

Internet of Things-based Smart Street System

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Abstract

Enormous amount of electrical energy is consumed in urban areas by means of street lights. Currently, the street lights are turned on and off manually which will lead to wastage of electrical energy. Due to inadequate dimming and low efficiency of lights, current is being wasted. The main aim of this smart LED system is to create a street light which will behave according to its surrounding. This LED will turn on automatically during dark time and off during bright time with the help of LDR. It will remain dim when there is no one near the light and turns on bright when people pass by it. By doing this, huge amount of energy is being saved. Though solar energy is efficient, it can't work during rainy season. Thus, piezoelectric sensor is a good replacement of it. It converts the pressure that applied on it to electrical energy. This sensor is fixed in the road which will convert the pressure applied to it by the vehicles to electrical energy which can be utilized by the LEDs. Finally, this system aims to present an overview of a profitable and green solution to the energy consumption problem imposed by street lighting.

Key-words: Arduino Uno R3, IR (Infrared) Motion Sensor, LDR (Light Dependent Resistor), LEDs (Light Emitting Diode), Resistor, Piezoelectric Sensor, Open CV, Light Intensity Control.

1. Introduction

There is a huge need for the wireless electrical energy which encouraged the interest towards piezoelectric energy harvesting, or the conversion of vibration into electrical energy [1]. Piezoelectric

transducers, has the inheritance of electromechanical coupling and it has high power density compared to electromagnetic transducers and electrostatic transducers, has a wide range of exploration to generate energy from vibration. Many researchers developed novel applications for piezoelectric energy harvesting in the past decades [2]. Kinetic energy is used by wide range of applications ranging from implanted devices and electronic devices to mobile electronics and wireless node which is self-powered. The use of piezoelectric energy is a great improvement when it comes to kinetic energy harvesting [3]. At present, there are three types of piezoelectric devices which is investigated and tested for determining each of their ability to transform the vibration into electrical energy and their capacity to recharge discharged batteries. That three types of piezoelectric devices are, monolithic piezoceramic material lead-zirconate-titanate (PZT), the bimorph Quick Pack (QP), actuator and Macro Fiber Composite (MFC). The most efficient device among this is piezoceramic material lead-zirconate-titanate (PZT) [4].

Automatic control system of street lights, whenever it is required, increases the efficiency of street lights. The pressure applied by the vehicles in the road is converted to electrical energy [5]. The kinetic energy obtained from the piezoelectric energy can be used to power piezoelectric compression [6]. By using piezoelectric ceramics, vivo electric energy can be generated which can be used for orthopedic implants. Since microprocessors used for orthopedic implants require much energy, piezoelectric ceramic is a good replacement [7]. Lighting Automatic Control System (LACS) is a Wireless Sensor Networks (WSN) design used for the applications that uses conservation of energy such as light control [8].

In order to control and monitor street lights, the lighting pole controller is used based on Wireless Sensor Network [9]. According to the latitude, longitude and seasonal variation, reasonable adjustments in the street lights can be made for efficient automation. Automation of street lights can be controlled according to the sunrise, sunset and light intensity algorithm [10]. There are many kinds of sensor for sensing the environment, but, multi-sensor exhibition can logically control automated street light system. Based on the degree of illumination control fixed time, street lights can be controlled by pre-installing time [11]. AT89S52, a single-chip microcomputer, is a combination of digital clock, a timer, a Liquid Crystal Display (LCD), a statistic of traffic flowing magnitude, a photosensitive induction, an infrared control, alarm function, a time cut-out function, an automatic control pattern by which automation of street lights can be more efficient [12]. The combination of automation, Power Line Communication and Web access provide a complete access for efficient automation of street lights [13]. Use of multiple sensors, LEDs with ZigBee protocol helps in providing energy efficient control of street lights from remote areas. Unique functions like sensing

frequency of persons passing by and using sensing devices like LDR and gas sensors also increases the efficiency of automation [14].

Street lights can be turned on when vehicle passes by and later turned off with the help of PIC microcontroller. Automatic time cut-out and an automatic control pattern can also be included for the electricity conservation [15]. Solar panel is an active form of solar energy. Solar Cells or photovoltaic cells are arranged in a grid-like pattern on the surface of solar panel. This, changes the direction of solar panel according to the intensity of the sunlight with the help of passive trackers and thus gain natural energy [16]. A ZigBee module with the help of graphical user interface (GUI) can be used for the detection of faulty lights and control of it. An intelligent automation system with decisions like ON/OFF/DIMMING gives more control towards street light automation [17]. High luminous efficiency, small size, lightweight and longer lifetime are the advantages of high frequency electronic ballast for high-intensity and efficient discharge lamps [18]. Nigerian households, which were poorly lit by kerosene wick lamp are adapting LED based lamps. But, since the power supply to LEDs are not regulated there is illumination losses. Thus regulated LED lamps can be replaced which shows more stability [19]. Smart street light system can be implemented by sensing an approaching vehicle towards the street light. This is achieved by using IR sensor which turns on light when vehicle passes by and using LDR for turning on light during night times. Thus, a lot of energy is saved [20].

