Variable Rotor Resistors

Prerequisites

- DC Power Circuits
- Single-Phase AC Power Circuits
- Three-Phase AC Power Circuits
- Three-Phase Rotating Machines

* **Note:** Course may still be under development (topic coverage subject to change). Contact your Lab-Volt sales representative for more information.

AC Transmission Line (86365)



The AC Transmission Line course familiarizes students with the fundamental principles of three-phase ac power transmission lines. Students will learn about the power handling capability and voltage regulation of three-phase ac power transmission lines. They will also learn, through experiments, which parameters can affect the active and reactive power that goes through the line and corrections that can be made to the system to increase its efficiency.

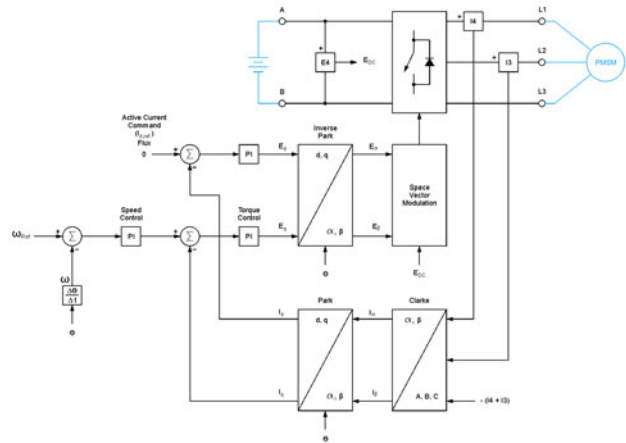
Topic Coverage (6 exercises)

- Voltage Regulation Characteristics
- Voltage Compensation
- Power Transmission Capacity
- Voltage Compensation in Long AC Transmission Lines
- Control of Active and Reactive Power Flow

Prerequisites

- DC Power Circuits
- Single-Phase AC Power Circuits
- Single-Phase Power Transformer
- Three-Phase AC Power Circuits
- Three-Phase Transformer Banks

Permanent Magnet Synchronous Motor (86373)



The Permanent Magnet Synchronous Motor course covers the conception and operation of that type of motor. Through lab exercises, students will experiment with the three most used types of controller: 120° Modulation Six Steps, PWM Six Steps and Field-Oriented Control (FOC).

Topic Coverage (to be determined)

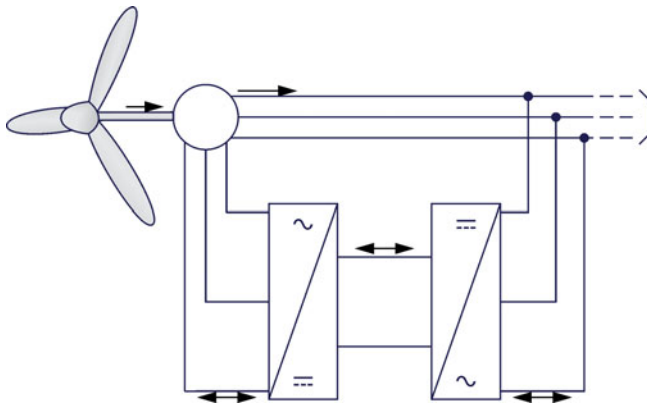
Prerequisites

- DC Power Circuits
- Lead-Acid Batteries
- Solar Power (photovoltaic)
- Introduction to Wind Power
- DC Power Electronics
- Single-Phase AC Power Circuits
- Single-Phase AC Power Electronics
- Single-Phase Power Transformer
- Three-Phase AC Power Circuits
- High-Frequency Power Transformer
- Three-Phase AC Power Electronics
- Three-Phase Rotating Machines
- Home Energy Production*
- Three-Phase PWM Rectifier/Inverter*
- Three-Phase Motor Drives

* **Note:** Course may still be under development (topic coverage subject to change). Contact your Lab-Volt sales representative for more information.

ELECTRICAL ENERGY TRAINING SYSTEMS SERIES 8010

Principles of DFIG (86376)



The Principles of DFIG course deals with the large-scale production of electricity from wind power using a doubly-fed induction generator (DFIG). This technology allows the generator to operate at different rotation speeds while keeping the frequency of the generated voltage and current fixed; a very useful feature when the generator is used in a wind turbine.

