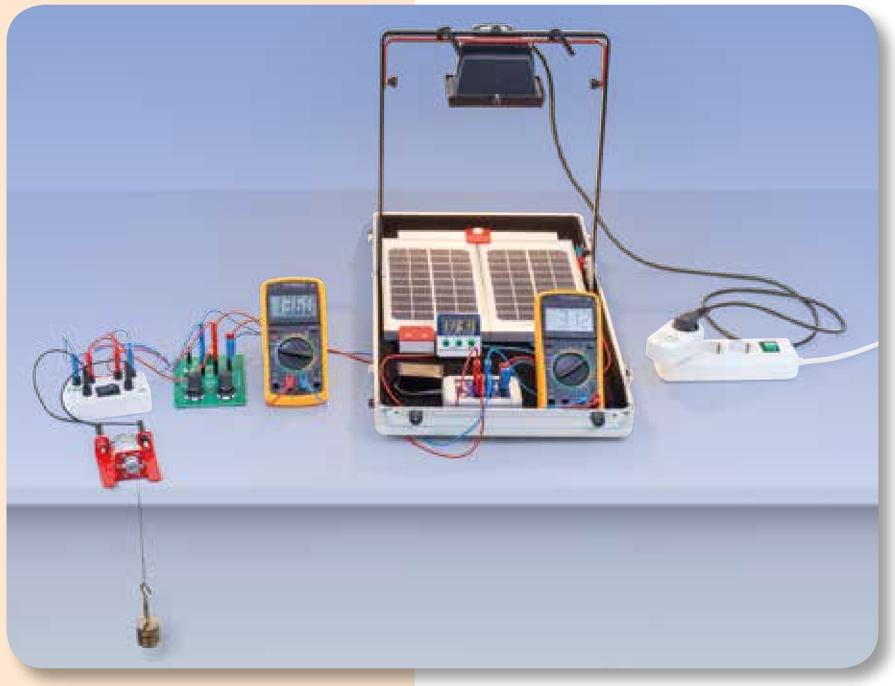
UE8020250

PHOTOVOLTAIC SYSTEMS



OBJECTIVE

Investigation of an island grid or micro-grid used to generate and store electrical energy

EXPERIMENT PROCEDURE

- **Determining the operating current of the electronic charge meter and the minimum illuminance required for operation.**
- **Investigating the current balance of the island grid for various resistive loads and different luminosities in lab operation.**
- **Measuring the solar power being delivered and the charging or discharging current as a function of the load current for different illuminance levels.**

You can find technical information about the equipment at 3bscientific.com

SUMMARY

Island grids or microgrids are power supply systems without any connection to a public utility grid and incorporate both generation and storage of electrical energy. Frequently photovoltaic modules are used to generate power and accumulators are used for energy storage. In order to simulate such an island grid in an experiment, two photovoltaic modules are used to charge up a nickel-metal hydride battery. A DC motor is deployed as the connected load which discharges the accumulator, while an electronic charge meter measures the electrical charging and discharging of the battery. Thanks to a series connection of the two modules a reliable charging of the accumulator is achieved also when there is less illuminance, since idle voltage is still far above the accumulator voltage level.

REQUIRED APPARATUS

Quantity	Description	Number
1	SEK Solar Energy (230 V, 50/60 Hz)	1017732 or
	SEK Solar Energy (115 V, 50/60 Hz)	1017731
1	Coulombmeter with Rechargeable Battery	1017734
1	Geared Motor with Pulley	1017735
1	Set of Slotted Weights, 5 x 50 g	1018597
1	Cord, 100 m	1007112
1	Two-pole Switch	1018439
1	Set of 15 Experiment Leads, 75 cm 1 mm²	1002840
1	Timer	1003009

BASIC PRINCIPLES

Island grids are off-grid power supply systems without a connection to a public utility grid. They include power generation and storage and are normally deployed when connection to the public utility grid is either impossible or inefficient, or when this offers insufficient flexibility and mobility. Photovoltaic modules are frequently used to generate power and accumulators for storing energy in this context. To emulate this kind of off-grid island system two photovoltaic modules are used in the experiment, each having a nominal power of 5 W for charging a nickel-metal hydride battery with a capacitance of 220 mAh. A DC motor functions as a connected load discharging the accumulator while an electronic charge meter is used to measure current charging and discharging. We dispense with the charge controller usually deployed in this context.

The voltage U_{Accu} of the accumulator has a nominal rating of 8.4 V, but depends on the charging state as well as the charge current I_{Accu} and conventionally reaches up to 10 V. It determines the voltage in all circuit branches connected in parallel (see Fig. 1):

(1) $$U_{Accu} = U_{Op} = U_L = U_{Solar}$$

The current supplied I_{Solar} is used as the basic operating current I_{Op} for the electronic charge meter, as charging current I_{Accu} for the accumulator and as current I_L flowing through the connected resistive load. The electric balance

(2) $$I_{Solar} = I_{Accu} + I_{Op} + I_L$$

This also applies for cases of negative charge current I_{Accu}, i.e. in cases where the accumulator is discharging power.