This paper is divided into five segments. Segment II explains about the components and its specifications that are involved in this paper. Segment III explains the functioning of the project. Segment IV explains about the outcomes of the system. Segment V gives the conclusion about the whole paper.

2. System Parameters

Arduino uno is an 8-bit AT mega 328p microcontroller. It consists of 14 digital input-output pins. With input voltage of 7-12 volts and with operating voltage of 5 volts. In our project, Arduino plays a major role in controlling inputs and outputs. Here, we have connected the IR sensors to the analog pins of Arduino by which it will be managing the output of the Led lights. Generally, an Arduino can be powered by USB cable by the 9 volts battery. Here, the output voltage we get from piezoelectric disc is 13 volts in these 9 volts can be used by the Arduino.

Table 1 - Arduino Specifications

MCU	ATmega328P
Flash Memory	32 KB
Clock Speed	16 MHz
Digital IO Pins	24
Analog Input Pins	6

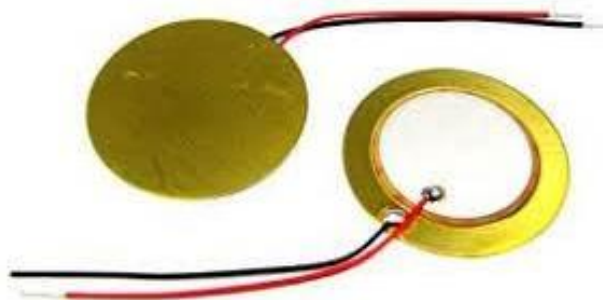
Fig. 1 - Arduino UNO



Here piezoelectricity is generated by applying the pressure to the material. It is based on piezoelectric effect which explains that whenever mechanical pressure is applied to quartz crystal then it will be generating the electric loads on the quartz crystal. Here the load generated will depend upon mechanical force applied to it. The piezoelectric transducer is sensitive hence it operates as a sensor and taken to accelerometer based on frequency of the reaction. Generally, 2 piezoelectric transducer pads will generate an output voltage of 3.5-4 volts.

Here in our project, we had used the 8 transducer pads. So, we get maximum output voltage as $3.5 \times 4 = 14$ volts. i.e. So it takes like 4 hours to charge a battery.

Fig. 2 - Piezoelectric Transducer



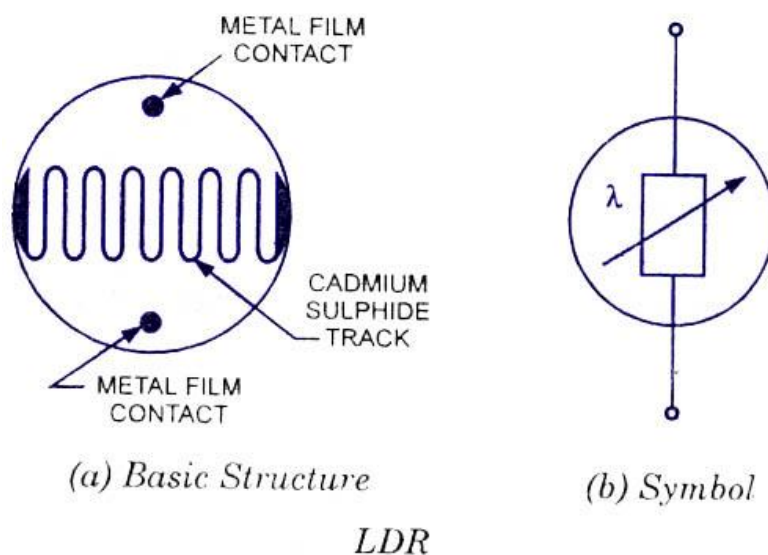
As name itself suggests that it is a light dependent resistor. Resistance decreases with increase in Light levels based on resistance the light intensity gets changed. The resistance values of the light

dependent resistor in darkness in in megaohms but whenever they are illuminated with light it will be dropped to 100 ohms. For example, if you take a light level of 1000 lux I.e., Bright light the resistance is 400 ohms when you take light level of 10 lux means low light then the resistance will be drastically risen to 1043000ohms by which light intensity gets changed. We had used 5mm LDR with maximum voltage of 100V DC and spectral resonance peak 540nm, Ambient temperature range of -30° -70°C Here are the illuminations if different light sources.

