SMART STREET LIGHT SYSTEM

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Submitted to the Faculty of Department of Electrical Engineering,
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In partial fulfillment for the requirements of a B.E degree in Electrical (Telecom) Engineering.

JUNE 2019

CERTIFICATE OF CORRECTNESS AND APPROVAL

It is certified that the work contained in this thesis titled “Smart Street Light System”, carried out by NC Hajra Ahmad, NC Komal Naseer, NC Mahjabeen Asif, PC Muhammad Farhan Alam under the supervision of Asst. Prof Mian Muhammad Waseem Iqbal for partial fulfillment of Degree of Bachelors Electrical Telecommunication Engineering, in Military College of Signals (MCS), National University of Sciences and Technology during the academic year 2018-2019 is correct and approved. The plagiarism is ____%.

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ABSTRACT

Statistics show that almost three-fourth of the demands of energy in the world is fulfilled by fossil fuels. Since fossil fuels are hydrocarbons, burning fossil fuels releases a large amount of carbon dioxide into the air. This increased percentage of carbon dioxide causes global warming. Combustion of fossil fuels not only emits carbon dioxide into the air, it also releases other gases like carbon monoxide, methane, nitrous oxide, etc. that cause air pollution. To avoid this we have to reduce wastage of electrical energy and try to produce energy through other means instead of using fossil fuels. Currently, enormous amount of electrical energy is being consumed by the street lights, which remain switched on throughout the night. This causes a huge waste of electrical energy across the world and should be prevented. The main aim of smart street light systems is that lights turn on only when there are vehicles or pedestrians on the road and remain off otherwise. The street lights will be powered by the electrical energy generated through the pressure applied by footsteps and vehicles. So we don't need to provide power to the street lights by energy from fossil fuels which are being depleted due to their increased demand. The smart street light system consists of DC lights, LDR, piezoelectric sensors, motion sensors and short-distance communication networks. Our main purpose is to reduce wastage of energy and make use of non-conventional sources for energy production.

DECLARATION

No portion of the work presented in this thesis has been submitted in support of another award or qualification either in this institution or anywhere else.

In the name of Allah, the most Beneficent, the most Merciful

DEDICATION

It is our warmest regard that we dedicate this work to our parents and teachers who have been a great source of inspiration and support. This work would not have been possible without their unstinting cooperation and assistance.

ACKNOWLEDGEMENTS

First we are thankful to ALLAH ALMIGHTY who enlightened us with the knowledge that we needed for the accomplishment of our project and gave us strength to complete our task successfully.

We acknowledge, with profound gratefulness, the motivation, backing and unceasing guidance provided to us by our project supervisor Asst. Prof. Mian Muhammad Waseem Iqbal to accomplish our project.

We are grateful to our colleagues and to the people who have been readily available and willing to help us in the development of the project.

Special thanks to our parents for their continuous support and motivation throughout the process.

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INTRODUCTION

CHAPTER 1

INTRODUCTION

1.1.Background/Motivation

During the last decade, it is known that the rate of Antarctica's ice mass depletion has tripled. The surface ocean waters are approximately 30 percent more acidic than they were at the start of Industrial Revolution. Scientists have predicted that the Arctic Ocean will barely have ice before 2050. During the last century, sea levels have also risen at double rate for the last 20 years. Global temperatures could also increase by 10.4 degree Fahrenheit by 2100 [1]. This is all due to global warming which is caused by increased use of fossil fuels for energy generation.

Statistics show that almost three-fourth of the demands of energy in the world is fulfilled by fossil fuels. Since fossil fuels are hydrocarbons, burning fossil fuels releases large amount of carbon dioxide into the air. This increased percentage of carbon dioxide causes global warming [2].

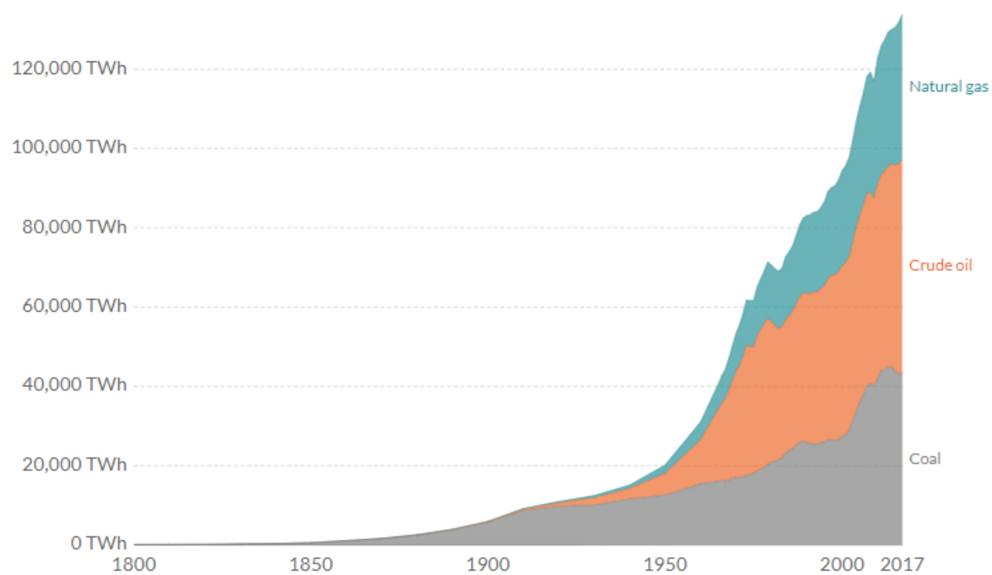

Figure 1-1: Increasing use of Fossil Fuels

Combustion of fossil fuels not only emits carbon dioxide into the air, it also releases other gases like carbon monoxide, methane, nitrous oxide, etc. that cause air pollution. To avoid this we have to reduce wastage of electrical energy and try to produce energy through other means instead of using fossil fuels [2].

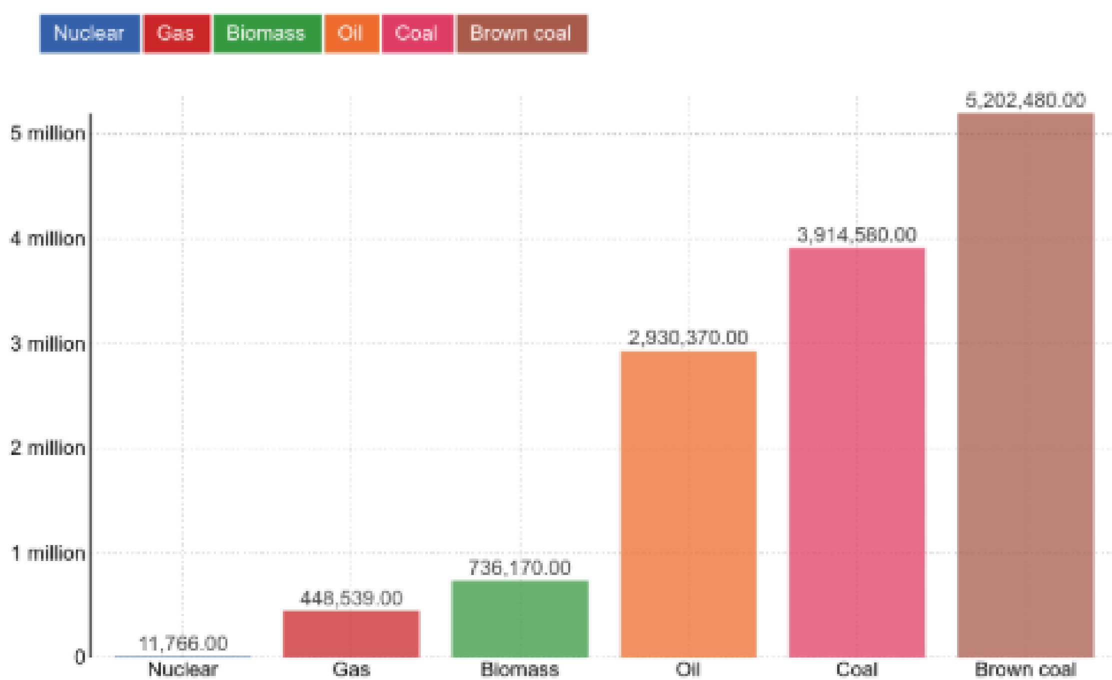

Figure 1-2: Hypothetical Number of Deaths from Energy Production

1.2. Project Overview

Urban areas across the world are dealing with increasing energy consumption and carbon emissions, a known contributor to climate change. Due to inadequate intensity control and low efficiency, current street lighting is wasteful in terms of energy usage, accounting for a major part of governmental electricity costs. Therefore, it has become desirable to design a new smart street lighting system that is more efficient and environment friendly.

