Smart Street Light System using Embedded System

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***Abstract*—**In today's world energy saving has become a major factor and need. This project is developed keeping this problem in mind. The huge amount of electrical power of many countries is consumed in lighting the streets. However, there are stages of time when there is less vehicle density during night time or even no vehicles during late night time. The main principle of this system is object detection and then triggering the respective circuit and to provide light only at that part of road where it is needed. Logically, this system may save a large amount of the electrical power. This paper focuses on the proposal of different possible architectures of this system.

Keywords: *Power Saving, Street Lighting System, System Monitoring and Control, IR proximity sensor, Arduino, LEDs*

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I. INTRODUCTION

A good civilization includes good transportation network. But in this we should not oversee the wastage of power in such developments.Efficient use of energy can be achieved through 2 ways:

1. Finding alternate source of energy.
2. By reducing energy conservation.

Consider a road at which the traffic reduces to 25% of the traffic at peak hours during late night times. If we let the street lights on during all night even if it is not needed then the time is not far when there will be scarcity of power around earth. [3].

This rises a question if it is possible to cut the electricity of a part of road where there is no car. If this system is implemented,

it will save a lot of power which can be used in the development of other parts of the country. Another benefit is that it will reduce the environmental pollution. The sole purpose of this project is to reduce the power consumption in low traffic density during late night. Objective is to manage trafficsmoothly during late night. The illumination is done by LED's and the system is controlled by an embedded system which can be easily modified easily according to the needs. The triggering circuit includes PIR sensors.The classical technologies like using cameras or cables to count the vehicles in any part are not feasible because they need very expensive hardware and computers to analyze the images to count the vehicles. Thus, there is a dire need of a system to lighten up only a part of road where there is vehicle. This system has to use the recent innovative technologies to reduce the implementation cost and to be accurate.

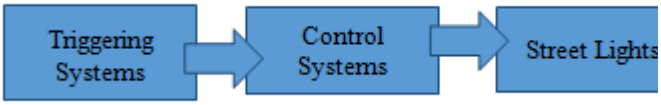
A. Related Work

Plenty of methods are there to conserve street light power and to reduce pollution The system is based on wireless network control that can implement real-time monitoring for road lighting. The proposed system uses the ZigBee wireless networks and GPRS standard to monitor the status of the lamps. The goal is to allow a central monitoring of the status of road light terminals that are equipped with wireless controller and electronic ballasts to be able to remotely switch on or off the terminals. Furthermore, the system can be programmed to switch all the terminals to half-power state at specific time to save the energy [2]. There are several limitations of this system. First, its complexity and cost: each node or terminal must have microprocessor, controller, and wireless interface. This can increase the cost too much and hence hinder the wide-scale deployment of the system. Second, it is using a completely new network rather than using the existing network for the road lighting control and management. Third, the system is not automatic. The system will be programmed to dime the terminals at specific time. The system does not take into account the presence of vehicles or not. Thus, it cannot achieve the maximum power saving

B. Principle and Architecture

The basic principle is to trigger a circuit using object detection and to control all this using embedded system. The architecture includes those blocks

1. Triggering system
2. Control system
3. Street lights



1. Block Diagram

Triggering Circuit includes PIR sensor, Control System includes Embedded System and Street Light should be made with LEDs to conserve as much power as possible.

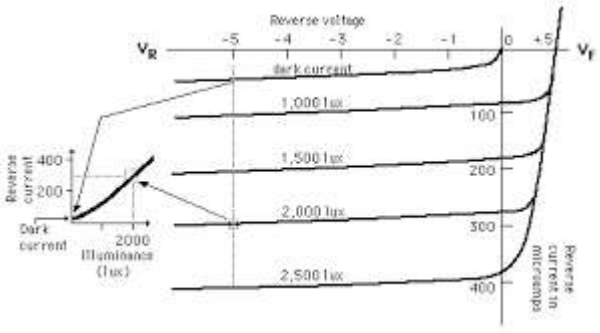
C. *Triggering Circuit*

In this system I have included a IR Proximity sensor. A proximity sensor is a sensor able to detect the presence of nearby objects without any physical contact. Proximity Sensor basically radiates electromagnetic wave and looks for and change in reflected wave.In our case it is IR. Properties of IR is that it has higher wavelengths than visible color therefore it is not visible to naked eye, although it is sometimes loosely called infrared light. The frequency varies from 430THz to 300Ghz. This IR is detected by IR photodiode.