Table 2 - LDR Specifications

Light source	Illumination (Lux)
Moonlight	0.1
60W bulb at 1m	50
1W MES bulb at 0.1m	100
Fluorescent lighting	500
Bright sunlight	30,000

Fig. 3 - Light Dependent Resistor



They work on the principle of light waves and the Infrared light reflected from the object to sensor will also be used to measure the distance between the object and the sensor. So here range plays a major role in detection of object. It has a transmitter in which it which it emits the Infrared radiations they are also called as IR-LRDs and the next is IR receivers in which they will receive the radiation from the IR transmitters.

Table 3 - IR Sensor Specifications

Operating voltage	5V DC
Range	20 cm
Supply Current	20 mA
Input and output pins	5v/10v

Fig. 4 - IR Sensor



Light emitting diodes are semiconductor devices they will be operating in low voltage and low power. they are used as the indicators in circuits. It is a process in which the diode will convert electric current to the light. The led generally contains 2 terminals known as anode and cathode. Here the brightness of every led depends on current taken by it. There is a threshold limit for every led when we increase it the LED may burn. Here we will be using the blue led of wavelength range 400-500 NM. Here we had used 5mm led of blue color of specifications with forward current of 20mA, peak forward current of 120mA, reverse voltage 5V. Power dissipation of 85mW and luminous intensity of 20mcd.

Fig. 5 - LED



Batteries are energy storage devices. Here, we will be using the lithium-ion battery of 12 V of 1.3A-h battery is used.

Table 4 - Battery Specifications

Nominal voltage	12V
Rated cap	1.3AH
Operational temperature	During Charge 0°C (32°F) - 40°C (104°F) During Discharge -20°C (-4°F) - 50°C (122°F) During Storage -20°C (-4°F) - 40°C (104°F)
Capacity 25° (77°F)	At 20-hour rate (0.165A) 1.3AH At 10-hour rate 1.17AH At 5-hour rate 1.04AH At 1 hour rate (1.98A) 0.78AH
Maximum discharge current	19.5A

Fig. 6 - Lithium Battery



It is a 2-terminal component that will be conducting current in only one direction it severely opposes the current to flow in other direction. Today, diodes are only made of silicon. Most of the diode uses p-n junction. Diodes can protect the circuits by limiting the voltage and it can also convert AC to DC.

Table 5 - Diode Specifications

Diode(used)	1N4007
Diode Type	Silicon Rectifier general usage diode
Max reverse voltage	1000V
Average forward current	1000mA
Maximum forward current	30A
Maximum storage and operating temperature	-55 to +175 Centigrade
Maximum power dissipation	3W

Fig. 7 - Diode (1N4007)



It will be converting ac voltage into dc voltage which will be given to the diode. Generally, a full wave bridge rectifier will use 4 diodes and one resistive load. They have low power loss so that no voltage signal is wasted in this process. Here we will be using W10 1000v, 1.5A silicon single phase bridge rectifier of specifications.

Table 6 - Full Wave Bridge Rectifier

Peak reverse voltage	1000V
Maximum RMS voltage	700V
Maximum DC blocking voltage	1000V
Maximum forward voltage	1V
Peak forward current	1.5A
Maximum reverse current	10 μ