The main aim of this new smart street lighting system is to control energy efficient LED street lights to turn on only when needed and to remain in a dim or off state otherwise. We are designing a system in which street lights become bright when a car comes closer to it and become dim when there is a distance between the car and light. So basically, we are trying to make a relationship of light intensity with the speed and distance of vehicle.

1.3. Problem Statement

Conventional street lighting systems in various parts of the world use constant illumination lighting which leads to high energy consumption accounting for up to 60% of a municipal government’s total electricity expenditure. [2] Furthermore, forecasts show that the amount of financial spending on street lights is likely to increase over the next few years as the demand and price for electricity increases. Many urban areas are facing high carbon emissions due to public lighting, which are a known contributor to climate change. For example, in Harrow, street lighting consumes 6,551,500 kWh of electricity, which leads to 3,900 tons of carbon emissions annually which is dangerous for our health.

Figure 1-3: Conventional Street lights System

1.4. Scope

This project is going to be the productive insight in the industry due to its low energy consumption as it is controlling the intensity of light, efficiently and also because of its energy generation mechanism by motion. In this system, intensity of light will be related to distance of vehicle from the light pole.

1.5. Approach

We will first reduce energy consumption by street lights by designing a system in which the lights remain off or are at minimum intensity level throughout the night and their brightness is only increased when there is some motion on the road. In the second part we will convert the mechanical energy produced due to motion on the road to electrical energy which in turn will be used to provide power to the street lights.

1.6. Objectives

Our main purpose is to make such a street light system in which the brightness of the street lights depends on the distance of vehicles from the light pole. If the car is closer to the street light then the light has full brightness and when it moves away the brightness decreases. We will also power the street lights using energy produced by motion on the road.

Our proposed design aims to efficiently control the intensity of the streetlights. Our system aims to fulfill the following requirements:

- The lights will be powered by energy produced by pressure applied by footsteps of pedestrians.
- We will use DC lights instead of AC lights to eliminate cost of conversion of DC to AC.
- Control energy efficient street lights to turn on only when needed and remain off otherwise
- This project will help to decrease wastage of electricity by controlling working of smart street light system that contributes to a good amount of electricity bills in our nation
- Smart street light system tries to find solution for faster depletion of energy resources due to inefficient usage and wastage of these resources

- Build an energy saving smart lighting system with integrated sensors and controllers.

1.7. Salient Features

The salient features of this project are:

- Reduce wastage of electricity by powering on street lights only when there is motion on the road
- Power is generated by the pressure exerted by people while walking or running
- No external source of power is used for powering the street lights
- Battery stores the generated power
- DC lights are used which consumes less power
- This system is eco-friendly as no fossil fuels are used in energy generation

1.8. Reasons/Justification for Selection of Topic

Pakistan has no indigenous street light system which saves energy and also generates energy. It needs its own efficient street light system which reduces resources. The main goal of this project is to design and develop a smart street light system.

1.9. Organization of Document

The document compromises of five major sections:

Chapter 1 First Chapter covers the background/motivation, brief overview, problem statement, scope, approach, objectives, salient features and reason for selection of topic.

Chapter 2 Second Chapter deals with the literature review done throughout the project and it lists the similar projects done or the projects that are currently being worked upon.

Chapter 3 Third Chapter deals with the technological specifications i.e. hardware and software specifications.

Chapter 4 Fourth Chapter gives the overview of Smart Street Light System design and also explains in detail the hardware design and development carried out.

Chapter 5 Fifth Chapter analyzes the project and shows the results of the project and basing on the performance the benefits of Smart Street Light System are also discussed.

Chapter 6 Conclusion

Chapter 7 Seventh Chapter discusses future work and enhancements.

CHAPTER 2

LITERATURE REVIEW

CHAPTER 2

LITERATURE REVIEW

2.1 Background Study

The normal system of street lights consumes enormous amount of energy, hence a lot of energy is wasted. In most of the systems the consumption of energy is minimized with the implementation of brightness sensors due to which lights remain off during day time and turn on during night time [1]. But in this system lights remain on throughout the night even if there is no traffic on the road hence this consumption of energy is consistent and has no concern with the frequency of traffic. This is a huge wastage of energy. Currently, when we are facing a major energy crisis and a lot of energy is wasted due to constant illumination of street lights, so there is a need to reduce this consumption of energy. With the upgradation of technology, many solutions like LED, brightness controller/dimmer (which reduce intensity of light), Wireless and ICT based systems have been proposed [9]. The main objective of this project is to evaluate and integrate these technologies to efficiently reduce the consumption of the energy in the street light system.

In majority areas, the street lights are replaced by LED lights which reduce energy consumption to some level. By using LED technology, the intensity of lights can be controlled easily. The power consumption can further be reduced by designing and implementing movement detection based Smart Street light system i.e. street lights remain off or in a dim state when there is no vehicle/pedestrian on the road and turn on when movement of vehicle/pedestrian is detected on the road/street by means of motion sensors. Hence, movement detection based street light control can be designed easily.

The street lights can be powered by energy generated through the pressure applied by footsteps. So there will be no need to power street lights separately. In energy generation through footsteps mechanical energy is converted into electrical energy.

Footstep power generation system is used to generate electricity by walking or running. As the demand of electricity is increasing day by day but generation conventional resources are not enough for total demand of electrical energy. Therefore, we need to use non-conventional energy resources for power generation. Our proposed system converts mechanical energy to electrical energy using piezoelectric sensors. This system can also be implemented on roads, bus stations and other public places.

Figure 2-1: Energy generation through footsteps tile [9]

Different methods used to design smart street light system are as follows:

2.2 Centrally-controlled smart street light systems

Smart street lights have been researched by many researchers. Some companies have developed centrally-controlled smart street light systems with the host computers. They might be suitable for being applied to a large area or a newly developed area based on a wide area. However, they might not be suitable for being applied to a small area. Moreover, centrally-controlled smart street light systems are expensive because the host computers, which support many street lights, must have high ability and it takes much cost to maintain networks of smart street lights [4].

