Smart Street Light System: Innovation and Revolution

Aashita Nyati, Emil Christian, Shairal Neema

Abstract*: Presently, 18-38% of the total energy bill goes to the global street lighting and most urban cities still use Metal Halide bulbs, High Pressure Sodium Vapor Lamps and CFLs that neither provide efficient lighting nor energy savings. Therefore this is one domain that needs major attention in an objective of saving energy. So, the paper discusses about the use of LED arrays powered by solar panels in the existing street light system and automate the same using Light Dependent Resistor(LDR),Passive Infrared(PIR) sensors, presence detectors and brightness sensor .

***Index Terms*: LDR, LED arrays, Zigbee, PIR, microcontroller.**

I. INTRODUCTION

Street lights are an integral part of a locality. The streets or highways with high vehicular traffic require better luminance than the streets with low vehicular traffic but this has not been considered in the existing street light system of India. If the street lights had been installed according to area-wise study of a particular area rather than the city-wise approach that the municipality follows today, the electricity consumption cost could have been reduced at a large scale.

The street lights in India are a combination of CFLs, Metal Halide bulbs and HPSV lamps and with the increase in environmental concerns, it is necessary that these be substituted by a greener and efficient technology of LED arrays. LED offers 50-80% of energy savings than the HPSV lamps, has a life of over 50,000 hours, that is, it works 10 hours a day for 13 years which is more than 5-10 times the life of a HPSV lamp. So, a switchover to LED is not only financially favorable but also environmentally beneficial. Using efficient lighting infrastructure could help reduce the energy usage between 25-60 percent in India. According to various studies, it was inferred that proper lighting and visibility on roads can lead to reduction in car accidents. The level of brightness on every street or highway should be managed from day till night to improve the efficiency of the current system.

Presently, the street lights are designed with the help of the brightness sensor which turns on/off automatically according to the brightness of the sun. After implementation of this innovation in various countries it was found that it is not of much use as it uses a large amount of energy and electricity sources. Nowadays a sensor light has been introduced with the help of brightness sensor and motion sensor that turns on when it detects the motion else it remains off. The main drawback of sensor light is it only turns on when an object is in front of it. The light should have been turned on before an object arrives at the source point (sensor light). According to our research, it was found that the utility electricity sector in India had an installed capacity of 288 GW as of 31 January 2016 and the per capita electricity consumption was 1010 kWh. A solution to minimize the electricity consumption is to dim the lights during off peak hours and brighten them at the normal (bright) mode whenever presence is detected. This would save a lot of energy and also reduce cost of operation of streetlights.

Revised Version Manuscript Received on April 08, 2016.

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II. EXISTING SYSTEM

In the present system, lighting up of street lights is done using CFLs, Metal Halide bulbs and HPSV lamps, whose energy consumption is high. So, several attempts have been applied to save energy and to control pollution caused by them. Furthermore, their intensity cannot be controlled according to the requirement of the roads. In many countries the concept of smart street light system is encouraged. Countries like Malaysia and Japan have adopted the smart street light in certain areas.

Some of the existing street light system have been proposed on wireless network system that can implement real –time monitoring for lighting on the roads. The wireless network been used is Zigbee and GPRS has been used to monitor the status of the lamps. Moreover the system has been programmed to switch all the terminals to half power state to save specific amount of energy. Though the system may be energy efficient as compared with the existing sodium vapor light bulbs there are certain limitations of the system. The first one is its complexity and cost i.e. each terminal or pole must consists of microprocessor , controller and wireless network interface. The second is the system is not automatic. The system may be programmed to dime the street lights at specific time but system does not take note of presence of vehicle. It does not have any motion sensor that could detect the presence of vehicle or any pedestrian passing through the road.

III. COMPONENT STUDY

A. Light Dependent Resistor(LDR)

An LDR(Fig. 1) is a component that has a variable resistance that changes with the light intensity that falls upon it. This allows them to be used in light sensing circuits. LDRs come in different shapes and colors. Normally the resistance of an LDR is very high, sometimes as high as 1000000 ohms, but when they are illuminated with light resistance drops dramatically. When a light level of 1000 lux is directed towards it, the resistance is 400 ohms. When the light level is of 10 lux is directed towards it, the resistance rises dramatically to 10430000 ohms. They are vital component in

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any electric circuit which is to be turned on and off automatically according to the level of ambient light, especially in alarms, switching devices, clocks and street lights.

