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Solar Panel Based Mobile Charger and Small Led Lamp

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Abstract: **To charge a mobile phone from the DC-DC converter built, a regulator would need to be used to supply a constant voltage to the phone itself. To supplying 5V to the mobile Phone would be sufficient. The output of the built buck converter should be between 5V and 10 V. These voltages would be low enough to be input to most 5V regulators. It was decided to use a simple 5V linear regulator to perform the task.**

This research involves designing a mobile phone charging system and a LED lamp which is powered via a solar panel and that is capable of charging multiple mobile batteries simultaneously. The project also requires research into the different solar panels available for the small scale system being designed, as well as into larger solar panels that may be implemented into a building's design. Investigations will also have to be made into how the overall system would change if these larger solar panels were implemented. The small scale test system will also be able to display information visually to the user of the system regarding the systems overall capacity to charge at any given time and will also include power management functions.

The goal of this project is to create a multiple output cell phone charger. The cell phone charger is essentially a DC-DC converter. A commercial charge controller IC was sourced that met with the specifications of the project. This is the design method that the final system is based on. It is comprised of a solar panel whose voltage is regulated by a DC-DC converter. The power management of the solar panel comes in the form of maximum power point tracking (MPPT), which will be discussed in greater detail further on. For this design it entails using an outside controller to control the duty cycle of the DC-DC converter. It was decided that the DC-DC converter would have to be built in the lab, as it was difficult to find a suitable commercial converter that could be controlled in this way. The output of the converter is then applied to the back-up battery and the load.

Finally, some implementations of solar charger for portable devices are analyzed, showing drawbacks and benefits for each architecture and a complete integrated solution is proposed.

Keywords: **Solar Panel, Mobile Charger, renewable energy, solar energy.**

I. INTRODUCTION

The energy extracted from solar radiation by solar cells is vital to expanding our source of energy. Alternative sources of energy are being sought out constantly and solar energy has already been a primary source as solar cells have been in existence for many years. By figuring out how to maximize the efficiency of solar cells, engineers can build better cells and models for usage in homes and businesses. The purpose of this lab is to gain a better understanding of the relationship between solar cell voltage output and the angle of incidence with the Sun's rays. Since the Sun is never stagnant, an understanding of this relationship will help in designing practical positioning of solar cells. Engineers and solar cell manufacturers have already determined that solar cells are most efficient when placed exactly perpendicular to the Sun's rays.

The question in mind is how much power can be generated in other angular arrangements and what relationship exists between angle of incidence and power. The expectation is that the solar cell will collect power very well for a certain range after its perpendicular position and then quickly fall eventually giving no power at all. Although temperature does affect the solar cells' ability to absorb energy, the majority of energy is dependent on the intensity of the Sun's rays (its self a function of angle). A logarithmic function is expected to describe the relationship between angle and voltage output, current and power.

Solar energy is an inexhaustible resource. The sun produces vast amounts of renewable solar energy that can be collected and converted into heat and electricity. Texas, due to its large size and abundant sunshine, has the largest solar energy resources among the states. Several other states, however, lead the nation in terms of *using* solar energy, mostly due to state policies and incentives that encourage the installation of solar energy systems. California is the nation's largest solar energy market by far, and has effective state initiatives promoting the industry. Other states with notable markets for solar energy include New Jersey, Arizona, Colorado and New York. Even so, in 2006 solar energy accounted for just 0.01 percent of all U.S. electricity, mainly because of its higher costs compared to other power options.

Solar energy plays an even smaller role in the Texas electricity market. Still, Texas has the sunshine, manufacturing base and research institutions needed to become a leader in the development of solar energy .The state is well positioned to compete with other states and countries in a global solar energy market worth $10.6 billion in 2006.3 One study estimates that Texas could capture about 13percent of all new jobs and investments related to solar photovoltaic technologies by 2015, primarily in manufacturing.

Humans have harnessed the power of the sun for millennia. In the fifth century B.C., the Greeks took advantage of passive solar energy by designing their homes to capture the sun's heat during the winter. Later, the Romans improved on solar architecture by covering south-facing windows with clear materials such as mica or glass, preventing the escape of solar heat captured during the day. In the 1760s, Horace de Saussure built an insulated rectangular box with a glass cover that became the prototype for solar collectors used to heat water. The first commercial solar water heaters were sold in the U.S. in the late 1890s,and such devices continue to be used for pool and other water heating .In the late 19th century, inventors and entrepreneurs in Europe and the U.S. developed solar energy technology that would form the basis of modern designs. Among the best known of these inventors are August Mooches and William Adams. Mooches constructed the first solar-powered steam engine. William Adams used mirrors and the sun to power a steam engine, a technology now used in solar power towers. He also discovered that the element selenium produces electricity when exposed to light.

