

Solar power training packages

From basic to industrial concepts



Solar Power Production

As solar power production becomes more and more affordable for residential applications, no wonder the number of installations worldwide is blooming. So comes the need to train qualified technicians in understanding and maintaining these systems.

Our solar power learning solutions come in modular packages that will fit your training needs starting with the fundamentals of photovoltaic panels and how they work all the way to actual photovoltaic energy production systems operating in stand-alone or grid-tied operation.

Features

- Flexible packages for specific training and budget needs
- A4 form factors
- Modular approach giving opportunity to combine these packages with other topics
- New and safer grounding methods between the modules
- Solar Panel Emulator for experiments requiring more power
- Two types of inverters: PWM and MPPT
- Top of the line data acquisition and control interface designed for learning purposes

Computerized tools made for learning

To guide students through their learning path, Festo Didactic provides state-of-the-art data acquisition tools for easy, safe and fast measurements in order to speed up the setup time but also reduce the downtime of using standard measuring instruments. The Data Acquisition and Control Interface comes also with an oscilloscope, a phasor analyser, a data table and a graph on specifically designed software optimized for learning purposes.

Training Content

The workbooks take the student starting with the basics and explaining the necessary theory in order to perform the different lab experiments planned. The first workbook focuses on the photovoltaic panels themselves, their construction and their operation under different conditions. The second workbook enables the students to experiment production scenarios either on a stand-alone mode (off-grid) or in grid-tied mode (parallel).

Please refer to the page 187 for the specific topic coverage of each workbook.

Three different packages are available

Solar Power Basic Package **596086**

Learn the fundamental principles of solar power in a cost-effective package

The most important components at a glance:

1	1x 12 V Lead-Acid Batteries*	595060
2	1x Solar Panel Test Bench	595057
	1x Monocrystalline Silicon Solar Panel	595058
	1x Solar Power (Instructor Guide)	603890

Also order Workbook: Solar Power

*A 12 V DC battery charger is required for this module. The user can use his own with right 4 mm safety plugs or use the following equipment

Required accessories for the basic package

2x Digital Multimeter	579782
1x Connection Lead Set and Grounding Kit	595916

Optional equipment for the basic package (to charge the 12 V Lead-Acid Batteries)

1x 4-Quadrant Power Supply and Dynamometer Controller... (including Manual and Computer-Based Control)	595028
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Solar Power Advanced Package **596087**

Train on the concepts of solar power production in stand-alone and also grid-tied scenarios

The most important components at a glance:

1x DC 48 V Lamps	595055
1x AC 230 V Lamps	595056
2x 1 AC Energy Meter	594904
1x 48 V Lead-Acid Battery Pack	595059
1x DC 48 V PWM Charge Controller	595051
1x DC 48 V MPPT Charge Controller	595050
1x AC 230 V Power Supply	595930
1x AC 24 V Power Supply	772050
1x 1 AC 230 V Stand-Alone Inverter	595052
1x 1 AC 230 V Grid-Tied Inverter	595053
1x 4-Quadrant Power Supply and Dynamometer Controller... (including Manual and Computer-Based Control)	595028
1x Firmware Function (4Q Power Supply/Dynamometer) Solar Panel Emulator	581440
1x Data Acquisition and Control Interface (including computer-based... instrumentation for 2x current inputs and 2x voltage inputs)	595912
1x Photovoltaic Systems (Instructor Guide)	593987

Also order Workbook: Photovoltaic Systems

Required accessories for the advanced package

1x Communications Gateway*	595054
1x Connection Lead Set and Grounding Kit	595916

* Only one per lab is necessary

Solar Power Complete Package **596088**

Contains both basic and advanced package in one complete solution

Required accessories for the complete package

2x Digital Multimeter	579782
1x Communications Gateway*	595054
1x Connection Lead Set and Grounding Kit	595916

* Only one per lab is necessary

Optional accessories for the basic and complete packages (for outdoor experiments)

1x Tripod	583216
1x Pyranometer	579784

A paper copy of the corresponding Instructor Guide is included if you order by package

1 12 V Lead-Acid Batteries

- 2x VRLA (valve regulated lead acid) batteries mounted on a A4 module
- Nominal voltage: 12 V (each battery)
- Nominal capacity: 2.3 Ah (each battery)
- Maximum charge current: 0.92 A (both batteries)
- Maximum Discharge Current: 5 A (each battery)
- Fuse: 5 A (auto reset, each battery)
- Test point fuse: 0.1 A (auto reset)
- Dimensions (H x W x D):
297 x 133 x 140 mm
- Weight: 5.5 kg

Order no. **595060**

2 Solar Panel Test Bench

The Solar Panel Test Bench is a tabletop module where the solar panel mounts into so that it can be illuminated and experiments can be conducted.

