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The converter enabling the cooperation of solar power panels and home devices

Abstract

This article describes an device designed by the author, which was built to enable the solar power panels and home devices cooperation. It can switch the power supply between batteries and mains depending on the power of the home devices and battery condition. The device works very well and save energy taken from the mains.

Keywords: Solar panels, green energy.

1. Introduction

As the solar energy becomes cheaper and cheaper many people think about its application in the household. Since 1997 to 2013 the cost of the solar photovoltaic cell per watt decreased from almost 77$ to 0,74$[1].

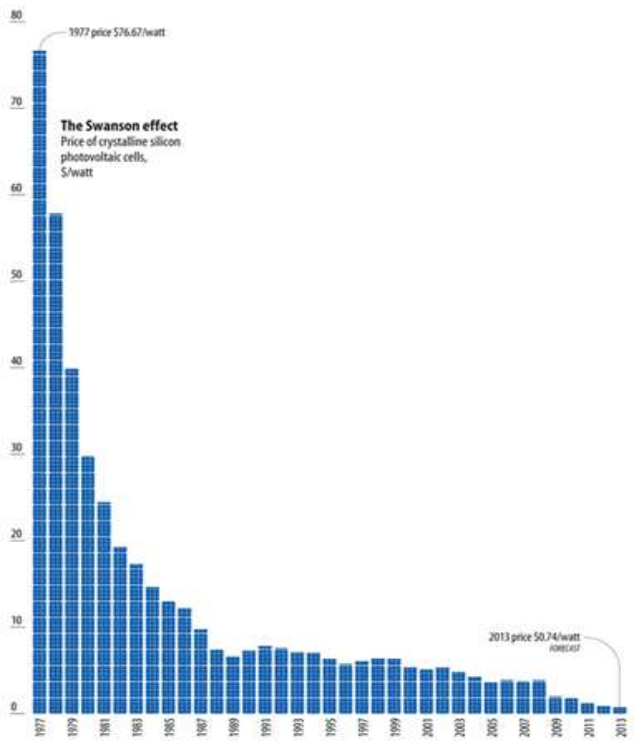

Fig. 1. The solar cell price per watt since 1977 to 2013 year[1]

Lower solar power panels' prices together with higher energy prices on the market made the solar energy more attractive. Now there are a lot of solar panels', converters' and batteries' manufacturers [2,3,4,5,6,7,8,9,10,11] so they are more and more available to customers and their share in the global energy production increase. Typical solar panel construction is shown in Figure 2 [21].

It consists of many solar cells (in Fig. 2 – 36 cells) connected together. The typical output voltage equals 18V and output power could achieve some hundreds watts. Table 1 presents the main solar battery parameters.

Fig. 2. The solar panel construction[21]

Tab. 1. Main parameters of solar battery [21]

Specification	
Weight (kg)	12
Peak power (Wp)	135
MPP voltage (V)	17,60
MPP current (A)	7,67 A
Voltage without load (V)	21,96
Short-circuit current (A)	8,41
Efficiency of solar panel (%)	16,1
Max. compressive load (kg/m2)	4500
Height (mm)	1473
Width (mm)	670
Depth (mm)	35
Nominal Voltage (V)	18
Width of cell (mm)	156
Height of cell (mm)	156
Number of cells	36

As was shown above this is a very thin element (depth = 35 mm) and its weight is not too big (12 kg). 18 V on the output allow to connect this module to the converter and typical 12 V battery. In this case the battery could be even 70 Ah (MPP current = 7,67 A). Also the solar power efficiency is quite good .According to the manufacturer it equals 16,1%. Another important features of the solar battery are shown in Figure 3.

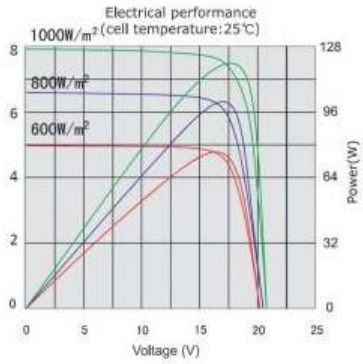

Fig. 3. Voltage and power of the solar battery for different lighting [21]

The green curve shows the maximum possible power which could be achieve from the solar battery for 1000 W/m^2. As was shown in Figure 3 in this case the maximum power equals 128 W. Other curves show that the output power decrease together with the lighting decreasing. This relationship is almost linear. Another factor which has influence on the solar battery parameters is temperature. Figure 4 shows that the higher temperature is the lower output power is possible to achieve.

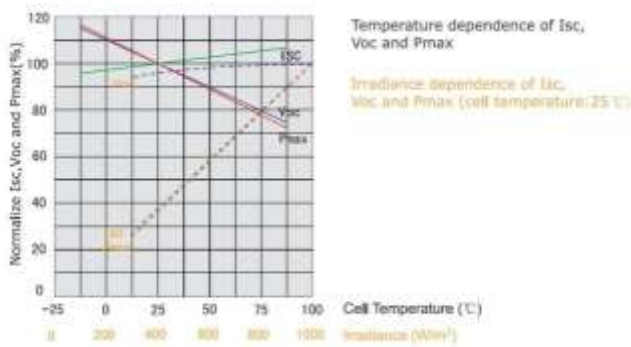

Fig. 4. Dependence of P_{max} and V_{oc} vs. the temperature [21]

Nowadays the solar battery installing become more and more popular. Also on the internet there is a lot of articles and guides helping people to choice the right configuration and to build the PV installation themselves [12,13,14,15,16, 17,18,19]. Although the prices drop down, many devices needed for solar installation are still expensive. In this article the author's low cost of the control device construction is described.

