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Review Article

Solar Powered Lighting System with New Technologies and Devices

Velivelli Vijaya Lakshmi[1]* and M Roshita Devi[2]

[1]*Professor, College of Community Science, PJTSAU, Hyderabad, India*

[2]*M Sc Student, PJTSAU, Hyderabad, India*

***Corresponding Author:** Velivelli Vijaya Lakshmi, Professor, College of Community Science, PJTSAU, Hyderabad, India.

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Abstract

Today, the worldwide research trends are heading towards manufacturing of environmental friendly outcomes embedded with new devices and technologies. PV technology is the most important technology in generating electricity which also provides a solution to the global warming. The paper presents an innovation of the automatic lighting system with the solar as the main source to harness its energy to power the solar lighting system. Using of new devices like microcontroller, solar concentrator, IR sensor, LDR, PIR motion sensor and Nano-wire LED based solar cell would improve the operation of the solar lighting system efficiently.

Keywords: Solar; Energy; Photovoltaic; LED; Charge Controller; Battery; Circuit

Introduction

The photovoltaic (PV) energy is proving to be the most useful non-conventional energy in the present scenario, by controlling global warming and energy depletion by increasing energy production. It is growing to be the strongest technology in generating electricity. It has demonstrated recent annual growth rates of around 40% and world production of 10.66 GW in 2009. It has no air pollution or waste. Also, it is a noise free energy. The lifetime of the solar cell is more than two decades which is helping the consumers to minimize the expenses of maintenance and management. PV generation has limitations on the amount of sunlight available, temperature raised in different places and different seasons, and other environmental conditions like fog, smoke and dust formation. Also, the efficiency of PV system is very low to convert the energy. Thus, to minimize these weaknesses, different techniques were suggested to increase the efficiency of the solar cell and electric power consumption by the users [6]. Although at present, various solar streetlamps are gaining popularity in the market to satisfy the basic needs of lighting, there is a great loss of energy during the daytime due to the ineffective and improper utilization of solar energy. Due to which there is a great loss of power as the luminance of the streetlamps remains constant. Because streetlamps are unable to adjust quickly as per the seasonal changes in the surrounding environment (C. Y. Fu, 2013). Therefore, it is very much essential to design an improved version of the existing solar street lamp system to conserve energy [8]. But to make the field technologies more viable in the present context, the main consideration has to be given to complete automation, energy conservation and cost effectiveness. Energy efficient mechanisms like disconnecting the lights from the grid and replacing the existing lights with solar LED lamps can reduce the lighting cost drastically. There are various strategies and methods like using rechargeable battery, regular cleaning of panels, remote control system etc. to control street lighting systems to reduce the energy consumption and money spent on maintaining it and to enhance its usage [2]. Thus, the present paper tried to explore the new devices helpful in improving the performance of solar lighting system.

Methodology

It is an exploratory work done to review the articles by using secondary sources of data. Search engines like Research gate, Academia, Google, Google scholar, CERA etc. were used to collect the information pertaining to the devices available in the market to operate the solar lighting system efficiently.

Findings

Various devices are traced out through review of literature and presented as follows.

Microcontroller-based solar charge controller

The microcontroller is the main component of the charge controller. The microcontroller will aid in charging the battery cell through maintaining constant voltage that enters and exits from the battery by optimally using the day light. During nighttime, Light Emitting Diode (LED) array unit will be turned on and charger will be turned off by micro controller [7]. RIDE software was used in writing and assembling the programme. Desired output by the solar charge controller is generated with the help of complete circuit along with programmed microcontroller by following the standard testing procedures. Parallel circuit is used in the controller so that voltage is constant across all the components and minimises the loss of mill amps of current also in order to charge the battery. Otherwise, the charging current will be wasted in a low value high wattage resistor once the battery is charged. Hence parallel regulation is used with slight modification in this charge controller. In order to save the charging current, battery is topped up by pulsing and applying the trickle current. Battery voltage is continuously monitored when the battery is being charged. As the battery voltage reaches up to maximum voltage i.e., 14V, the charging current is interrupted by microcontroller and starts the 5 min timer by energizing relay connected to MOSFET T2. The LCD shows "Battery full" at this juncture. When power is on, value is displayed on an LCD by reading the battery voltage using ADC. Accordingly, signals from a dusk-to-dawn sensor are monitored and activates a load or charging relay (RL_1). The relay reconnects the panel to the battery after 5 min. Now, the charging current is pulsed at 5 min intervals. "Load On" message will be displayed when MOSFET T3 via optocoupler IC3 is switched on by getting activated by microcontroller, which is possible only when voltage of ZDI of the dusk-to-dawn sensor is more than panel voltage. Low battery is monitored by the microcontroller monitors in this mode [6].