- Input voltage: 230 V/50 Hz
- Nominal current: 1.5 A
- Dimensions (H x W x D):
392 x 250 x 370 mm
- Weight: 5.5 kg

Order no. **595057**

Also order:

Workbooks

Solar Power

The exercises in the workbooks contain the theory and lab manipulations to cover the following exercises:

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

Campus licence →

www.festo-didactic.com, en 596125

Student Manual, en **603887**

Instructor Guide, en **603890**

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Photovoltaic Systems

The exercises in the workbooks contain the theory and lab manipulations to cover the following exercises:

- Stand-Alone PV Systems for DC Loads
- Use of an MPPT Charge Controller in Stand-Alone PV Systems
- Stand-Alone PV Systems for AC Loads
- Grid-Tied PV Systems

Campus licence →

www.festo-didactic.com, en 596125

Student Manual, en **593985**

Instructor Guide, en **593987**

Accessories

Solar power training packages

1 Monocrystalline Silicon Solar Panel

The Monocrystalline Silicon Solar Panel are mounted on a common metal chassis that can be installed in the Solar Panel Test Bench, when performing exercises indoors, or on a tripod when performing exercises outdoors.

- PV Module: 2 monocrystalline silicon solar panels
- Open-circuit voltage (VOC): 9 V @ STC
- Short-Circuit Current (ISC): 100 mA @ STC
- Load potentiometer: 500Ω – 2 W
- Diodes: 3
- Thermometer: -50°C to +150°C
- Dimensions (H x W x D): 240 x 237 x 58 mm
- Net Weight 2.0 kg

Order no. **595058**

2 1 AC Energy Meter

The 1 AC Energy Meter is an A4 module that includes a single-phase energy meter.

- AC network voltage: 230 V – 50 Hz
- Current: 16 A
- Monitored Values: voltage, current, energy, power
- Dimensions (H x W x D): 297 x 133 x 140 mm
- Weight: 5.5 kg

Order no. **594904**

3 DC 48 V PWM Charge Controller

The DC 48 V PWM Charge Controller is an A4 module used to perform charge controlling experiments with batteries and DC energy sources like solar.

- Charge controller type: MPPT (maximum power point tracking)
- Battery Output: Max. current 7 A, absorption voltage 57.6 V, float voltage 55.2 V
- Recommended battery pack voltage: 48 V DC
- Photovoltaic panel input: 7 A, 100 V (max.)
- Input protection: reverse polarity and overvoltage (100 V)
- Battery connection protection: Reverse polarity and overvoltage (64 V)
- Dimensions (H x W x D): 297 x 266 x 218 mm
- Weight: 5.5 kg

Order no. **595051**

4 DC 48 V MPPT Charge Controller

The DC 48 V MPPT Charge Controller is an A4 module that is used to control the charge of batteries with DC energy sources like solar panels. It uses the MPPT technology which adjusts its input voltage and find the maximum power operating point from the solar array and transfer this power to the battery and load.

- Charge controller type: MPPT (maximum power point tracking)
- Battery Output: Max. current 7 A, absorption voltage 57.6 V, float voltage 55.2 V
- Recommended battery pack voltage: 48 V DC
- Photovoltaic panel input: 7 A, 100 V (max.)
- Input protection: reverse polarity and overvoltage (100 V)
- Battery connection protection: Reverse polarity and overvoltage (64 V)
- Dimensions (H x W x D): 297 x 266 x 218 mm
- Weight: 5.5 kg

Order no. **595050**



1 AC 230 V Power Supply

The AC 230 V Power Supply consists of a single-phase power supply which, connected to the AC line voltage, supplies the necessary power for single-phase experiments. This power supply is mounted in an A4 module.