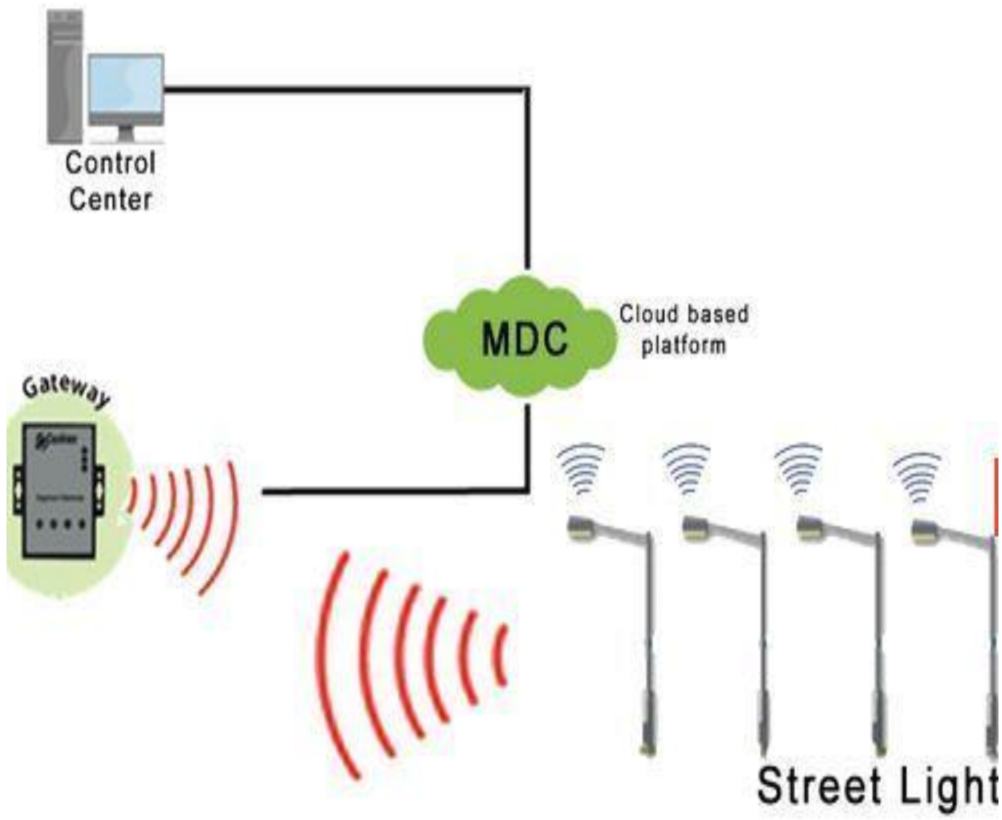

Figure 2-2: Centrally controlled smart street light system [4]

2.3 Pedestrian aware Smart Street Lighting system

This kind of smart street lights exchange information of detecting moving objects and turn on so that neighborhood of the moving objects lightens. Basically it is SSL system, a framework developed for a dynamic switching of street lamps based on pedestrians' locations and desired safety zones. In the developed system prototype, each pedestrian is localized via his/her smartphone, periodically sending location and configuration information to the SSL server. For street lamp control, each and every lamppost is equipped with a ZigBee-based radio device, receiving control information from the SSL server via multi-hop routing. But experiments have shown that objects like trees can interrupt wireless communication between lampposts and that inaccuracy of global positioning system position detection can lead to unexpected lighting effects [5].

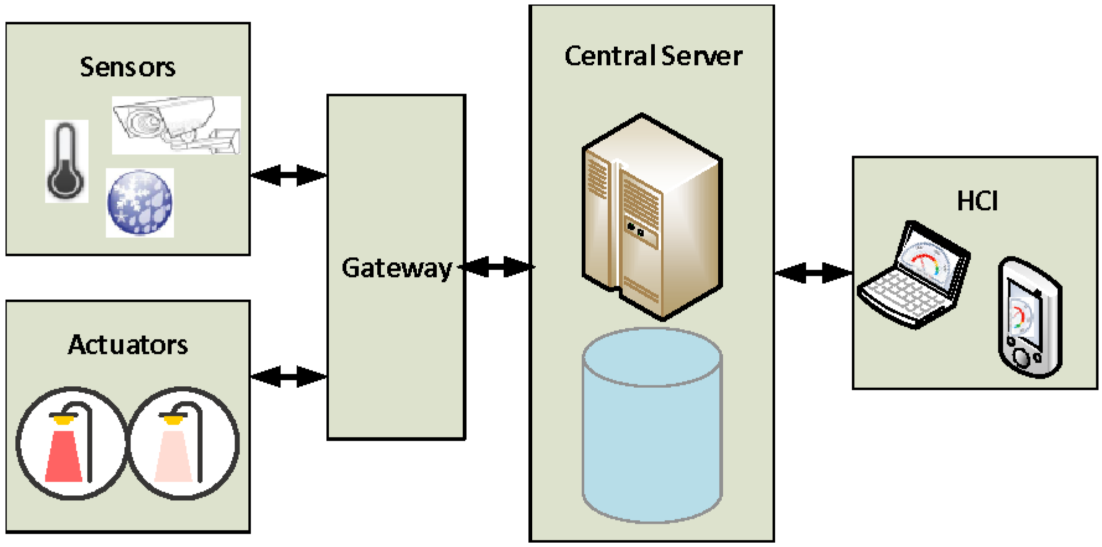

Figure 2-3: Dynamic Street Lighting System Overview [5]

2.4. Multi object tracking for mobile navigation with embedded tracker

In this system the method of pedestrian tracking is proposed for smart street light systems. Detection of existence of pedestrians or vehicles is important for smart street light systems. An efficient processing platform is required to achieve the objective that tracking in real-time and without data losing [6].

2.5 IOT based smart and adaptive lighting in street lights

The system is mainly used for smart and weather adaptive lighting in street lights. The automatically ON/OFF of street lights can be accessed anywhere anytime through internet. A camera is placed on top of the street light to track the actions performed on the road where the footages are stored in a server. A panic button is placed on the pole, in-case of any emergency or danger, the person in danger can press this button which raises an alarm at the nearby police station. Whenever the panic button is pressed, the footage at that time recorded by the camera is sent directly to the cloud account. The access of the account is given to the particular police station by which they can view the incident's spot. Each area's street lights are connected to the particular area's police station and each of them has a cloud accessible account [7].

2.6 Street light system using computer vision and image processing techniques

This system suggest a new method for monitoring the street lighting system which is completely isolated from electricity network and applies picture shooting of street lighting network, image processing and computer vision techniques and separating light source method in the picture [8].

2.7 Street light automation by self-responsive cars for smart transportation

Vehicle and pedestrian aware smart street light automation can save tremendous amount of electricity which may be diverted towards rural electrification. It is nothing but energy efficient street light automation based on objective motion. Self-responsive car helps driver to learn and understand the benefits of street light automation based on self-responsive car, also it can have a beneficial effect on road safety when used on motorways with non-congested traffic. Thus it will reduce number of accidents due to uncontrolled vehicle [9].

2.8 Power Generation by Footsteps

When an individual passes it push the tile on ground surface which turn the shaft beneath the tile, turn is limited by clutch bearing which is underpinned by holders. Primary shaft rotates approximately twice by a single tire push. The movement of prevailing shaft turn the gear box shaft which builds it fifteen times then its movement is smoothen by the help of flywheel which temporarily store the movement, which is conveyed to DC generator. Energy generated is stored in batteries, an inverter circuitry is implemented to convert DC to AC [10].

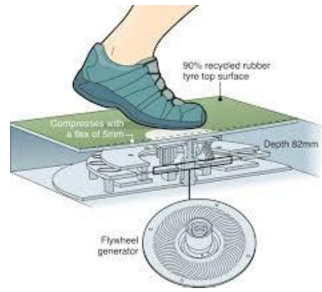

Figure 2-4: Energy Generation through Footsteps [10]

2.9 Intelligent Street Light System in Context of Smart Grid

Energy utilization & management schemes at home, business and industry have been successfully implemented in the context of smart grid. But the public street light system has not been taken under serious consideration. The conventional street light system is the potential consumer of electricity, and large amount of electricity wasted. The consumption of energy is consistent and has no concern with the activity and frequency of traffic.

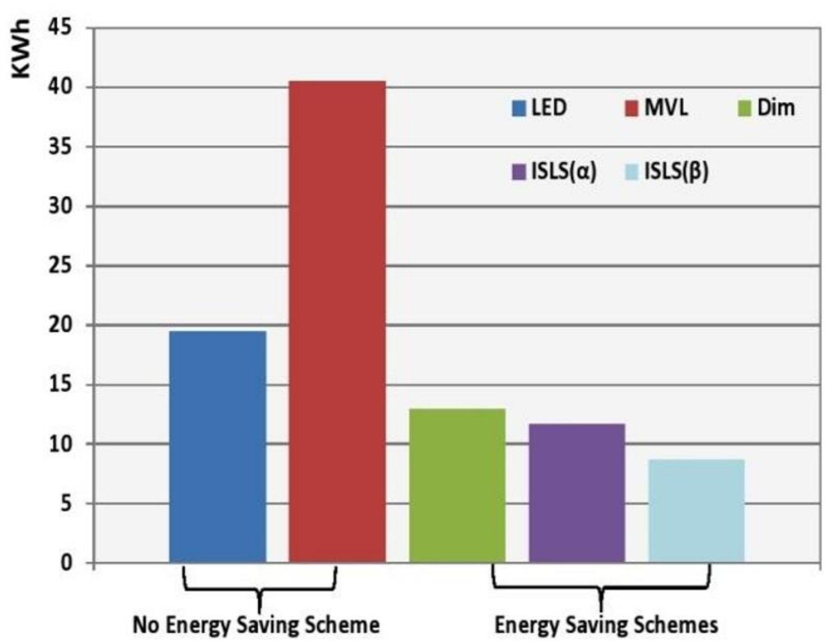

Figure 2-5: Comparison of Energy Consumption in different techniques at night [35]

The lighting system is widely implemented in roads, commercial and residential areas to facilitate the passenger, cars and pedestrian. In the security sensitive areas continuous lightening is essential to protect the passengers from robbers and animals at night. But in rural areas and intra city highways the constant lightening is required; it is wastage of energy which ultimately raise the carbon footprint. The purpose of this project is to propose the smart street light system in combination with smart grid system to efficiently utilize the energy at night. Street Light is the potential consumer of electricity. In developing countries no significant work has been done to reduce energy consumption in the street light system. Conventional street light system consumed 35% of electricity during nights, while after 12:00 am 90% of electricity wasted in low traffic areas. And the street lights remain turned on whole night till morning.