Fig. 8 - Full Wave Bridge Rectifier

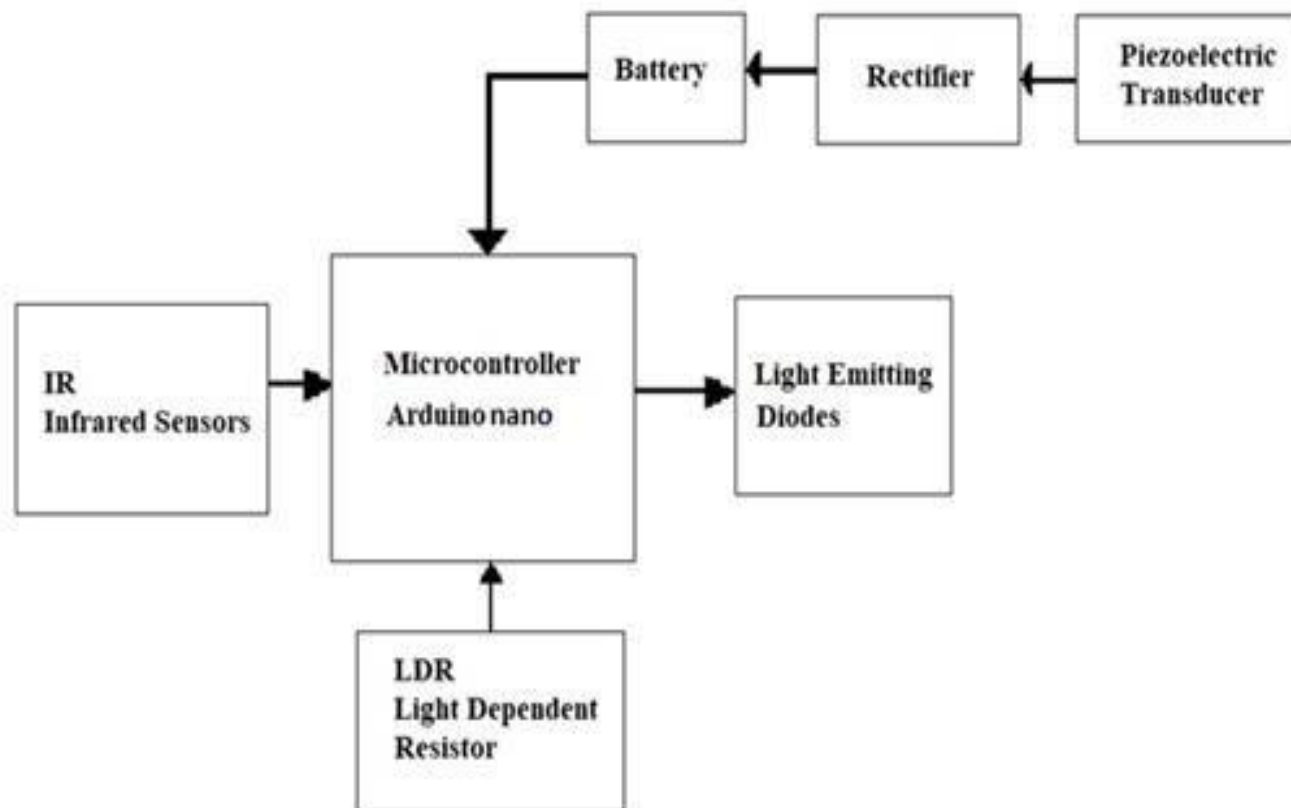


3. System Implementation

The basic principle is to convert the mechanical energy into electric energy, through the piezoelectric transducer. The figure shows the block diagram of working of smart LED. The piezoelectric transducers are placed on the road, The energy is harvested from these piezoelectric transducers and stored in the battery using the rectifier circuit, This energy which is stored in a battery by the piezoelectric process is used as the power supply for the circuit, The system starts to works only at low or poor lighting conditions i.e. in evening and night time, Once the system starts

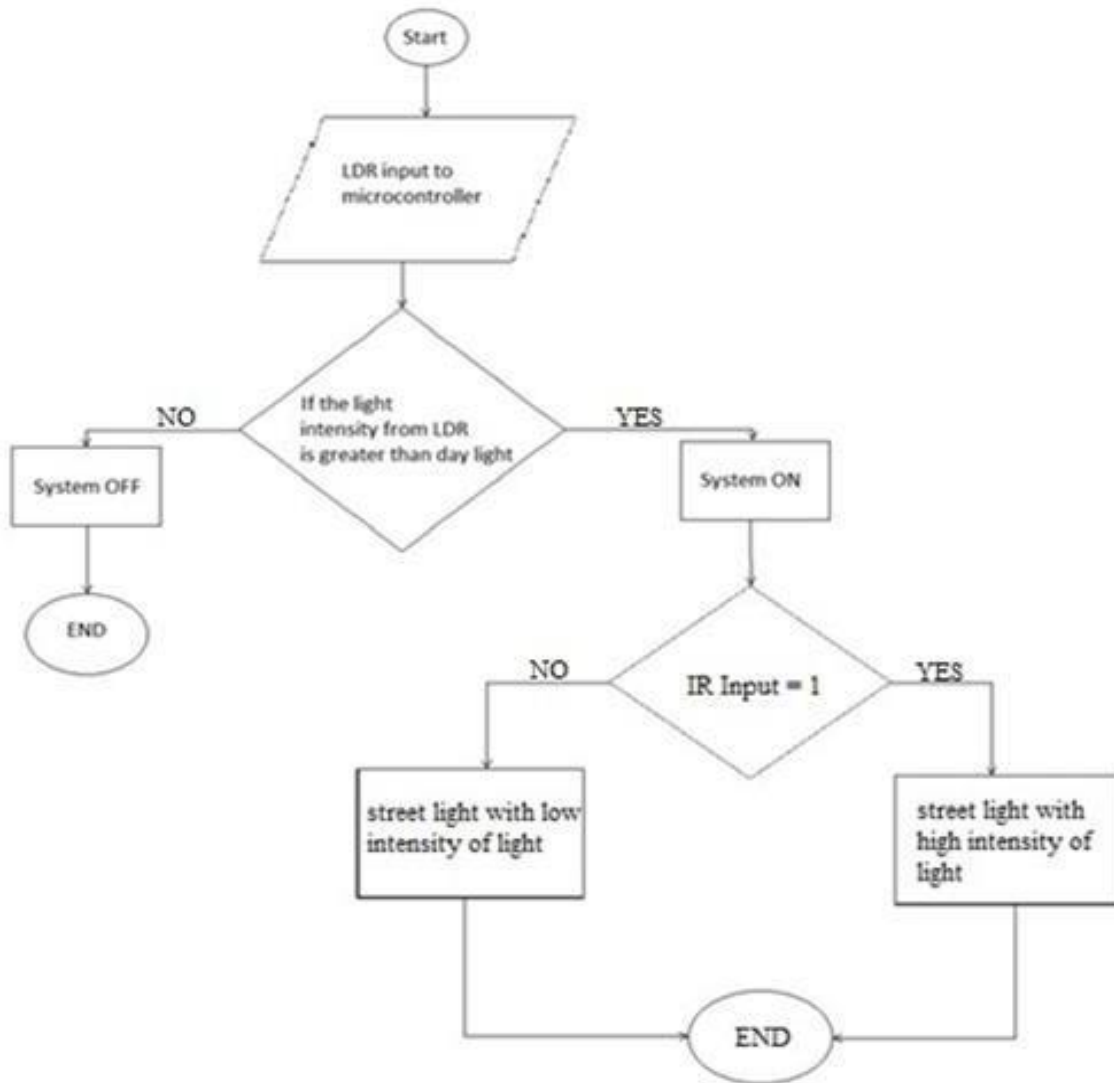
working the light will be on and will be glow at low intensity, The IR Sensor will be monitored continuously and once the vehicle movement is sensed the lights will start glow at the high intensity and lights will glow in low intensity when there is no movement.

