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Intelligent Street Light System using RF Transmission

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Abstract— ***Street lights are the large consumer of energy in the cities, consuming up to fifty percent of the city's energy. In order to reduce energy consumption, an intelligent street light system based on LED lamps and wireless communication technologies can be designed. The proposed prototype of intelligent street light can detect daylight and vehicles and vary the intensity of the LED based street lamps as per the traffic flow. It can also help in monitoring of street light system and fault detection through RF wireless technology. If intelligent street light is designed and installed in the cities, then, lot of power can be saved and this will also minimize the cost of maintenance over traditional wired systems. The system is versatile, and can be extended as per user needs.***

Keywords— Intelligent Street Light System, LED street lamps, Arduino, RF transceiver, LDR, power consumption.

I. INTRODUCTION

In recent years, environmental issues have gained widespread international attention, resulting in the development of energy-efficient technologies aimed at reducing energy consumption. One aspect of the situation is an increasing demand for the reduction of the amount of electricity used for illumination. In particular, energy conservation for large scale illumination tasks such as street lighting is gaining considerable importance. The street light system is one of the largest energy expenses for a city, accounting for upwards of 35-45% of a municipality's utility budget. An intelligent lighting control system can cut municipal street lighting costs as much as 70% [1].

A Street light use HID (High-Intensity Discharge) Lamp as light source. Due to global concerns regarding the amount of power consumed by HID lamps and the amount of atmospheric CO_2 released because of power consumption, LED array illumination has received attention recently as an energy reducing light source. LED illumination requires about one third to one half of the electric power needed for HID lighting. The lifecycle of an LED can be more than three times as long as an HID light and LED system would be comparatively maintenance free. In recent years, LED lighting can be expected to fully replace earlier used light sources.

An intelligent street lighting system is a system that adjusts light intensity based on usage and occupancy of the traffic as it illuminates a certain number of street lights ahead and fewer behind, depending on movement of vehicles. The system also proposes the wireless based system to remotely track and control the actual energy consumption of the street lights and take appropriate energy consumption reduction measures through power conditioning and control.

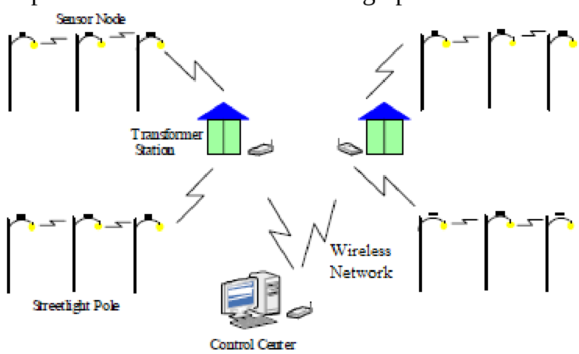


Fig.1 Structure of streetlight power cable monitoring system based on wireless sensor networks

As shown in Fig. 1 [2], the street light controller should be installed on the pole lights which consist of microcontroller along with various sensor and wireless module. The street light controller installed on the street light pole will control LED Street lighting depending on traffic flow of the road, and will transmit this data of each street light to control station via wireless technology to monitor the system. The mode of operation of the system can be conducted using auto mode and manual mode. The control system will switch on-off the lights at required timings and can also vary the intensity of the street light according to requirement.

The benefits of this technology are [3]:

1) Energy savings: During night, the intensity of LED lamp varies according to traffic, thus, energy can be saved.

2) Maintenance cost reduction: The lifetime of LEDs is more than the exiting lamps, thus, there can be reduction in maintenance cost.

3) Reduction in CO_2 emissions: As power consumption can be reduced with this technology, therefore, reduction in CO_2 emissions can be observed.

4) It doesn't contain toxic chemicals, such as, mercury in the light lamp.

The comparison of the lamps used in the present street lights and the proposed street lights are shown in table I [4]. It is inferred that LED light provides many advantages over high pressure sodium light.

Table I: Comparison of Light technology

Light technology	**Life time**	**lumens per watt**	**Ignition time**	**Remarks**
High pressure sodium light	12.000 - 24.000	45 – 130	up to 15 min	low color rendering index with yellow light, contains mercury and lead
LED light	50.000 - 100.000	70 – 150	instant	relatively higher initial cost

The comparison of the different wireless technologies that can be used for monitoring the proposed street light system is shown in table II [5].