In 1954, three scientists at Bell Labs developed the first commercial photovoltaic (PV) cells, panels of which were capable of converting sunlight into enough energy to power electrical equipment. PV cells powered satellites and space capsules in the 1960s, and continue to be used for space projects. In the 1970s, advances in solar cell design brought prices down and led to their use in domestic and industrial applications. PV cells began to power light houses, railroad crossings and off shore gas and oil rigs. In 1977, solar energy received another boost when the U.S. Department of Energy created the Solar Energy Research Institute. It was subsequently renamed as the National Renewable Energy Laboratory (NREL), and its scope expanded to include research on other renewable energy sources. NREL continues to research and develop solar energy technology.

In the last 20 years, solar energy has made further inroads and now is used extensively in off -grid and remote power applications such as data monitoring and communications, well pumping and rural power supply, and in small-scale applications such as calculators and wristwatches. But solar energy has not yet achieved its potential to become a major contributor to world electrical grids. Private and government research and development in solar energy technologies have led to continuing innovation over the last 30 years. The conversion efficiency of PV cells — that is, the percentage of sunlight hitting the surface of the cell that is converted to electricity — continues to improve. Commercially available cells now on the market have efficiencies approaching 20 percent. Cell efficiencies achieved in research laboratories recently surpassed 40 percent.

The worldwide PV market has grown by an average of 30 percent annually for the past 15 years, an increase that has improved economies of scale for manufacturers. As a result, the cost of electricity generated from PV modules has fallen significantly, from more than 45 cents per kilowatt hour (kWh) in 1990 to about 23 cents per kWh in 2006. In 2006 and 2007, a shortage of silicon (a primary component of crystalline silicon PV systems) temporarily increased PV module costs, but prices are expected to decline once again between 2008 and 2011, when silicon plants currently under construction are completed.

II. CIRCUIT DIAGRAM

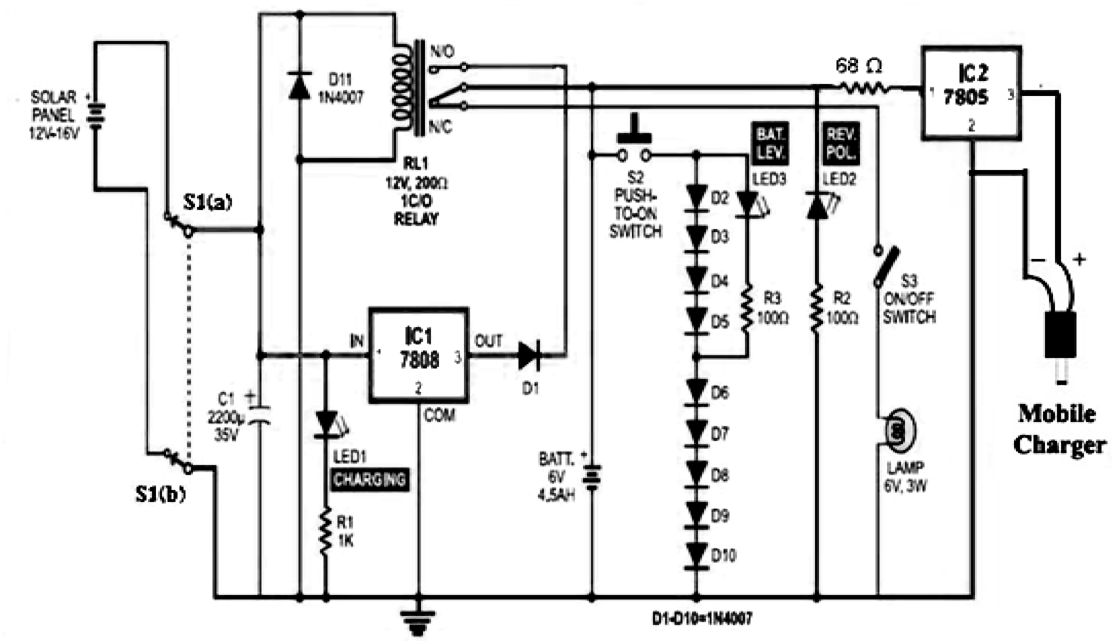

Fig 1: Solar panel based Mobile Charger and Small LED Lamp

III. CIRCUIT OPERATION

The world cannot continue to rely for long on fossil fuels for its energy requirements. Fossil fuel reserves are limited. In addition, when burnt, these add to global warming, air pollution and acid rain. So solar photovoltaic systems are ideal for providing independent electrical power and lighting in isolated rural areas that are far away from the power grid. These systems are non-polluting, don’t deplete the natural resources and are cheap in the long run. The aim of this circuit is to demonstrate how we can utilize solar light to electrify the remote areas, i.e., how we can store the solar energy and then use it for small-scale lighting applications. Solar cells generate direct current, so make sure that DPDT switch S1 is towards the solar panel side.