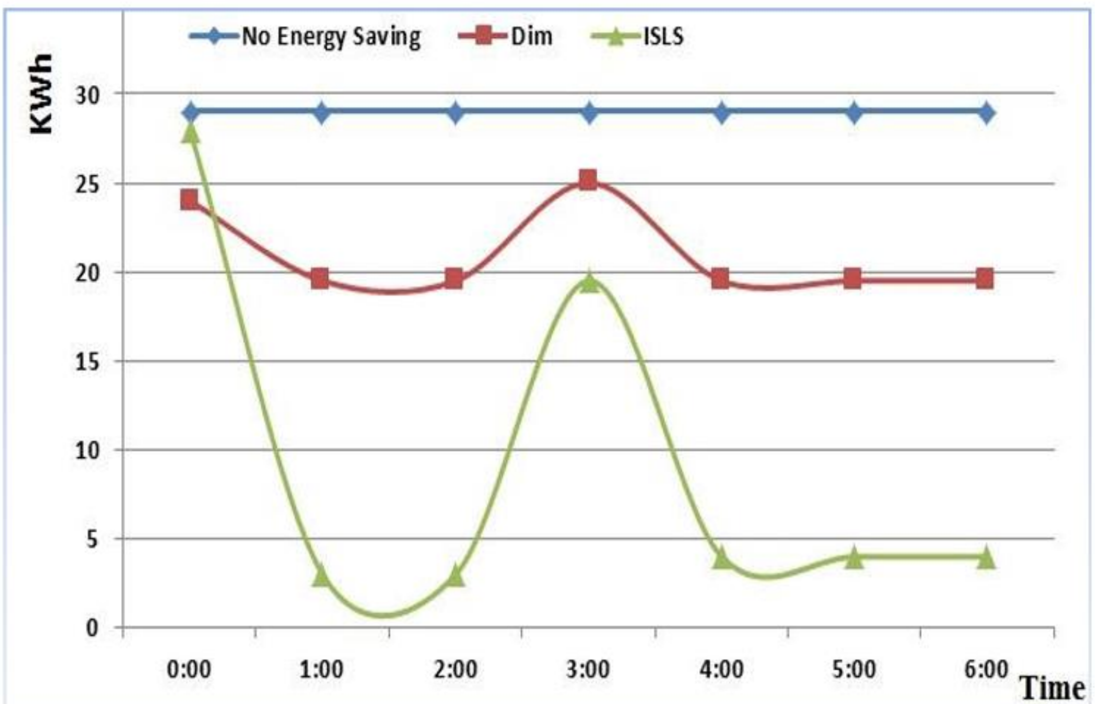

Figure 2-6: Energy Consumption in Off peak hours with low Traffic [35]

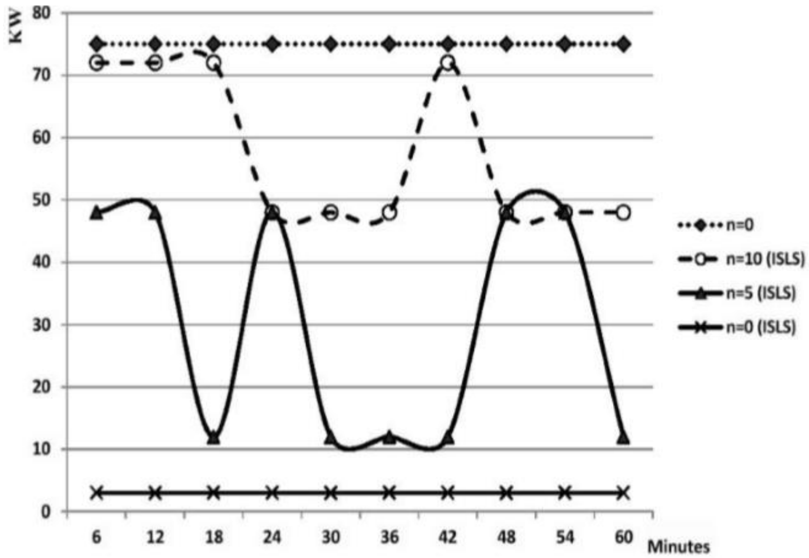

Figure 2-7: Graph showing Energy Consuming Profile in highway [35]

In conventional street light system manual control (turn on switch mounted on each pole or whole distribution line), time control and optical control are used to turn on and off the lights. In small and medium cities, time-optical-control is commonly implemented. The advancement in technology provoked the idea of the smart grid and smart cities. In developed countries smart grid is becoming common to monitor, control and manage the electrical grid system.

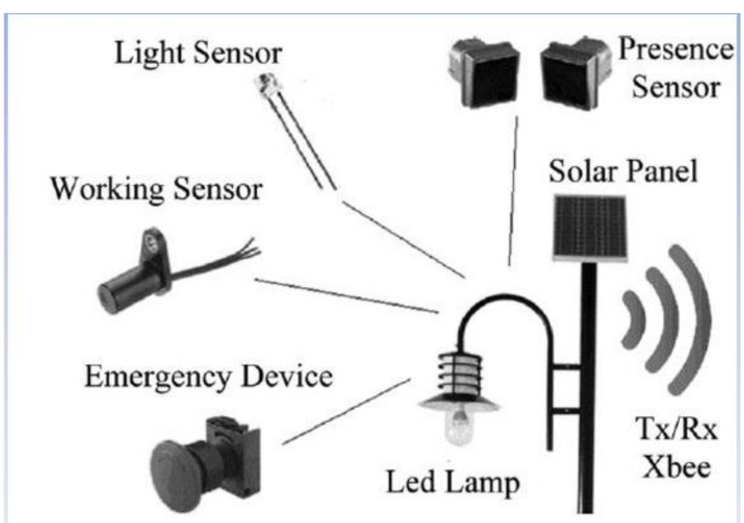

Figure 2-8: Energy Consuming Profile at different frequency of traffic [35]

2.10 IOT Based Smart Street Light Management System

The aim of automated streetlight management system using IOT is the conservation of energy by reducing electricity wastage as well as to reduce the manpower. Streetlights are the elemental part of any city since it facilitates better night visions, secure roads, and exposure to public areas but it consumes a quite large proportion of electricity. In the manual streetlight system lights it is powered from sunset to sunrise with maximum intensity even when there is sufficient light available. This energy wastage can be avoided by switching off lights automatically. The saved energy can be efficiently utilized for other purposes like residential, commercial, transportation etc. This can be achieved using an IOT enabled streetlight management system [14].