Table II: Comparison of Wireless technology

Parameters	**PLC**	**Zigbee**	**nRF24L01 Single Chip Transceiver**
Data rate(kbps)	0.625-50	250	250, 1000 and 2000
Power consumption	More	Less	Less
Installation cost	Expensive	Expensive	Low
Maintenance cost	Good	Very Good	Low
Frequency	-	900 MHz and 2.4 GHz	2.4-2.525 GHz
Range	-	10m-1.6km	100 m and can be extended using antenna

II. SYSTEM ARCHITECTURE

The system can be designed as a modular system which can be extended effectively. The measuring stations are used to observe street conditions depending on the intensity of daylight and flow of the traffic on the road, based on the observed conditions; lamp is either activated or remains off. The different factors affecting the activation are: seasons, climatic conditions, geographical location, etc [6]. Consequently, every street lamp is designed independently to decide about the activation of light.

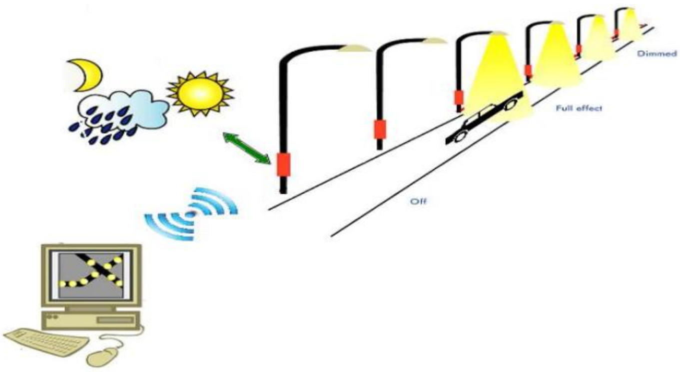


Fig. 2 Schematic of Intelligent Street Light System

The base station co-jointly checks if any lamp is correctly operating and sends the message using the wireless network to the operator who will act in case of malfunction.

Fig. 2 [6] shows the function of the intelligent street light system. The street lights are switched ON when the vehicles come near the lamp. The LED in the street lamp is set to DIM condition when the vehicle or human crossed the first lamp and reaches the second lamp. This dimming of LED is controlled using PWM technique. All these data's are sent through wireless communication to the base station.

III. SYSTEM DESIGN

The block diagram of the proposed system is depicted in Fig. 3(a) and 3(c). A microcontroller ATmega 328 used on developed Arduino Uno board performs controlling actions along with certain sensors namely, LDR sensors and temperature sensor. These sensors are connected to the ports of the microcontroller through an interfacing circuit. The microcontroller generates a PWM signal which is fed to the LED circuit which changes the operating cycles of each LED in the LED Array.

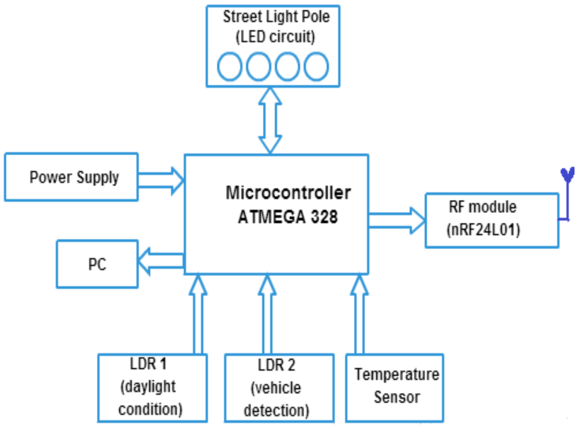


Fig. 3(a) Block Diagram of Transmitter-end on the Pole

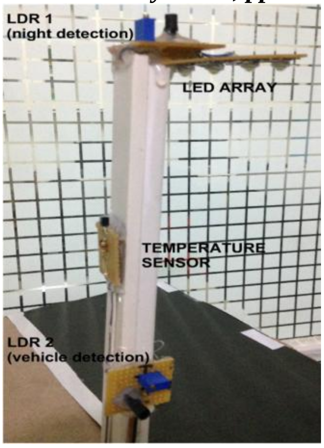


Fig. 3(b) Street Lamp of the proposed system

In Fig. 3(a), microcontroller ATmega 328 is interfaced with LDR1 circuit which senses night, LDR2 which senses presence of vehicle. It is also interfaced with temperature sensor and RF module (nRF24L01). The sensors are mounted on street light as shown in Fig 3(b). When power is supplied to the system, system starts functioning. As LDR1 circuit, senses day light, the LED array (i.e., 4 LEDs) remains in OFF state. As LDR1 circuit, detects night condition, the LED array turns ON with half of its LEDs (i.e., 2 LEDs turn ON). When LDR1 is ON, then only LDR2 circuit will function, where, LDR2 detects vehicle approaching the lamp. As vehicle approaches LDR2 circuit, resulting in increase in intensity of light at LDR2, thus, all LEDs in the LED array turns ON (i.e., all 4 LEDs are in ON state). As soon as vehicle crosses the lamp, intensity of light decreases near LDR2 circuit, resulting in turning off 2 LEDs of the LED array for reducing wastage of power of the system. The temperature sensor is connected to sense the temperature of the environment. The changes in parameters i.e., LDR1 light intensity (in %), LDR2 light intensity (in %), temperature (in ºC), current at lamp node (in mA) is observed on PC which is connected to developed Arduino board on the other end. All the information displayed on transmitter PC is transferred to receiver terminal in the form of encoded packet with the help of RF module (nRF24L01) for monitoring of the system at receiver-end.

