Intelligent Street Light System for Smart City

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ABSTRACT
The electricity consumption in public places is increasing with enormous speed daily in developing countries like India. As contrasted and the utilization, the electricity generation process is growing with very little pace. Also, nowadays human life has become so busy that he didn't get time to switch off the light wherever not required. The current structure looks like the street lights that will be traded in the night prior to the sun sets and switched off the next morning after there is satisfactory light in the city. In this paper, we are presenting the best answer for electrical power wastage. Here, with the help of advanced embedded system design, it can be possible to enormously save the energy consumed by street lights, especially on highways. Additionally, the manual task of switching off the lighting framework is totally dispensed with this proposed system. Here the IR sensor module network is used which is a blend of IR LED and photodiode to identify the presence of vehicles out and about. The microcontroller atmega 328p is programmed using embedded D programming language and used as the frontal cortex to control. Finally, the framework has been effectively composed and actualized as a model framework. With the results and graph, it can be concluded that in, the proposed system 50-60 % less energy is consumed than in the regular system. Also, LDR is used here so that during the daytime light should remain turned off.

Keywords
Smart city; arduino; IR sensor module; street light.

1. INTRODUCTION
Planning another framework for the streetlamp that doesn't consume a colossal measure of power and enlighten enormous regions with the most noteworthy light intensity is a research challenge to the engineers working in this area. Giving road lighting is one of the most significant and costly obligations of city authorities. Out of the total lighting expenses, street lights count for 10-40% of the complete energy bill globally [1]. Road lighting is an especially basic worry for city authorities in an emerging economy like India in view of its essential significance for financial and social security. Wasteful lighting squanders huge monetary assets consistently, and unfortunate lighting makes perilous circumstances. Energy proficient innovations and system design can decrease the cost of road lighting definitely.

Manual control is inclined to blunders and prompts energy wastages and physically decreasing the light intensity during midnight is unreasonable. Additionally, progressively following the light level is impracticable. The latest technology focuses on automation and distance management solutions for controlling road lighting [2].

There are different control methodologies and strategies in controlling the streetlamp framework, for example, CPLD-based sunlight-oriented power saving framework for streetlamps and automatic traffic controller [1], plan and manufacture of programmed streetlamp control framework [3], embedded system programmed streetlamp power control and street wellbeing module utilizing[4], programmed streetlamp control framework [5], Intelligent Street Lighting System Using GSM [6].

In this paper, an IR sensor module network is suggested which is a combination of IR LED and photodiode sensors. The IR sensor module detects the presence of vehicles on the street and accordingly activates the ON/OFF switch which will turn ON the street light. IR LED i.e. transmitter used to transmit the IR signal continuously throughout the width of the street, which returns the echo of the transmitted light signal to the IR photodiode. The IR sensors are placed on the roadside barricades which are connected to the microcontroller Atmega 328P. The three consecutive street lights will be turned ON only when any object is recognized by the particular IR sensor. When the next IR sensor in the network recognizes the presence of an object, the system will automatically turn OFF the lights that were ON earlier and will turn ON the next three consecutive lights. By using this as a basic principle, the intelligent system is designed and proposed for the perfect usage of streetlights on highways.

The proposed block diagram of the street light system is as shown in Fig. 1. It consists of a microcontroller (Atmega 328P), IR sensor module network, relays, and power supply. During the night time when visibility will be below the threshold, the proposed system will start working.

When any obstacle comes across the IR module, the echo signal will be detected by the IR photodiode. The photodiode will recognize the presence of the abject and it will send the command to the microcontroller. As soon as the microcontroller receives the signal from the photodiode, it will activate the relay which will further turn ON the lights. We use a relay to act as an ON/OFF switch.