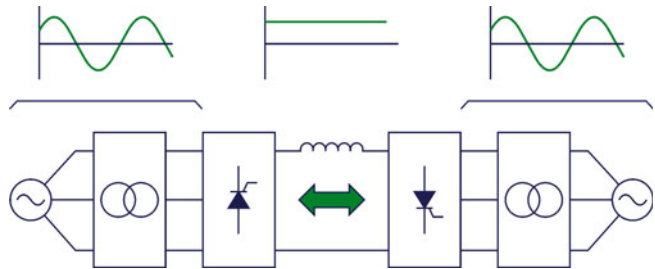
Topic Coverage (3 exercises)

- Three-Phase Wound-Rotor Induction Machine used as a Synchronous Machine
- Doubly-Fed Induction Motor
- Doubly-Fed Induction Generator

Prerequisites

- DC Power Circuits
- DC Power Electronics
- Single-Phase AC Power Circuits
- Single-Phase AC Power Electronics
- Three-Phase AC Power Circuits
- Three-Phase AC Power Electronics
- Three-Phase Rotating Machines
- Three-Phase Motor Drives
- Three-Phase Wound-Rotor Induction Machine

High-Voltage DC Transmission Systems* (86380)



The High-Voltage Direct-Current (HVDC) Transmission Systems course describes the operating characteristics of this type of power transmission systems and the technology involved. HVDC transmission systems are used at several points in a power network for several reasons like: long-distance power transmission, submarine link, back-to-back link for easy interconnection with another network.

Topic Coverage (5 exercises)

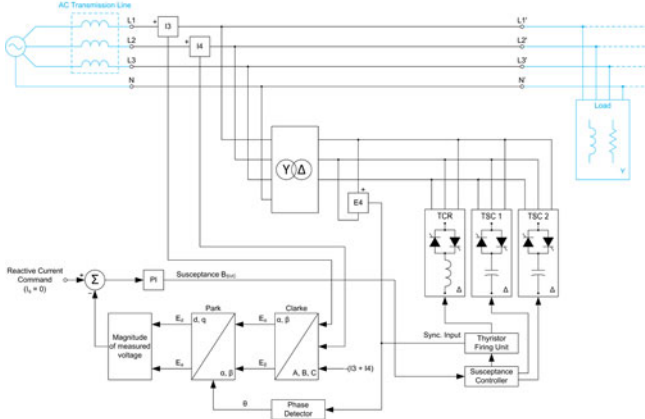
- Voltage Regulation and Power Factor in Thyristor Three-Phase Bridges
- Basic Operation of HVDC Transmission Systems
- Automatic Power flow Control in HVDC Transmission Systems
- Commutation Failure at the Inverter End
- Harmonic Reduction using Thyristor 12-Pulse Converter

Prerequisites

- DC Power Circuits
- Single-Phase AC Power Circuits
- Single-Phase Power Transformer
- Three-Phase AC Power Circuits
- Thyristor Power Electronics
- Three-Phase Transformer Banks
- AC Transmission Line

* **Note:** Course may still be under development (topic coverage subject to change). Contact your Lab-Volt sales representative for more information.

Static VAR Compensators (86370)



The Static Var Compensators (SVC) course deals with the automatic control of the voltage or the power factor in three-phase power networks. As part of the FACTS (Flexible AC Transmission Systems), this technology is used by power utilities to maintain voltage quality for the distribution system as well as by industrial plants for power factor regulation at the plant electric power entrance.

Topic Coverage (3 exercises)

- Main Components of a Static VAR Compensator
- Voltage Compensation of AC Transmission Lines using SVCs
- Power Factor Correction using SVCs (Arc Furnaces)

Prerequisites

- DC Power Circuits
- Single-Phase AC Power Circuits
- Single-Phase Power Transformer
- Three-Phase AC Power Circuits
- Thyristor Power Electronics
- Three-Phase Transformer Banks
- AC Transmission Line

Wind Power Electricity Generation (PMSG with FOC)* (86372)

The Wind Power Electricity Generation (PMSG with FOC) course deals with the large-scale production of electricity from wind power using permanent magnet synchronous generator using field-oriented control. This technology simplifies the mechanical design of a wind turbine, thereby reducing mechanical maintenance, but requires additional power electronics.

