Determining the power and efficiency of a solar cell (Example report)

Student : ………………………..   Data: ……………….

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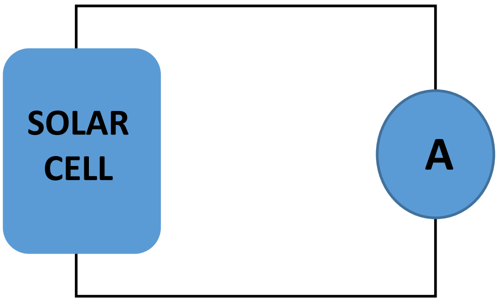
Practical task 1. Solar cell short circuit current dependence on illuminance.

The solar cell was connected to a multimeter and the 20 mA direct current (DC) measuring range was chosen. The experimental setup is sketched on the figuure.
Then, the solar cell was placed under the light source and next to it the detector of the lux meter was brought. By lowering the lamp, this experimental setup allowed to find the correspondence between the value of illuminance measured in lx and short circuit current in mA. To find the value of power of light Pv in mW for each value of illuminance the equation:

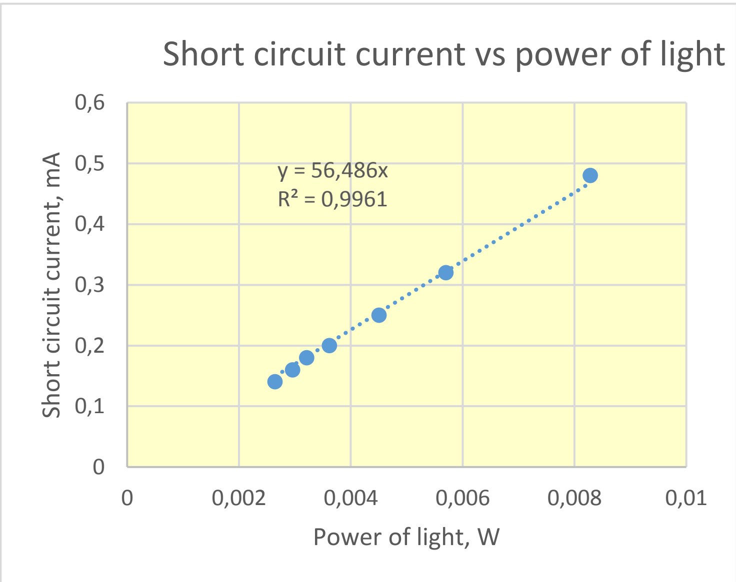


$$Pv\ (mW) = E \cdot S \cdot 3.5 \cdot 10{-}4$$

was used, where ***E*** is given in lx and the ***S*** in cm^2 ($S = 9cm^2$).

The data are shown in the table 1 below. Using the data analysis and graphics, Pv (W) as function of I (mA) was plotted. Then the obtained data was fit with a linear function F(x) = a + bx.

Illuminance	Power of light	Short circuit current
E, lx	Pv, W	Isc, mA
840	0.002646	0.14
940	0.002961	0.16
1020	0.003213	0.18
1150	0.0036225	0.2
1430	0.0045045	0.25
1810	0.0057015	0.32
2630	0.0082845	0.48



The dependence can be written as following: I (mA) = 56,49 · Pv (W)

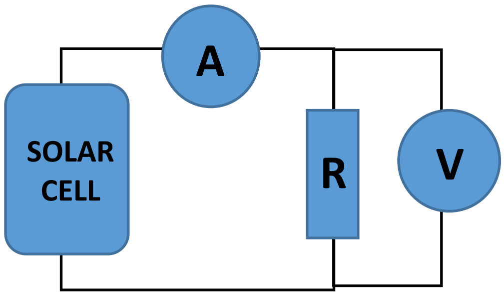
CONCLUSION ON THE PRACTICAL TASK 1.