The DC voltage from the solar panel is used to charge the battery and control the relay. Capacitor C1 connected in parallel with a 12V relay coil remains charged in daytime until the relay is activated. Capacitor C1 is used to increase the response time of the relay, so switching occurs moments after the voltage across it falls below 12V. Capacitor C1 also filters the rectified output if the battery is charged through AC power. The higher the value of the capacitor, the more the delay in switching. The switching time is to be properly adjusted because the charging would practically stop in the early evening while we want the light to be ‘on’ during late evening. Due to energization of relay RL1, the positive terminal of the battery is connected to the output of regulator IC 7808 (a 3- terminal, 1A, 8V regulator) via diode D1 and normally-open (N/O) contacts of relay RL1. Here we have used a 6V, 4.5Ah maintenance-free, lead-acid rechargeable battery. It requires a constant voltage of approx. 7.3 volts for its proper charging. Even though the output of the solar panel keeps varying with the light, intensity, IC 7808 (IC1) is used to give a constant output of 8V. Diode D1 causes a drop of 0.7V, so we get approx. 7.3V to charge the battery. LED1 indicates that the circuit is working and the battery is in the charging mode. At night, there will be no generation of electricity. The relay will not energize and charging will not take place. The solar energy stored in the battery can then be used to light up the lamp and mobile charging system. A 3W lamp glows continuously for around 6 hours if the battery is fully charged. Instead of a 3W lamp, you can also use a parallel array of serially connected white LEDs and limiting resistors to provide sufficient light for even longer duration. In case the battery is connected in reverse polarity while charging, IC, 7808 will get damaged. The circuit indicates this damage by lighting up LED2, which is connected in reverse with resistor R2. However, the circuit provides only the indication of reverse polarity and no measure to protect the IC.

A diode can be connected in reverse to the common terminal of the IC but this would reduce the voltage available to the battery for charging by another 0.7 volt. There is also a provision for estimating the approximate voltage in the battery.

This has been done by connecting ten 1N4007 diodes (D2 through D11) in forward bias with the battery. The output is taken by LED3 across diodes D2, D3, D4 and D5, which is equal to 2.8V when the battery is fully charged. LED3 lights up at 2.5 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 to prolonged operation, LED3 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. Micro switch S1 has been provided to do this test whenever you want. If the weather is cloudy for some consecutive days, the battery will not charge. This is particularly helpful in those areas where power supply is irregular; the battery can be charged whenever mains power is available.

IV. RESULT AND DISCUSSION

Simply multiplying the %error Voltage with the %error current would lead to a false account of error (error would come out to high.) The significance of these graphs is very important to the understanding of solar cells. From the results, it shows that voltage does not change dramatically until an angle of incidence of about 45° is reached, after which voltage drops rapidly. The current and power responses to angle do not have a threshold and are non-linear. Significance of last graph: Voltage Drop vs.Angle – This graph clearly illustrates the linear and nonlinear properties of solar panel voltage output. When used in a practical application, a solar panel is commonly connected to a DC->AC converter or DC->DC transformer. What is important is that the voltage stay above a given value, the current may fluctuate depending on solar intensity. For example, a cell phone charger will work properly on 110 VAC and it will draw whatever current it needs by *Fluke*, the manufacturer of oIf the current fluctuates a little the charger will still work, but if the voltage drops below 110 VAC the charger may not work properly. Its performance is hinged on voltage much more than current. This is why solar panels have been designed to give a relatively flat voltage output within a certain span, in this case 0° ± 45° (0° = solar panel perpendicular with solar rays). The final graph shows that beyond a ± 45° angle of incidence the tested solar panels will not provide a reliable voltage.

V. CONCLUSION

The voltage output of a solar panel is approximately linear until a certain angular threshold is reached, in our case this was approximately 45°, after which voltage drops significantly. Current output fits a cosine trend: $I = IMAX * COS(\theta)$**.** Power roughly fits the we felt that this experiment went very well, but it could have been done better. Firstly, we were lucky to have absolutely no clouds in the sky, but by taking our data in November, in San Francisco, we were limited to less than optimal solar luminosity. At high noon on the day of our data collection the sun rose no higher than 31.5° above the horizon. We would recommend performing solar cell data collection at a location closer to the equator. Secondly, we ran into a problem with reflected light at oblique angles (greater than 70°.) Even though our column was covered in black fabric it still reflected light. Despite its high cost, we would recommend using black felt instead of fabric. Also, to reduce the quantity of light reflected off the base [inside the column] we recommend suspending the solar panels in the middle of the column instead of close to the base. Same trend: $P = Pmax * COS(\theta)$**.**

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