

# ET 250

## Photovoltaic modules measurements



### Learning objectives/experiments

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

The ET 250 trainer contains two such photovoltaic 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.

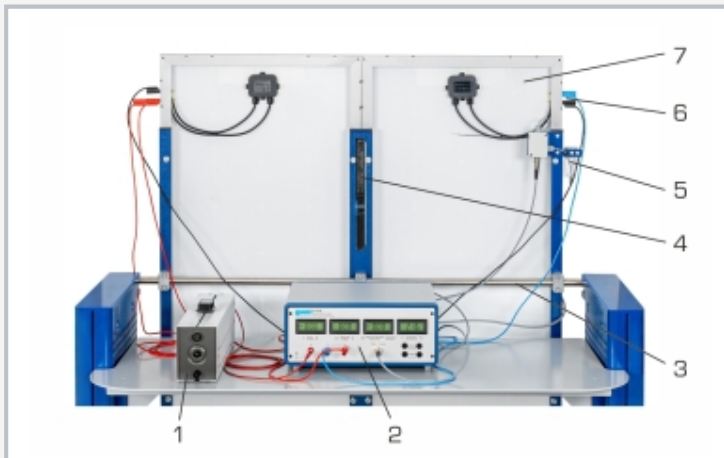
The separate measuring amplifier provides displays for all relevant variables. Two power resistors in the measuring amplifier are used to expand the measuring range for measurements at low illuminance. Sensors on the solar module detect illuminance and temperature.

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.

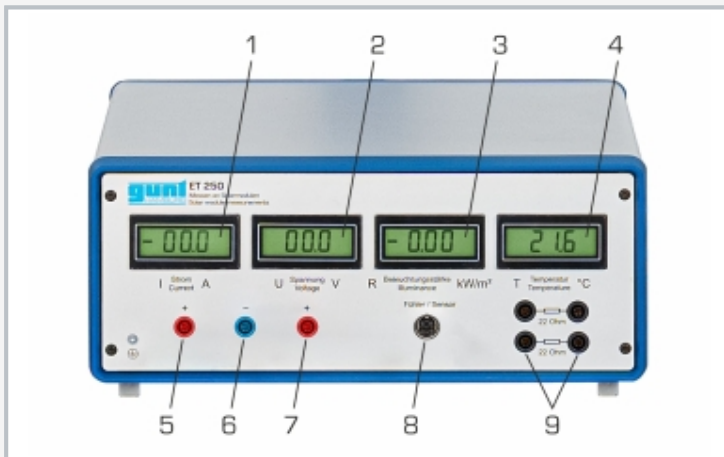
ET 250 can be expanded easily by using ET 250.01 Photovoltaic in grid-connected operation and ET 250.02 Stand-alone operation of photovoltaic modules.

# ET 250

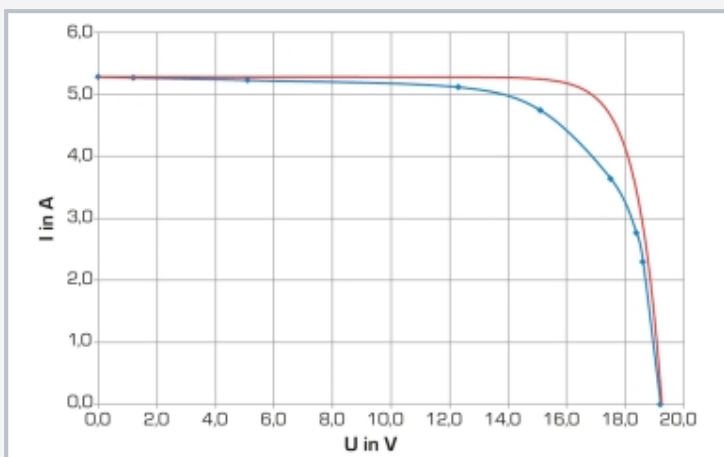
## Photovoltaic modules measurements



1 slide resistor, 2 measuring amplifier, 3 inclination axis for inclination adjustment, 4 inclinometer, 5 illuminance sensor, 6 temperature sensor, 7 photovoltaic 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 photovoltaic module (module temperature 55°C): theoretical after single diode model (red), measured (blue)

### Specification

- [1] trainer for photovoltaic module measurements
- [2] 2 pivoting 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
- [8] expansions available as accessories: ET 250.01 Photovoltaic in grid-connected operation and ET 250.02 Stand-alone operation of photovoltaic modules

### Technical data

- 2 photovoltaic modules
  - number of cells per module: 36
  - cell material: monocrystalline silicon
  - effective area per module: 0,54m<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, adjustment range: 0...10Ω  
2 power resistors: 22Ω/50W

Measuring ranges

- temperature: 0...100°C
- voltage: 0...200V
- current: 0...20A
- illuminance: 0,1...1,8kW/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

### Photovoltaic modules 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