An array of solar cell simply being under exposition of light gives a flow of excited electrons which can be transformed in electrical energy. More light (photons) we sent, more electrons excited by light travel through the solar cell which produce a measurable current which we detect using a multimeter. It explaines the linear dependence on power of light.

PRACTICAL TASK 2.

THE CURRENT–VOLTAGE CHARACTERISTIC AND THE ENERGY CONVERSION EFFICIENCY OF A SOLAR CELL.

To study the electrical properties of a solar cell the electrical circuit allowing to measure the current-voltage characteristic of the solar cell was built.



Different voltage and current was measured varying resistance values at constant temperature and light intensity. The lamp was brought on the height to give the illuminance underneath approximately **3000 lx.** Knowing current in mA and voltage in V for a given resistance, electrical power can be calculated

Pe (mW) = I(mA) · U(V)

It means that for the given power of light Pv we cannot transform into electricity all but only a part of it.
The equation linking the given power and the effective one:

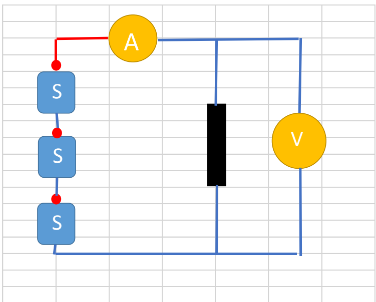
$$\eta\ (\%) = Pe/Pv$$

Electrical *I-V* characteristics of the the <u>single solar cell</u> for light 3140 lx = 9,89 W/9 cm2

R	U (V)	I (mA)	Pe (mW)	Pv(mW)	efficiency(%)
0	0	0.61	0.00	9.56	0.00
100	0.05	0.6	0.03	9.56	0.31
500	0.3	0.6	0.18	9.56	1.88
1000	0.59	0.59	0.35	9.56	3.64
1500	0.88	0.59	0.52	9.56	5.43
2000	1.17	0.58	0.68	9.56	7.10
3000	1.66	0.55	0.91	9.56	9.55
5000	2.03	0.4	0.81	9.56	8.49
8000	2.13	0.26	0.55	9.56	5.79
10000	2.15	0.21	0.45	9.56	4.72
20000	2.19	0.11	0.24	9.56	2.52
50000	2.21	0.04	0.09	9.56	0.92

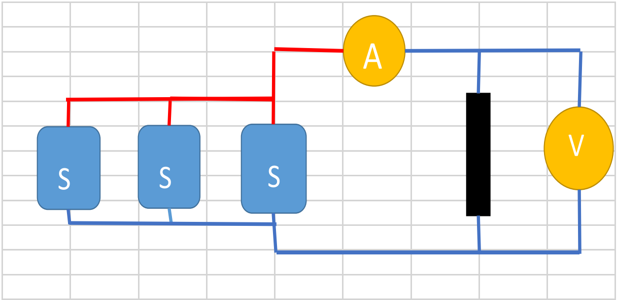
PRACTICAL TASK 3. CONNECTING SINGLE SOLAR CELLS INTO A SOLAR PANEL.

A solar panel can be thought as an arrangement of single solar cells. In this particular work, we studied two case: 2 or 3 solar cells in series and in parallel.



For both case, illuminance was fixed as in previous practical task. The final Pv is obtained multiplying Pv by 2 or 3 since we have 2 or 3 solar cells.
For three cells connected in series the current through the two cells is the same. The total voltage produced is the sum of the individual cell voltages. Since the current must be the same, a mismatch in current means that the total current from the configuration is equal to the lowest current.

For 2-3 cells connected in parallel the voltage across the cell combination is always the same and the total current from the combination is the sum of the currents in the individual cells. Therefore, for 2-3 solar cells in parallel we should have a higher short-circuit current .



