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Design and Construction of Solar Power-Based Lighting System

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Abstract

Over the years, security posed a major concern at night due to the total darkness. The need to supply light without manually switching it on and off arises as years roll by. Automatic Street Light Control System is a simple yet powerful concept, which uses transistor as a switch. This paper presents how solar energy is being harnessed to power street light and virtually removes manual works to 100%. The system automatically switches ON lights when the sunlight goes below the visible region of the eyes. This is done by a sensor called Light Dependant Resistor (LDR) which senses the light actually like the human eyes. It automatically switches OFF lights whenever the sunlight comes, visible to the eyes.

By using this system energy consumption is also reduced because presently the manually operated street lights are not switched off at sunlight nor switched on earlier before sunset.

Keywords:

Introduction

Light is crucial in everyday activity for the continuity of normal life. From plants to animals, from human beings to domestic insects, from technology to science, nothing seems to maximize its existence without the availability of light (Garg, and Prakash, 2000). Even the human eye requires some amount of light to function well (Perlin, 1999). Light from the sun is natural and it is called sunlight. This sunlight can serve as a source of solar power which is converted to electric power for both household and industrial utilization.

Solar power is the generation of electricity from sunlight. This can be direct as with photovoltaic (PV) or indirect as with concentrating solar power (CSP) (Holladay, 2008) where the sun's energy is focused to boil water which is then used to provide energy. Solar power is a predictably intermittent energy source, meaning that while solar power is not available at all times, we can predict with a very good degree of accuracy when it will not be available (Wikipedia, 2010). One area of application of solar energy is found in the construction of solar-powered street lights. This is the equipment that is paramount to meeting the security needs of every community in the 21st century (Maloney, 1996).

Solar street lights are beneficial in that the day to day running and maintenance costs are reduced, save energy, environment friendly and convenient to install. It is powered by mono-crystalline and poly-crystalline solar panels which convert the solar energy into electricity saved in the storage batteries without maintenance (Callister, 1997). It can be controlled by a control system to prevent storage batteries from over-charging and over-discharging.

Automatic streetlight needs no manual operation of switching ON and OFF. The system itself detects whether there is need for light or not. When darkness rises to a certain level then automatically streetlight is switched ON and when there is other source of light, the streetlight switches OFF. This is done by a sensor called light dependent resistor (LDR) which senses the light actually like our eyes. This vital use of light gives rise to the idea of using solar energy to power street lights as an alternative to electricity. These solar-powered street lights can then be used for the provision of illumination on roads at night to enhance security and prevent accidents that may otherwise occur due to poor visibility (Mischke and Shigley, 2002).

The System Design

The design is such that the solar panel will be installed on the galvanized pole considering some specifications like angle of tilt and direction of sunlight. The 12V dc battery that will power the LED bulbs will be connected to the solar panel via the charge controller for charging purpose. The pole will be constructed such that it will be able to hold the LED bulb or lamp.

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PV Module

Photovoltaic (PV) is a method of generating electrical power by converting solar radiation into direct current electricity using semiconductors that exhibit the photovoltaic effect. Photovoltaic power generation employs solar panels composed of a number of solar cells containing a photovoltaic material. Materials presently used for photovoltaics include monocrystalline silicon, polycrystalline silicon, amorphous silicon, cadmium telluride and copper indium gallium selenide/sulfide.

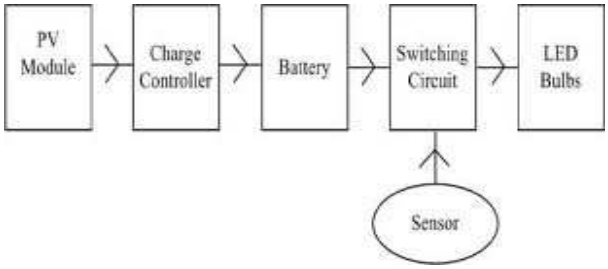

Figure 1: The Block Diagram of the System.

Photovoltaic module or solar module is a packaged, connected assembly of photovoltaic cells. The solar panel can be used as a component of larger photovoltaic system to generate and supply electricity. Because a single solar panel can produce only a limited amount of power, most installations contain multiple panels. a photovoltaic system typically includes an array of solar panels, an inverter, and sometimes a solar tracker and interconnection wiring. Electrical connections are made in series to achieve a desired output voltage and/or in parallel to provide a desired current capability. The conducting wires that take the current off the panels may contain silver, copper or other non-magnetic conductive transition metals. The cells must be connected electrically to one another and to the rest of the system.