Topic Coverage (to be determined)

Prerequisites

- DC Power Circuits
- Lead-Acid Batteries
- Solar Power (photovoltaic)
- Introduction to Wind Power
- DC Power Electronics
- Single-Phase AC Power Circuits
- Single-Phase AC Power Electronics
- Single-Phase Power Transformer
- Three-Phase AC Power Circuits
- High-Frequency Power Transformer
- Three-Phase AC Power Electronics
- Three-Phase Rotating Machines
- Three-Phase PWM Rectifier/Inverter*
- Three-Phase Motor Drives
- Permanent Magnet Synchronous Motor*

* **Note:** Course may still be under development (topic coverage subject to change). Contact your Lab-Volt sales representative for more information.

ELECTRICAL ENERGY TRAINING SYSTEMS SERIES 8010

Electric Vehicles* (86375)



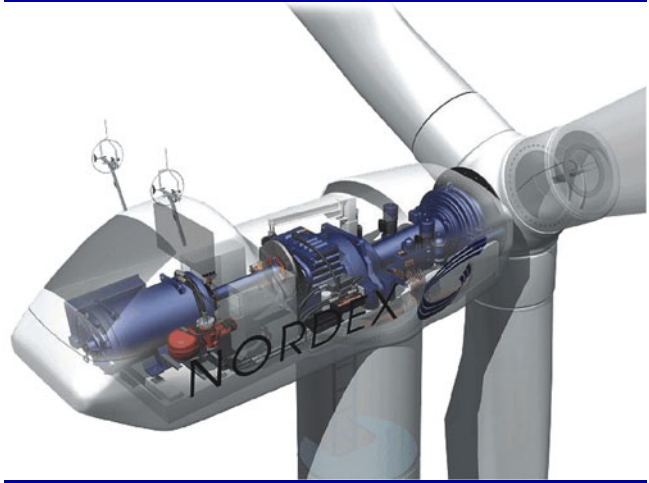
The Electric Vehicles course introduces the student to the operation of the drive system in modern electric vehicles (cars, light truck, etc.), which are considered an essential step toward a larger use of renewable energy. The course then deals with the control of the permanent magnet DC motor and permanent synchronous motor when used in an electric vehicle application.

Topic Coverage (to be determined)

Prerequisites

- DC Power Circuits
- Permanent Magnet DC Motor
- DC Power Electronics
- Single-Phase AC Power Circuits
- Single-Phase AC Power Electronics
- Three-Phase AC Power Circuits
- Three-Phase AC Power Electronics
- Three-Phase Rotating Machines
- Three-Phase Motor Drives
- DC Motor Drive*

Wind Power Electricity Generation (Async. Gen.)* (86374)



The Wind Power Electricity Generation (Async. Gen.) course deals with the large-scale production of electricity from wind power using asynchronous generators. This technology is used widely as it is relatively easy to implement. The course begins with the study of the asynchronous generator operation, then focuses on the control of an asynchronous generator used in a wind turbine.

Topic Coverage (to be determined)

Prerequisites

- DC Power Circuits
- DC Power Electronics
- Single-Phase AC Power Circuits
- Three-Phase AC Power Circuits
- Thyristor Power Electronics
- Three-Phase Rotating Machines
- Three-Phase Motor Starters*

* **Note:** Course may still be under development (topic coverage subject to change). Contact your Lab-Volt sales representative for more information.

**Wind Power Electricity Generation (DFIG with FOC)
(88809)**



The Wind Power Electricity Generation (DFIG with FOC) course demonstrate the different types of control of a doubly-fed induction generators, the most used type of generators in large-scale wind turbines. This generator principles have been reviewed in the Principles of DFIG course (prerequisite). This course brings the student a step further and helps him demonstrate the Field-Oriented Control (FOC) method to generate power in this type of wind turbines.