Fig. 9 - Flowchart of the System



The system starts working by making use of power supply which is store in the battery by the piezoelectric process, the microcontroller will keep on monitoring the LDR once the resistance is high the streets will turn on, If the resistance of LDR is low the microcontroller will continue monitoring, once the lights are on the microcontroller will monitor IR sensor output when the vehicles are detected by the IR sensor the lights will start glowing in high intensity, when no vehicles are detected the lights will glow with low intensity, as soon as the LDR resistance is low the system stops working and microcontroller will continue to monitor LDR.

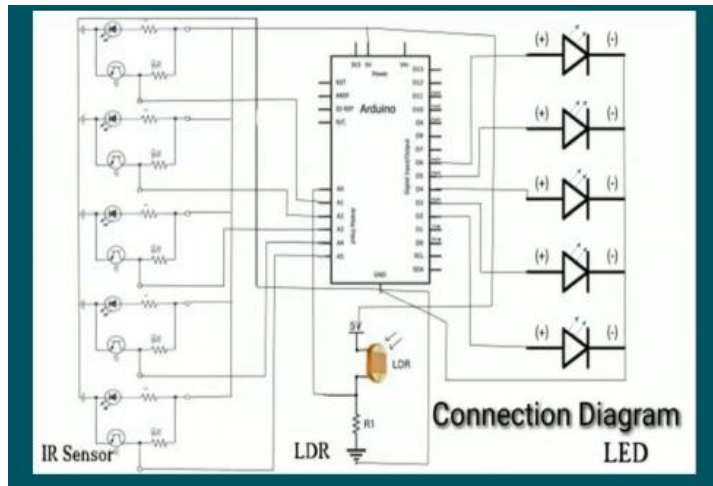
Fig. 10 - Flowchart for LDR



Firstly, Connections are made as of the circuit diagram. Code plays a major role in the working of the equipment. Present days Smart Street Light system is a major component of smart city infrastructure.

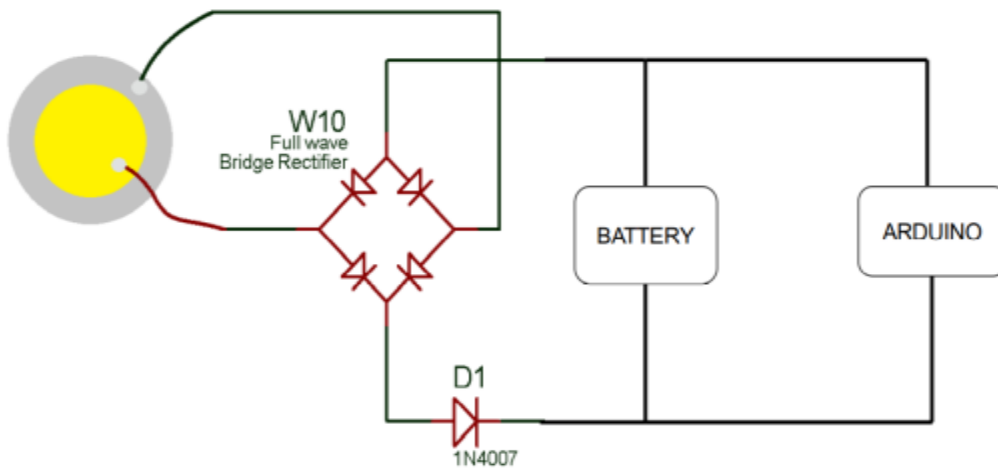
The main function of this system is to lighten the city streets using Sensors so that we can save power energy. In the existing system using normal lamps consumes more amount of energy and also it is very expensive. In order to minimize the consuming of power and cost we must use LED's. Using IOT systems is all around the world. It is mandatory to watch all kinds of places in the cities.

