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Harvesting Solar Energy using LED Array

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ABSTRACT*:* Solar energy is radiant light and heat from the Sun harnessed using a range of evolving technologies such as solar heating, photo-voltaics, solar thermal energy, and artificial photosynthesis**.** Its additional merits include the properties like renewable, sustainable, free of cost and clean. This project evaluates the concept of employing light emitting diodes (LEDs) to harvest maximum solar energy. LEDs as a photodiodes can absorb photons and generate electron-holes. Thus, LEDs behave as small photovoltaic cells from which power can be harvested. Unlike photovoltaic cells, LEDs are not optimized to absorb light. Hence LEDs have lower light-to-electricity conversion efficiencies. However, in the scenarios such as traffic lights where a large amount of LEDs are already installed represent an energy resource whose installation and fabrication costs have already been covered by the primary application of signaling from which maximum energy can be harvested. This project evaluates the optimal array formation to harvest maximum energy and store it the rechargeable battery which can be used for various purposes.

KEYWORDS: Energy Harvesting, Optimal Array, Rechargeable Battery, Intensity, Real Traffic signal setup

I. INTRODUCTION

Energy is everywhere in the environment in the form of thermal energy, solar energy, wind energy, and mechanical energy. Energy Harvesting, plays an important role in supplying energy to various applications, is the process of capturing minute amounts of energy from one or more naturally-occurring energy sources in the environment accumulating them and storing them for small autonomous devices.There are several ways for harvesting the solar energy from the sun. Some of which includes Photovoltaic cell, Solar Thermal power plants and Pyro-electric generation systems.

This proposed method describes the technique of utilizing Light Emitting Diodes (LEDs) to harvest the abundantly available, renewable and clean solar energy from the Sun [1]. Light emanation of LEDs occurs when it is forward biased they are also capable of generating photo-current when exposed to Sun light and are hence referred to as Bidirectional devices. The internal architecture of LEDs makes them much more efficient at emitting light than at generating power. However, there are circumstances in which LEDs are already installed outdoors and exposed to sun light. These include uses such as information displays, billboards, illumination lamps and traffic signals as shown in Fig 1.These LED-based devices acts an energy resource that has been deployed already and whose installation cost has already been covered by their primary intended application of signal display[2].

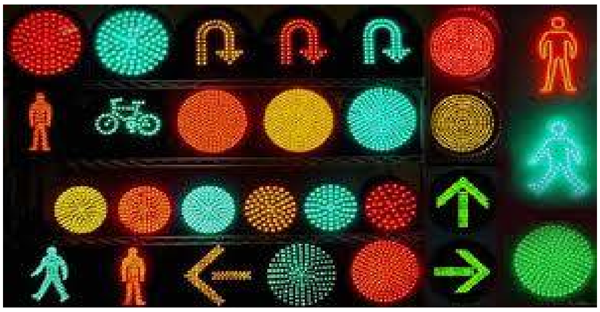

Fig.1 Traffic Signals

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II. RELATED WORK

Golsa Moayeri pour, Walter D. Leon-Salas evaluated the concept of employing Light Emitting Diodes (LEDs) to harvest solar energy [1]. Due to the optical properties of the semiconductor materials employed in the fabrication of LEDs, LEDs can absorb photons and generate electron-holes. Thus, in principle LEDs can behave as small solar cells from which power can be harvested. Unlike solar cells, LEDs are not optimized to absorb light. As a result LEDs have lower light-to-electricity conversion efficiencies. An evaluation of the energy harvesting capability of a number of LEDs has been carried out in this work. In their proposed concept, LEDs become a source and a sink of energy. A bidirectional buck-boost DC-DC converter able to transfer energy to and from the LED has been built and tested. They found that red LEDs provide the highest power.

Daniel A. Steigerwald, Jerome C. Bhat, Dave Collins, Robert M. Fletcher, Mari Ochiai Holcomb, Michael J. Ludowise, Paul S. Martin, and Serge L. Rudaz described the current state of high-power LED technology and the challenges that lay ahead for development of a true "solid state lamp" [4].They demonstrated performance and reliability for high-power colored and white LEDs and showed results from the world's first 100-plus lumen white LED lamp, the solid state equivalent of Thomas Edison's 20-W incandescent light bulb approximately one century later.

III. LIGHT EMITTING DIODES

A Light Emitting Diode (LED) is a two-lead semiconductor device made up of semiconductor materials comprising Gallium Arsenide,Gallium indium phosphide,Gallium indium arsenide phosphide,Gallium nitrite etc [3]. It is a p–n junction diode, which emits light when triggered. Electroluminescence effect is accountable for emitting light in which the electrons recombine with holes when voltage is applied across its leads of a LED. Colors of the LED highly rely on the semiconductor materials used for its manufacture. Among various colored LEDs red LEDs are found to be brightest due to its longer wavelength.