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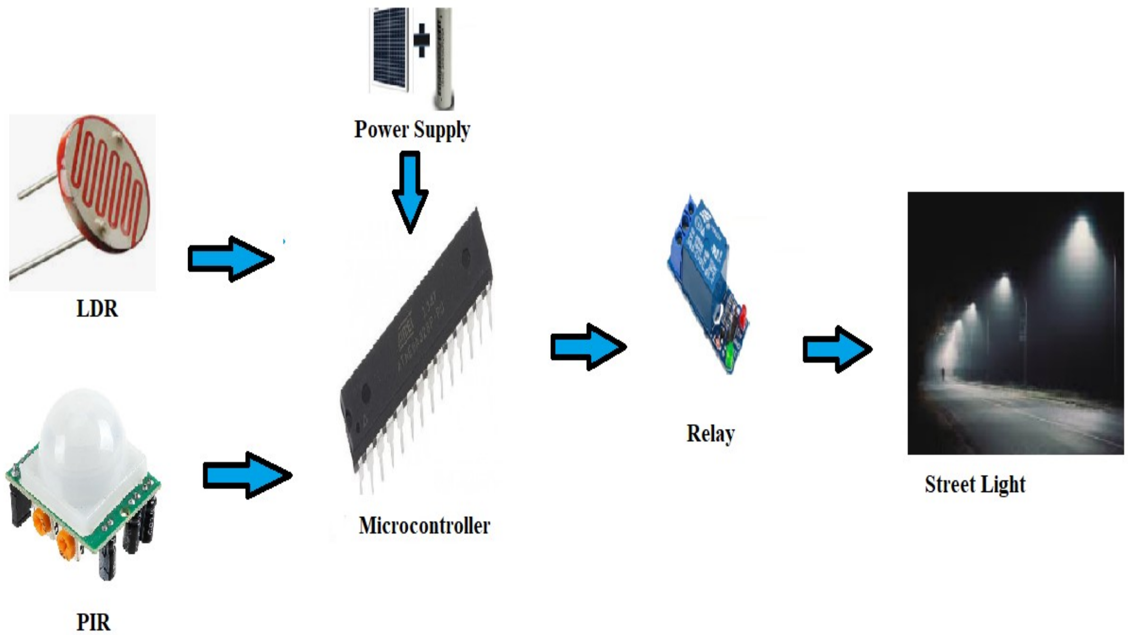

Fig. 1 Smart street light system

2. CIRCUIT DESIGN

Following are the components described in details which are utilized in the system design implementation.

2.1 Regulated Power Supply

Usually, transformer or battery provides output voltage in the range of 9 volt to 12 volt. The power requirement for the proposed system is 5V dc. To make a 5volt power supply, KA8705 voltage regulator IC as shown in figure below has been used.

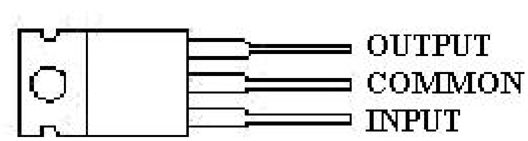

Fig. 2 Voltage Regulator (7805)

The KA8705 is a 3 pin voltage regulator IC which is very simple to use. Simply connect the positive lead form unregulated DC power supply to the input pin, connect the negative lead to the common pin and then turn on the power and 5V regulated power is ready to use.

2.2 IR Sensor Module

Infrared innovation tends to a wide assortment of remote applications. In the electromagnetic range, the infrared part is separated into three areas: close to infrared locale, mid infrared, and far infrared area. The basic IR module is as shown in Fig. 3.

The basic concept of an Infrared Sensor which is used as Obstacle detector is to transmit an infrared signal, this infrared signal bounces from the surface of an object and the signal is received at the infrared receiver as shown in Fig. 4.

Fig. 3 IR sensor module

Infrared Transmitter is a light emitting diode (LED) which emits infrared radiations. Hence, they are called IR LED's. Even though an IR LED looks like a normal LED, the radiation emitted by it is invisible to the human eye.

Infrared receivers are also called as infrared sensors as they detect the radiation from an IR transmitter. IR receivers come in the form of photodiodes and phototransistors. Infrared Photodiodes are different from normal photo diodes as they detect only infrared radiation.

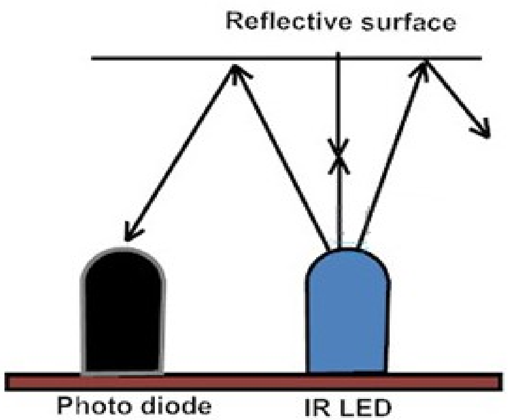

Fig. 4 Pictorial Representation of IR sensor.

- Input Power: 3.3V or 5VDC.
- Two LED indicators, one (Red) as power indicator, another (green) as object detection indicator.
- Obstacle detection range: 2cm to 10cm
- Adjustable sensitivity with on board potentiometer, this translate to adjustable detection range.
- Detection angle: 35 degree
- Small size makes it easy to assembly.
- Single bit output.
- Compatible with all types of microcontrollers.
- Dimension: 3.1cm x 1.5cm

2.3 Relays

Relays are remote control electrical switches that are controlled by another switch, such as a horn switch or a computer as in a power train control module. Relays allow a small current flow circuit to control a higher current circuit. Several designs of relays are in use today, 3-pin, 4-pin, 5-pin, and 6-pin, single switch or dual switches. Relays which come in various sizes, ratings, and applications, are used as remote control switches. Fig. 5 shows different types of relays. In this paper, the 4-pin relay will be used.