Topic Coverage (to be determined)

Prerequisites

- DC Power Circuits
- DC Power Electronics
- Single-Phase AC Power Circuits
- Single-Phase AC Power Electronics
- Three-Phase AC Power Circuits
- Three-Phase AC Power Electronics
- Three-Phase Rotating Machines
- Three-Phase Motor Drives
- Three-Phase Wound-Rotor Induction Machine

**Static Synchronous Compensators (STATCOM)*
(86371)**

This course deals with static synchronous compensators (STATCOM). This type of compensator, which is part of the FACTS (Flexible AC Transmission Systems), provides fast and accurate reactive power compensation in a power transmission system. A STATCOM is a power electronics based device that is basically a voltage-source converter that can transfer reactive power, and even active power, to and from the network.

Topic Coverage (2 exercises)

- Voltage compensation of AC transmission line using STATCOM
- Power Factor Correction using STATCOM (Arc Furnaces)

Prerequisites

- DC Power Circuits
- Lead-Acid Batteries
- Solar Power (photovoltaic)
- Introduction to Wind Power
- DC Power Electronics
- Single-Phase AC Power Circuits
- Single-Phase AC Power Electronics
- Single-Phase Power Transformer
- Three-Phase AC Power Circuits
- High-Frequency Power Transformer
- Three-Phase Transformer Banks
- Home Energy Production*
- Three-Phase PWM Rectifier/Inverter*
- AC Transmission Line

* **Note:** Course may still be under development (topic coverage subject to change). Contact your Lab-Volt sales representative for more information.

ELECTRICAL ENERGY TRAINING SYSTEMS SERIES 8010

POWER REQUIREMENT

For systems 8010-1 to 8010-8 (inclusively), a standard single phase AC outlet is required.

For other courses, a three-phase installation that meets the requirements below is necessary.

Service Installation: 20 A, 3 phases, 5 wires, star (wye) configuration, including neutral and ground wires

Nominal Power: 500 VA (each system)

PERSONAL COMPUTER REQUIREMENTS

A currently available personal computer with a USB 2.0 port, running under one of the following operating systems: Windows® XP, Windows® Vista (32-bit version only), or Windows® 7.