LEDs are generally known as dual devices. On one hand, they emit light when electrons and holes recombine generating photons on applying voltage across its Leads[4] .On the other hand, when photons with energy larger than the band gap of the semiconductor material used in the manufacture strike the LED, electron-hole pairs are generated giving rise to photo-current. Thus LEDs turns out to be a resource for harvesting solar energy [5].

III. BLOCK DIAGRAM

In the proposed concept of harvesting solar energy from LEDs, an array of LEDs was formed by connecting the LEDs in various patterns and the best array is revealed. The array is connected to the rechargeable battery to store the energy harvested from the sun. Fig.2 illustrates the block diagram for the Solar Energy Harvesting from the LEDs

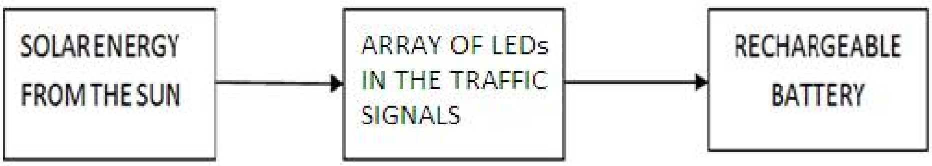

Fig.2 Block diagram

IV. ARRAY FORMATION

To explore the best possible array of LEDs to harvest huge amount of energy from the Sun, various experiments were done by connecting the LED in various fashions.

First the series connection of LEDs was made by connecting the cathode of one LED with the anode of the second LED and so on .The voltage across the connection was measured using by placing the probes of the multimeter across the

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connection. The voltage across a single LED was found to be around 0.8-1.35V. On escalating the number of LEDs the voltage increases.

Next the parallel array of LEDs was made by connecting the cathode of one LED with the cathode of next and anode of first LED with the anode of second one and so on. The voltage across the combination was measured by placing the probes of the multimeter. The voltage across single LED was found to be around 0.8 to 1.35V.On growing the combination by increasing the number of LEDs the voltage remains constant.

On evaluating the series and parallel connections it is found that in series connection the voltage increases as the number of LEDs increases where as in parallel connection the voltage remains constant even on increasing the number of LEDS.

Comparison between the voltage generated in series and parallel connection can be clearly visualized by plotting the graph between them as shown in the Fig.3

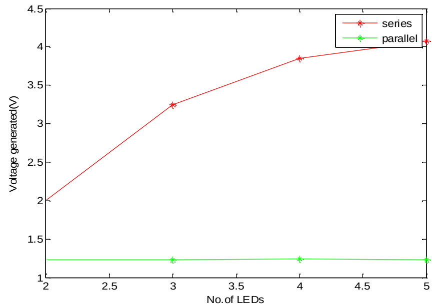

Fig.3 Plot between voltage generated and number of LEDs

Combination of Series and Parallel connection was made by connecting some LEDs in Series and some LEDs in parallel. First five LEDs were connected in series and then this connection was given parallel to other five LEDs in series connection. This combination founds to be optimum in generating the required voltage and current ratings.

V. INTENSITY OF SUNLIGHT

The Intensity of the sunlight is measured at different timings by using Lux Meter which measures the intensity of illumination. The Intensity of light is measured in Lux which is the S.I unit for measuring the intensity of illumination. It is found that the intensity of Sunlight is maximum during the afternoon.

VI. TRAFFIC LIGHT PROTOTYPE

The existing Traffic light like prototype is developed by designing a PCB with three parallel combinations of twenty four Green LEDs in series. The designing of the PCB is done using PCB wizard3 software as shown in the Fig.4 and the PCB layout is fabricated.

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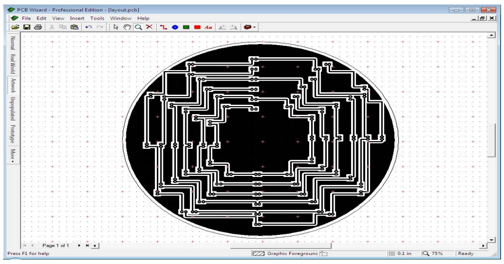

Fig.4 Design of PCB

The designed PCB is mounted on the vertical Stand of height six feet and the voltage is measured using the multimeter across the two ends from the PCB. The experiment was done around 3.20 PM and the voltage generated by the single LED is around 0.08-0.5V. It is found from the Table 2 that the maximum voltage of 5.37V is recorded which is lower compared to when the PCB is exposed directly to the Sun. The reason is that exposure to light will be less as the PCB is vertical with respect to the ground.

