Training systems for basic and future oriented education in natural science and engineering

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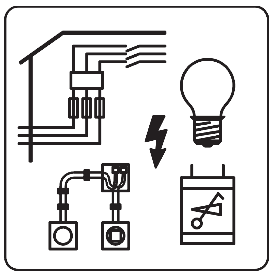
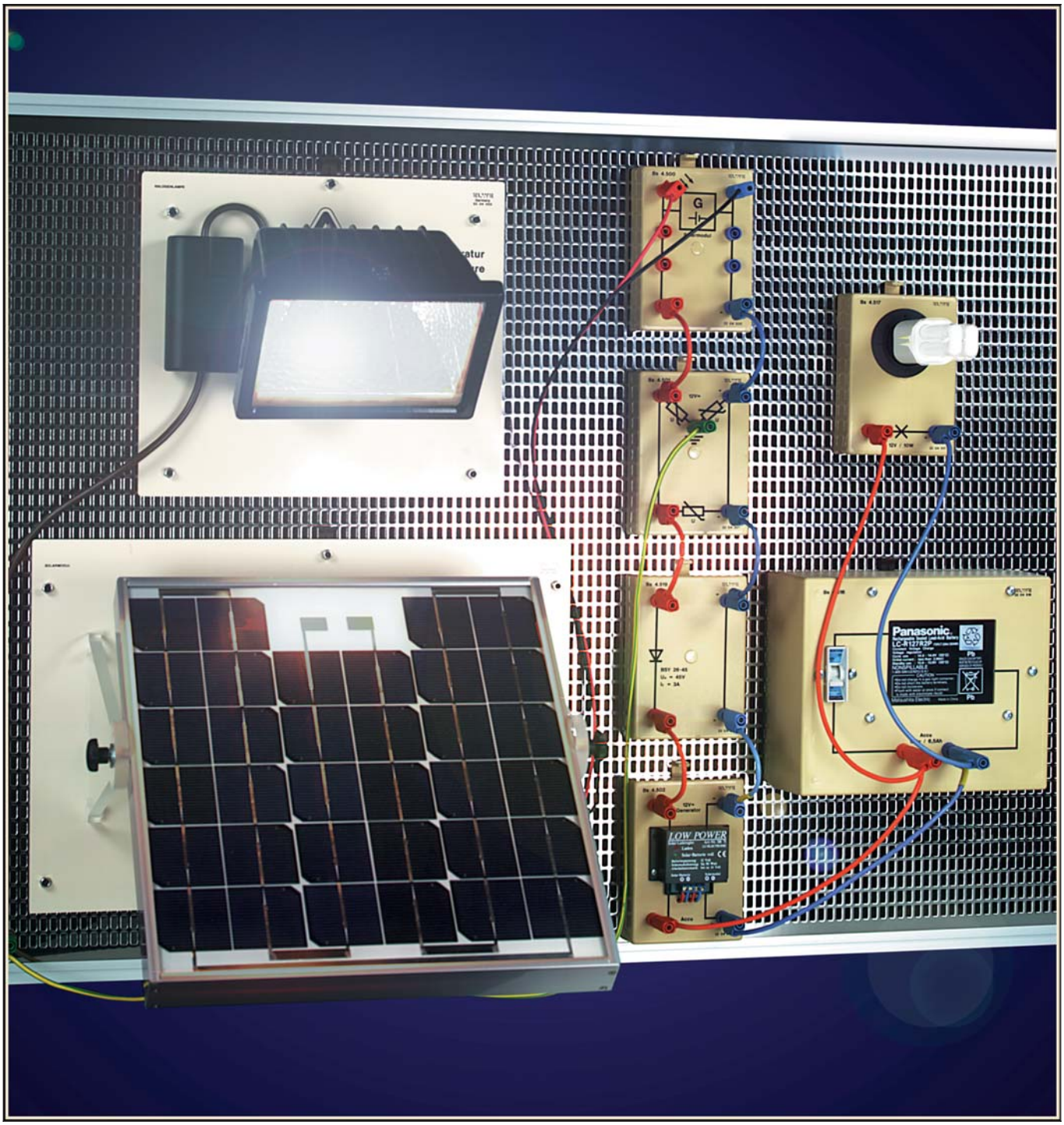
Photovoltaic Engineering



Experimental Module System



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Photovoltaic engineering becomes increasingly popular as an environmentally friendly alternative to the conventional generation of electricity even in industrial countries. In 1997 this field experienced an annual growth of approx. 30 % compared with approx. 20 % in the previous years.

The largest share on the world market however is covered by the countries that are rich of sun and in which one to two thousand million people of the worldwide population still do not have any access to commercial power supply. Here, the field of photovoltaic engineering offers separate systems with storage batteries, which supply sufficient power to operate e.g. a few lamps, telecommunications equipment (radios, television sets etc.) and small refrigerators.

