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CONSTRUCTION AND OPERATION OF A SOLAR LIGHTING SYSTEM

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ABSTRACT

A solar lighting system which can make a 3w lamp glow continuously for about one hour if the battery is fully charged has been constructed. The device can be used for small-scale lighting applications in remote areas that are far away from the power grid. The system has a panel to collect the sun's energy, a battery to store that energy and a light source to use the energy. The system operates like a bank account. Withdrawals from the battery to power the light source must be compensated for by commensurate deposits of energy form the solar panels.

KEYWORDS: Solar lighting system, solar panel, integrated circuit, light source

1.0 INTRODUCTION

Solar lighting system is the use of natural light to provide illumination. Solar lighting system is the technology of obtaining usable energy from the light of the sun using semi conductor materials and this is energy efficient lighting technology. (Muhs, 2006; Earl and Muhs, 2001; Earl and Maxay, 2003). Solar panels are devices that generate power from the sun by converting sunlight into electricity with no moving parts, zero emissions and no maintenance. They are used in residential, commercial, institutional and light industrial applications.

The construction of a solar lighting system serves as a means of reducing energy imports and dependence upon oil and gas, which mitigate the risk of fuel-price volatility and supplies energy for small-scale lighting applications when and where electricity is most limited and most expensive.

2.0 MATERIALS AND METHODS

2.1 Materials

The components used in the construction are 12-16V solar panel, 12VaC 500mA transformer, capacitor, relay, integrated circuit (IC 7808), light emitting diodes, diodes, resistors, switches, lamp and printed circuit board (Muhs, 2000 and Schlegel, *et al*, 2004).

2.1.1 The relay

Fig. 1 shows the circuit symbol for a relay. A relay in an electrically operated switch that allows one circuit to switch a second circuit which can be completely separate from the first. Current flowing through the coil of the relay creates a magnetic field which attracts a lever and charges the switch contacts. The coil current can be ON or OFF, so the relays have two switch positions and can be double throw (changeover) switches as shown in figure 1.

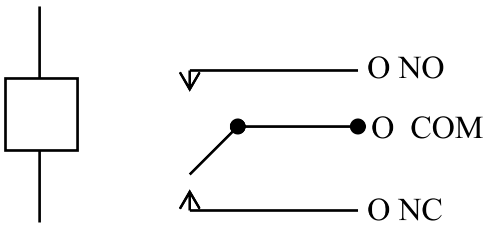

Fig. 1: Circuit symbol for a relay

2.1.2 The regulator

An automatic voltage regulator circuit is designed to be powered by a 12 AC supply. The designed circuit will fail to operate at a voltage below 12V. However, if the entire circuit draws up to 0.5A and voltage passing through it is about 12V, then the power dissipated by the regulator will be

$$1\left[\left(V_M - V_{regulated}\right)\right]$$
$$0.5\left(12 - 8\right) = 2w$$

Where 8v is the regulated voltage. Figure 2 shows the circuit diagram of the regulator.

The regulator requires a heat sink to avoid it shutting down when operated for a long time.

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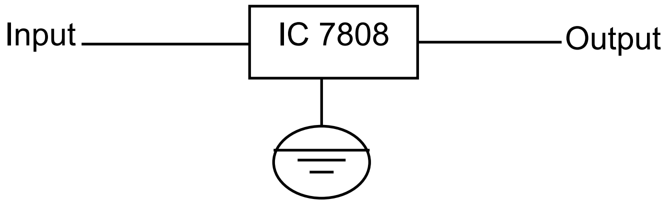

Fig. 2: Circuit diagram of a regulator

2.1.3 The power supply

The 6v, 4.5AH battery used here is charged by means of a power supply unit constructed for this purpose. Fig. 3 shows the power supply of 6V using one 2200 µf(35V) capacitor, one IC 7808 regulator, one 12V 2000Ω relay, twelve diodes, one kiloohm resistor, two 100 ohms resistors, three light emitting diodes, 12-16v solar panel and 12v transformer.