Fig. 3(c) Block Diagram of Receiver-end

In Fig. 3(c), microcontroller ATmega 328 is connected to RF module (nRF24L01) to receive packets, decode these received packets and display the information of LDR1 light intensity (in %), LDR2 light intensity (in %), temperature (in ºC), current at lamp node (in mA) on receiver PC.

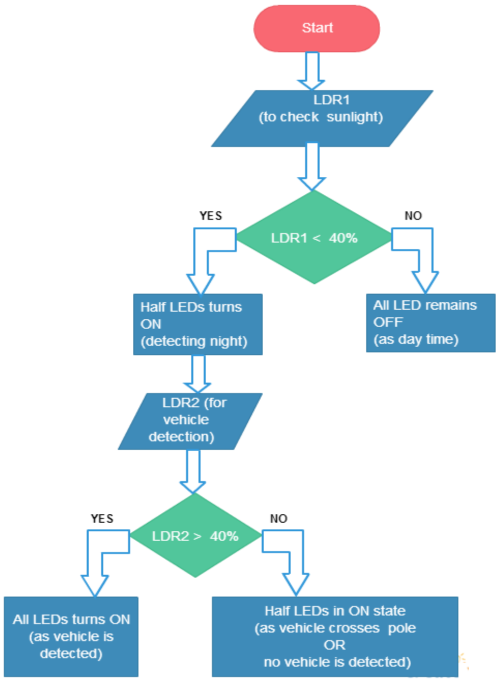


Fig. 4 Flowchart of the Proposed Intelligent Street Light System

The flowchart of the system is given in Fig 4. The working of the entire system is mainly with the sensors present. The main idea behind the system is that the LED array will be in OFF state at day time using LDR1 sensor. At night, the array will remain in half ON condition, i.e., if 4 LEDs are connected in an array, then, only 2 will be in ON state and the other 2 will be in OFF state. The rest 2 LEDs will get turned ON only if the LDR2 sensor detects vehicle. This is done so as to minimize the power consumption of the array. Here light is activated only when it is needed. At night, when roads are empty, there is no use of illuminating all the lamps. So, half set of LEDs are ON and can conserve the power.

In order to operate the proposed system intelligently, LDR1 will check daylight with condition LDR1 < 40% and LDR2 will check detection of vehicle with condition LDR2 > 40%. Thus, detection of night and vehicle can be identified with LDR1 and LDR2 respectively, resulting in autonomous operation of the system.

IV. RESULTS AND ESTIMATION OF POWER CONSUMPTION

In the proposed intelligent street light system, the following steps are observed during its operation:-

STEP1: During day light, the LED array is in OFF state (as shown in Fig. 5(a)).

STEP 2: During night, which is sensed by LDR1, half of the LEDs of LED array turns ON (as shown in Fig. 5(b)).

STEP 3: The variation of the current at the lamp node can be observed (in table III) according to the variation of light intensity in LDR1 and LDR2 (as shown in Fig. 5(c)).

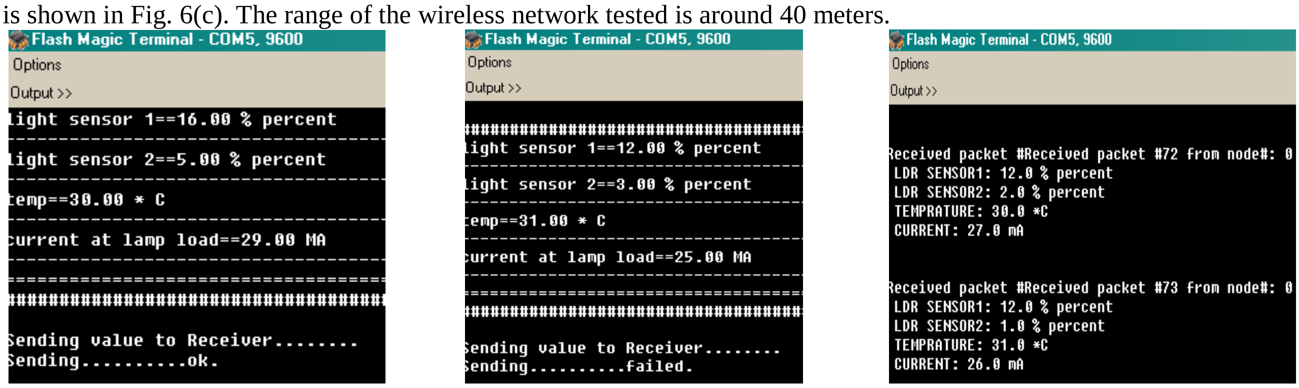
STEP 4: When vehicle is detected by the LDR2, all the LEDs of LED array turns ON and correspondingly, there is increase in the current at lamp node(as shown in Fig. 5(d)).