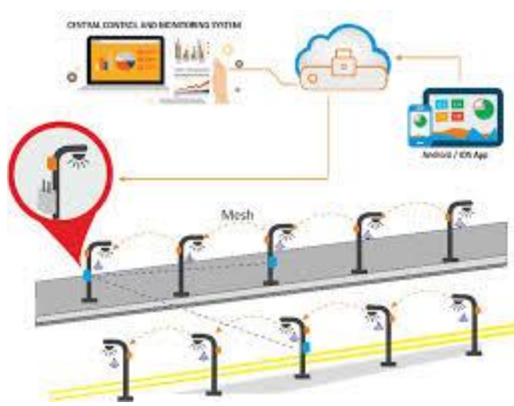

Figure 2-9: IoT based System [14]

The project uses Light Emitting Diodes (LED) that do not consume an enormous amount of electricity to replace the power consuming traditional HID lamps. LED lights along with LDR enable the intensity variation which is infeasible with the HID lamps. As LEDs are directional light sources it can emit light in specific direction thereby optimizing the efficiency of the street lights. This system includes an additional DHT11 Temperature-Humidity sensor. This provides the exact temperature and humidity of a particular region. DHT11 is a composite sensor that contains a calibrated digital signal output of the temperature and humidity. It ensures high reliability and excellent long-term stability. This work is implemented using a programmed Arduino board for providing the required intensity of light at various times. The proposed work has achieved a better performance compared to the existing system.

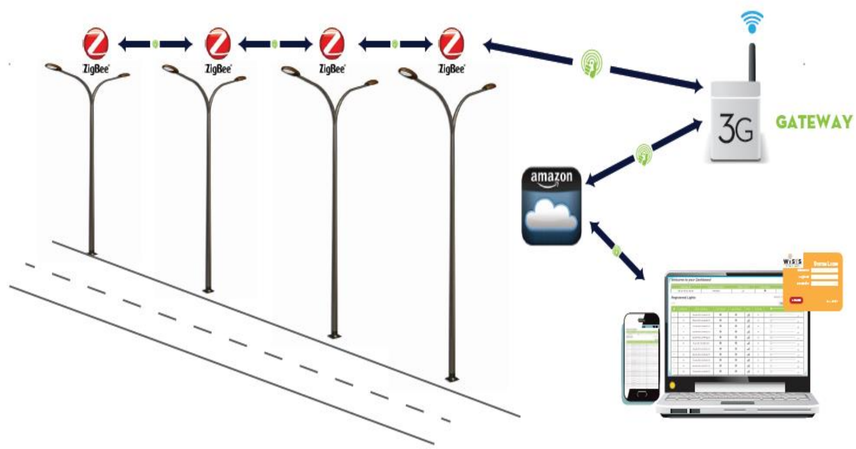

Figure 2-10: IoT Based System Overview [14]

2.11 Conclusion

Piezoelectric sensors are arranged in series and parallel combinations and this arrangement of sensors is placed under the footpath tiles. When pedestrians are passed through the footpath a certain amount of pressure is applied on the sensor due to this pressure AC voltage will be generated. Amount of voltage that is produced by piezoelectric sensor will depend on the pressure applied either by the weight of the moving vehicles or by the weight of the people walking on it. Due to sensitivity of the sensor, the output voltage will keep on fluctuating. This fluctuating voltage is given as an input to the full wave rectifier circuit that converts AC voltage into DC voltage. This DC voltage is then stored in a rechargeable battery. Street lights are powered by energy stored in battery, these lights will turn ON only when there are vehicles or pedestrians on the road otherwise lights will remain turn OFF.

CHAPTER 3

TECHNOLOGICAL REQUIREMENTS

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3.1. Project Hardware

Some of the major hardware components required in this project are:

- PIR Sensors
- Piezoelectric Sensors
- LDR
- Battery
- Reed Relay
- Relay Module
- Arduino UNO

3.1.1. PIR Sensors

PIR sensor stands for Passive Infrared sensor. This is an electronic sensor that detects a human being or vehicles moving around within approximately 10m from the sensor. This is an average value, as the actual detection range is between 5m and 12m. PIR sensor is fundamentally made of a pyro electric sensor, which can detect levels of infrared radiation.

These sensors are also known as “PID”, for "passive infrared detector".

The term passive refers to the fact that PIR devices do not radiate energy for detection purposes. They work entirely by detecting infrared radiation (radiant heat) emitted by or reflected from objects.

Here is the diagram of a PIR motion detector used to control an outdoor, automatic light.

Figure 3-1: PIR motion detector used to control an outdoor, automatic light.[15]

They are small, inexpensive, low power, easy to use and don’t wear out. For that reason, they are commonly found in appliances and gadgets used in homes or businesses.

Figure 3-2: PIR Sensor [16]

3.1.1.1. PIR Sensor Features [17]

- Wide range on input voltage varying from 4.V to 12V (+5V recommended)
- Output voltage is High/Low (3.3V TTL)
- Can distinguish between object movement and human movement
- Has to operating modes – Repeatable (H) and Non- Repeatable (H)
- Cover distance of about 120° and 7 meters
- Low power consumption of 65mA
- Operating temperature from -20° to +80° Celsius

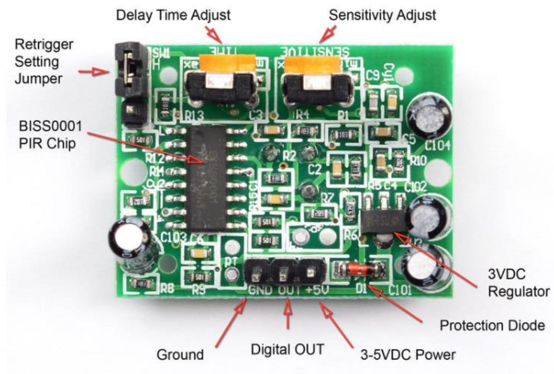

Figure 3-3: PIR sensor with labeling [16]

3.1.1.2. Pin Configuration

Table 3-1: PIR Sensor Pin Configuration [17]

Pin Number	Pin Name	Description
1	Vcc	Input voltage is +5V for typical applications. Can range from 4.5V-12V
2	High/Low Output (Dout)	Digital pulse high (3.3V) when triggered (motion detected) digital low (0V) when idle no motion detected
3	Ground	Connected to ground of circuit

3.1.1.3. Connecting to a PIR

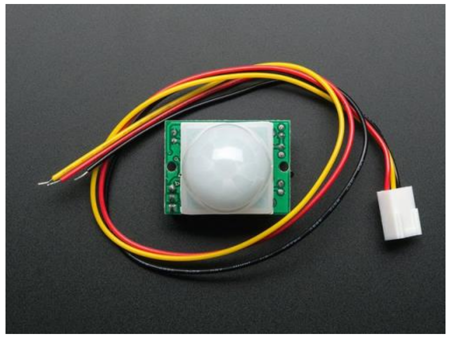

Figure 3-4: PIR Sensor [18]

Most PIR modules have 3 pin connections. The pinout may vary between modules. One pin will be ground, another will be signals and the final one will be the power.

Power is usually 3-5 Vdc input but may be as high as 12V.

3.1.1.4. Applications

- Automatic Street/Garage/Warehouse or Garden Lights
- Burglar Alarms
- Security cams as motion detectors
- Industrial Automation Control

3.1.1.5. How to use PIR motion sensor?

The module can be powered from voltage 4.5V to 20V but, typically 5V is used. Once the modula is powered, allow the module to calibrate itself for few minutes. 2 minutes is a well settled time. Then observe the output on the output pin.

There are two operating modes in this sensor, such as Repeatable (H) and Non-Repeatable (L) mode. The Repeatable mode is the default mode.

The output of the sensor can be set by shorting any two pins on the left of the module as shown below.

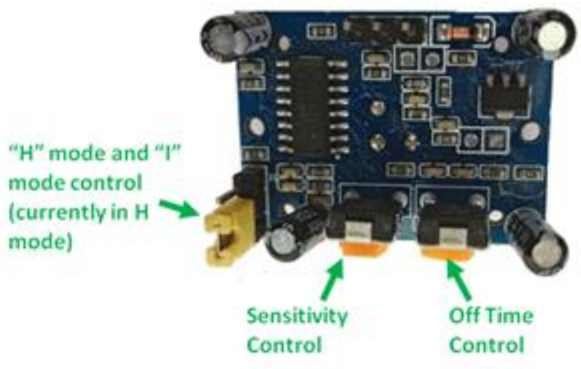

Figure 3-5: PIR sensor modes [17]

Repeatable (H) Mode

In repeatable (H) mode, output pin goes high (3.3V). When a person is detected within the range and goes low after a particular time.