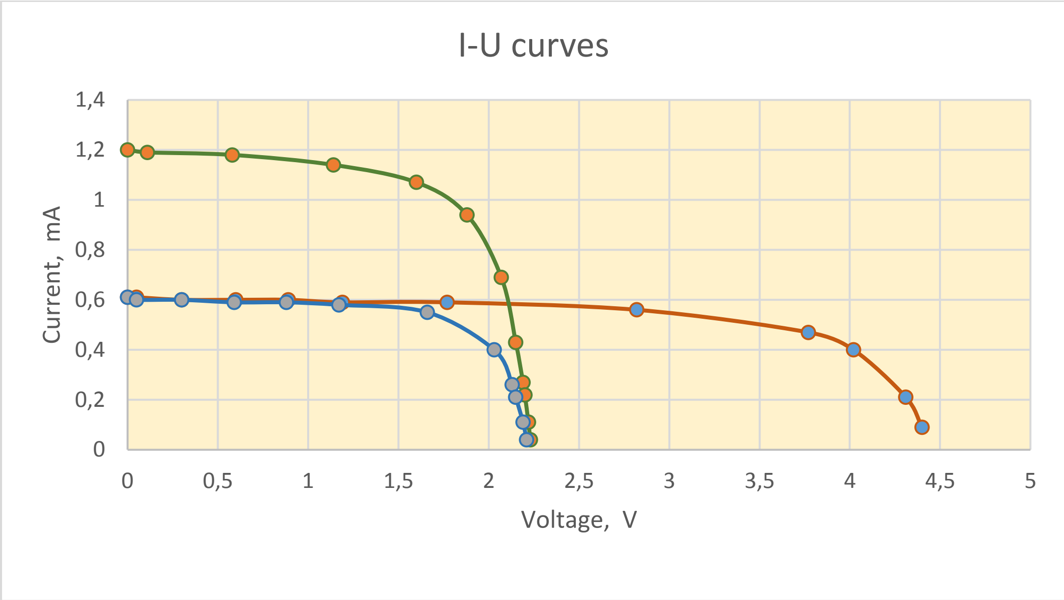
Electrical I-V characteristics of <u>two solar cells in parallel</u> for $Pv = 19.78\ mW$

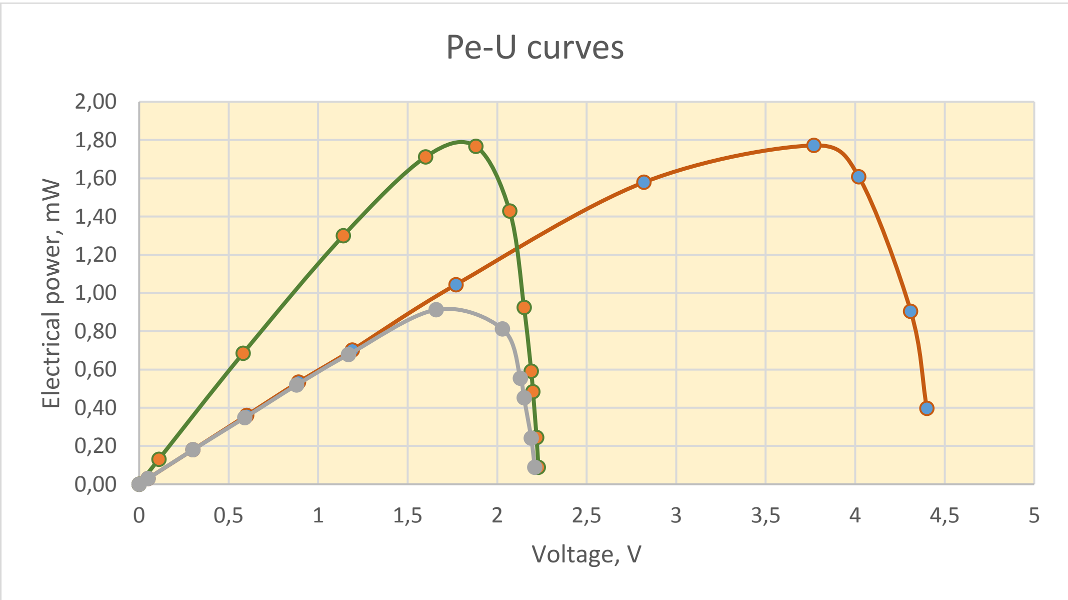
R	U (V)	I (mA)	Pe (mW)	Pv(mW)	Efficiency(%)
0	0	1.2	0.00	19.13	0.00
100	0.11	1.19	0.13	19.13	0.68
500	0.58	1.18	0.68	19.13	3.58
1000	1.14	1.14	1.30	19.13	6.79
1500	1.6	1.07	1.71	19.13	8.95
2000	1.88	0.94	1.77	19.13	9.24
3000	2.07	0.69	1.43	19.13	7.47
5000	2.15	0.43	0.92	19.13	4.83
8000	2.19	0.27	0.59	19.13	3.09
10000	2.2	0.22	0.48	19.13	2.53
20000	2.22	0.11	0.24	19.13	1.28
50000	2.23	0.04	0.09	19.13	0.47

