Series and parallel connections of solar cells – idle voltage and short-circuit current (Item No.: P1382800)

Curricular Relevance

Area of Expertise: Physics

Education Level: Age 16-19

Topic: Energy

Subtopic: Solar energy (solar heat, photovoltaics)

Experiment: Series and parallel connections of solar cells – idle voltage and short-circuit current

Difficulty	Preparation Time	Execution Time	Recommended Group Size
Intermediate	10 Minutes	10 Minutes	2 Students

Additional Requirements:

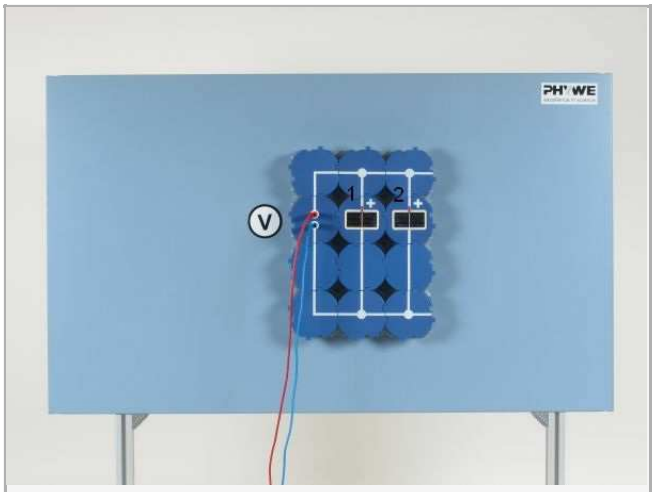
Experiment Variations:

Keywords:

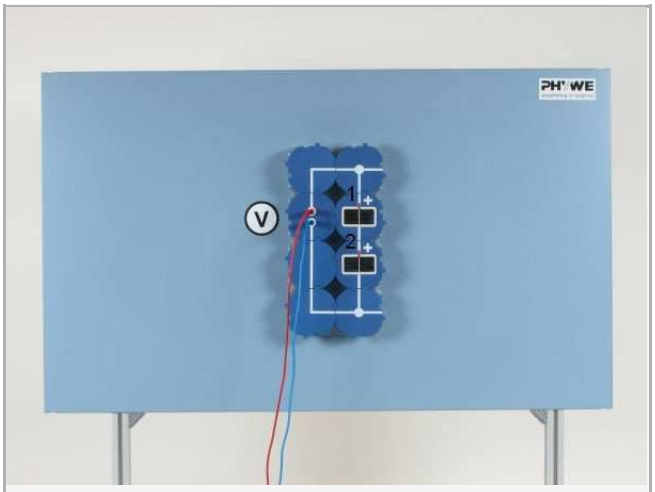
Principle and equipment

Principle

The effect of connecting solar cells in series or parallel on their idle voltage and short-circuit current is to be examined.



Experimental set-up Part 1



Experimental set-up Part 2

Equipment

Position No.	Material	Order No.	Quantity
1	Multimeter ADM2, demo., analogue	13820-01	1
2	Demo Physics board with stand	02150-00	1
3	Ceramic lamp socket E27	06751-01	1
4	Solar cell (2.5x5)cm,module DB	09470-00	2
5	Clamp on holder	02164-00	1
6	Connector interrupted, module DB	09401-04	1
7	Electr.symbols f.demo-board,12pcs	02154-03	1
8	Connector, straight, module DB	09401-01	5
9	Connector, angled, module DB	09401-02	2
10	Connector, T-shaped, module DB	09401-03	4
11	Filament lamp,220V/120W,w.refl.	06759-93	1
12	Support rod, stainless steel, 500 mm	02032-00	1
13	Connecting cord, 32 A, 1000 mm, red	07363-01	1
14	Connecting cord, 32 A, 1000 mm, blue	07363-04	1

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Set-up and procedure

1. Measurement of the idle voltage

- Connect up the circuit as in Fig. 1a; use the support material and the clamp to attach the reflector lamp to the top edge of the board in a position that will allow it to irradiate each of the solar cells with the same illuminating intensity.
- Select the 3 V- measurement range, switch on the lamp; insert solar cell 1 in the circuit, measure the idle voltage U_0, enter the measured value in Table 1.
- Replace solar cell 1 by solar cell 2, measure and note the idle voltage.
- With both solar cells in the circuit, measure and note the idle voltage.
- Change the circuit to that shown in Fig. 1b, first replace solar cell 2 by a straight connector module, measure and note the idle voltage.
- Replace solar cell 1 by solar cell 2, measure and note the idle voltage.
- With both solar cells in the circuit, measure and note the idle voltage, switch off the lamp.