In order to be able to install and maintain photovoltaic systems competently, certain technical skills are required. ELWE have developed the experimental module system "Photovoltaic Engineering, Stand-by Supply" to help obtain these skills in a very plain and almost autonomous way.

The experimental module system has essential advantages compared with steady-state systems with external solar modules:

- The whole concept of a photovoltaic system including its structure and influences of action can be learnt entirely.
- The experiments can be carried out at any time and independently of the position of the sun which means that the sessions can be planned exactly.
- The intensity and the angle of incidence of the sunlight can be reproduced within a short space of time at any time.
- The system can be set up step by step which means that the functions of individual components can also be examined.
- Several working stations can be set up at much lower costs guaranteeing action-oriented learning.
- The basic equipment allows you to set up a complete photovoltaic system in isolated operation with low voltage. A spotlight with a 500-W halogen dimmer lamp is used instead of the sunlight.
- The power inverter is an essential part of the supplementary equipment because it allows you to operate 230-V equipment by means of the photovoltaic system, too. It is possible to examine the structure and circuit engineering of a stand-by supply system for a photovoltaic system simply by extending the set-up with emergency lighting.

Experimental Manual "Photovoltaic Engineering and Stand-by Supply" ***52 04 501 0***

part of the basic equipment 02 04 500

The experimental manual covers the following subjects:

Determining the Electrical Characteristics of a Solar Module
- Measurement of the open-circuit voltage U_L and the short-circuit current I_K of the cold solar module at full illumination
- Measurement of the open-circuit voltage and the short-circuit current at different values of illuminance
- Measurement of the open-circuit voltage and the short-circuit current at different angles of incidence
- Open-circuit voltage and short-circuit current as a function of temperature
- Measurement of voltage and current at constant illuminance and variable load
- Influence of partial shading on the power output of the module
- Working point when a consumer is directly connected to the solar module

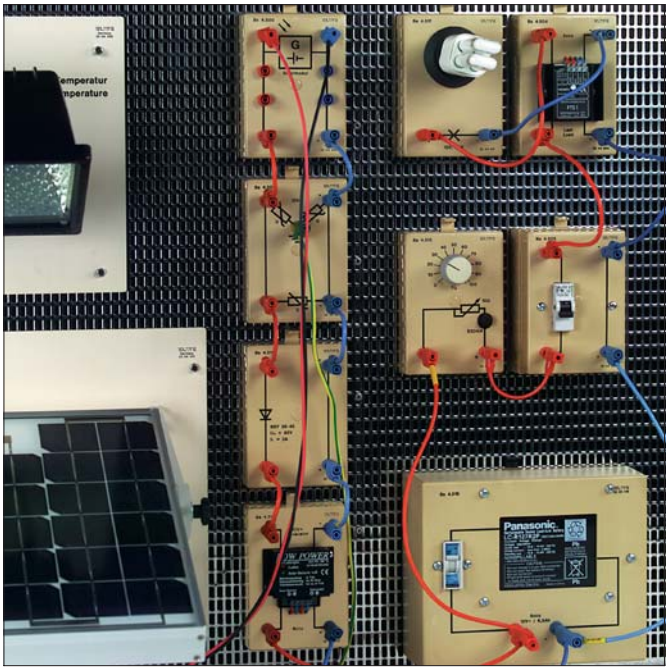
Components of a Separate Photovoltaic System
- Connection of the solar module to a solar 12-V accumulator battery
- Overvoltage protection
- Charge controller
- Exhaustive discharge protection
- Reverse voltage protection

Electrical Safety of a Photovoltaic System
- Short-circuit protection for solar modules
- Short-circuit protection for accumulator batteries
- Studies on the selectivity of the applied overcurrent protective devices

Inverters
- Areas of application and methods of operation of inverters
- Measuring the input current and the output voltage of an inverter
- Oscillograms of output voltage and input current

Solar Stand-by Supply Systems
- Stand-by supply and emergency lighting
- Technical supply conditions of a stand-by supply system
- Current flowchart of the stand-by supply system for the emergency lighting
- Set-up and testing of the solar stand-by supply system