- Input: 3 A/230 V/50 – 60 Hz
- Output: 3 A/230 V/50 – 60 Hz
- Circuit Breaker: 3 A
- Dimensions (H x W x D): 297 x 133 x 140 mm
- Weight: 2.8 kg

Order no. **595930**

2 1 AC 230 V Grid-Tied Inverter

The 1 AC 230 V Grid-Tied Inverter is used to return power from a DC power source such as batteries directly to the grid and it is mounted in an A4 module.

- Inverter type: Grid-Tied with MPPT
- Output power: 215 W
- Output voltage: 1 AC/230 V/50 Hz/ 0.94 A (max.)
- Input voltage: DC 48 V
- MPPT voltage range 27 – 39 V
- Input protection: Reverse polarity and overvoltage (42 V DC)
- AC output protection: Inverter built-in protections
- Dimensions (H x W x D): 297 x 266 x 140 mm
- Weight: 5.5 kg

Order no. **595053**

3 Communications Gateway

The Communications Gateway is an A4 module that is used to communicate and set grid-tied inverters over the AC line voltage directly.

- Input: 1 AC/230 V/50 Hz/0.05 A (fused)
- Communication with inverters through ac power line
- Dimensions (H x W x D): 297 x 266 x 140 mm
- Weight: 5.5 kg

Order no. **595054**

4 Pyranometer

The Pyranometer is a high-quality instrument for measuring solar irradiance.

Order no. **579784**

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Wind power training packages

Learn the concepts of residential wind power production



Wind power study in a classroom

Just like solar power, wind power is getting more attention due to its ease of use and cost-effective installation. The small wind turbines represent a lot of decentralized production nodes that have to be taken into account in today's electrical network.

Our wind power learning solutions come in a modular way which can also be mixed with other learning solutions. The packages start with an introduction to wind power using real wind turbine parts into a safe working environment along with our dynamometer that recreates realistic wind condition as well as the real power-torque curves. Once the introduction is done, student will experiment energy production to supply power to AC and DC loads.

Features

- Flexible packages for specific training and budget needs
- A4 form factors
- Modular approach giving opportunity to combine these packages with other topics
- New and safer grounding methods between the modules
- Wind Turbine Emulator embedded in a flexible Dynamometer
- Real wind turbine parts in safe working environment
- Top of the line data acquisition and control interface designed for learning purposes

Computerized tools made for learning

To guide students through their learning path, Festo Didactic provides state-of-the-art data acquisition tools for easy, safe and fast measurements in order to speed up the setup time but also reduce the downtime of using standard measuring instruments.

The Data Acquisition and Control Interface comes also with an oscilloscope, a phasor analyser, a data table and a graph on specifically designed software optimized for learning purposes. In the same vein, the Dynamometer provided connects to your computer through USB using the same software in order to set it up quickly and easily to enhance the learning experience and recreates wind turbine conditions in the classroom environment.

Training Content

The workbooks take the student starting with the basics and explaining the necessary theory in order to perform the different lab experiments planned. The first workbook focuses on introducing wind power production to then charge batteries and power simple loads. The second workbook provides the student the knowledge to setup stand-alone applications to produce power and use it with DC loads or with AC loads in combination with an inverter.

Please refer to the page 191 for the specific topic coverage of each workbook.

Three different packages are available

Wind Power Basic Package	596083
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Learn the fundamental principles of wind power in a cost-effective package.

The most important components at a glance:

1	1x Wind Turbine Generator/Controller	595061
2	1x Wind Turbine Load Resistors	594819
	1x Resistive Load	594820
	1x 48 V Lead-Acid Battery Pack	595059
	1x 4-Quadrant Power Supply and Dynamometer Controller (including Manual and Computer-Based Control, Pb-Acid Battery Charger, Turbine Emulator)	596127
	1x 4-Quadrant Dynamometer Motor	595062
	1x AC 24 V Power Supply	772050
	1x Timing Belt	793141
	1x Protective Guard – Side-by-side	794195
	1x Introduction to Wind Power (Instructor Guide)	603893

Also order Workbook: Wind Power

Required accessories for the basic package

2x Digital Multimeter	579782
1x Connection Lead Set and Grounding Kit	595916

Wind Power Advanced Package	596084
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Learn how to produce power and use.