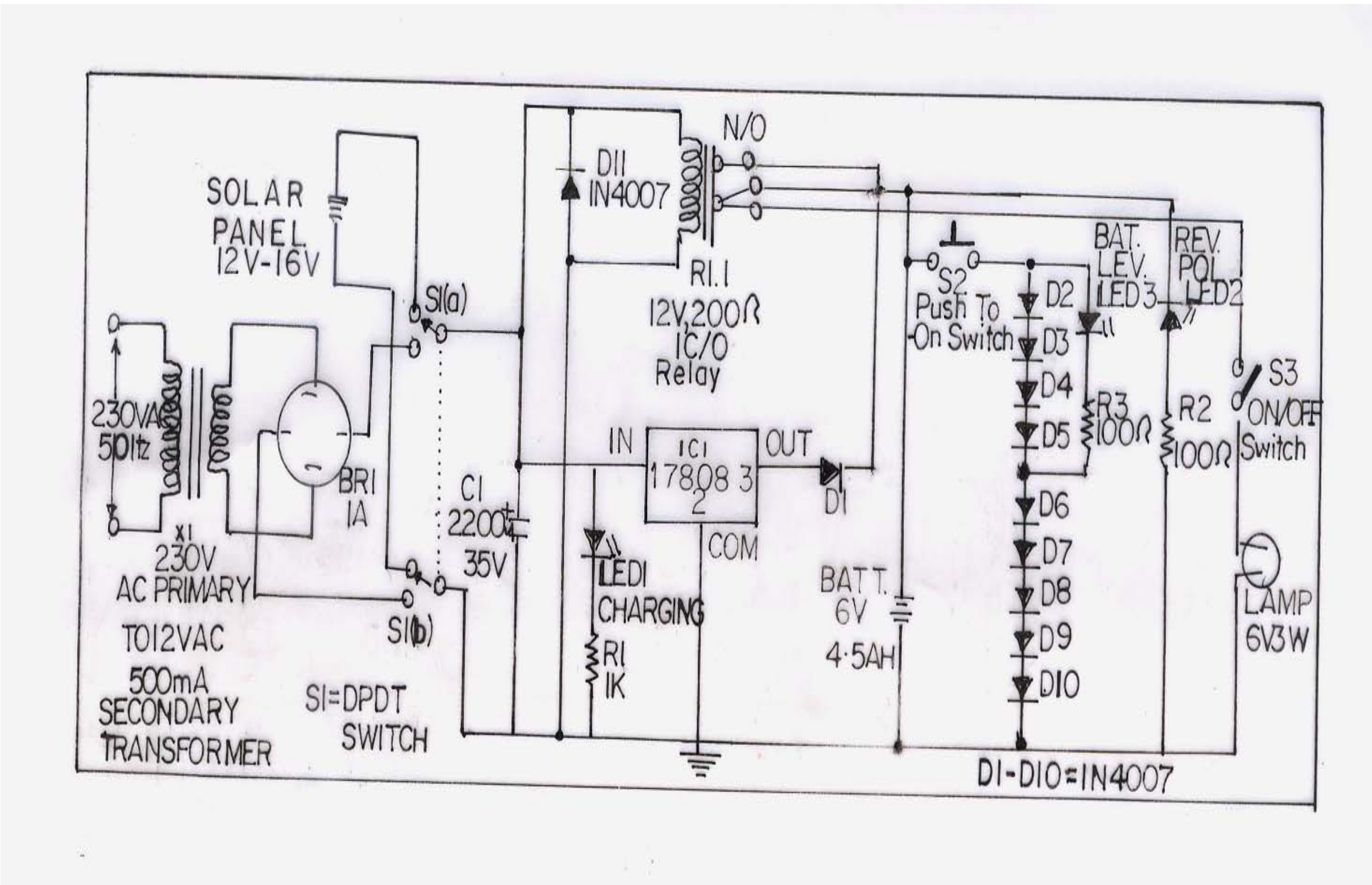

Fig. 3: Power supply circuit with component values

2.2 Method

The printed circuit board forms the chassis on which all the components listed in modules 2.1 to 2.13 were mounted and soldered as shown in the circuit layout diagram in Fig. 4. Care were taken to avoid bridging in the circuit.