Charge Controller

The charge controller serves as an interface between the current generated by the module and the battery charging during the day. The battery is prevented from over-current or over- charging by the charge controller. The charge controller is an electronic circuit comprising an operational amplifier (connected in comparator mode), an electronic switch (transistor) and an electromechanical switch (relay). The circuit is switched ON or OFF by the transistor in saturation region or cut off region respectively, which is controlled by the signal from LDR. The collector current from the transistor toggles between ON or OFF modes.

Battery

A Battery is an electric cell or a device that converts chemical energy into electricity. It consists of two or more cells connected in series or parallel, but the term is also used for single cells. All cells consist of a liquid, paste, or solid electrolyte and a positive electrode, and a negative electrode. The electrolyte is an ionic conductor; one of the electrodes will react, producing electrons, while the other will accept electrons. When the electrodes are connected to a device to be powered, called a load, an electrical current flows.

Swicthing Circuit And Sensor

The sensor is used to detect the intensity of light. Used in this system is a light-sensitive sensor that responds to the amount of light detected. When the light is too low such as at dusk or under heavy overcast skies: the switching circuit within the street light system is ignited by the sensor to activate the flow of electricity. When the sensor detects too much light, the sensor will tell the switching circuit to deactivate the light. The switching circuit is responsible for the activation and deactivation of light based on the response received from the sensor.

LED Bulbs

These are lamps made from semiconductor materials in the similitude of light emitting diodes such that several light emitting diodes are combined to yield an LED lamp. Since the output of an individual unit in terms of power is small compared to incandescent and compact fluorescent lamps, the most recent of these lamps possess internal circuits that make them operate from standard AC voltage. However, for the sake of this project, DC lamps are to be used. LED lamps offer long life and high efficiency, but with initial high costs compared to fluorescent tubes or lamps. LED units naturally emit light in a very small band of wavelengths, thereby producing strongly coloured lights. The
colour is a characteristic of the energy band gap of the semiconductor material used in manufacturing it. The complete connection of the system is shown in figure 2.

The System Operation

The solar tracker in the solar panel tracks the sunlight and the light detected is converted to electric power using the photovoltaic effect. The electric power is used to charge the battery and the charger controller embedded in the street light system is used to prevent the overcharging of the battery. The photocells detect if light is needed. Photocells are light sensitive sensors that respond to the amount of light detected. When the light is too low, such as at dusk or under heavy overcast skies,

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the sensor tells the switching circuit within the street light system to activate the flow of electricity and the electricity is sent through high-intensity discharge lamps. When the sensor detects too much light, the sensor will deactivate the street light (e.g., at dawn). Figure 3 and figure 4 show the complete installation and the connection to the battery respectively. Figure 5 also shows the working mode of the system.

Figure 3: The Complete Installation

Figure 2: The Complete Connection

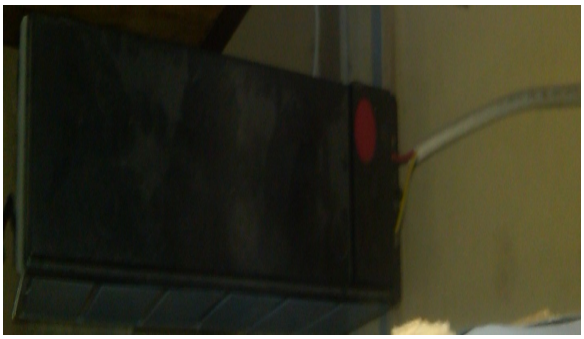

Figure 4: Connection to the Battery

Figure 5: Light glow from the LED lamp

Conclusion

The solar-powered street light was designed and constructed such that the conventional need for inverter or utility power source is eliminated. As known due to prior knowledge that the street light system needs a charge controller to prevent the battery from damage and also a sensor to help in the automatic switching, the equipment was fabricated along with a switching circuit which activates and deactivate the system as well as a charge controller unit that prevents the battery from overcharging.

The system was also built to conserve energy with the use of a light emitting diode lamp (LED lamp) to replace other lamps such as the fluorescent lamp which might reduce the efficiency of the battery. Also, the use of an inverter was eliminated since the solar panel supply direct current (dc) necessary to charge the battery without the need for a con- version to an alternating current (ac). The main improvement of this project has been the elimination of a dc to ac inverter unit.

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