STEP 5: As vehicle crosses the lamp node, half of the LEDs again turns OFF.

(a) (b) (c) (d)

Fig. 5 (a) Lamp is OFF during day light, (b) Half of the LEDs of Lamp turns ON detecting night, (c) Variation in intensity of Lamp according to LDR1 and LDR2, (d) All LEDs of Lamp turns ON detecting vehicle.

Due to variation in intensity of light, there is change in current at lamp node, thus, power consumption is reduced which results in energy saving of this system. The monitoring of the variation in the parameter of lamp node can be observed in FLASH MAGIC terminal at transmitter as well as receiver end using RF module (nRF24L01). If the transmission between transmitter-end and receiver-end is successful, then, the message "Sending….ok." (Fig. 6(a)) is displayed, else, the message "Sending….failed" (Fig. 6(b)) is displayed at transmitter terminal. The information received by receiver-end is shown in Fig. 6(c). The range of the wireless network tested is around 40 meters.



(a) (b) (c)

Fig. 6 (a**)** Sending Ok for transmitting information at transmitter terminal of the system, (b) Sending Failed for transmitting information at transmitter terminal of the system, (c) Receiver terminal for monitoring the system.

Table III: Analysis of various parameters:-

S. No.	**LDR1 Light Intensity**	**LDR2 Light Intensity**	**TEMP-ERA-TURE**	**CURRENT AT LAMP NODE**	**POWER-CONSU-MPTION**	**REMARKS**
1	599%	0%	32ºC	0 mA	0 mW	During day light, LDR1 senses more light intensity, and if LDR2 is not exposed to light, then, no LEDs will turn on, resulting in no current at lamp node.

2	212%	13%	31ºC	0 mA	0 mW	During day light, LDR1 senses more light intensity, and if LDR2 light intensity also starts increasing, then, also, no LEDs will turn on, resulting in no current at lamp node.
3	0%	9%	31ºC	27 mA	27mA x 12V= 324 mW	During night, LDR1 will sense no light and light intensity at LDR2 is also less. In this condition, half of the LEDs connected in LED array turns ON will full intensity.
4	12%	8%	31ºC	23 mA	23mA x 12V= 276 mW	During night, light intensity at LDR1 is less and light intensity at LDR2 is also less. In this condition, half of the LEDs connected in LED array remain ON but the current at lamp node varies according to intensity of light falling on LDRs.
5	12%	13%	32ºC	26 mA	26mA x 12V= 312 mW	During night, light intensity at LDR1 is less and light intensity at LDR2 is also less. In this condition, half of the LEDs connected in LED array remain ON but the current at lamp node varies according to intensity of light falling on LDRs.
6	12%	481%	32ºC	30 mA	30mA x 12V= 360 mW	During night, light intensity at LDR1 is less and light intensity at LDR2 is more, then, all the LEDs connected in LED array turns ON and the current at lamp node starts increasing.
7	14%	564%	33ºC	32 mA	32mA x 12V= 384 mW	During night, light intensity at LDR1 is less and light intensity at LDR2 is even more, then, all the LEDs connected in LED array turn ON and the current at lamp node starts increasing.

V. CONCLUSIONS

The proposed intelligent street light can detect day/night time and vehicles and vary the intensity of the street lights using PWM technique in LED lamps as per the traffic flow. This system helps in monitoring of street lights and can also detect fault through RF technology. Thus, if intelligent street light is designed and installed in the cities, then, lots of power can be saved. The intelligent street light system may be criticized as being expensive, however, considering its advantages: slightly higher prices of the lampposts are compensated by lack of costly wiring and the availability of power network and considerably lower prices of maintenance. The goal is, therefore, reduction of power consumption and harmful atmosphere emissions. The system is versatile and can be extended according to user needs.

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