In this mode the output pin will go high irrespective of whether the person is still present inside the range or has left the area.

Non Repeatable (L) Mode

In this mode, the output pin goes high (3.3V) when a person is detected within range and stays high as long as that person stays within the limit of the sensors range.

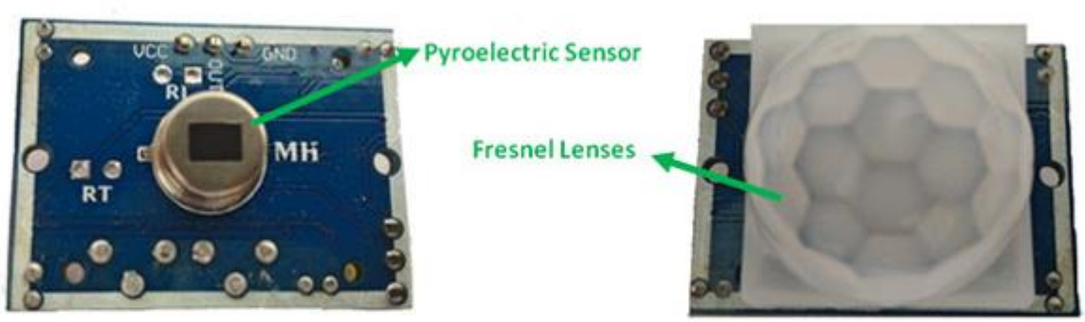

Figure 3-6: Pyroelectric Sensor and Fresnel Lenses [17]

There are two important materials present in this sensor:

Pyro electric Crystal (Can detect the heat signatures from a living organism)

Fresnel Lenses (Can widen the range of the sensor)

3.1.2. Piezoelectric sensor

Basically, the prefix “piezo” is Greek for 'press' or 'squeeze'.

It utilizes the piezoelectric effect, to measure changes in acceleration, strain, pressure, and force by converting them into electrical charge. Piezoelectric effect causes the occurrence of electric dipole moments in solids due to the pressure applied to piezoelectric crystal that produces electric charge. This piezoelectric charge is proportional to the pressure applied to piezoelectric crystal [20].

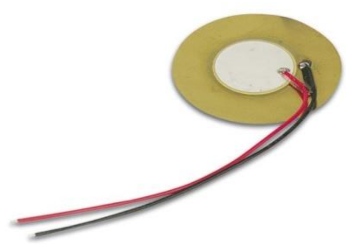

Figure 3-7: Piezoelectric sensor [20]

A piezoelectric accelerometer has a charge frequency response capacity ranging from 20 Hz to 10 KHz. The maximum pressure applied by piezoelectric sensors can be 1,000 psi and the voltage measurement range can be up to 5 volts.

Piezoelectric sensors are designed and manufactured to meet most industry specifications.

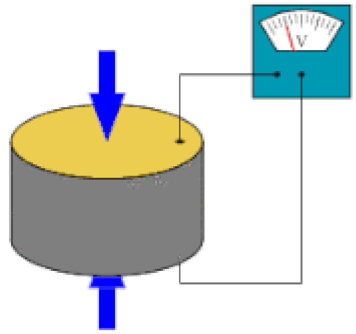

Figure 3-8: Piezoelectric disk generating a voltage when deformed [19]

3.1.3. LDR

LDR stands for light dependent resistor. This is also known as photo resistor or photo-conductive cell [27].

An LDR 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.

It is used to sense day and night. LDR turns the street lights ON when there is dark and turns the street lights OFF during day time.

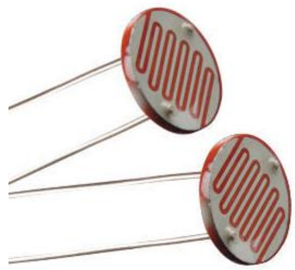

Figure 3-9: LDR [29]

LDRs are made up of semiconductor materials having high resistance. There are many different symbols used to indicate an LDR, one of the most commonly used symbol is shown in the figure below. The arrow indicates light falling on it.

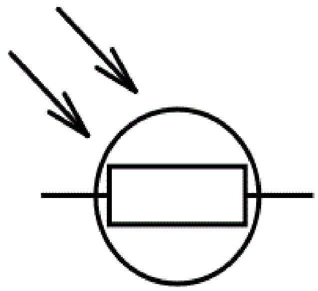

Figure 3-10: LDR Symbol [28]

An LDR works on the principle of photo conductivity. Photo conductivity is an optical phenomenon in which the conductivity of materials is increased, when light is absorbed by the material.

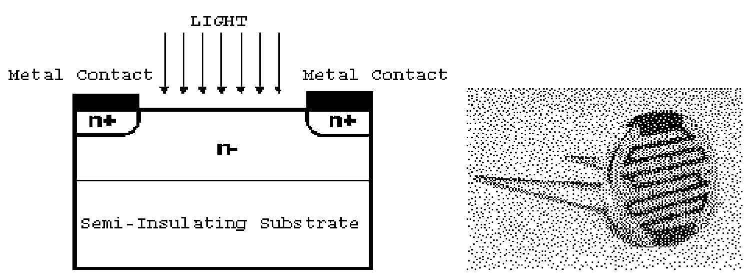

Figure 3-11: Photo conductivity [30]

LDRs are light dependent devices whose resistance is decreased when light falls on them and that is increased in the dark. When an LDR is kept in the dark, its resistance is very high. This resistance is known as dark resistance. It can be as high as $10^{12}\Omega$ and if the device is allowed to absorb light, its resistance will be decreased drastically. If a constant voltage is applied to it and intensity of light is increased the current starts increasing.

Here is the resistance vs. illumination curve for a particular LDR.

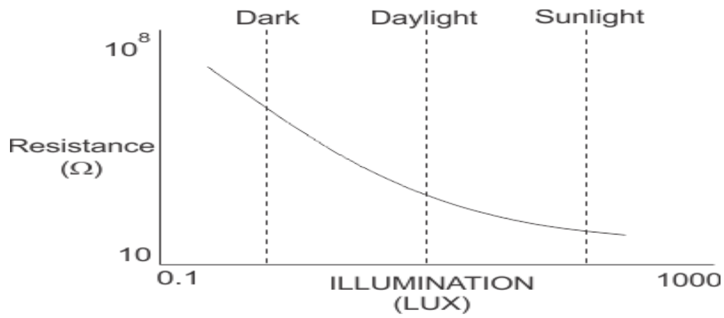

Figure 3-12: Resistance vs. illumination [28]

LDRs are non-linear devices. There sensitivity varies with the wavelength of light incident on them.

Also, LDRs are less sensitive than photo diodes and phototransistors.

Moreover, LDRs have two types, based on the materials [30]:

- Intrinsic photo resistors
- Extrinsic photo resistors

LDRs have low cost and they have simple structure.

Because of the ability to detect presence or absence of light like in a camera light meter, they are used in street lamps, alarm clock, burglar alarm circuits, light intensity meters, for counting the packages moving on a conveyor belt, etc.

3.1.4. Battery

Battery is used to store the electric energy generated by piezoelectric crystal.

The battery used in this project is 12V DC battery. This battery consists of electrochemical cells with external connections provided to power electrical devices. This battery has two terminals, positive terminal is known as cathode and negative terminal is known as anode. The terminal marked negative is the source of electrons that will flow through an external electric circuit to the positive terminal.

Historically the term "battery" specifically referred to a device composed of multiple cells, however the usage has evolved to include devices composed of a single cell.

Figure 3-13: 12V Battery [20]

Batteries are classified into two forms:

- **Primary:** These batteries are designed to be used until exhausted of energy then discarded. Their chemical reactions are generally not reversible, so they cannot be recharged. When the supply of reactants in the battery is exhausted, the battery stops producing current and is useless.
- **Secondary:** These can be recharged; that is, they can have their chemical reactions reversed by applying electric current to the cell. This regenerates the original chemical reactants, so they can be used, recharged, and used again multiple times.

3.1.5. Reed Relay

A reed relay is a type of relay that uses an electromagnet to control one or more reed switches.

