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Portable LED lamps

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Abstract. The purpose of this study was to design the Portable LED Lamp to overcome the problem of the need for power sources and lighting for outdoor activities such as camping, mountain climbing or long trips. The equipment is made up of solar cells that charge the charger through a charge controller to turn on the LED light or recharge the phone battery. The method used in this research is float charging by using the main components of LM7805 voltage regulator. The charger battery used is Li-Ion (Lithium-Ion) which is cheaper, easy to maintain and does not contain harmful substances so it is quite safe when compared to Ni-Cd (Nicke-Cadmium) and Ni-MH (Nickel-Metal Hydride). The advantages of this made system is the lithium battery can be recharged its electric charge by using solar cell power source and PLN power grid.

1. Introduction

Currently every individual has a dependence on the phone either for indoor or outdoor activities. For that we need a power source that can help power supply when the phone used its electric charge is almost gone. The rise of power bank usage is seen from the bany akad street vendors who peddle power bank with various brands with affordable price range.

Power bank is a solution that when effective in the midst of busyness, especially people who live in urban areas. Such a portable power bank instrument has been studied by several researchers. Varadarajan has created a Portable Battery Charger based solar cell to charge the battery charge for several cellular phone brands [1]. Al-Mashhadany and Attia have created Portable Battery Charger-based solar cells to charge the battery charge of portable electronics devices such as laptops and cell phones [2]. Syed and Memon have made Battery Charger-based solar cells mounted on jacket shirts [3].

Portable solar cell-based LED lights to charge lithium batteries with light weight and attractive shapes for lighting and power bank purposes have been pre-made by several researchers [1,2,3] but these are very different tools, the one that sets it apart is in terms of shape and has a function as a lamp illumination or emergency light that can overcome electrical power.

2. Methods

Portable LED Light is a portable construction tool with materials consisting of solar cells, rechargeable batteries and Charger Controller (LM7805 voltage regulator IC). Solar cells convert solar energy into electrical energy through Photovoltaic Effect [4,5] stored on lithium batteries. Charger

Controller controls the charging of lithium batteries so that the charging process is maintained at a safe condition [6,7]. Portable LED system design concept can be seen in Figure 1.

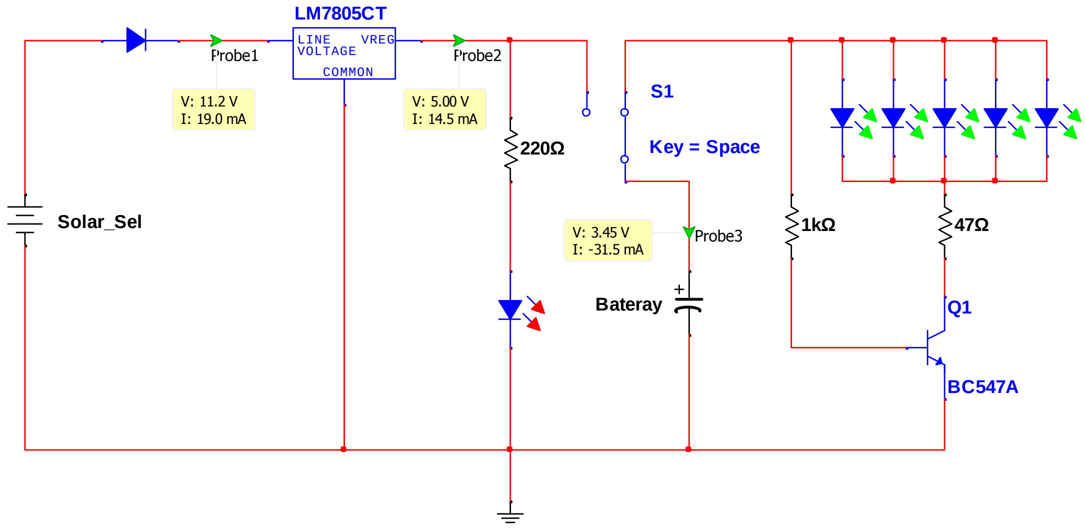

Figure 1. Concept design of Portable LED Light.