A photodiode is a transducer which converts light to electrical current.

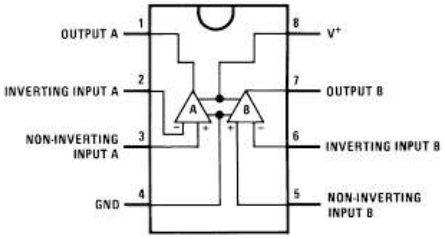
2. Photo Diode

The current is generated when photons are absorbed in the photodiode.The characteristics of photodiode is as such



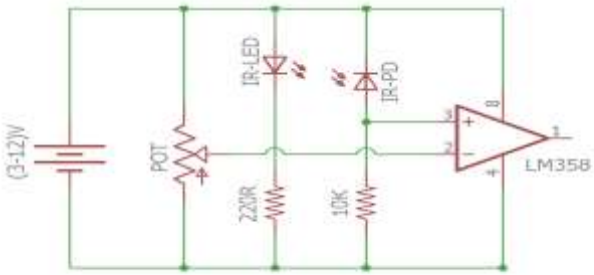
3. Photodiode Characteristics

- The residual current is called Dark Current when there is no incident illumination. The reverse current increases as incident illumination increases.An array of proximity sensing elements can replace vision-camera or depth camera based solutions for object detection over long distances [3]. The advantage of this over PIR sensor is that what if a bird or some nonvehicle crosses over the PIR sensor then it will trigger the circuit unnecessarily causing power loss. Also, the car paint is IR reflective therefore it will easily reflect IR energy triggering the circuit more easily. The range of the Proximity Sensor should be set properly according to the width of the road. The power supply required is also very less and are highly efficient and inexpensive. To show the basic working I have used a basic IR led and an IR photodiode.
- The circuits work on the principle of comparison. The voltage produced (as the object is neared more the voltage) is compared with the voltage by the potentiometer according to our need. To change the range, we just have to change the reference voltage. The comparator used is IC LM358. The LM358 IC is a great, low power and easy to use dual channel op-amp IC. IC is able to handle 3V to 32V DC supply and up to 20mA per channel current. It does not require dual power supply. It can also bare surrounding temperature ranging from - 65˚C to +150˚C.



4. LM358 Internal Diagram

The circuit is as follows:

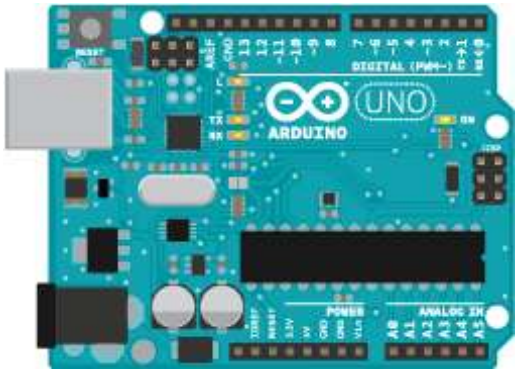


5. Triggering Circuit

Consider a scenario when an object cuts the sensor the voltage across photodiode increases and when this voltage is greater than the reference voltage set by you, the output voltage of the op amp becomes high. This output can be further processed. Similarly, when the object is far enough to produce less voltage across photodiode which will be less than the reference voltage producing low output voltage from opamp This circuit will be constructed in the form of array alongside the road.