ORDERING NUMBERS

| 120 V – 60 Hz | | | 220 V – 50 Hz | | | 240 V – 50 Hz |
|-------------------|---------|---------|---------------|---------|---------|---------------|
| ENGLISH | FRENCH | SPANISH | ENGLISH | FRENCH | SPANISH | ENGLISH |
| 8010-10 | 8010-11 | 8010-12 | 8010-15 | 8010-16 | 8010-17 | 8010-1A |
| 8010-20 | 8010-21 | 8010-22 | 8010-25 | 8010-26 | 8010-27 | 8010-2A |
| 8010-30 | 8010-31 | 8010-32 | 8010-35 | 8010-36 | 8010-37 | 8010-3A |
| 8010-40 | 8010-41 | 8010-42 | 8010-45 | 8010-46 | 8010-47 | 8010-4A |
| 8010-50 | 8010-51 | 8010-52 | 8010-55 | 8010-56 | 8010-57 | 8010-5A |
| 8010-60 | 8010-61 | 8010-62 | 8010-65 | 8010-66 | 8010-67 | 8010-6A |
| 8010-70 | 8010-71 | 8010-72 | 8010-75 | 8010-76 | 8010-77 | 8010-7A |
| 8010-80 | 8010-80 | 8010-80 | 8010-80 | 8010-80 | 8010-80 | 8010-80 |
| 8010-90 | 8010-91 | 8010-92 | 8010-95 | 8010-96 | 8010-97 | 8010-9A |
| 8010-A0 | 8010-A1 | 8010-A2 | 8010-A5 | 8010-A6 | 8010-A7 | 8010-AA |
| 8110-20 | 8110-20 | 8110-20 | 8110-20 | 8110-20 | 8110-20 | 8110-20 |
| 8131-00 | 8131-00 | 8131-00 | 8131-00 | 8131-00 | 8131-00 | 8131-00 |
| 8134-20 | 8134-20 | 8134-20 | 8134-20 | 8134-20 | 8134-20 | 8134-20 |
| 8213-00 | 8213-01 | 8213-02 | 8213-00 | 8213-01 | 8213-02 | 8213-00 |
| 8216-00 | 8216-01 | 8216-02 | 8216-00 | 8216-01 | 8216-02 | 8216-0A |
| 8216-D0 | 8216-D0 | 8216-D0 | 8216-D0 | 8216-D0 | 8216-D0 | 8216-D0 |
| 8221-B0 | 8221-B1 | 8221-B2 | 8221-B5 | 8221-B6 | 8221-B7 | 8221-BA |
| 8231-B0 | 8231-B1 | 8231-B2 | 8231-B5 | 8231-B6 | 8231-B7 | 8231-BA |
| 8241-00 | 8241-01 | 8241-02 | 8241-05 | 8241-06 | 8241-07 | 8241-0A |
| 8311-00 | 8311-01 | 8311-02 | 8311-00 | 8311-01 | 8311-02 | 8311-A0 |
| 8311-00 | 8311-01 | 8311-02 | 8311-05 | 8311-06 | 8311-07 | 8311-0A |
| 8321-00 | 8321-01 | 8321-02 | 8321-05 | 8321-06 | 8321-07 | 8321-0A |
| 8325-A0 | 8325-A1 | 8325-A2 | 8325-A5 | 8325-A6 | 8325-A7 | 8325-A5 |
| 8326-00 | 8326-01 | 8326-02 | 8326-05 | 8326-06 | 8326-07 | 8326-0A |
| 8326-A0 | 8326-A1 | 8326-A2 | 8326-A0 | 8326-A1 | 8326-A2 | 8326-AA |
| 8329-00 | 8329-01 | 8329-02 | 8329-05 | 8329-06 | 8329-07 | 8329-0A |
| 8331-00 | 8331-01 | 8331-02 | 8331-05 | 8331-06 | 8331-07 | 8331-0A |
| N/A ¹⁰ | N/A | N/A | 8333-05 | 8333-06 | 8333-07 | 8333-0A |
| 8334-00 | 8334-01 | 8334-02 | 8334-05 | 8334-06 | 8334-07 | 8334-0A |
| 8348-40 | 8348-41 | 8348-42 | 8348-45 | 8348-46 | 8348-47 | 8348-4A |
| 8349-00 | 8349-01 | 8349-02 | 8349-05 | 8349-06 | 8349-07 | 8349-0A |
| 8353-00 | 8353-01 | 8353-02 | 8353-00 | 8353-01 | 8353-02 | 8353-00 |
| 8354-00 | 8354-01 | 8354-02 | 8354-05 | 8354-06 | 8354-07 | 8354-0A |
| 8380-00 | 8380-00 | 8380-00 | 8380-00 | 8380-00 | 8380-00 | 8380-00 |
| 8381-00 | 8381-00 | 8381-00 | 8381-00 | 8381-00 | 8381-00 | 8381-00 |
| 8622-00 | 8622-01 | 8622-02 | 8622-05 | 8622-06 | 8622-07 | 8622-0A |