The most important components at a glance:

1	1x Wind Turbine Generator/Controller	595061
	1x DC 48 V Lamps	595055
	1x AC 230 V Lamps	595056
	1x 48 V Lead-Acid Battery Pack	595059
	1x AC 24 V Power Supply	772050
	1x 1 AC 230 V Stand-Alone Inverter	595052
	1x 4-Quadrant Power Supply and Dynamometer Controller (including Manual and Computer-Based Control, Pb-Acid Battery Charger, Turbine Emulator)	596127
	1x 4-Quadrant Dynamometer Motor	595062
	1x Data Acquisition and Control Interface (including computer-based instrumentation for 2x current inputs and 2x voltage inputs)	595912
	1x Timing Belt	793141
	1x Protective Guard – Side-by-side	794195
	1x Wind Power Systems (Instructor Guide)	603896

Also order Workbook: Wind Power Systems

Required accessories for the advanced package

1x Connection Lead Set and Grounding Kit	595916
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Wind Power Complete Package	596085
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Contains both basic and advanced package in one complete solution

Required accessories for the complete package

2x Digital Multimeter	579782
1x Connection Lead Set and Grounding Kit	595916

A paper copy of the corresponding Instructor Guide is included if you order by package

1 Wind Turbine Generator/Controller

The Wind Turbine Generator/Controller is a tabletop module that provides a wind turbine for experimentation. It can be coupled to a dynamometer motor to be externally driven.

- Turbine type: Direct-drive, fixed-pitch
- Nominal power: 200 W at a wind speed of 12.5 m/s
- Charge voltage setpoint range: 54.4 – 68.0 V
- Recommended battery pack voltage: 48 V
- Diode rectifier 110 V – 5 A
- Dimensions (H x W x D) 211 x 200 x 370 mm
- Weight: 5.5 kg

Order no.	595061
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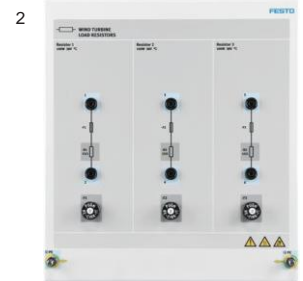


2 Wind Turbine Load Resistors The

Wind Turbine Resistive Load is an A4 module that provides a resistive electrical load for wind turbine experiments.

- Resistance Value (each resistor) 15 Ω
- Nominal Voltage: 38 V AC/DC
- Max. Current: 2.53 A (each resistor)
- Resistance Accuracy: ± 5%
- Load at Nominal Voltage (each resistor): 84 W
- Overcurrent Protection (each resistor) Thermal circuit breaker: 3 A
- Dimensions (H x W x D): 297 x 266 x 140 mm
- Weight: 5.0 kg

Order no.	594819
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Also order:

Workbooks

Introduction to Wind Power

The exercises in the workbooks contain the theory and lab manipulations to cover the following 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

Campus licence → www.festo-didactic.com, en 596126

Student Manual, en	603893
Instructor Guide, en	603896

Wind Power Systems

The exercises in the workbooks contain the theory and lab manipulations to cover the following exercises:

- Stand-Alone Wind Power Systems for DC Loads
- Stand-Alone Wind Power Systems for AC Loads

Campus licence → www.festo-didactic.com, en 596126

Student Manual, en	593989
Instructor Guide, en	593991

Accessories

Wind power training packages

1 Resistive Load

The Resistive Load is an A4 module that provides a universal resistive electrical load for a wide range of experiments.

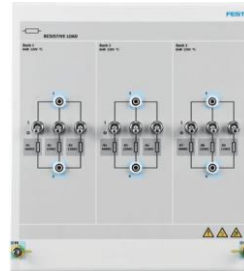
- Three banks of manually switchable resistive loads
 - Resistance Values (Each Bank):
1100/2200/4400 Ω
 - Nominal Voltage: 230 V AC/DC
 - Resistance Accuracy: $\pm 5\%$
 - Load at Nominal Voltage (Each Bank): 84 W
 - Dimensions (H x W x D)
297 x 266 x 140 mm
 - Weight: 5.5 kg
- Order no. **594820**

2 4-Quadrant Power Supply and Dynamometer Controller

The 4-Quadrant Power Supply and Dynamometer Controller is an A4 module that offers two main operating modes: Power supply and dynamometer. For the dynamometer, a dynamometer motor is also required. In the power supply mode, the unit acts as a versatile four-quadrant voltage or current source, in the dynamometer mode the unit acts as a fully configurable mechanical brake or prime mover.

