

# ET 250

## Solar module measurements



### Learning objectives/experiments

- physical behaviour of solar modules under a variety of effects
  - ▶ illuminance
  - ▶ temperature
  - ▶ shading
- familiarisation with key parameters
  - ▶ short-circuit current
  - ▶ open-circuit voltage
  - ▶ current at maximum output
  - ▶ voltage at maximum output
- relationship between module inclination, illuminance, short-circuit current and electrical output
- recording a module's current-voltage curve
- determining the efficiency
- connection types for the modules
  - ▶ series connection
  - ▶ parallel connection
- how cells covered by shadow affect the current-voltage curves

### Description

- two pivotable solar modules on mobile frame
- series and parallel connection
- adjustable electrical load
- measuring amplifier for current, voltage, illuminance and temperature
- suitable for sunlight and artificial light
- expandable with the experimental units ET 250.01 and ET 250.02

Photovoltaic solar modules convert sunlight directly into electrical current and are therefore an ideal component for renewable energy supply. Typical solar modules from the field of photovoltaics are made of several silicon solar cells connected in series.

The ET 250 trainer contains two such solar modules. The inclination of the modules can be adjusted. Cables can be used to connect the two modules in series or in parallel. A slide resistor simulates varying loads. Thus the slide resistor makes it possible to record current-voltage curves.

The separate measuring amplifier provides displays for all relevant variables. Two power resistors in the measuring amplifier are used to expand the measuring range for measurements at low illuminance. Sensors on the solar module detect illuminance and temperature.

In order to ensure there is sufficient illuminance, the trainer should be operated with sunlight or the optionally available artificial light source HL 313.01.

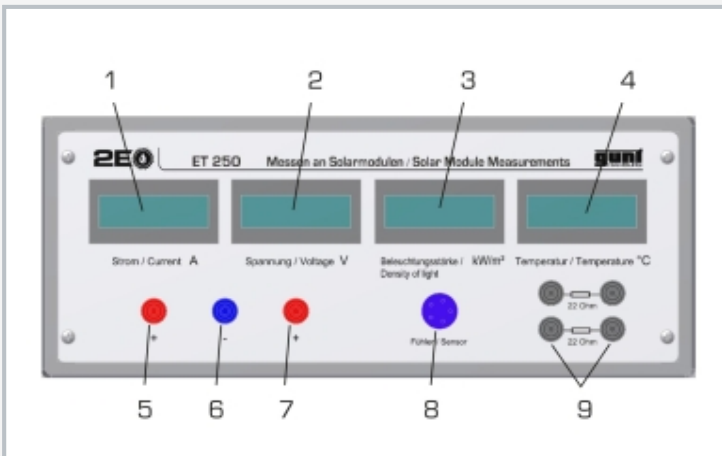
ET 250 can be expanded easily by using ET 250.01 Photovoltaic in grid-connected operation and ET 250.02 Stand-alone operation of photovoltaic modules.

# ET 250

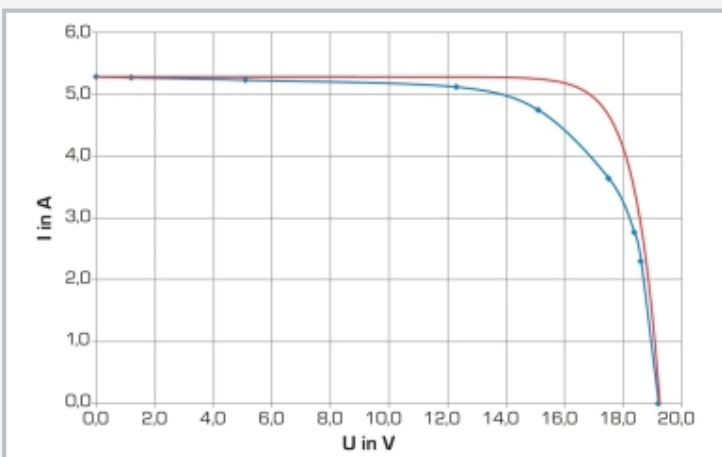
## Solar module measurements



1 slide resistor, 2 power cable, 3 set of cables for parallel and series connection, 4 measuring cable, 5 measuring amplifier, 6 inclination axis, 7 inclinometer, 8 illuminance sensor, 9 temperature sensor, 10 solar modules



Displays: 1 current, 2 voltage, 3 irradiation intensity, 4 temperature; connections: 5 current and voltage, 6 sensors, 7 power resistors



Current-voltage curve of a solar module (module temperature 55°C): theoretical after single diode model (red), measured (blue)

### Specification

- [1] trainer for solar module measurements
- [2] 2 pivoting solar modules on mobile frames
- [3] series and parallel connection options
- [4] slide resistor as variable load
- [5] 2 power resistors for expanding the measuring range
- [6] measuring amplifier with digital displays for current, voltage, illuminance and module temperature
- [7] reference cell as illuminance sensor

### Technical data

#### Module design

- number of cells: 36
- cell material: monocrystalline silicon
- module area: 0,64m<sup>2</sup>

#### Typical module parameters under STC (Standard Test Conditions)

- max. output: 100W
- short-circuit current: approx. 6,14A
- open-circuit voltage: approx. 21,6V

Slide resistor: 0...10Ω

Two power resistors: 22Ω/50W

#### Measuring ranges

- temperature: 0...100°C
- voltage: 0...200V
- current: 0...20A
- illuminance: 0...3kW/m<sup>2</sup>
- inclination: 0...90°

230V, 50Hz, 1 phase

230V, 60Hz, 1 phase

120V, 60Hz, 1 phase

UL/CSA optional

LxWxH: 1400x800x1490mm

Weight: approx. 93kg

### Scope of delivery

- 1 trainer
- 1 slide resistor
- 1 measuring amplifier
- 1 set of cables
- 1 inclinometer
- 1 set of instructional material

# ET 250

## Solar module measurements

### Optional accessories

ET 250.01	Photovoltaic in grid-connected operation
ET 250.02	Stand-alone operation of photovoltaic modules
HL 313.01	Artificial light source
ET 256	Cooling with solar electricity