Table 1. Equipment Ordering Numbers

¹⁰ N/A = Not available

| 120 V – 60 Hz | | | 220 V – 50 Hz | | | 240 V – 50 Hz |
|---------------|-------------------|----------|---------------|----------|----------|---------------|
| ENGLISH | FRENCH | SPANISH | ENGLISH | FRENCH | SPANISH | ENGLISH |
| 8801-00 | 8801-01 | 8801-02 | 8801-00 | 8801-01 | 8801-02 | 8801-00 |
| 8801-A0 | 8801-A1 | 8801-A2 | 8801-A0 | 8801-A1 | 8801-A2 | 8801-A0 |
| 8802-10 | 8802-11 | 8802-12 | 8802-10 | 8802-11 | 8802-12 | 8802-10 |
| 8803-00 | 8803-00 | 8803-00 | 8803-00 | 8803-00 | 8803-00 | 8803-00 |
| 8805-00 | 8805-01 | 8805-02 | 8805-05 | 8805-06 | 8805-07 | 8805-0A |
| 8806-00 | 8806-01 | 8806-02 | 8806-00 | 8806-01 | 8806-02 | 8806-00 |
| 8821-20 | 8821-21 | 8821-22 | 8821-25 | 8821-26 | 8821-27 | 8821-2A |
| 8823-00 | 8823-01 | 8823-02 | 8823-05 | 8823-06 | 8823-07 | 8823-0A |
| 8835-00 | 8835-01 | 8835-02 | 8835-05 | 8835-06 | 8835-07 | 8835-05 |
| 8837-B0 | 8837-B1 | 8837-B2 | 8837-B5 | 8837-B6 | 8837-B7 | 8837-BA |
| 8841-20 | 8841-21 | 8841-22 | 8841-25 | 8841-26 | 8841-27 | 8841-2A |
| 8842-A0 | 8842-A1 | 8842-A2 | 8842-A5 | 8842-A6 | 8842-A7 | 8842-AA |
| 8894-00 | 8894-00 | 8894-00 | 8894-00 | 8894-00 | 8894-00 | 8894-00 |
| 8942-00 | 8942-00 | 8942-00 | 8942-00 | 8942-00 | 8942-00 | 8942-00 |
| 8946-20 | 8946-20 | 8946-20 | 8946-20 | 8946-20 | 8946-20 | 8946-20 |
| 8951-L0 | 8951-L0 | 8951-L0 | 8951-L0 | 8951-L0 | 8951-L0 | 8951-L0 |
| 8951-N0 | 8951-N0 | 8951-N0 | 8951-N0 | 8951-N0 | 8951-N0 | 8951-N0 |
| 8951-P0 | 8951-P0 | 8951-P0 | 8951-P0 | 8951-P0 | 8951-P0 | 8951-P0 |
| 8960-C0 | 8960-C1 | 8960-C2 | 8960-C5 | 8960-C6 | 8960-C7 | 8960-CA |
| 8960-D0 | 8960-D1 | 8960-D2 | 8960-D5 | 8960-D6 | 8960-D7 | 8960-DA |
| 8960-E0 | 8960-E1 | 8960-E2 | 8960-E5 | 8960-E6 | 8960-E7 | 8960-EA |
| 8960-F0 | 8960-F1 | 8960-F2 | 8960-F5 | 8960-F6 | 8960-F7 | 8960-FA |
| 8968-10 | 8968-10 | 8968-10 | 8968-10 | 8968-10 | 8968-10 | 8968-10 |
| 8968-20 | 8968-20 | 8968-20 | 8968-20 | 8968-20 | 8968-20 | 8968-20 |
| 8968-30 | 8968-30 | 8968-30 | 8968-30 | 8968-30 | 8968-30 | 8968-30 |