Table 1 Voltage recorded with the designed PCB consisting of LED array

Experimental Condition	Voltage Generated (Volts)
Direct exposure to the Sunlight(With the LEDs facing upwards)	10.30
PCB fixed to the vertical stand and transparent sunshade	8.68

VII. REFLECTION OF LIGHT WITH THE HELP OF MIRROR

In order to focus the sunlight on to the LED array, mirror can be used. The advantages of using mirror to reflect the sunlight is that it is cost effective and easy to implement in the existing traffic signal system.

Table 2 Experiments with the Mirror

Experimental Condition	Voltage Generated(Volts)
With Sunshade like Setup (using Metal Sheet)	7.692
With Sunshade like Setup (using Metal Sheet) & Mirror	8.562

The experiments with the mirror as shown in Fig.5 yielded better results compared to the results experiments without mirror as inferred from the Table 2.The experiment is done at 3.30PM and the voltage generated by the single LED is around 0.07-0.5V

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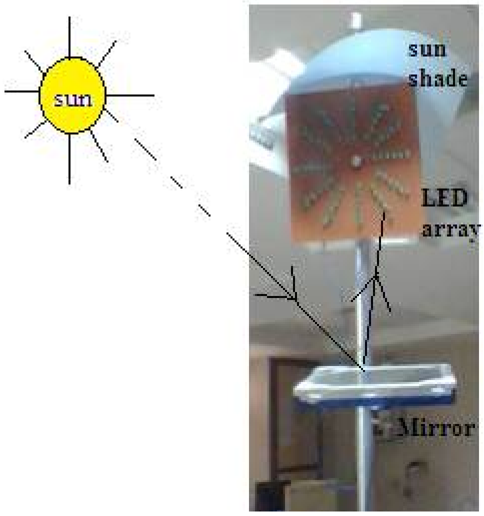


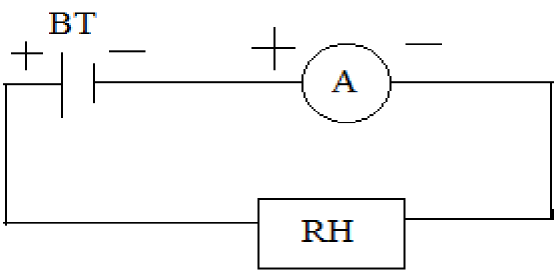
Fig.5 Real Traffic signal like Set up

VII. CHARGING OF RECHARGEABLE BATTERY

The Rechargeable battery was completely exhausted by applying variable load with the help of a rheostat. The fully exhausted rechargeable battery is connected to the array of LEDs to store the voltage generated when exposed to sunlight. The intensity of the sunlight during charging was measured using Lux Meter and the time required for charging was noted down. The array contains a combination of series and parallel connection of LEDs

VIII. MEASUREMENT OF CURRENT

Current rating of the rechargeable battery can be determined by applying a variable load with the help of a rheostat. The current rating of battery is a desired parameter for the usage of the battery in various applications. The rheostat provides a variable loads on varying the position of the slider. The multimeter is used for measuring the current. The Fig.6 illustrates circuit for the measurement of current. The current provided by the battery for various load resistance.



BT-Battery A-Ammeter RH-Rheostat

Fig.6 circuit for the measurement of current

From the conduct test it is found that as the resistance of the load increases the current drawn from the battery is reduced.

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IX.DESIGNED PROTOTYPE

Finally the designed Traffic Light signal with the mirror fixed with the adjustable screw is as shown in the Fig.7.The mirror is fixed with the adjustable screw in order to vary the angle of tilt of the mirror according to the location of Sun. The voltage generation greatly depends on the materials used for the LED manufacture as different shades of colour have different wavelength.

Fig 7 Designed Prototype Model

X.CONCLUSION

An evaluation of the concept of using LEDs to harvest solar energy has been offered. Optimal LEDs array was the combination of Series and Parallel connection as it provides a considerable voltage and current rating. The intensity of the light was measured using Lux Meter and found that the intensity is maximum during afternoon. The optimal array containing the combination of series and Parallel combination was designed using PCB wizard software and fabricated. Various experiments are done using the designed PCB. Mirror was used to reflect the sunlight on to the PCB. The ends of the PCB are connected to rechargeable battery to store the harvested solar energy for various purposes. The charging of a battery took a twice longer time than the time taken for charging using electrical supply. The Rechargeable battery which stored the solar energy was applied to the various loads by means of rheostat. The generation of voltage varies from one LED to another due to its internal characteristics of materials used for its manufacture. Finally a prototype of traffic light with the solar energy harvesting capability is made and the abundant free of cost solar energy is harvested.

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