Basic "Photovoltaic Engineering" — *02 04 500*



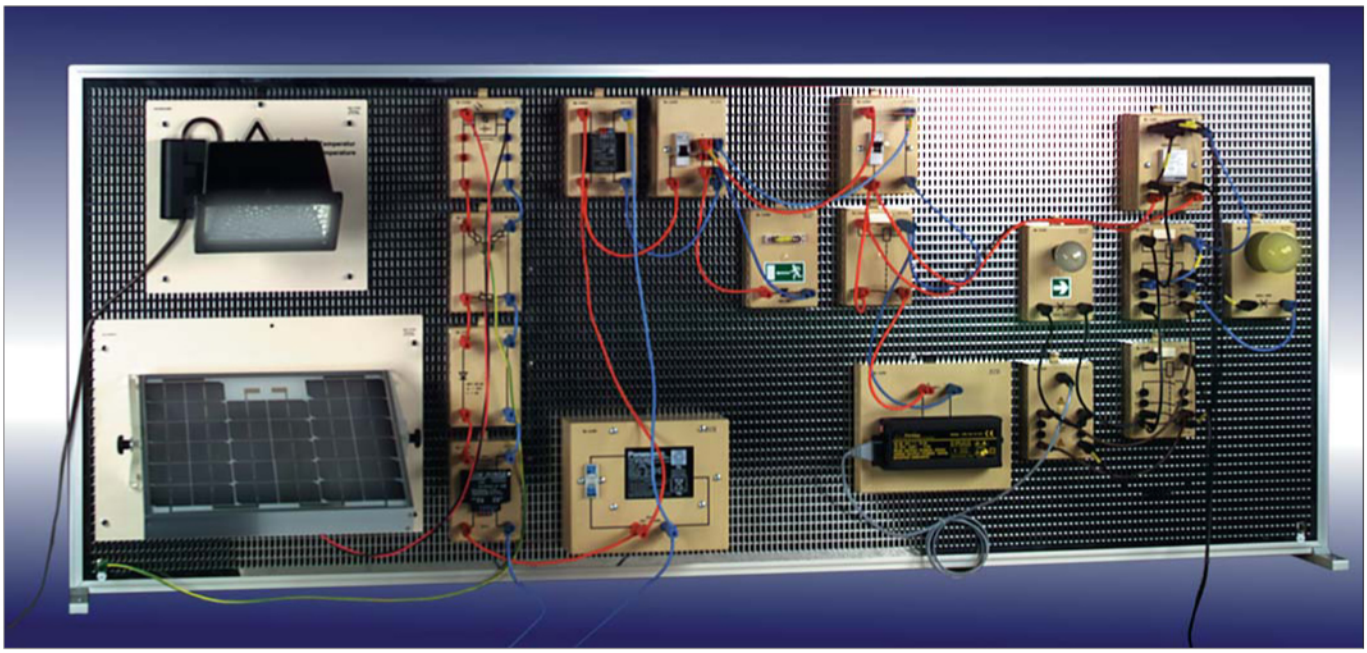
The basic equipment includes:

1	BS 4.500	Terminal unit for the solar module, 12 V	22 04 500
1	BS 4.501	Overvoltage protection	22 04 501
1	BS 4.502	Charge controller	22 04 502
1	BS 4.503	Distribution board with fuse 10 A	22 04 503
1	BS 4.504	Exhaustive discharge protection	22 04 504
1	BS 4.505	Fuse 6 A	22 04 505
1	BS 4.513	Rheostat 10 Ω, 4 W	22 04 513
1	BS 4.514	Rheostat 470 Ω, 20 W	22 04 514
1	BS 4.516	Accumulator battery 12 V, 6,5 Ah	22 04 516
1	BS 4.517	Lamp socket, E 27, for 12 V/10 W lampe	22 04 517
1	BS 4.519	Schottky diode, 45 V, 3 A	22 04 519
1	Solar module 12 V, 12 W		23 04 001
1	Spotlight with halogen lamp 230 V, 500 W		23 04 002
1	Energy-saving lamp 12 V, 10 W, E27		59 50 882
1	Connection cable 20 cm, 4 mm^2		55 00 820
1	Experimental manual on CD		52 04 501 0

Additionally required:

2	2 Multimeters, e.g. multimeter MA 1H	25 00 020
1	Set of safety cables for 02 04 500	57 04 500
1	Mounting wall, type 120, 1200 mm wide	73 01 112
	alternatively: type 150, 1500 mm wide	73 01 115
	alternatively: type 180, 1800 mm wide	73 01 118

Supplementary Equipment "Inverter, Stand-by Supply" — *02 04 510*



Experimental set-up on the subject "Solar stand-by supply"

The supplementary equipment includes:

2	BS 4.506	Relays, 3 make contacts, 1 break contact	22 04 506
1	BS 4.507	Open-phase relay	22 04 507
1	BS 4.508	Starter relay, 1 make contact	22 04 508
1	BS 4.509	Emergency lighting, maintained	22 04 509
1	BS 4.510	Emergency lighting, stand-by circuit	22 04 510
1	BS 4.512	Lamp socket, E 27, for 230 V/25 W lamp	22 04 512
1	BS 4.515	Inverter 12 V DC / 230 V AC, 150 VA	22 04 515
1	BS 4.518	Terminal unit for mains connection 230 V	22 04 518
1	Filament lamp E 27, 230 V, 25 W		59 50 825
1	Filament lamp E 14, 230 V, 25 W		59 50 725

Additionally required:

1	Oscilloscope, e.g. 35-MHz dual-trace oscilloscope HM 303	25 00 302
1	Set of accessories for the HM 303/305	25 00 312
1	Mounting wall, type 150, 1500 mm wide	73 01 115
	alternatively: type 180, 1800 mm wide	73 01 118