D. Control System

The signals from triggering circuit will be fed to an embedded system. The job of the embedded system is to take those signals, compare them and then take actions. If a vehicle triggers the circuit then the output is high saying that a vehicle is detected. This high signal will be fed to the respective embedded system which allows the relays to turn on the street lights to almost 500mtrs along the direction of the vehicle. The choosing of the embedded system should be such that it should be inexpensive, resistive to high temperature and easy to modify and use. In my case I am using Arduino kit.



6. Arduino module

E. Street Lights

The majority of saving of power consumption comes from the street lights. These technologies are Incandescent, Halogen, Fluorescent, Compact Fluorescent (CFL), Light Emitting Diodes (LED), and Discharge. Example of the Discharge is the High-intensity discharge (HID) lamps. Please refer to the following table for a comparison between the characteristics of these technologies. All the technologies except LED and Discharge have very limited lamp lifetime. This limits their uses in the modern street lighting systems due to the replacement cost and the maintenance. Comparing between LEDs and normal discharge lamps like mercury vapor lamps and sodium vapor lamps we observer that LEDs has far more lifetime (50,000 hrs.). One major drawback that makes all the Discharge lamps not suitable for the proposed system is the start-up time. We can see that Discharge lamps can take up to 30 seconds to become full bright. LED, on the other side, has instant start-up time (around 0.01 second). Another drawback of the discharge lamps is that they are not dimmable. LED on the contrast is dimmable. Discharge lamps suffer from the flicker, but not the LED. For all these reasons, LED is the perfect choice to be used with our proposed system. Fortunately, most of the street lighting manufacturers are now recommending the use of LED and they are switching to use LED for the modern street lighting equipment.

light technology	life time	lumens per watt	ignition time
incandescent light	1.000 - 5.000	11 - 15	Instant
mercury vapour light	12.000 - 24.000	13 - 48	up to 15 min
compact fluorescent light	12.000 - 20.000	50 - 72	up to 15 min
LED light	50.000 - 100.000	70 - 150	Instant

7. Source Light Comparison

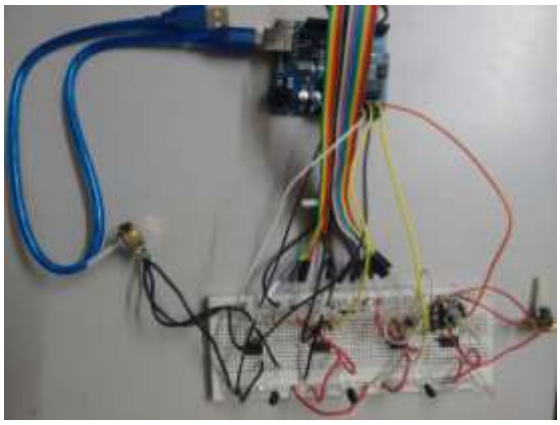
8. LED street light

Cases of Emergency

Regarding the emergency cases, the proposed system provides the required level of visibility to the drivers. On the highways, only vehicles are passing. The system is proposed to cut the parts of the streets that have no vehicles at any time. However, in the city centers, where people may exist in the city, the system does not cut the light, but dimming it to the lowest allowed range in some periods which is 50% from the full power. In the can, be implemented so that the automatic control of the light be bypassed [4] .

F. Performance and Analysis

The way to find out the performance of this system is by comparing a general street light system which is on all night long. Let the power consumed by one street lamp all night is 50W and considering the energy if it is on for say 11hrs then the total energy consumed is 550 units and if there are say 100 lamps at a stretch then total will be 55000 units. Now if we install this system then say the average time each lamp on is 8.5 hrs. then the total energy consumed will be 42500 units. Which saves around 12500 units.