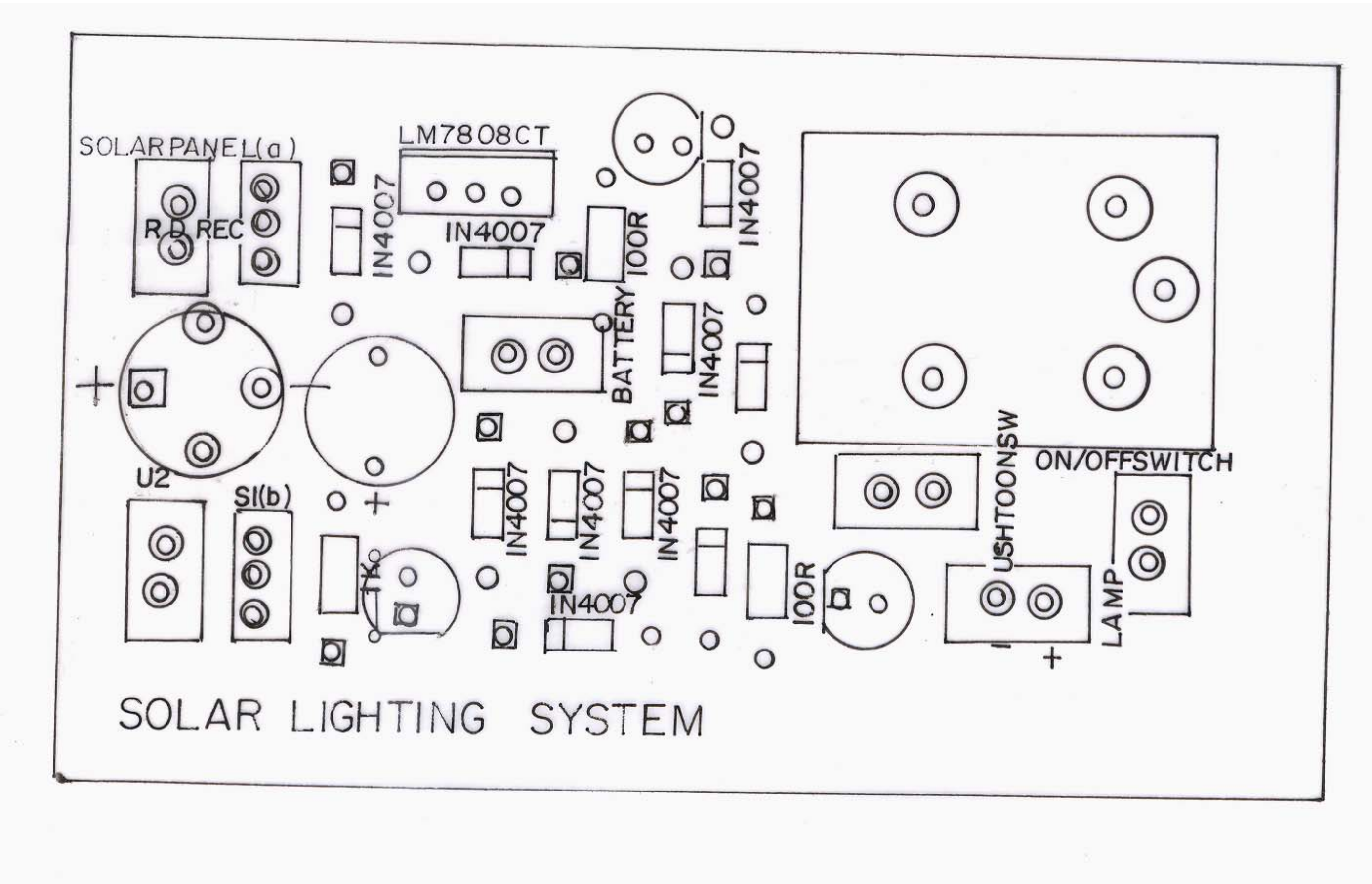

Fig. 4: Circuit layout of the constructed solar lighting system (Source: Muhs, 1999)

A dc voltage from a solar panel or a transformer was fed into the circuit as shown in the layout diagram and was regulated by double pole double throw (DPDT) switch. The circuit layout diagram of the constructed solar lighting system helps in providing the knowledge of the position of a particular component and how it is linked with other components in the circuit.