There are 4 design steps from Portable LED Light, among others are (1) calculation of solar cell size, (2) LED lamp design, (3) design of charger controller and (4) design of product form portable. The size of the amount of solar cell power (P) required to charge the lithium battery can be calculated using the following equation [6]:

$$P = \frac{C\,x\,E}{2{,}48}\,x\,1{,}1 \tag{1}$$

The materials needed in this study are solar cells with monocrystalline type and with the following specifications: Maximum Power (P_{max}) = 2,00 W_P, Voltage at Maximum Power (V_{mpp}) = 5, 00 V, Current at Maximum Power (I_{mpp}) = 0,40 A, Open Circuit Voltage (V_{oc}) = 6,00 V, Short Circuit Current (I_{sc}) = 0,44 A and Dimensions Panel (H/W/D) = 150,00 mm.

Figure 2. Solar cells.

Battery used from lithium type, because this type of battery material easy to get, cheap and easy in its care.

The voltage generated by the solar cell is supplied to the controller charger to control the lithium battery charging process. The brighter the intensity of the sunlight received by the surface of the solar cell, the greater the voltage generated by the solar cell, of course this can be bad for lithium battery

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charging process, because it takes the charger controller to overcome it. For lithium battery charging, the maximum charging voltage is 1.2 volts per cell [7].

Figure 3. Lithium battery.

The lithium battery is recharged (charge) using a constant current of 333 mA so as not to exceed the maximum voltage of each cell [6]. Battery lithium 700 mA battery charging current of 333 mA for 2 hours 10 minutes. There are several methods used in the process of charging lithium batteries such as, floating charging, taper charging (3-stage charging), pulse charging and rapid charging [7,8,9]. For this study using floating charging method, lithium batteries are charged by using a fixed voltage source that has been regulated using IC LM7805 [10]. The lithium battery charging capacity can be determined by measuring the voltage at the battery terminals when the battery is open (open circuit).

Table 1. The remaining capacity of lithium batteries.

Time Capacity (Percent)	Voltage Withoud Load (Volt)
99	6,70
89	5,85
79	5,82
69	5,64
59	5,63
49	5,40
39	5,21
29	5,02
19	4,89
9	4,49

3. Results and discussion

Rechargeable batteries are used from Li-Ion (Lithium-Ion) type. This battery is easy to obtain, cheap and easy to maintain, so it is suitable for use in Portable LED Lighting device that is concerned with safety and security factor of product and user of the product. The maximum no-load voltage generated is 6 volts with the maximum current capacity without a load of 700 mAh. The form of lithium battery used can be seen in figure 3.

With a maximum voltage of 6-volt battery, it takes 5 lithium series batteries, so the maximum battery charging voltage is 5 x 1.2 volts = 6 volts. For the voltage limits with the float charging method is 5 x 1.03 volts = 5.15 volts.

The amount of solar cell power required to charge the lithium battery charge is calculated using equation (1). Where the value of C = 700 mAh, E = 6 volts and h = 2.48 hours, obtained P = 1.18 watts. Solar cells with a maximum power of 2 watts sufficient in the design of the tool. Specification of solar cell used: Maximum Power = 2 watt, Maximum Voltage = 6 volt, Optimum Current = 333 mA, the load Voltage is zero = 7,2 volt, Type of Solar Cell = Monocrystalline and the size of Solar Cell = 11 cm x 6 cm x 0,25 cm.

To obtain a portable light design, the rectangular mechanical construction, the top of the solar cell, the inside of the supporting components and the lithium battery and the bottom is the LED light, so the shape and design of the Portable LED Lamp is shaped like a power bank in general. The design form of Portable LED Lamp can be seen in figure 4.

Figure 4. Portable LED luminaire design.

LM7805 voltage regulator circuit (charge controller) using floating charging method, as shown in Figure 1, LM7805 voltage regulator circuit capable of carrying electric current up to 5 A, for it is very suitable when connected with solar cells that have the ability to flow to reach 2 A. Filling current battery is limited to 1.89 A.

The operation of LM7805 voltage regulator starts when the condition is no load or battery is not installed. Voltage without load about 6.7 volts. The charging current is limited to 1.5 amperes. With a base-emitter transistor voltage of 0.7 volts, then the base-emitter resistance is 0.7/1.5 = 0.47 Ohm. Resistors 0.47 Ω 5 watts have been used for base-emitter resistance.