Fig. 11 - Connection diagram of Arduino UNO



The Working Procedure of Smart Street Light using IR sensors is described as follows. It consists of following steps. The output pin of LDR is connected to Analog port of Arduino Uno board. Connecting all the output pins of IR sensors to the input port of Arduino Board respectively. Connecting all the ground of IR sensors to the GND port. The output of all the LEDs is connected to port 2, 3, 4, 5, 6 respectively. Connecting all the negative terminals of LEDs to the GND port.

Fig. 12 - Circuit Diagram of Piezoelectric Transducer



4. Result

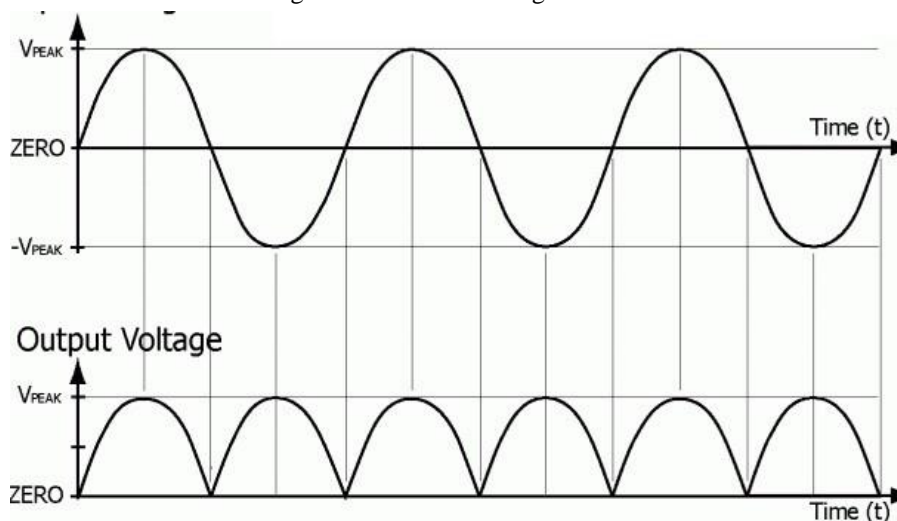
As a result of this project, we are using piezoelectric transducers, IR, LDR sensors and LEDs. The Use of IR sensor is to detect the vehicles which pass on the road and then the light will glow with high intensity. Intensity of the lights get reduced when the vehicle passes away from the sensor

detection.it can save the power. Using a piezoelectric transducer which will be able to convert the pressure (given by the vehicles in roads) to electrical energy which is stored in the battery.

LDR sensor will operate the light automatically and reduces the manpower. It will help to stop the lights during daytimes. The main result is that calculating the battery power and battery life of the li -ion battery.

1. Piezoelectric Transducer Implementation

Fig. 13 - Full Wave Bridge Rectifier



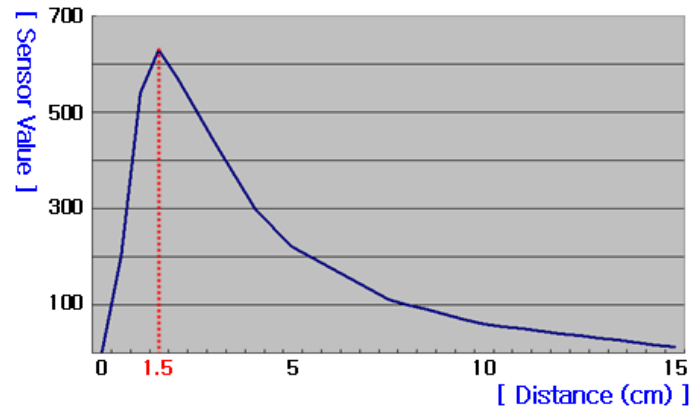
The pressure is given by the vehicles on the road, this pressure of mechanical energy able to convert into electrical energy. This electrical energy in the form of ac current using full wave bridge rectifier (W10) to convert into dc source of energy. With the help of diode (1N4007), it will help to control the flow of current in forward direction not reverse direction. This energy which is stored in the form of chemical energy in the battery. This all kinds of activities works under the Arduino uno.