Order no. **596127**

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Accessories

Solar and wind power training packages

1 4-Quadrant Dynamometer Motor

The 4-Quadrant Dynamometer Motor consists of a tabletop motor that is used as a complete 4-Quadrant dynamometer in conjunction with the 4-Quadrant Power Supply and Dynamometer Controller. This dynamometer can then act as a prime mover, a brake, a motor test bench and can also emulate various types of pre-defined loads and even custom ones.

- Torque: 0 to 3 Nm
- Direction of Rotation: CW/CCW
- Speed: 0 to 2500 r/min
- Nominal Power: 350 W
- Protection: Detachable protective cover with interlocking start switch
- Dimensions (H x W x D): 232 x 207 x 377 mm
- Weight: 5.5 kg

Order no. **595062**

2 DC 48 V Lamps

- Mounted on a A4 module
- Lamp types: 1x LED and 1x incandescent
- Voltage: 48 V DC
- Current: 1.5 A
- Input protection: Reverse polarity and overvoltage (60 V)
- Dimensions (H x W x D): 297 x 133 x 140 mm
- Weight: 5.5 kg

Order no. **595055**

3 AC 230 V Lamps

- Mounted on a A4 module
- Lamps types: Incandescent, CFL and LED
- Voltage: 230 V 50/60 Hz
- Current: 0.36 A
- Dimensions (H x W x D): 297 x 133 x 140 mm
- Weight: 5.5 kg

Order no. **595056**

4 48 V Lead-Acid Battery Pack

- 4x 12 V lead-acid batteries mounted in series in an A4 module
- Nominal voltage: 48 V DC (12 V for each battery)
- Nominal capacity: 9 Ah
- Maximum charge current: 2.7 A
- Maximum discharge current: 7 A
- Breaker: 10 A
- Dimensions (H x W x D): 297 x 266 x 140 mm
- Weight: 5.5 kg

Order no. **595059**

5 AC 24 V Power Supply

The AC 24 V power supply is an A4 module that provides auxiliary power for various system components.

- Input Voltage: 230 V/50 – 60 Hz/ 0.3 A (max.)
- Inlet via IEC C14 terminal
- Main switch with integrated 0.3 A thermal breaker
- Output voltage: 24 V/50 – 60 Hz/ 2.5 A (max.)
- Outlet via dedicated barrel connectors (2) 5.5/2.1 mm
- LED indicator for output voltage
- Dimensions (H x W x D): 297 x 133 x 140 mm
- Weight: 2.8 kg

Order no. **772050**

6 1 AC 230 V Stand-Alone Inverter

The 1 AC 230 V Stand-Alone Inverter converts a DC power source such as batteries in an AC power source for “off-the-grid” applications.

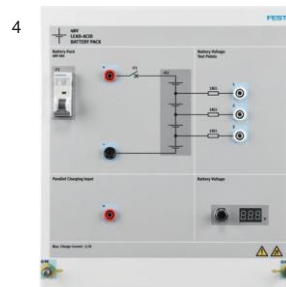
- Inverter type: pure sine wave
- Nominal output power: 300 W
- Output voltage: 1 AC/230 V/50 Hz/ 1.4 A (max.)
- Input voltage: DC 48 V
- Input protection: Reverse polarity and overvoltage (64 V max.)
- Output protection: Inverter built-in shortcircuit and overload protection
- Dimensions (H x W x D): 297 x 266 x 212 mm
- Weight: 5.5 kg

Order no. **595052**

7 Data Acquisition and Control Interface

The Data Acquisition and Control Interface (DACI) is versatile and complete device in an A4 module used for measuring, observing, and analyzing electrical and mechanical parameters in electric power systems and power electronics circuits.

Order no. **595912**



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