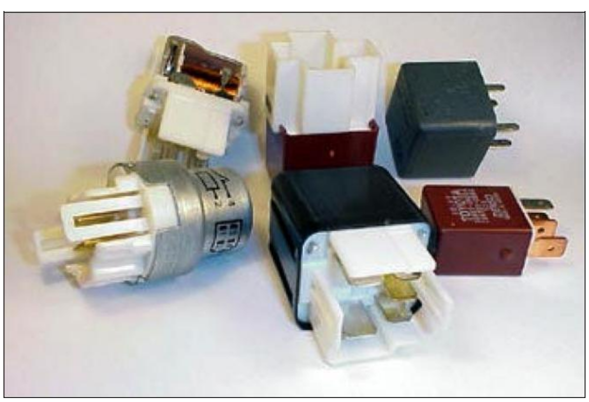

Fig. 5 Relay

2.4 Microcontroller

The high-performance Atmega 328P, 8-bit AVR RISC-based microcontroller combines 32KB ISP flash memory with read-while-write capabilities, 1024B EEPROM, 2KB SRAM, 23 general purpose I/O lines, 32 general purpose working registers, three flexible timer/counters with compare modes, internal and external interrupts, serial programmable USART, a byte-oriented 2-wire serial interface, SPI serial port, a 6-channel 10-bit A/D converter, programmable watchdog timer with internal oscillator, and five software selectable power saving modes. The device operates between 1.8-5.5 volts.

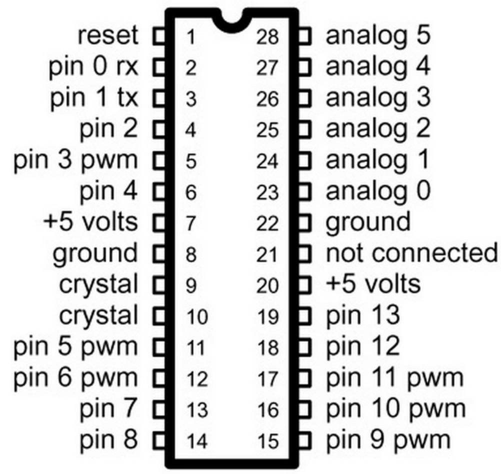

Fig. 6 Pin Diagram of Atmega 328P

By executing powerful instructions in a single clock cycle, the device achieves throughputs approaching 1 MIPS per MHz, balancing power consumption and processing speed.

The inputs in the streets lighting system are IR sensors, which after detection of any object on the road, turn ON the consecutive streetlights. Lamps will be used as streetlights in this paper.

2.5 Circuit Schematic

In this section circuit, which has been designed will be discussed. The details of this circuit can be summarized as follow:

1. Pins 9 & 10 of the atmega 328p microcontroller are connected to the Oscillator circuit and Crystal which consisting of 16 MHz crystal connected to two 22 P*f* capacitors.

2. Pin 7 is connected to VCC +5V through 10KΩ resistor, connected to reset bottom for resetting the circuit.

3. Pins 23 and 24 is connected to the IR sensors module.

4. Pins 14, 15, 16 and 17 connected to the consecutive street lights through relay column 1, 2, 3 and 4, and 2.2KΩ resistor-transistor switch.

