FULLY AUTOMATIC ALL IN ONE SOLAR STREET LIGHT FOR SMART CITIES IN INDIA

[1]Rahul G. Suryavanshi, [2]Sonal Suryavanshi, [3]Balwant Patil, [4]Aniket Pawar
[1]Assistant Professor, [2] Assistant Professor, [3] Assistant Professor, [4]Student
[1]Electrical & Electronic Department,
[1]Gogte Institute of Technology, Belagavi, INDIA

Abstract— With the growing awareness towards the use of energy efficient systems the most prominent step by the government of India is to replace the convention street lighting system by the stand alone solar LED street lights. This system has almost no running cost with minimum maintenance. These street lights are environmental friendly & provides better illumination at lower wattage which has made them a popular choice amongst the developed and developing countries.
These street lights require a panel, charge controller and a bulky battery along with the battery holding box to be mounted on a single pole. The major issue concerned with this system in rural areas or in the isolated areas are theft of the batteries, maintenance issues during the failure of lamp or any other component and ON OFF control.
This paper deals in developing an all in one solar LED Street light which is a intelligent compact lighting solution integrated along with the body of the solar panels empaneled with the dawn to dusk charge controller, lithium-ion batteries, GSM module and a PIR motion sensor. This entire assembly is mounted at the backside of the solar panel in an enclosed system which avoids the theft. The use of the PIR motion sensor enables the adjusting of LED light brightness intelligently and can subsequently lead to energy saving, also the use of GSM module sends a sms to the maintenance person whenever the LED light is not working.
The project was carried out using a 40W solar panel, 14Ah Li-Po battery and 24W LED plate. The results obtained from this product were satisfactory.

Index Terms—LED, Solar Panel, PIR sensor, GSM module, dawn to dusk controller

I. INTRODUCTION

Today the major concern in the world is global warming and climate change issue. All the countries are promoting renewable energy sources to tackle these issues which have made the researchers to work in his area. Government of India has also promoted the use of renewable energy sources for various applications through various schemes and subsidy. One of the major step towards this is replacement of conventional lighting system with the highly efficient LED based solar street lighting system. The street lighting system has become a prominent source of lighting mostly in rural India. These are self-sustained standalone system which does not require any grid connectivity avoiding any kind of transmission loss. As the LED work on DC supply, AC to DC convertor losses are also avoided making them more efficient systems. So, solar powered LED lighting systems are the ideal combination for outdoor lighting. This system has almost no running cost with minimum maintenance. They are environmental friendly & provide better illumination at lower wattage which has made them a popular choice amongst the developed and developing countries [1][2].

These street lights require a panel, charge controller and a bulky battery along with the battery holding box to be mounted on a single pole. The major drawback with this system is the theft of the batteries which are mounted on the pole. Also if they are in any of remote locations then the maintenance issues such as failure of lamp due to drivers, converter or battery failure is unattended due to lack of information to the maintenance persons. Apart from this another major issue is these street light is they are kept ON during day time resulting in completely discharging the battery and affects the battery life.

This paper deals in developing an all in one solar LED Street light which is an intelligent compact lighting solution integrated along with the body of the solar panels empaneled with the dawn to dusk charge controller, lithium-ion batteries, GSM module and a PIR motion sensor. The use of the PIR motion sensor enables the adjusting of LED light brightness intelligently and can subsequently lead to energy saving, also the use of GSM module sends a sms to the maintenance person whenever the LED light is not working.

II. WORKING COMPONENTS

Wherever Times is specified, Times Roman or Times New Roman may be used. If neither is available on your word processor, please use the font closest in appearance to Times. Avoid using bit-mapped fonts. True Type 1 or Open Type fonts are required. Please embed all fonts, in particular symbol fonts, as well, for math, etc.

A. ***Solar Panel***: Solar panel is one of the most important parts of a solar street lights. It concerts the solar energy into electricity in DC form. A 40W polycrystalline solar panel is used for the entire concept.

B. ***MPPT Charge Controller:*** maximum power point tracker (MPPT) charge controller is an electronic DC to DC converter that optimizes the match between the solar panels and the battery bank. To put it simply, they convert a higher voltage DC output from solar panels down to the lower voltage needed to charge batteries. These controllers extract the maximum available power from PV module by making them operate at the optimum voltage (maximum power point) i.e. MPPT checks output of PV module and compares it to battery voltage then finds the maximum power that PV module can produce to charge the battery and converts it to the optimum voltage so as to get the maximum amps into the battery. The MPPT charge controller used in the project was designed using a incremental conductance algorithm for a rated voltage of 12V at 6A.