3.0 OPERATION

The circuit was powered by a solar cell, which generates direct current as the DPDT switch was directed towards the solar panel side. The dc voltage generated from the solar panel was used to charge the battery and control the relay.

Capacitor C1 connected in parallel with a 12V relay coil remained charged in daytime until the relay was activated. Capacitor C1 was used to increase the response time of the relay, so switching occurred moments after the voltage across it fell below 12V. Capacitor C1 also filters the rectifier output where the battery is charged though AC power.

During daytime, relay RL1 is energized provided DPDT switch S1 faces the solar panelside. Due to energization of relay RL1, and the positive terminal of the battery was connected to the out of regulator, IC7808 (a 3-terminal, 1A, 8V regulation) through diode D1 and normally-open (N/o) contacts of relay RL 1. Here, a 6V, 4.5AH maintenance-free, lead-acid rechargeable battery was used. It requires a constant voltage of approximately 7.3volts for its proper charging. Even though the output of the solar panel kept varying

with the light intensity, IC 7808 (IC1) was used to give a constant output of 8V. Diode D1 caused a drop of O. 7V, so giving approximately 7.3V which was used to charge the battery. LED 1 indicates that the circuit was working and the battery was in the charging mode.

At night, there will be no generation of electricity. The relay will not be energized and charging will not take place. The solar energy stored in the battery can then be used to light up the lamp. A 3w lamp glows continuous for about one hour if the battery was fully charged.

If the battery is connected in reverse polarity while charging, IC 7808 will get damaged. The circuit will indicate this damage by lighting up LED 2, which was connected in reverse with resistor R2. There is also a provision for estimating the approximate voltage in the battery. This has been done by connecting the IN4007 diodes (D2 through D11) in forward bias with the battery. The output is taken by LED 3 across diodes D2, D3, D4 and D5, which is equal to 2.8V when the battery id fully charged. LED 3 lights up at 25 volts or above. Here, it glows with the voltage drop across the four diodes, which indicates that the battery is charged. If the battery voltage falls due prolonged operation, LED 3 no longer glows as the drop across D2, D3, D4 and D5 is not enough to light it up. This indicates that the battery has gone weak. Push-to-on switch S2 has been provided to do this test whenever necessary.

If the weather is cloudy for consecutive days, the battery will not charge. So, a transformer and full wave rectifier have been added to charge the battery by using DPDT S1.

3.1 TEST AND RESULT

When the constructed system was completed, it was necessary that some tests be conducted to confirm that the circuit is working. The solar panel, when DPDT switch S1 was switched to solar panel side, supplied the required 12V dc needed to drive the charging circuit. The output of the regulator IC 7808 (a 3 terminal, 1A, 8V regulator) connected through diode, D1 was the required 7.3V dc (due to 0.7V drop across the diodes, D1) needed to charge the battery. LED 1 was 'ON' when the battery was connected in reverse polarity while charging and LED 3 was 'ON' when push-to-on switch, S2, was pressed to show the level of the battery. Finally, the lamp glows when ON/OFF switch, S2, is switched 'ON' to confirm that the battery was delivering the required voltage to the output.

Thus, the result obtained from the test shows that there was no short circuit in the system and that the designed circuit worked as it was meant to.

3.2 CONCLUSION

The process of constructing the solar lighting system just like that of any other electronic device is interesting but not quite easy. The difficulty is due to variations existing between theoretically calculated values and the actual component values used in the construction of the circuit. These variations posed problems in a situation where the researcher is a novice in the field of electronics. For instance, the practical output voltage of the solar lighting system was measured to be 5.78V on the multimeter while its theoretically calculated value from components was 6.0V. This error is mainly due to the tolerances of the components and the intensity of sunlight reaching the solar panel.

The result obtained revealed that a 3W lamp glows continuously for about one hour when the battery is fully charged.

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