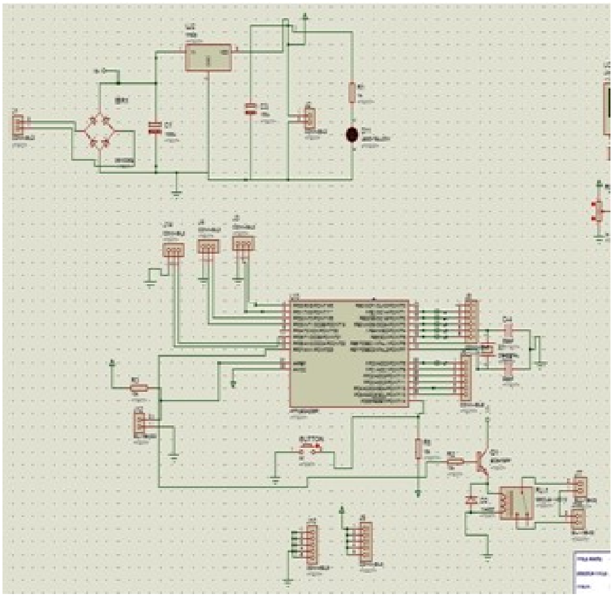

Fig. 6 Schematic Circuit for microcontroller

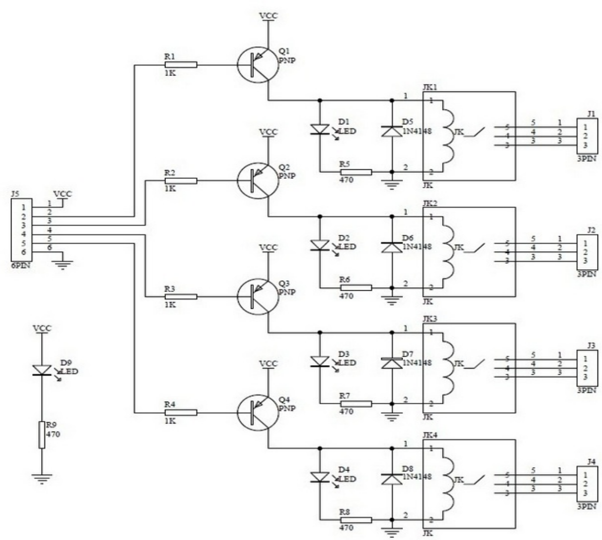

Fig. 7 Schematic of relay circuit design

Two IR sensor is used in this paper as a demonstration model. Their function is to sense the object that will pass through the street, at the same time give a signal to the microcontroller to turn on the four consecutive lamp. The idea to save the energy, where the system have been designed to light ON the lamp in the night only and only if there is any object passes through the street. Except to that the light will be OFF. First IR sensor is used to turn ON the first two lighting column via microcontroller automatically when any object passes in front of it. Meanwhile the second IR sensor will turn ON the next four lighting column and turn OFF the earlier lights when the object passes in front of second IR sensor and so on. The concept can be understood more practically through below mentioned figure 8.

Fig. 8 Prototype of street light system

3. PERFORMANCE ANALYSIS

The proposed system is explained in detail here. During the daytime, the light will remains switched off as we have utilized LDR. During the nighttime, the performance of the system can be tested depending on the time slot and road traffic. Typically, the distance between two streetlamp lights ought to be 30 meters. This is usually calculated by pole height and other factors. Nowadays, LED lights are utilized in streetlamp as it consumes less power than metal halide or incandescent lamps. A 22-watt LED light will illuminate the identical light of a 100Watt incandescent lamp. The street light lamps typically range from 35 to 250 watts. Usually, 120 watts is preferred. Here we consider 1KM of road distance to prove the performance analysis of the proposed system. So to cover 1 Km of distance, 34 (1000/30) lamps will require. As we assume each lamp consumes 120 watts (0.12kW) of power, so for 12 hours total energy consumed can be calculated as,

Energy = Power X Time = 0.12 X 1 = 0.08 kWh = 0.12 units.

Thus the total energy consumed by 34 lamps to illuminate a road of distance 1 Km for an hour is,

Total Energy = 34 X 0.12 = 4.08 Units per hour.

For 12 Hour,

Total Energy Units = 4.08 X 12 = 48.96 ≈ 49 Units.

The energy consumed by the street light could vary according to the traffic density and time. Thus we have divided the total time of 12 hours into four slots of 3 hour each.

Time Slot 1: From 6 PM to 9 PM

In this time span, maximum road traffic density can be seen. Thus the system has to keep the lights turn ON for almost 80% of the time. So here we can presume that our proposed light framework will actually want to save 15 to 20 % of the complete energy i.e, 0.8 units. So for 3 hours, it will save 2.04 units of complete energy.

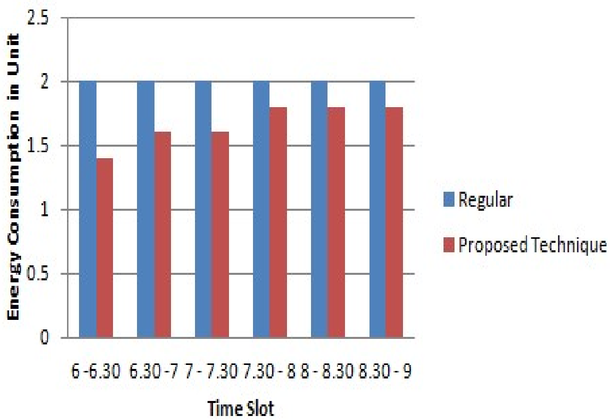

Fig 9, Energy consumption between 6 to 9 PM

Time Slot 2: From 9 PM to 12 PM

In this time interval moderate to high traffic density can be noted. Thus system has to keeps the light turn On for 50 to 60% of the time. So during this time interval with proposed system 40 to 50% of the total energy consumed could be saved i.e, 2 units. Thus in this 3 hour of time interval total 6 units of energy can be saved as compared to normal 12 units of energy.