| 8968-40 | 8968-40 | 8968-40 | 8968-40 | 8968-40 | 8968-40 | 8968-40 |
| 8968-50 | 8968-50 | 8968-50 | 8968-50 | 8968-50 | 8968-50 | 8968-50 |
| 8968-60 | 8968-60 | 8968-60 | 8968-60 | 8968-60 | 8968-60 | 8968-60 |
| 8989-00 | 8989-01 | 8989-02 | 8989-00 | 8989-01 | 8989-02 | 8989-00 |
| 8990-00 | 8990-01 | 8990-02 | 8990-05 | 8990-06 | 8990-07 | 8990-0A |
| 9063-00 | 9063-01 | 9063-02 | 9063-00 | 9063-01 | 9063-02 | 9063-00 |
| 9063-B0 | 9063-B1 | 9063-B2 | 9063-B0 | 9063-B1 | 9063-B2 | 9063-B0 |
| 9063-C0 | 9063-C1 | 9063-C2 | 9063-C0 | 9063-C1 | 9063-C2 | 9063-C0 |
| 9063-D0 | 9063-D1 | 9063-D2 | 9063-D0 | 9063-D1 | 9063-D2 | 9063-D0 |
| 9063-E0 | 9063-E1 | 9063-E2 | 9063-E0 | 9063-E1 | 9063-E2 | 9063-E0 |
| 9063-F0 | 9063-F1 | 9063-F2 | 9063-F0 | 9063-F1 | 9063-F2 | 9063-F0 |
| 9069-10 | 9069-10 | 9069-10 | 9069-10 | 9069-10 | 9069-10 | 9069-10 |
| 9069-20 | 9069-20 | 9069-20 | 9069-20 | 9069-20 | 9069-20 | 9069-20 |
| 9069-30 | 9069-30 | 9069-30 | 9069-30 | 9069-30 | 9069-30 | 9069-30 |
| 9069-40 | 9069-40 | 9069-40 | 9069-40 | 9069-40 | 9069-40 | 9069-40 |
| 9069-50 | 9069-50 | 9069-50 | 9069-50 | 9069-50 | 9069-50 | 9069-50 |
| 9069-60 | 9069-60 | 9069-60 | 9069-60 | 9069-60 | 9069-60 | 9069-60 |
| 9069-70 | 9069-70 | 9069-70 | 9069-70 | 9069-70 | 9069-70 | 9069-70 |
| 9069-80 | 9069-80 | 9069-80 | 9069-80 | 9069-80 | 9069-80 | 9069-80 |
| 30004-20 | 30004-20 | 30004-20 | 30004-25 | 30004-25 | 30004-25 | 30004-2A |
| 30011-04 | 30011-04 | 30011-04 | 30011-04 | 30011-04 | 30011-04 | 30011-04 |
| 40208-10 | 40208-10 | 40208-10 | 40208-10 | 40208-10 | 40208-10 | 40208-10 |
| 86350-00 | TBE ¹¹ | 86350-02 | 86350-00 | TBE | 86350-02 | 86350-00 |
| 86350-10 | TBE | 86350-12 | 86350-10 | TBE | 86350-12 | 86350-10 |
| 86351-00 | TBE | 86351-02 | 86351-00 | TBE | 86351-02 | 86351-00 |
| 86351-10 | TBE | 86351-12 | 86351-10 | TBE | 86351-12 | 86351-10 |
| 86352-00 | TBE | 86352-02 | 86352-00 | TBE | 86352-02 | 86352-00 |
| 86352-10 | TBE | 86352-12 | 86352-10 | TBE | 86352-12 | 86352-10 |
| 86353-00 | TBE | TBE | 86353-00 | TBE | TBE | 86353-00 |
| 86353-10 | TBE | TBE | 86353-10 | TBE | TBE | 86353-10 |