The reed relay consists of a switch with magnetic contacts that move under the influence of an external magnetic or the induced field from its solenoid. They have faster switching speed compared to the electromechanical ones but their switching current and voltage is lower mainly because of its contacts thickness [21].

3.1.5.1. Composition

Basis of reed relay is the reed switch, which is the core element of the reed relay.

A reed switch consists of two reed contacts, typically made up of nickel-iron and then plated with materials to ensure the maximum life of the device.

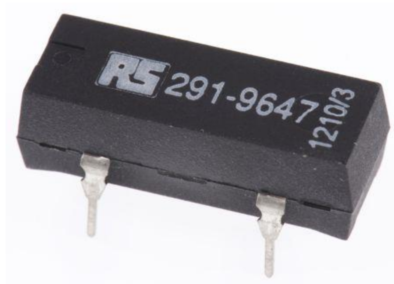

Figure 3-14: Reed Relay [22]

Often the nickel-iron allows is around 52% nickel. The reed contact materials used include ruthenium, rhodium and sometimes iridium or where high voltages are involved it might be tungsten or molybdenum. Often rhodium is usually electroplated onto the reed element, whereas ruthenium is generally sputtered. There were also a very few reed switches that used gold, often for audio - but the low melting point of gold meant they used to stick and they are not seen these days [24].

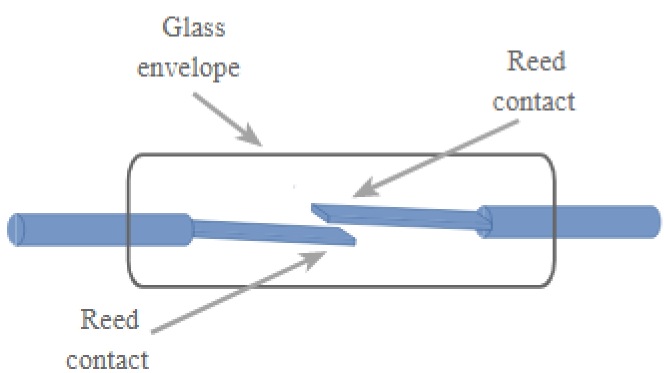

Figure 3-15: Internal assembly of a reed switch [23]

3.1.5.2. Working

It works by placing a magnetic field close to the reed switch contacts. By doing so, each of the reeds become magnetically oriented such that the two ends of the reed attract each other and move together closing the contact.

Under conditions where no magnetic field is applied, the two contacts will not be magnetically orientated and the spring loading in the contacts will keep them apart.

As the magnet is brought closer to the reed contacts which are made of a magnetic material, typically nickel iron, this starts magnetically orientated the two reed relay contacts. A north pole will appear in one contact and a south in the other.

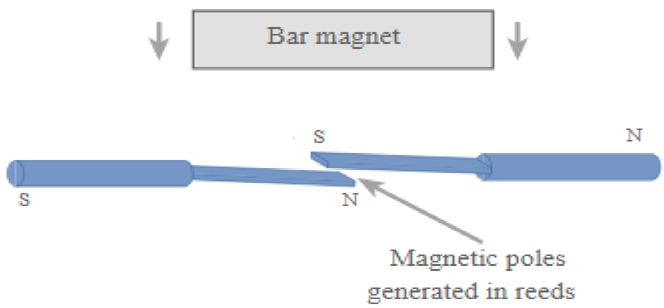

Figure 3-16: Basic operation of a reed switch [23]

3.1.6. Relay Module

Relay module is used for remote device switching. By using this module, we can remotely control devices over a network or the Internet. Devices can be remotely powered on or off with commands coming from Clock Watch Enterprise delivered over a local or wide area network [25]. We can control computers, peripherals or other powered devices from across the office or across the world.

Figure 3-17: 2 Channel 5V 10A Relay Module [26]

3.1.6.1. Pin Configuration

Figure 3-18: Pin Configuration of relay Module [26]

1. VCC: 5V DC

2. COM: 5V DC

3. IN1: high/low output

4. IN2: high/low output

5. GND: ground

3.1.6.2. Wiring Diagram

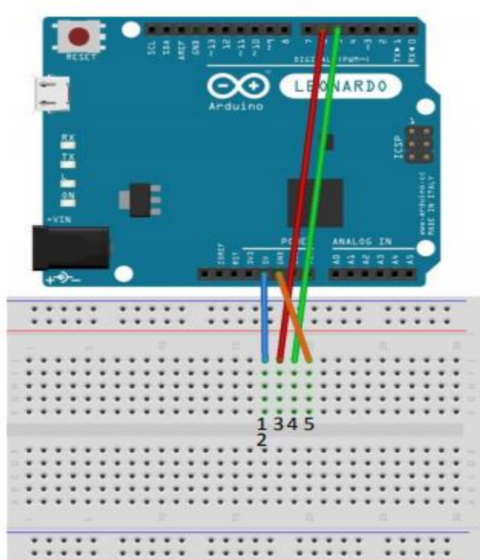

Figure 3-19: Wiring Diagram [26]

3.1.6.3. Schematic Diagram

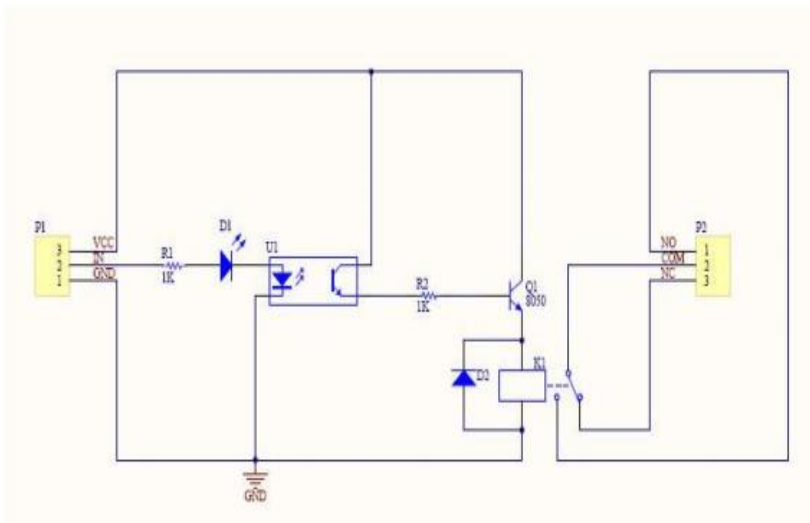

Figure 3-20: Schematic Diagram [26]

3.1.7. Arduino UNO

The Arduino UNO is an open-source microcontroller board based on the Microchip ATmega328P microcontroller and developed by Arduino cc [31].

The board is equipped with sets of digital and analog input/output (I/O) pins that may be interfaced to various expansion boards (shields) and other circuits.

Figure 3-21: Arduino UNO [31]

3.1.7.1. Pin Configuration

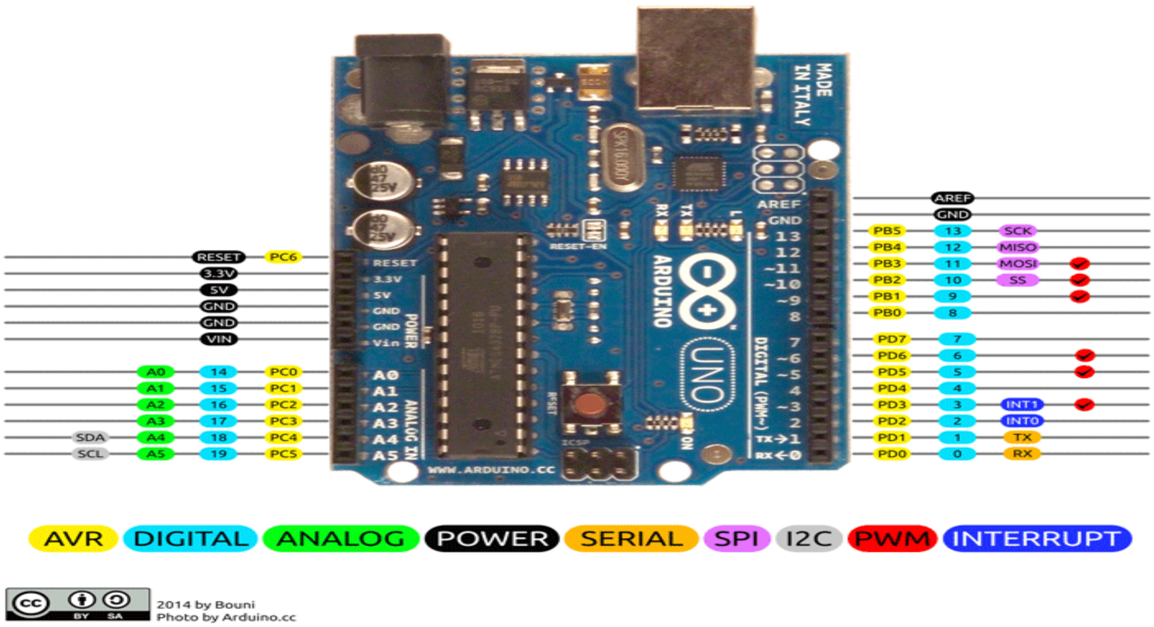

Figure 3-22: Pin Configuration [33]