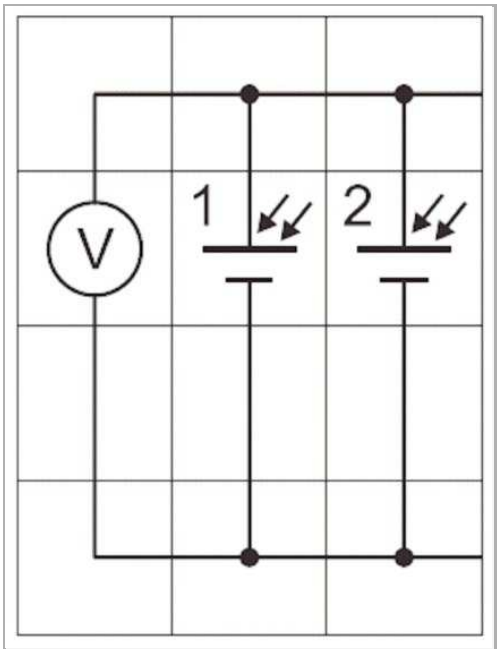

Fig. 1a

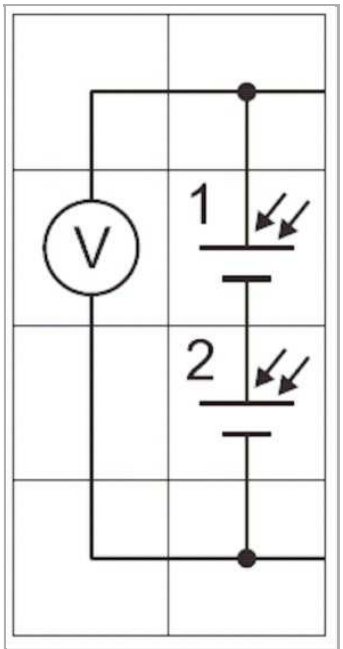

Fig. 1b

2. Measurement of the short-circuit current

- Change the circuit to that shown in Fig. 2a; select the 300 mA- measurement range, switch on the lamp and successively insert one solar cell, the other solar cell , then both of them, illuminate them as uniformly as possible and note the measured values for the short-circuit current I_{SC} .
- Change the circuit to that shown in Fig. 2b; first successively replace solar cell 1 and solar cell 2 by a straight connector module, then illuminate both solar cells as uniformly as possible; measure the short-circuit current I_{SC} and note the measured values.

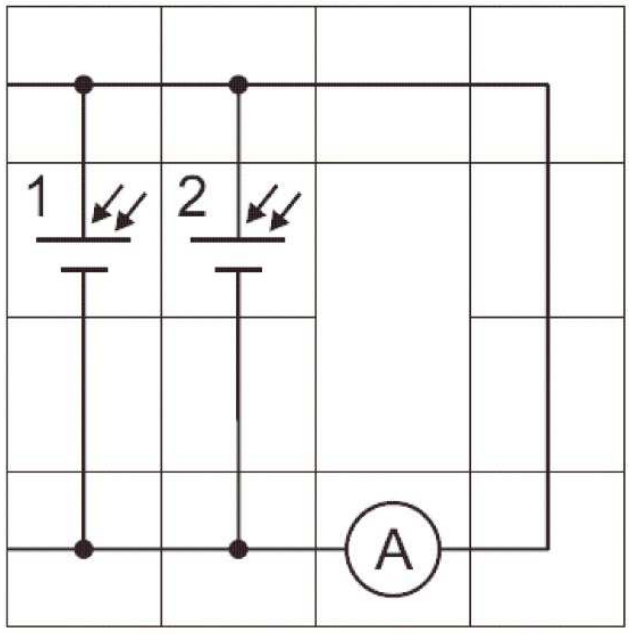

Fig. 2a

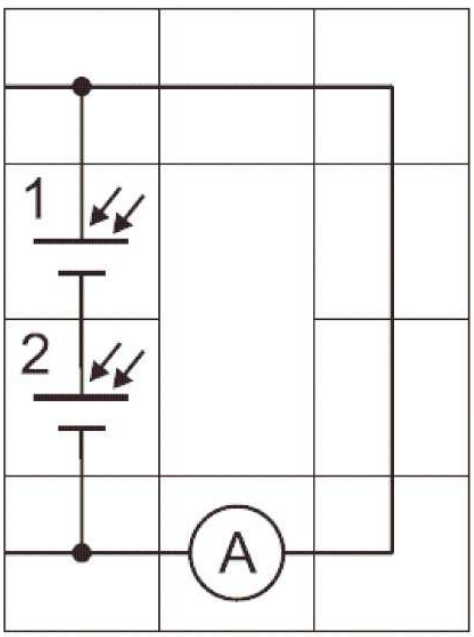

Fig. 2b

Observation and evaluation

Observation

Table 1

Connection	Solar cell	$\frac{U_0}{\mathrm{V}}$	$\frac{I_K}{\mathrm{mA}}$
In parallel	1	0.53	150
	2	0.52	140
	1 and 2	0.53	290
In series	1	0.51	145
	2	0.51	150
	1 and 2	1.05	145

Evaluation

With a parallel connection of two solar cells no increase in the idle voltage is attained. The short-circuit currents of the two solar cells are additive to each other, however, so that the short-circuit current reaches about the doubled value in the parallel connection.

With a series connection of two solar cells the idle voltages are additive, so that two solar cells connected in series give an idle voltage that is double the value for a single solar cell. An increase in the short-circuit current cannot be attained by connecting two solar cells in series.

Remarks

When one of two illuminated solar cells in a parallel connection is covered by a hand or piece of paper, the shortcircuit current is reduced to the value for one solar cell, whereas the idle voltage remains almost constant.

In a series circuit, covering one solar cell leads to a large reduction in the short-circuit current, as the high resistance of the solar cell that is no longer illuminated influences the current. This makes the demand for uniform illumination, particularly in a series connection of several solar cells, understandable. In practice, solar modules are used which have a number of solar cells connected in parallel and in series, so that here also uniform illumination must be strived for.

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