Charge controller circuit

An LM2941CT low voltage dropout and a 1N5817 Schottky diode are embedded in the charge controller. Solar power is passed through integrated concentrating to the rechargeable battery till it is filled. After that, charge voltage is maintained by charge current. At nighttime, discharge of the battery is prevented through the charge controller by the Schottky diode. The charge controller is connected to the load that has USB port by LED circuitry which has an IC, a switch, and a sub-circuit. This LED circuitry also consists of an LM317L and a low voltage disconnects circuit (LVD) which is operated by a switch fixed in the circuitry. LED will light up or turn off depending on the on/off position of switch. Switch will be on when there is a current flow. A Zener diode and a 2N3904 transistor are present in LVD that will cause the LED power to drop. In this situation, the battery gets discharged like a laptop battery. This transistor and diode thus improve the lifespan of the battery. The LM317L IC acts as current regulator and provides overload protection for the load [5].

Light sensor

In the system for sensing sun light uses the cadmium sulphide (CdS) photocell. This is a cheaper and a simple component. The resistance of CdS photocell is inversely proportionate to the quantity of light intensity. It means with increasing the light intensity the resistance of the photocell is getting decrease and vice versa [1].

IR (Infrared) LED

It's widely known as IR transmitter, its mainly used for transmission of a special purpose infrared rays within the range of 760 nm wavelength. This can be two types- gallium arsenide and aluminium gallium arsenide [1].

PIR motion detector

It is a great invention known as Pyroelectric or passive infrared (PIR) sensor. Thermal energy is emitted in the form of radiation by every living object that has a temperature above perfect zero. Thus, human beings radiate at wavelength of 9-10 micrometres though out the day. This wavelength is detected when a human being comes in the proximity of the PIR sensor, which gets turned on during detection. Gizmo does not even reach the 2 c.m. mark in size behind the smart response to motion. When electricity is generated with low amplitude from heat, it is known as pyro electricity. Sensors are termed as passive when they do not have an infrared

source of its own. It has a range of 10 meter. PIR sensor detects infrared radiation of the human body. It has a single output that goes high when motion is detected. In the case of security when someone comes closer to PIR sensor its monitoring circuit turn on the light and burglar alarm [4].

LCD

LCD (Liquid Crystal Display), a very thin technology based on the combination of liquid and crystal is used to display all the status of the circuit such as voltage of battery, motion detected notification and display which power source utilise. Liquid state produces an image for display [4].

LDR

Resistance of the Light dependent resistor (LDR) is varied according to the amount of light falling on its surface. Its resistance will get decreased when the LDR detects light which in turn increases the resistance [3]. The LDR has two major roles i.e., to sense daylight, by distinguishing day from night in order to initiate the charging process if required and to manage the consumption of the voltage of the battery during dawn and dusk. This can be achieved when traditional light bulbs are replaced by an array of LEDs. Based on the voltage output of the LDR, an array of LEDs to be switched on or off will be controlled by the microcontroller through its output ports [7].

XBee module

It is a low cost and wireless sensor works like a radio which is compact in size with low power consumption and less expensive. Thus, it became a feasible choice for the application in this solar techonological system. It has a range less than 3.5 kilometer. The status of the system is observed with the help of a central controlling and monitoring unit. This is possible only when the XBee interface allows the node to communicate. Thus, the status of its LEDs, LDR reading, and the voltage level of its battery are reported by each node to the central unit. Any malfunction in the nodes is deducted by the central monitoring unit [7].

GSM interface

A global system for mobile communication (GSM) module could be installed into one of the nodes, over and above its XBee module. However, GSM is adapted only if the central unit is placed in a remote area where the XBee module cannot reach, and to communicate with the central unit. In this context, nodes will directly report to central unit provided they are within range to this master node [7].

Conclusion

Use of renewable energy sources like solar lighting systems ensures 100% energy saving and CO^2 emissions. Cost of hardware requirements of solar power-based technologies will be covered by the cost of energy saved. Solar powered outdoor lighting system is efficient in several aspects like power saving, in traffic sensing system, auto bright and dim technique. Based on the comparative studies on several lighting systems, it is energy efficient and makes this cost effective reliable. However, proper care and maintenance is required for long term sustenance of these technologies. Users need to be educated about post purchase use and care while manufacturers must take the responsibility of providing after sales services.

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