2. Assumptions for control device

The design's device should enable switching power supply from battery to mains if the power demand is too high or the batteries are discharged. It should also enable the cooperation with 24 V batteries (which are now used) or 48 V batteries (which are planned to install in the future). The device should be easy to connect to the installation and possible small. Also the low cost is important.

3. The problem solution

To solve this problem the microprocessor system was applied. The schematic diagram is shown in Figure 5.

As was shown in Figure 5 the device contains of 5 units. Switch SW1 is set by the user depending on the battery voltage (24 V or 48 V). If this switch is set on 24 V and the user connect 48 V battery the unit1 of the circuit protects the whole device against destroying. Unit 2 is the typical stabilizer which makes 24 V if the 48 V battery is connected. Unit 3 is the comparator which compare the battery voltage with the voltage set on the potentiometer. If the voltage is high enough the RELAY1 is switched on, and the output is connected with the 24 V/230 V converter, if not the output is connected to the mains.

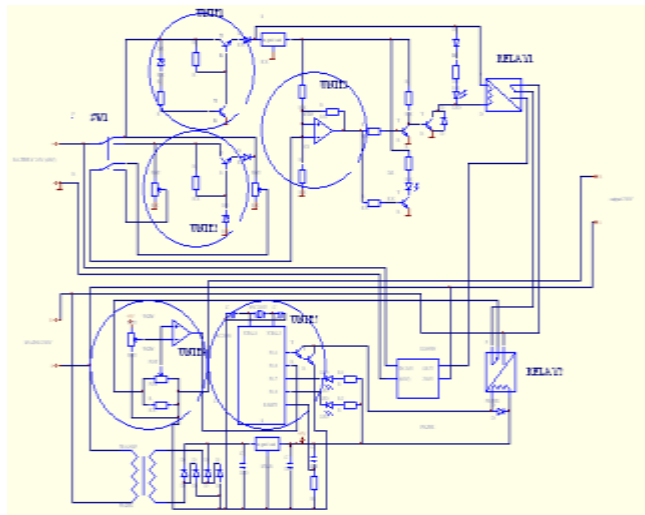

Fig. 5. Schematic diagram of the designed device

Units 4 and 5 are the circuits which test the power consumption. If the power is higher than 2 kW the voltage on the operational amplifier output is set high, and the microprocessor switchs the RELAY2 connecting the output with the mains. This situation is signalized by the LED diodes, what inform the user that the power consumption is too high for 24 V/230 V converter. If the power consumption becomes lower the microprocessor with 3 seconds delay switchs the RELAY2 again and the energy will be taken from battery. So finally the energy to the output is taken from the battery if they have enough high voltage and the power consumption is less than 2 kW.

4. The battery selection

If the maximum output power equals 2 kW the maximum current intensity depends on the battery voltage. For 24 V battery it is 2 kW/24 V ≈ 83A (for 48 V battery ≈ 42 A). If the device should work without mains for 3 hours, the battery capacity should be at least 3 h x 83 A = 249 Ah. This could be achieved in different ways. Typical batteries have capacity from 1 to about 100 Ah. The examples of different batteries and their prices [20] are given in the table 2.

Tab. 2. Typical 12 V batteries and their prices [20]

Battery capacity Ah	Price £
12	21,01
17	33,62
24	39,08
33	91,00
38	115,10
40	129,38
55	132,79
70	159,82
110	340,92

For our application different batteries can be used, but the costs will differ. For example if the 110 Ah batteries are chosen, 6 batteries are necessary (each battery 12 V, the whole minimum capacity 249 Ah). In this case the whole cost equals 6 x 240,92 £ = 2045,52 £. For 70 Ah batteries, 8 batteries are necessary. The total cost in this case is 8 x 159,82 = 1278,56 £. As was shown above although the number of batteries is bigger, the total cost is lower. Table 3 shows the total cost for different kind of batteries.

Tab. 3. The total cost of batteries for designed installation

Battery capacity Ah	Total cost £
12	42 x 21,01=882,42
17	30 x 33,62=1008,60
24	22 x 39,08 = 856,79
33	16 x 91,00=1456
38	14 x115,10=1611,40
40	14 x 129,38 = 1811,32
55	10 x 132,79=1327,90
70	8 x159,82=1278,56
110	6 x 340,92=2045,52

As was shown in Table 3 the cheapest set can be built of 24 Ah batteries. To tell you the truth 22 batteries are needed, what takes more place than the bigger capacity batteries but the cost 856,79 £ is less than a halve for the 110Ah batteries.

5. Conclusion

The device presented in this article was built and applied in solar installation. Up to now it works problem with no problems. Many times it was tested in different situations such as lack of electricity, discharged batteries and similar. It works properly. In the future the new possibilities are planned.

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