Table 1. Equipment Ordering Numbers (cont'd)

¹¹ TBE = To be established (Contact your Lab-Volt representative for additional information).

**ELECTRICAL ENERGY TRAINING SYSTEMS
SERIES 8010**

| 120 V – 60 Hz | | | 220 V – 50 Hz | | | 240 V – 50 Hz |
|---------------|----------|----------|---------------|----------|----------|---------------|
| ENGLISH | FRENCH | SPANISH | ENGLISH | FRENCH | SPANISH | ENGLISH |
| 86354-00 | TBE | TBE | 86354-00 | TBE | TBE | 86354-00 |
| 86354-10 | TBE | TBE | 86354-00 | TBE | TBE | 86354-00 |
| 86355-00 | TBE | TBE | 86355-00 | TBE | TBE | 86355-00 |
| 86355-10 | TBE | TBE | 86355-00 | TBE | TBE | 86355-00 |
| 86356-00 | TBE | TBE | 86356-00 | TBE | TBE | 86356-00 |
| 86356-10 | TBE | TBE | 86356-10 | TBE | TBE | 86356-10 |
| 86357-00 | TBE | TBE | 86357-00 | TBE | TBE | 86357-00 |
| 86357-10 | TBE | TBE | 86357-10 | TBE | TBE | 86357-10 |
| 86358-00 | TBE | TBE | 86358-00 | TBE | TBE | 86358-00 |
| 86358-10 | TBE | TBE | 86358-10 | TBE | TBE | 86358-10 |
| 86359-00 | TBE | TBE | 86359-00 | TBE | TBE | 86359-00 |
| 86359-10 | TBE | TBE | 86359-10 | TBE | TBE | 86359-10 |
| 86360-00 | TBE | TBE | 86360-00 | TBE | TBE | 86360-00 |
| 86360-10 | TBE | TBE | TBE | TBE | TBE | TBE |
| 86361-00 | TBE | TBE | 86361-00 | TBE | TBE | 86361-00 |
| 86361-10 | TBE | TBE | TBE | TBE | TBE | TBE |
| 86362-00 | TBE | TBE | 86362-00 | TBE | TBE | 86362-00 |
| 86362-10 | TBE | TBE | TBE | TBE | TBE | TBE |
| 86363-00 | TBE | TBE | 86363-00 | TBE | TBE | 86363-00 |
| 86363-10 | TBE | TBE | TBE | TBE | TBE | TBE |
| 86364-00 | TBE | TBE | 86364-00 | TBE | TBE | 86364-00 |
| 86364-10 | TBE | TBE | TBE | TBE | TBE | TBE |
| 86365-00 | TBE | TBE | 86365-00 | TBE | TBE | 86365-00 |
| 86365-10 | TBE | TBE | TBE | TBE | TBE | TBE |
| 86366-00 | TBE | TBE | 86366-00 | TBE | TBE | 86366-00 |
| 86366-10 | TBE | TBE | TBE | TBE | TBE | TBE |
| 86367-00 | TBE | TBE | 86367-00 | TBE | TBE | 86367-00 |
| 86367-10 | TBE | TBE | TBE | TBE | TBE | TBE |
| 86368-00 | TBE | TBE | 86368-00 | TBE | TBE | 86368-00 |
| 86368-10 | TBE | TBE | TBE | TBE | TBE | TBE |
| 86370-00 | TBE | TBE | 86370-00 | TBE | TBE | 86370-00 |
| 86370-10 | TBE | TBE | TBE | TBE | TBE | TBE |
| 86373-00 | TBE | TBE | 86373-00 | TBE | TBE | 86373-00 |
| 86373-10 | TBE | TBE | TBE | TBE | TBE | TBE |
| 86376-00 | TBE | TBE | 86376-00 | TBE | TBE | 86376-00 |
| 86376-10 | TBE | TBE | TBE | TBE | TBE | TBE |
| 86377-00 | TBE | TBE | 86377-00 | TBE | TBE | 86377-00 |
| 86377-10 | TBE | TBE | 86377-10 | TBE | TBE | 86377-10 |
| 86378-00 | TBE | TBE | 86378-00 | TBE | TBE | 86378-00 |
| 86378-10 | TBE | TBE | TBE | TBE | TBE | TBE |
| 86379-00 | TBE | TBE | 86379-00 | TBE | TBE | 86379-00 |
| 86379-10 | TBE | TBE | TBE | TBE | TBE | TBE |
| 86380-00 | TBE | TBE | 86380-00 | TBE | TBE | 86380-00 |
| 86380-10 | TBE | TBE | TBE | TBE | TBE | TBE |
| 86618-00 | 86618-00 | 86618-00 | 86618-00 | 86618-00 | 86618-00 | 86618-00 |
| 86630-00 | 86630-00 | 86630-00 | 86630-00 | 86630-00 | 86630-00 | 86630-00 |
| 87948-00 | 87948-00 | 87948-00 | 87948-00 | 87948-00 | 87948-00 | 87948-00 |
| 88197-00 | TBE | TBE | 88197-00 | TBE | TBE | 88197-00 |
| 88197-10 | TBE | TBE | TBE | TBE | TBE | TBE |
| 88553-00 | TBE | TBE | 88553-00 | TBE | TBE | 88553-00 |
| 88553-10 | TBE | TBE | TBE | TBE | TBE | TBE |
| 88809-00 | TBE | TBE | 88809-00 | TBE | TBE | 88809-00 |
| 88809-10 | TBE | TBE | 88809-10 | TBE | TBE | 88809-10 |

Table 1. Equipment Ordering Numbers (cont'd)

Reflecting Lab-Volt's commitment 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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