2. Sensor Detection of Street Light System

During daytime, the entire system will be off condition, and only the battery will be charging. Daytime or night time will be sensed by the LDR sensor.it will work during night time. The system automatically works on when there is no light falls occur on the LDR sensor. Which is called an active mode. In the presence of vehicles on the road, the IR sensor can be detected, it will help the lights glow with high intensity. And also, any pressure occurring from the vehicles helps the

transducer to convert it and store it in the battery. Overall result is that the hardware implementation of smart led street lights under works on Arduino uno.

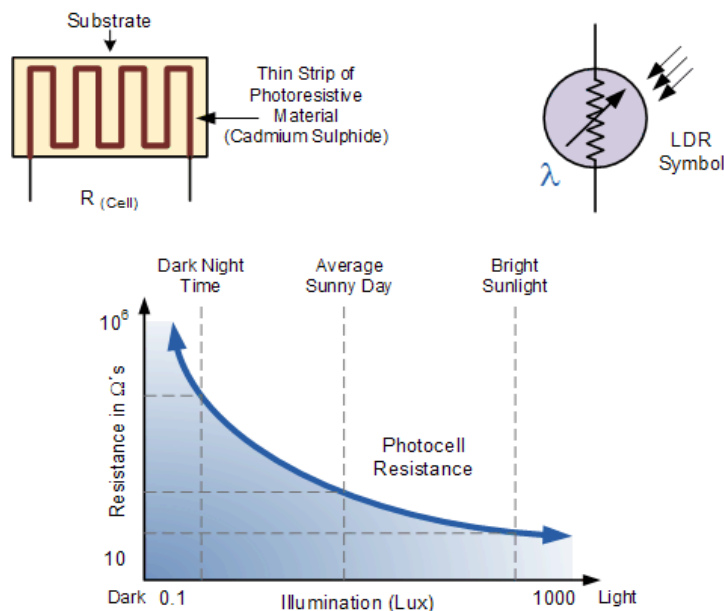
Fig. 14 - Graph for IR Sensor, between Sensor Value and Distance



Normally sodium vapor lights and mercury vapor lamps consume 250w to 400w of power. As modern world smart led street lights can consume the power of 60w. It can save about 40% on high energy consumption. The energy consumption depends on the pole distance; it takes nearly 5,7,9 meters. Each pole of street light takes about 10-15w of power in the whole night.

Where a piezoelectric transducer gives the 2mw of energy where pressure occurred on the road.it is able to charge the battery of 40mah in one hour. Phase of the wire, we can either use single phase(230v) or three phases(440v).

Fig. 15 - Light Dependent Resistor (LDR)



The intensity of light depends on the luminous power. Which is luminous flux per area illuminated by the light, measured in lux. $1\text{lux}=0.092\text{fc}$ (lumen/mq). That is equal to one square meter. This means that the light will be brighter closer to the light source. Otherwise, it's far away from the light source.

Calculate the intensity of light Where i = light intensity (cd), K = luminous efficacy ϕ = Flux(lm). The K average luminous efficacy of 1 watt lamp types HPLN is 42 lm/watt with power (P) is 1 watt and the angle is $\omega = 4\pi$ space is

Consider 12 hours of a day during night time, a bulb can consume the energy of 150w/number of nodes is nearly 15.and calculate the power consumed per day= $15*12*150/1000 = 27$ units that is $27*30=810$ units per month.

Calculate the battery power and battery life of the li ion battery.in our project, Average current=8mA, operating voltage=5v, average power stored by the battery= $V*A=12*5=60\text{mW}$.

Battery life: battery capacity=1.3mAh, battery voltage=12v, power= $12*1.3=156\text{mWh}$, Battery life= $156/60=2.6$ hrs.