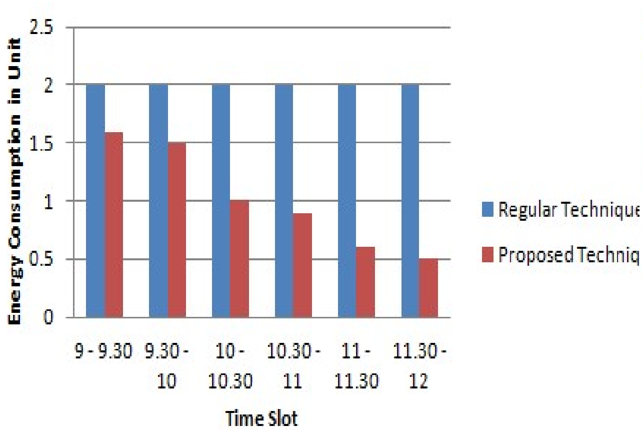

Fig 10, Energy consumption between 9 to 12 PM

Time Slot 3: From 12 PM to 3 AM

During this time interval usually low traffic density can be seen. Thus almost for almost 80% of the time the lights should remains turned off. Thus in this 3 hours of time interval total 9.5 units of energy can be saved as compared to normal 12 units of energy.

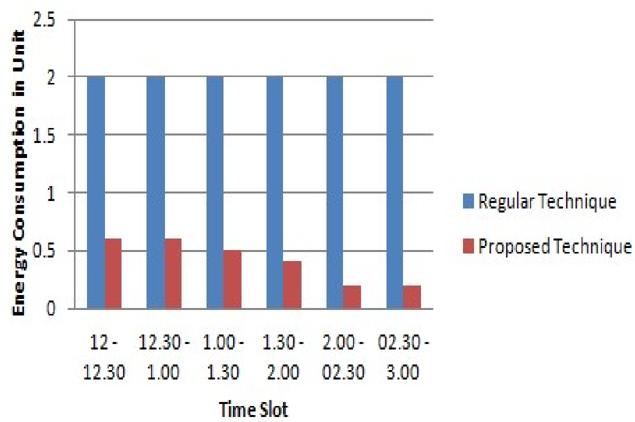

Fig 11, Energy consumption between 12 to 3 AM

Time Slot 3: From 3 AM to 6 AM

Very rare traffic density can be seen during this time on road. Thus for almost 90% of this time interval the lights will remains OFF. So with the proposed system only 2 unit of energy will be consumed which is only 10% of the total energy usage in normal condition.

Thus if we add all this time interval, total energy consumed with the proposed system is approximately 21 Units. Thus it will saves around 60% of total energy consumed without proposed system

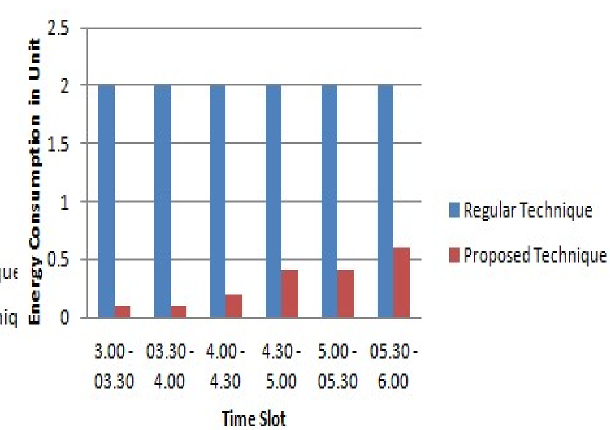

Fig 12, Energy consumption between 3 to 6 AM

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4. CONCLUSION

This paper elaborates the design and construction of intelligent street light control system that can used Smart City proposal by Government of India. From the performance analysis, it is concluded that the power utilization is improved by 70 to 80% which will ultimately increase the efficiency of proposed system. Furthermore the drawback of the street light system using timer controller has been overcome, where the system depends on photoelectric sensor. Finally this control circuit can be used in long roadways between the cities. LDR helps to keep the system OFF during the day time.

We can also add Internet of Things (IoT) technology in the future to monitor the real time operation of the proposed system.

5. REFERENCES

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