C. ***LED array:*** An SMD LED Module (surface-mount device light-emitting diode module) is a type of LED module that uses surface-mount technology (SMT) to mount LED chips on printed circuit boards (PCB). It is a self-contained plate on which LED's are mounted on the top surface and is specially designed to function on its own or to plug into a compatible unit. A 20W, SMD with 3030 LED array was used.

D. ***Lithium Polymer (Li-Po) battery:*** These battery are compact, lightweight and are rechargeable. They work on lithium-ion technology using a polymer electrolyte instead of a liquid one. A highly conductive semisolid (gel) polymers form this electrolyte. These batteries provide a higher specific energy than other lithium-battery. A 12V, 14Ah battery was used. This provides a battery backup of 12 hours for the load of 20W LED array. It has a weight of 600 Gms and has a dimension of 29.4 x 21.4 x 8.8 cm [3].

E. ***PIR sensor:*** A passive infrared sensor (PIR sensor) is an electronic sensor that measures infrared (IR) light radiating from objects in its field of view. These sensors are usually used for for motion detection. All objects with a temperature above absolute zero emit heat energy in the form of radiation. Usually this radiation isn't visible to the human eye because it radiates at infrared wavelengths, but it can be detected by PIR sensors. A single PIR sensor detects change in the infrared radiation on it, which varies depending on the temperature and surface characteristics of the objects in front of the sensor. When an object, such as a human, passes in front of the background, such as a wall, the temperature at that point in the sensor's field of view will rise from room temperature to body temperature, and then back again. The sensor converts the resulting change in the incoming infrared radiation into a change in the output voltage, and this triggers the detection.

F. ***GSM Module:*** A SIM900 GSM module is used in this product. It is a complete Quad-band GSM/GPRS module in a SMT type and designed with a very powerful single-chip processor integrating AMR926EJ-S core. It delivers GSM/GPRS 850/900/1800/1900MHz performance for voice, SMS, Data, and Fax in a small form factor and with low power consumption. It has a compact design of 24mm x 24mm x 3 mm.

- ***General features***
  - Quad-Band 850/900/1800/1900 MHz
  - GPRS multi-slot class 10/8
  - GPRS mobile station class B
  - Compliant to GSM phase 2/2+
  - Class 4 (2 W @850/ 900 MHz)
  - Class 1 (1 W @ 1800/1900MHz)
  - SAIC (Single Antenna Interference Cancellation) support
  - Dimensions: 24 x 24 x 3 mm
  - Weight: 3.4g
  - Control via AT commands (GSM 07.07 ,07.05 and SIMCOM enhanced AT Commands)
  - SIM application toolkit
  - Supply voltage range : 3.2 ... 4.8V
  - Low power consumption: 1.0mA (sleep mode & BS-PA-MFRMS=9)
  - Operation temperature: -40°C to +85 °C.

G. ***Photoresistor:*** A photoresistor (light-dependent resistor, LDR) is a light-controlled variable resistor. The resistance of a photoresistor decreases with increasing incident light intensity. The LDR is connected along with a resistance in the circuit. The voltage drop at the connection between the LDR and resistance changes as the light amount falling on the LDR changes. This voltage change is detected by the analog pin of the Arduino. Internally this analog voltage signal gets converted into digital signal or values. This forms the input to the Arduino. The output of the arduino is connected to a relay which turns on when the supply is high and turns ON the LED lamp.

H. ***Voltage Sensor:*** This module is based on resistive voltage divider design principles. It reduces the terminal voltage by 5 times of original voltage and gives it to the input port of the arduino. The max Arduino analog input voltage is 5 V, so the input voltage of this module should be not more than 5 V x 5 = 25 V whereas the input voltage of should be more than 0.00489 V x 5 = 0.02445 V.

I. ***Arduino uno processor:*** The Arduino Uno is a microcontroller board based on the ATmega328. The Arduino Uno has 14 digital input/output pins (of which 6 can be used as PWM outputs),6 analog inputs, a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It has a Atmega8U2 microcontroller chip programmed as a USB-to-serial converter [9].