3. Code Snippet

```
int led = 3;
int led1 = 10;
int led2 = 5;
int led3 = 9;
int ldr = A0;
void setup(){
  Serial.begin (9600);
  pinMode (led,OUTPUT);
  pinMode (led1,OUTPUT);
  pinMode (led2,OUTPUT);
  pinMode (led3,OUTPUT);
  pinMode (ldr,INPUT); }
void loop()
{int ldrStatus = analogRead (ldr); //ldr
  if (ldrStatus <=14){
    if (analogRead(A1)<500){ // IR 1 CODE
```

```

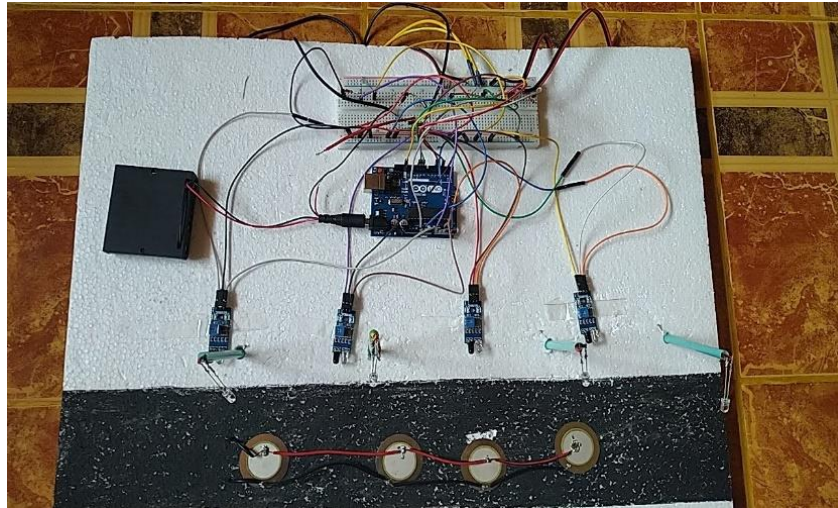
digitalWrite(led,HIGH);
digitalWrite(led1,HIGH);
delay(1000);}
else {digitalWrite(led,HIGH);
analogWrite(led,255/5);
delay(50); }
if (analogRead(A2)<500) {      // IR 2 CODE
digitalWrite(led1,HIGH);
digitalWrite(led2,HIGH);
delay(1000);}
else{
digitalWrite(led1,HIGH);
analogWrite(led1,255/5);
delay(50);}
if (analogRead(A3)<500){      // IR 3 CODE
digitalWrite(led2,HIGH);
digitalWrite(led3,HIGH);
delay(1000);}
else {
digitalWrite(led2,HIGH);
analogWrite(led2,255/5);
delay(50);}
if (analogRead(A4)<500){      // IR 4 CODE
digitalWrite(led3,HIGH);
delay(1000);}
else{
digitalWrite(led3,HIGH);
analogWrite(led3,255/5);
delay(50);} }
else{
digitalWrite(led, LOW);
digitalWrite(led1, LOW);

```

```
digitalWrite(led2, LOW);  
digitalWrite(led3, LOW);}}
```

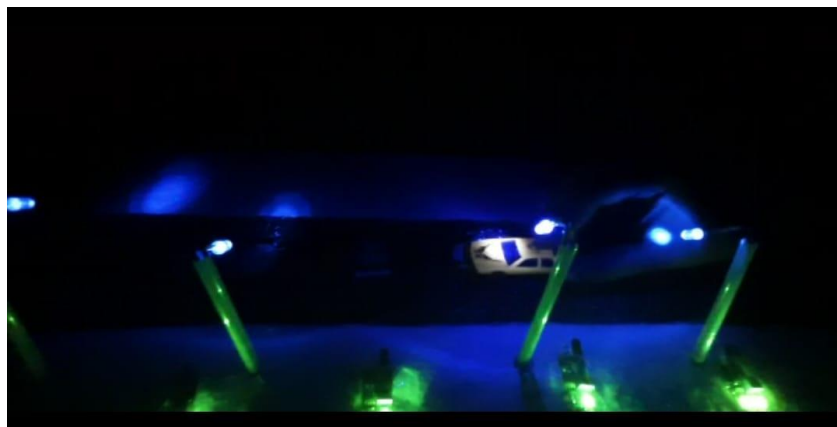
4. Hardware Implementation

Fig. 16 - Output during Daytime



The pressure which is applied in the road by the vehicles which has piezoelectric transducer is converted to electrical energy by piezoelectric transducer. To maintain it in DC current, a full wave bridge rectifier is used and a diode is attached to neglect backward current.

Fig. 17 - Output during Night Time



This current is stored in the lithium-ion battery which can be used for the power supply of Arduino UNO. Thus, it will control the LEDs, IR sensor and LDR. When vehicle passes the street light, the LED will glow bright which is sensed by the IR sensor and will remain dim when there is

no vehicle. Also, during daytime, the LEDs will be in OFF condition and during night time, it will be in ON condition which is detected by LDR.

5. Conclusion

This paper presents adaptive research for Smart LED Street lights. LEDs play a major role for lighting options in future facilities, due to its low power consumption and very cost effective. Our main objective is to use the piezoelectric transducer it helps to run the smart led street lights. It will help to eliminating the conventional power source and sodium vapor street lights. We can use sensors to monitor the vehicles in the road. The use of transducer it able to convert pressure (mechanical energy) into electrical energy, this energy which is used in our street lights. During daytime, charging takes place which is stored in the battery. This charged energy using during night time it depends on vehicles cross on the road. Otherwise, the light will be dim.

In conclusion, we conclude that the conventional lights consume the most energy from thermal power stations and other energy resources.in case of that we were using smart led street lights it takes nearly 60% more energy than conventional. It helps to save energy. Furthermore, we conclude that the intensity of light will be controlled according to the environmental need using sensors to detect the vehicles which are all controlled by Arduino Uno. With the few limitations such as low amount of power generated using the power harvesters, the researchers are working towards generating new methods.

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