A series of lithium battery charging tests by solar cells is shown in the figure. Tests are conducted around 08:00 to 16:00 on sunny weather conditions and on cloudy weather conditions. Before performing the test, the no-load voltage on the lithium battery is measured with a value of 6.7 volts. The process of testing the voltage at the terminal solar cell (V_1) current out of the terminal solar cell (I_1) is measured, as well as the current coming out of the LM7805/terminal lithium voltage regulator (I_2) and the outlet of the LM7805 terminal terminal/lithium battery terminal (V_2).

Table 2 shows the voltage generated by solar cells in clear weather conditions from 08:00 to 16:00. From the data obtained got the average value of the large current generated by the solar cell in the no-load conditions around $i_{average}$ = 0.087, so the length of charging lithium batteries to full time takes about t_{bright} = 0,700/0,087 = 8,065 hour.

Table 2. Results of solar cell testing during sunny weather conditions.

Time	**Current (mA)**	**Voltage (*Volt*)**	**Power (*Watt*)**
08:00 - 08:59	0,016	4,490	0,072
09:00 - 09:59	0,032	4,890	0,156
10:00 - 10:59	0,101	5,820	0,588
11:00 - 11:59	0,117	5,850	0,684
12:00 - 12:59	0,298	6,000	1,788
13:00 - 13:59	0,162	5,640	0,914
14:00 - 14:59	0,092	5,630	0,518
15:00 - 15:59	0,025	5,400	0,135
15:00 - 15:59	0,014	5,210	0,073
16:00 - 16:59	0,011	5,020	0,055

Table 3 shows the voltage generated by solar cells in cloudy weather conditions from 08:00 to 16:00. From the data obtained got the average value of the large current generated by the solar cell in the condition without load about $i_{average}$ = 0.057, so the length of charging lithium batteries to full it takes about t_{dim} = 0,700/0,057 = 12,302 hour.

Table 3. The results of solar cell testing during cloudy weather conditions.

Time	Current (mA)	Voltage (*Volt*)	Power (*Watt*)
08:00 - 08:59	0,012	4,340	0,052
09:00 - 09:59	0,046	4,740	0,218
10:00 - 10:59	0,084	5,670	0,476
11:00 - 11:59	0,093	5,700	0,530
12:00 - 12:59	0,189	5,850	1,106
13:00 - 13:59	0,092	5,490	0,505
14:00 - 14:59	0,021	5,480	0,115
15:00 - 15:59	0,014	5,250	0,074
15:00 - 15:59	0,012	5,060	0,061
16:00 - 16:59	0,006	4,870	0,029

Table 4 shows the process of using the voltage stored in the lithium battery to turn on the lamp or to supply the phone battery. From these data obtained that the charge of the lithium battery capable of turning on the LED lights or supplying the phone battery with a maximum time of about 5 hours.

Table 4. Test results of tool usage.

Time of use (minute)	Residual current (mA)	Residual voltage (*Volt*)	Residual power (*Watt*)
30	0,325	4,897	1,592
60	0,307	4,759	1,461
90	0,289	4,621	1,335
120	0,271	4,483	1,215
150	0,253	4,345	1,099
180	0,235	4,207	0,989
210	0,217	4,069	0,883
240	0,199	3,931	0,782
270	0,181	3,793	0,687
300	0,163	3,655	0,596

4. Conclusion

By using appropriate technology from materials that are relatively inexpensive and easy to obtain, can be made Portable LED Lamps that form and function like a power bank in general. Portable LED Light is designed and can be used to charge the phone battery like a power bank with medium capacity, other than that this tool is equipped with LED lights that serve as lighting to overcome the power outages or while being camped. The test results indicate that the device can charge lithium batteries for 8 hours (sunny) to 12 hours (cloudy) weather. From 08:00 to 16:00. This LM7805 regulator-based floating charging method is relatively long in lithium battery charging process with maximum service life (turn on the LED light or supply / recharge the phone battery) about 5 hours. Improvement steps need to be done so that the lithium battery charging process is much faster with longer lifetime is certainly a more efficient and more effective step, for example by using dc-dc converter and 3-stage charging method.

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