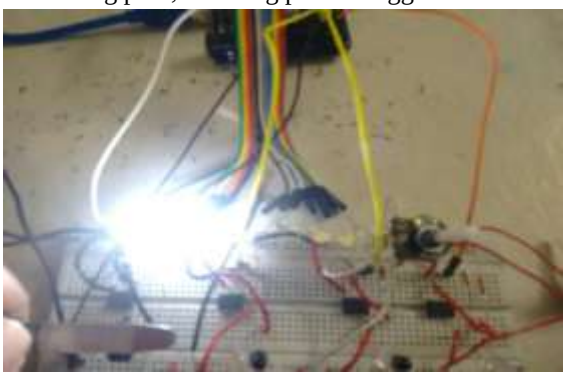


9. Circuit

Performance

The output from the triggering circuit is fed into Arduino analog input pins which then turns on street lights.

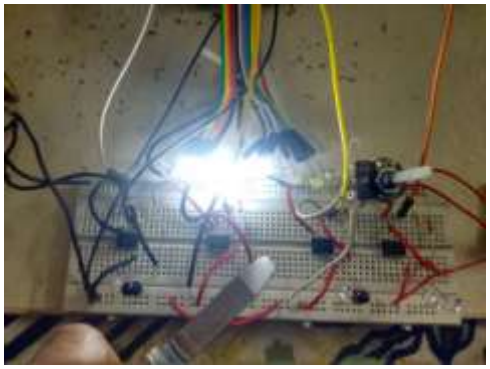
Consider analog pin0, if analog pin0 is triggered then



10. Trigger-1

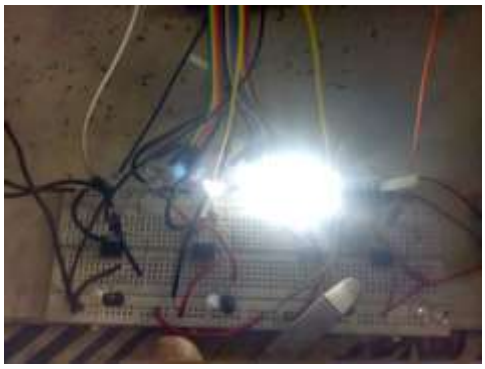
If analog pin1 is triggered then

11. Trigger-2



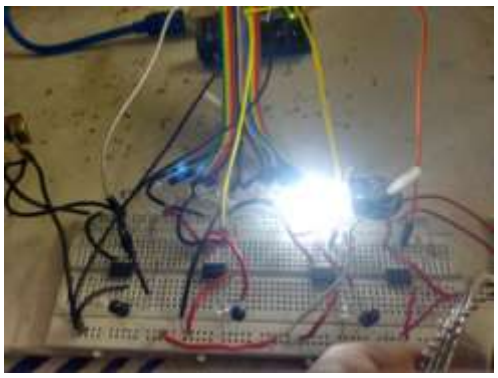
If analog pin 2 is triggered then:

12. Trigger-3



If analog pin 3 is triggered then

13. Trigger-4



G. ***Problem Faced***

The first problem which was in front of us was to select the correct trigger circuit. One idea was to select TSOP sensor which can be reliable due to selectivity. But this sensor requires fixed input frequency which can change due to environmental conditions. Change in resistance due to weather change can change the circuit properties changing functionality of the circuit which will lead to further problem.

Other was to whether use cameras for object detection. This technique is more sensitive and reliable but was pretty expensive and need intensive care and maintenance.

Second problem occurred is that what if due to street light the trigger circuit gets triggered. To solve this the direction and the sensitivity of the transmitter has to be synchronized.

H. ***Result***

Results clearly shows that the energy saved is around 12500 units which can be used in development of other cities.

This system is very user friendly because we can easily set the range according the width of the road.

I. ***Conclusion***

In this paper, an efficient autonomous street lighting control and monitoring system. The advantages of the system can be summarized as follows. Huge energy can be saved without

affecting the visibility and the safety of the drivers. It can extend the lifetime of the lamps. No expensive techniques like camera monitoring is required.

Research extension to this work may include considering the security issues and the possible attacks to the system. The security measures have to be considered. We can also add Solar Cells to save power during day time and use it during night.

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