- ***Features of the Arduino UNO***
  - Microcontroller: ATmega328
  - Operating Voltage: 5V
  - Input Voltage (recommended): 7-12V
  - Input Voltage (limits): 6-20V
  - Digital I/O Pins: 14 (of which 6 provide PWM output)Analog Input Pins: 6
  - DC Current per I/O Pin: 40 mA
  - DC Current for 3.3V Pin: 50 mA
  - Flash Memory: 32 KB of which 0.5 KB used by boot loader
  - SRAM: 2 KB (ATmega328)
  - EEPROM: 1 KB (ATmega328)
  - Clock Speed: 16 MHz

III. METHODOLOGY

The Smart Solar Street light is, in essence, an integration or combination of a PV module, a Charge controller, a battery, smart circuitry & LED lights.

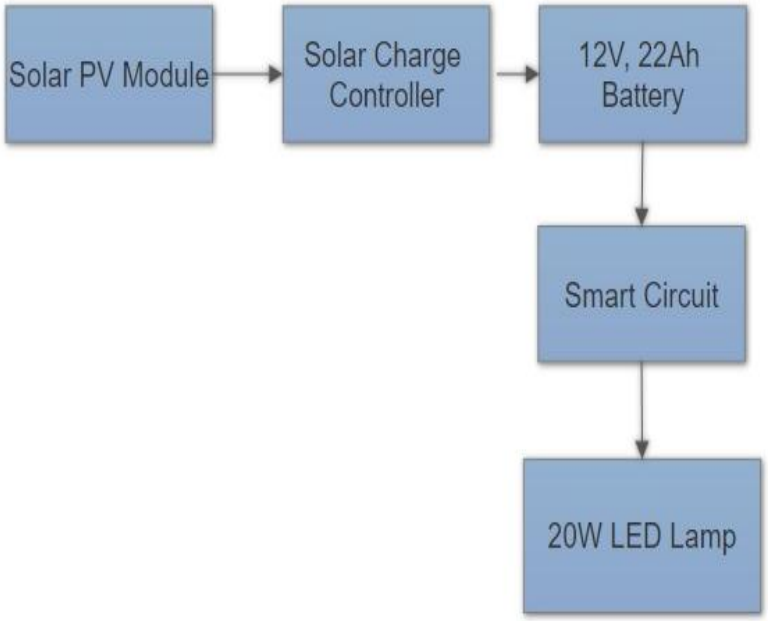

Figure 1: Working Block Diagram

Figure 1 shows the complete block diagram for a fully automatic solar powered LED Street light. The Solar PV module receives solar energy from the Sun and converts it into electrical energy. This output cannot be directly given to the battery as the solar PV module output is fluctuating and may not result in better charging of the batteries or may affect the life of battery. Thus a charge needs to be used. The Charge Controller is basically a buck-boost converter which maintains the input to the battery at a constant value. Another important function of the Charge Controller is to prevent the reverse flow of power towards the PV module during periods of low sunlight. The output of the charge controller is given to the 12V, 14Ah Li-Po battery. The Battery is used to store the electrical energy from the PV module to power the LED Street light. The battery gets charged up during the day time using the solar energy and discharges during the night by giving a constant output to 20W LED array through a smart controller.

This smart circuitry consist of a dawn to dusk controller for ON OFF control of the lamp, a PIR sensor to detect the motion and regulate the brightness accordingly and a GSM module which intimates the maintenance officer by sending an SMS whenever the street light is not functioning or has failure.

IV. SMART CIRCUIT:

A. Dusk to Dawn Operation:

The Dusk to dawn circuit is used for automatic switching of street lighting systems. The operation of the system is based on sensing the ambient light level which actuates the electronic controller (MOSFET - IRF540N) to switch ON the street lights in the evening and switch OFF in the morning. Here a voltage sensor is connected to the output of solar panel as shown in figure 2. The output of voltage sensor is connected to pin A0 of the arduino board. This output is compared with the standard predefined value in the processor. When the sunlight drops the output voltage of the panel drops. This drop is sensed by a voltage sensor and given to the processor which turns on the MOSFET and provide a close for the battery to discharge itself to the load which turns ON the street light. When the sun appears creating brightness beyond the set limit, it increases the output voltage of the panel resulting in a low gate signal to the MOSFET which turns OFF the street light [7].