Fig. 1 Light Dependent Resistor

B. Passive Infrared Sensor(PIR)

PIR(Fig. 2) are currently the most popular type of motion detecting system. They are small, inexpensive, low-power, easy to use and do not wear out. Unlike infrared optical sensors that use LED transmitter and IR receiver, the PIR emits nothing. It uses an optical collection system in combination with several different sensing elements. The surrounding heat radiation is grouped by a segment lens and guided to the pyro-detector. If a heat source moves in the detection area, the heat radiation changes and the pyrosensor releases aa voltage. This voltage is assessed by the downstream electronics. This allows the sensor to detect any changes that occur in ambient infrared radiation. The most common object a PIR sensor detects is the human body, so these sensors find use in automatic light switches, alarm systems and door openers.

Fig. 2 Passive Infrared Sensor

C. Light Emitting Diode(LED) Arrays

LED array(Fig. 3) is an integrated light that uses light emitting diodes as its light source . The intensity and uniformity of light output from an array depends upon the method of LED array manufacturing used. Many LED lightings have been claimed to dramatically reduce energy use and they do not take time to power on as the HID bulbs.

Fig. 3 LED Array

D. Solar Panel

A photovoltaic module is packaged, connected assembly of typically 6x10 solar cells. Solar Photovoltaic panels(Fig. 4) constitute the solar array of a photovoltaic system that generates and supplies solar electricity in commercial and residential applications. Every system provides cost savings by eliminating the need to trench standard electric wires for installation and providing no electric bill for the life of the system. Solar street lights have been installed on highways, freeways, neighborhood streets, rural roads, etc. and provide security, sustainability and an overall green image.

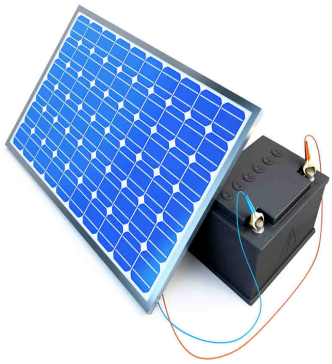

Fig. 4 Solar Panel Array

IV. PROPOSED SYSTEM

We propose a smart street light system which will have the following components as shown in the block diagram in Fig. 1.

A. Communication Module

It will consist of Light Dependent Resistor, Passive infrared sensor, communication device and a program that controls the functioning of each component. The LDR will sense the light, whose resistance reduces drastically in the day light to disable control power to the LEDs. The controller will turn on as soon as any motion is detected in its area and it will pass a message to other units with the help of the communication device and when no motion is detected it will turn off to save the electric power. It will include a real time clock for the current date and time and Pulse width modulation for dimming the LED array during late night hours. Analog to digital Conversion used to save energy during the day.

B. Sensor Unit

This unit will consist of the controller, communication module and PIR sensor. For supplying power to this unit solar

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energy will be considered as a good option. The controller will turn on as soon as any motion is detected by the PIR sensor and will pass a message to other units using the communication module and when no motion is detected it will turn off to save power.

C. *Series of LEDs*

LED lighting has the potential to save energy and improve lighting quality and performance beyond that of the conventional lighting technologies. Therefore we consider a row of LEDs connected together as street lights. These are controlled by the controller to turn on/off /dim at a certain point of time. The LEDs can be dimmed up to 10-50% of their normal intensity and this saves a lot of energy at late night hours when there is no activity on the roads.

D. *Power Module*

As awareness of solar energy is increasing, more and more institutions are opting for solar energy. Photovoltaic(PV) cells are used for charging batteries by converting sunlight into electricity. A PV solar panel is used to maximize the output from the battery. Lead acid battery used because of fast charging rates and high energy density.