The operating current I_{Op} = 10 mA is defined by the electronic circuit of the charge meter, while the load current I_L depends on the ohmic resistance R_L of the connected load. The accumulator is thus charged up when the photovoltaic system supplies power and the load resistance is not too low. To ensure reliable charging of the accumulator during lower illuminance levels, it is important to configure the photovoltaic system so that its idle voltage U_{OC} is significantly higher than the voltage U_{Accu}. A comparison with the characteristics measured in the experiment UE8020100 shows that this can be reasonably reached by connecting the two modules in series configuration. Then the solar power supplied I_{Solar} is, in good approximation, proportional to the luminosity E and under laboratory conditions reaches values up to 50 mA, which are optimal for rapid charging of the accumulator.

A DC motor and a cascade resistor configuration are used as resistive loads with which the charging current/load current characteristics of the island grid is sampled and furthermore verified that the solar current supplied is independent of the resistive load. In the results the minimum brightness can be specified, for example, which is needed to charge the accumulator in the absence of all loads.

NOTE

When operating the photovoltaic module in sunlight outdoors, considerably higher electrical currents are reached. Here the accumulator should not be connected without additional resistive load which should ensure that the charging current does not exceed I_{Accu} = 44 mA.

EVALUATION

The operating current of the charging meter is determined from the charge flowing in 30 s out of the accumulator, if neither module nor load are connected.

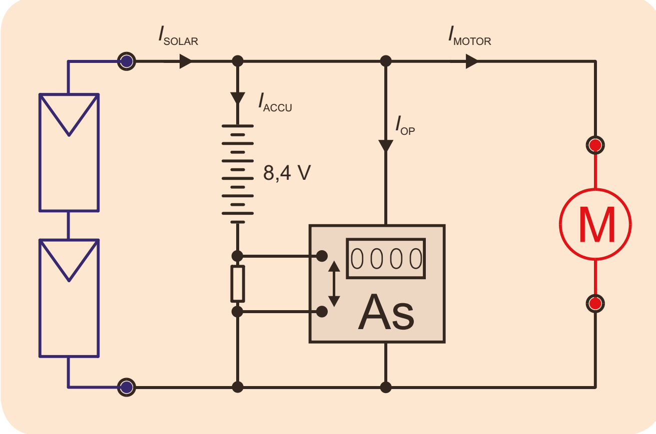


Fig. 1: Block circuit diagram of island grid

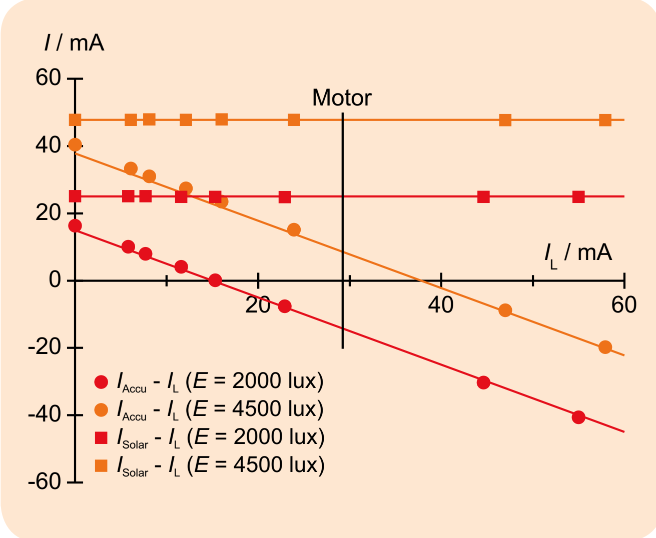


Fig. 2: Load characteristics of island grid

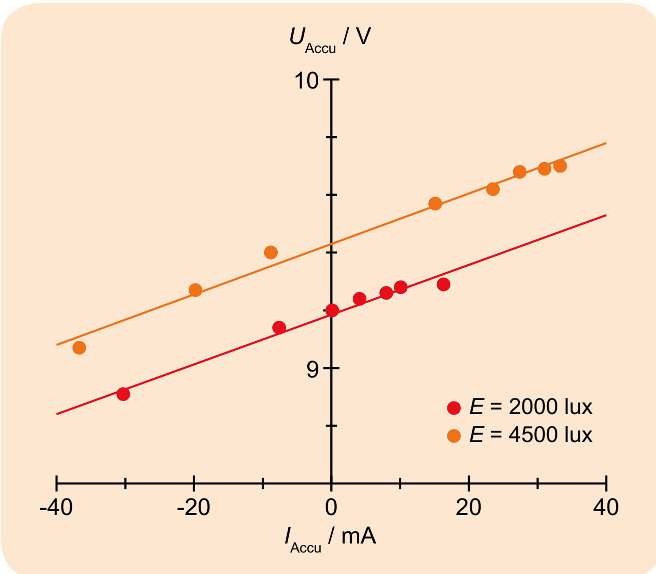


Fig. 3: Characteristics of the accumulator, measured at different luminosities. Depending on the accumulator's charging state, these characteristics are shifted up or down on the y-axis.