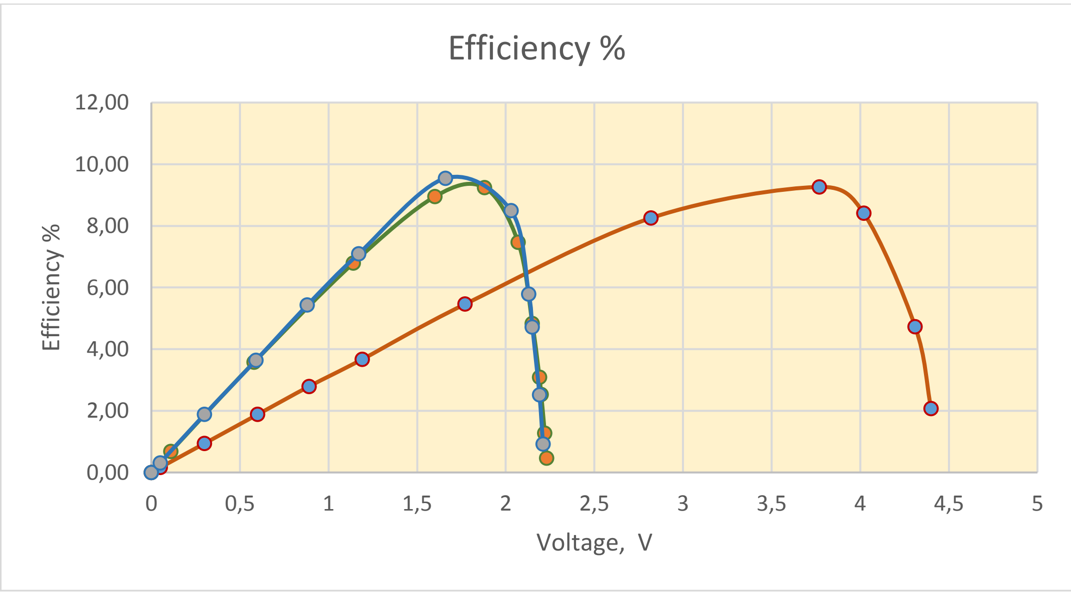
Electrical I-V characteristics of <u>two solar cells in series</u> for $Pv = 19.78\ mW$