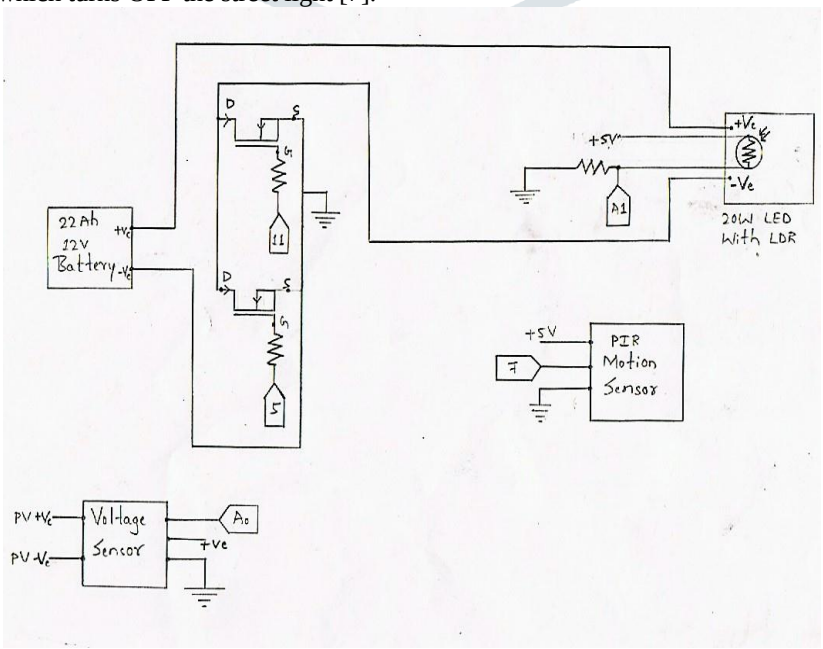

Figure 2: Circuit diagram for smart circuit

B. Light Intensity Control

The light intensity is controlled in 3 intervals. From 6pm to 11pm full brightness, from 11 pm to 6 am intensity is controlled using a PIR sensor. The light intensity is controlled based on the movement using a PIR motion sensor. In this interval, the light glows at 50% of the full illumination. Here the output pin of PIR sensor is connected to the pin no. 7 of arduino processor. A PIR sensor sense the movement on the street, at the same time give a signal to the Arduino processor to glow the lamp at full brightness and if no movement is sensed then it gives signal to the Arduino processor to reduce the brightness to half full brightness. The idea here is to save energy. The energy saved here is then used to increase the back-up time of the street light.

The Arduino processor uses the PWM (Pulse Width Modulation) signal to set the duty cycle of the electronic controller (MOSFET - IRF540N) which in-turn controls the intensity of the street light.

C. SMS Service

The SMS service is another added feature that aids in the efficient operation of the smart solar street light. A GSM module is made use for this purpose. This feature is of great advantage as it not only gives the status of operation of the street light but also helps in the identification and isolation of any unanticipated issue with the various components used. Maintenance time can be reduced significantly due to this as the problem can be accurately pointed to a definite part of the system and the maintenance personnel can directly go about fixing the issue. As quick and pin point location of the error is available, the down time is reduced to a great extent. The formal procedures of reporting that can be a problem with the conventional street lights are bypassed and thus, more reliable street lighting is achieved.

V. RESULTS:

Table 1: Results

Sl. No	**Date**	**Timing**	**Lumens**	**Status of Street light**
Dusk to Dawn Operation				
1	22/10/17	6:40 PM	24 lux	ON
2	23/10/17	6:05 AM	24 lux	OFF
Light Intensity Control				
1	22/10/17	6:40 PM	160 lux	ON (Full Bright)
2	22/10/17	11:00 PM	90 lux	ON (Half Bright)

SMS Service				
Sl. No	**Date**	**Timing**	**Status of Street light**	**SMS**
1	22/10/17	8:00 PM	OFF	STREET LIGHT NO. 1 NOT Working,

From the above table it can be observed that the all in one solar powered street light works very efficiently with all the smart attachments given to it.

VI. CONCLUSION:

This Paper deals in design and implementation of an Integrated all-in-one Smart Solar LED Street Light along with a next generation smart circuitry using arduino UNO Microcontroller. Due to its compact size, this light can be easily mounted on pole top by anyone. The light has automatic dusk to dawn operation and needs negligible maintenance once installed. The use of PIR sensor enables to reduce the utilisation of battery, which helps to use a smaller capacity battery efficiently. The GSM module helps in proper intime maintenance of the system. The All in One Solar Street light uses high quality material and is designed to suit the Indian environmental conditions.

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