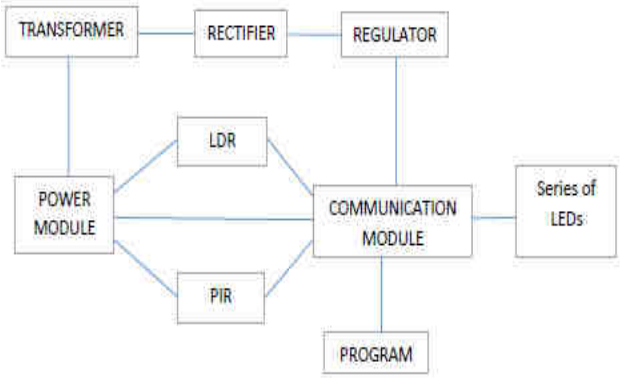

Fig. 5

V. FEATURES OF PROPOSED SYSTEM

1. Easy installation and extensibility: By setting parameter each smart street light can be installed in a network. The system will be autonomous distributed which will help in extensibility.
2. Low cost: The main aim of installing the smart street light is to lower the cost than the amount which is being spent on normal street light system. Thus by using the smart street light the cost shall be lowered.
3. Self – diagnosis: One of the worst case in smart street light is the light do not turn on when any vehicle is detected. In the proposed smart street light system it will recognize the failures, in which the motion will be detected in front of it without any signal or message from other units.
4. No difference from usual lights: The smart street light will be no different in appearance as compared to normal street light.

VI. RESULTS

Table 1 Comparison of light technologies

Light Technology	Life cycle(hours)	Lumens per watt	Ignition time	Considerations
Incandescent bulbs	1,000-5,000	11-15	Instant	Very inefficient, short life time
Mercury Vapor light	12,000-24,000	13-48	Up to 15 min	Very inefficient, UV radiation, contains mercury
Metal Halide	10,000-15,000	60-100	Up to 15 min	high
High pressure sodium light	12,000-24,000	45-130	Up to 15 min	Low CRI with yellow light, contains mercury and lead
Low pressure sodium light	10,000-18,000	80-180	Up to 15 min	Low CRI with yellow light, contains mercury and lead
Fluorescent light	10,000-20,000	60-100	Up to 15 min	UV radiation, contains mercury, prone to glass breaking
Compact Fluorescent light	12,000- 20,000	50-72	Up to 15 min	Low life/ burnout, dimmer in cold weather, contains mercury
Induction light	60,000-100,000	70-90	instant	Higher initial cost, limited directionality, contains lead, negatively affected by heat
Led light	50,000-100,000	70-150	instant	Relatively higher initial cost

It is shown from the Table 1, that LED not only has a long life cycle but a faster ignition time as compared to other light technologies. So the power required by the HID bulbs to ignite is now saved by the use of LED in the proposed system. It can also be noted that the initial cost of LED is high but this is negligible compared to the power savings it provides in the long run due to its low degree of maintenance. Further, LED is the green technology among the others as it does not contain mercury or lead as its constituents.

Table 2 Comparison of motion detectors.

Features	PIR	CWR	Ultrasonic
Output	Digital pulse high (3V) when triggered	Continuous wave radio energy is transmitted	uses Ultrasonic waves
Price	Rs 600	Approx. Rs 6800	Approx. Rs 2230
Range	Up to 20 KHz	Up to 100KHz	30-50KHz

Table 2 shows a comparison between different motion detectors . The table reveals that CWR has a broad frequency range than the rest of the motion detectors while PIR has a low cost. If we compare the prices and the frequency range it can be inferred that PIR provides a reasonable frequency at low price while CWR and Ultrasonic are very expensive.

VII. CONCLUSION

In this paper we present a system that can replace the existing system comprising of the highly energy consuming HPSV lamps and CFLs with a greener approach. The proposed system consists of a row of LEDs, Light Dependent Resistor (LDR), Passive Infrared Sensor(PIR), a

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communication module and a solar panel that powers the battery. LED offers 50-80% of energy savings than the HPSV lamps, has a life of over 50,000 hours, that is, it works 10 hours a day for 13 years which is more than 5-10 times the life of a HPSV lamp. This system would prove beneficial for the authorities to save energy in the areas with low traffic activity. However the system not only provides energy efficiency but also decreases the degree of maintenance of the street lights to an extent. The cost of design of such a system can be complemented with the high energy savings that the system provides. To check the real life applicability of our system we will analyze the system through simulation and implement the same.

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