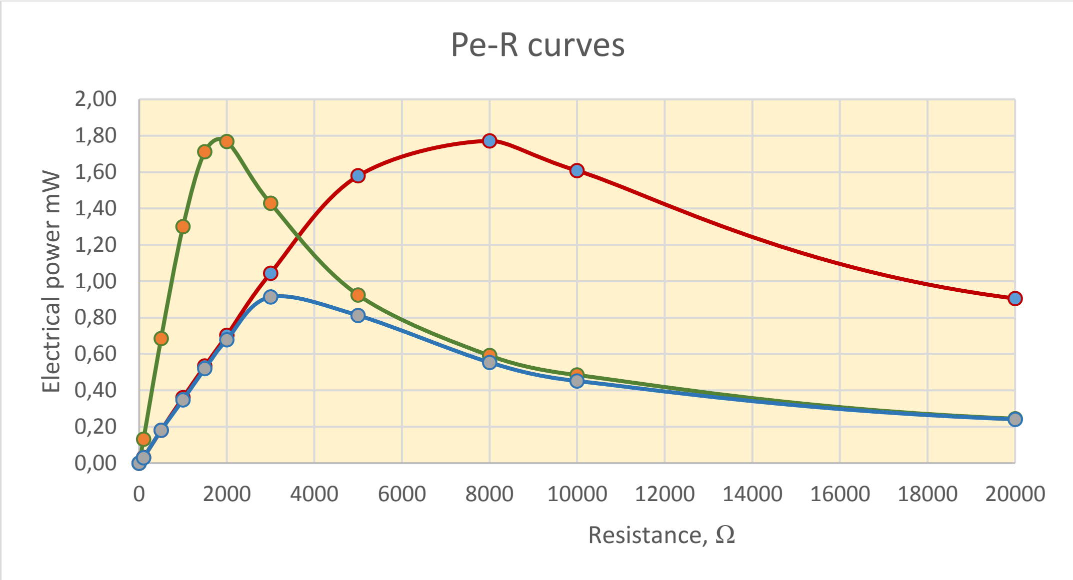
R	U (V)	I (mA)	Pe (mW)	Pv(mW)	Efficiency(%)
0	0	0.61	0.00	19.13	0.00
100	0.05	0.61	0.03	19.13	0.16
500	0.3	0.6	0.18	19.13	0.94
1000	0.6	0.6	0.36	19.13	1.88
1500	0.89	0.6	0.53	19.13	2.79
2000	1.19	0.59	0.70	19.13	3.67
3000	1.77	0.59	1.04	19.13	5.46
5000	2.82	0.56	1.58	19.13	8.26
8000	3.77	0.47	1.77	19.13	9.26
10000	4.02	0.4	1.61	19.13	8.41
20000	4.31	0.21	0.91	19.13	4.73
50000	4.4	0.09	0.40	19.13	2.07

Plotted Current-Voltage , Power-Voltage, Efficiency-Voltage, Power-Resistance curves (blue – single cell, green – 2 cells in paralleel, orange – 2 cells in series):









Current, Voltage, Load resistance at which the maximum output power appears and the maximum efficiency

nr of cells	Connection	Pv	R	Isc	Uoc	Pmax	Pmp	η	Pmp/Pmax
		mW	Ω	mA	V	mW	mW	%	%
1	single	9.56	3000	0.61	2.21	1.35	0.91	9.55	67.72
2	parallel	19.13	2000	1.20	2.23	2.68	1.77	9.24	66.04
2	series	19.13	8000	0.61	4.40	2.68	1.77	9.26	66.02

CONCLUSIONS ON THE PRACTICAL TASKS 2 and 3.

I-V curves analysis allows as to explicitly study the electrical characteristics of a solar cell.

For the two solar cells in parallel configuration a higher short-circuit current was observed comparing to a single solar cell configuration considered in practical task 2.

For the two solar cells in series configuration a higher open-circuit voltage was recorded comparing to a single solar cell configuration considered in practical task 2.

Efficiency does not much vary for two configurations.

ANSWERS TO THE CONTROL QUESTIONS

1. How does the actual maximum power relate to the theoretical?
2. Does a solar cell work with UV-radiation? What about heat radiation (infrared)?
3. What does the short circuit current value depend on?
4. How do semiconductors differ from metals?
5. What is semiconductor doping?