3.1.7.1.1. Details of Arduino Pins

Arduino Uno is a very valuable addition in the electronics that consists of USB interface, 14 digital I/O pins, 6 analog pins, and Atmega328 microcontroller. It also supports serial communication using Tx and Rx pins [32].

Each of the 14 digital pins on the Arduino Uno can be used as an input or output, using pinMode(), digitalWrite(), and digitalRead() functions. They operate at 5 volts. Each pin can provide or receive a maximum of 40 mA and has an internal pull-up resistor (disconnected by default) of 20-50 kOhms.

Pins 2 and 3 are for external interrupts. These pins can be configured to trigger an interrupt on a low value, a rising or falling edge, or a change in value. See the attachInterrupt() function for details.

There is a built-in LED connected to digital pin 13. When the pin is HIGH value, the LED is on, when the pin is LOW, it’s off [34].

Table 3-2: Arduino Pin Configuration [33]

Pin Category	Pin Name	Details
Power	Vin, 3.3V, 5V, GND	Vin: Input voltage to Arduino when using an external power source. 5V: Regulated power supply used to power microcontroller and other components on the board. 3.3V: 3.3V supply generated by on-board voltage regulator. Maximum current draw is 50mA. GND: ground pins.
Reset	Reset	Resets the microcontroller
Analog pins	A0-A5	Used to provide analog input in the range of 0-5V
Input/output pins	Digital pins 0-13	Can be used as input or output pins
Serial	0(Rx), 1(Tx)	Used to receive and transmit TTL serial data.
External Interrupts	2,3	To trigger an interrupt
PWM	3,5,6,9,11	Provides 8 bit PWM output
SPI	10 (SS), 11 (MOSI), 12 (MISO) and 13 (SCK)	Used for SPI communication
Inbuilt LED	13	To turn on the inbuilt LED
TWI	A4 (SDA), A5 SCA	Used for TWL communication
AREF	AREF	To provide reference voltage for input voltage

3.1.8. NodeMCU

NodeMCU is an open source IoT platform. It includes firmware which runs on the ESP8266 Wi-Fi SoC from Espressif Systems, and hardware which is based on the ESP-12 module. The term "NodeMCU" by default refers to the firmware rather than the DevKit. The firmware uses the Lua scripting language. It is based on the eLua project, and built on the Espressif Non-OS SDK for ESP8266. It uses many open source projects, such as lua-cjson, and spiffs.

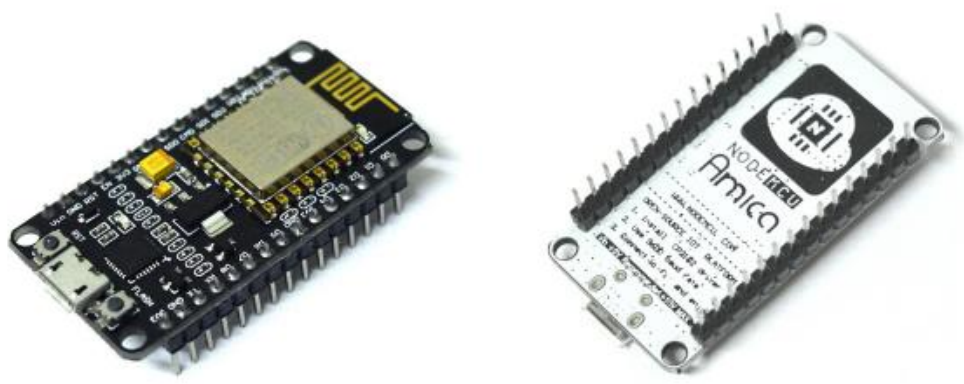

Figure 3-23: Front and Back View of NodeMCU [36]

3.1.8.1. Features

- Version : DevKit v1.0
- Breadboard Friendly
- Light Weight and small size
- 3.3V operated, can be USB powered.
- Uses wireless protocol 802.11b/g/n.
- Built-in wireless connectivity capabilities
- Built-in PCB antenna on the ESP-12E chip
- Capable of PWM, I2C, SPI, UART, 1-wire, 1 analog pin
- Uses CP2102 USB Serial Communication interface module
- Arduino IDE compatible (extension board manager required)
- Supports Lua (alike node.js) and Arduino C programming language.

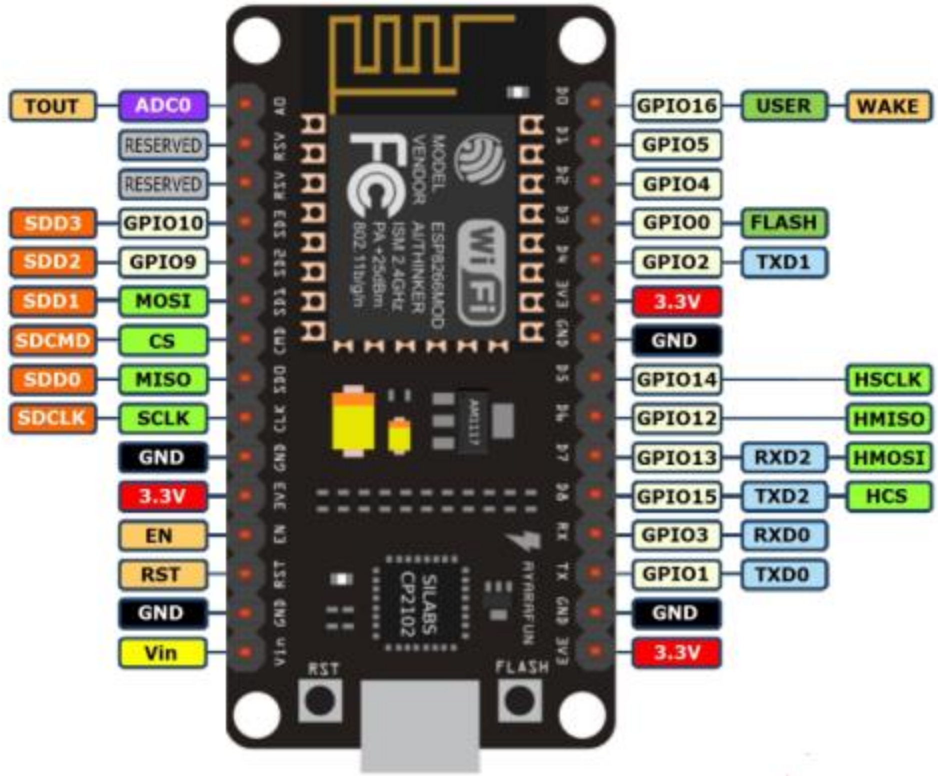

Figure 3-24: Pin Configuration of NodeMCU v1.0 [36]

3.2. Project Software

We have done coding on Arduino UNO in this project.

- Arduino
- Proteus
- Android Studio

3.2.1. Arduino

The Arduino integrated development environment is a cross-platform application that is written in the programming language Java. It is used to write and upload programs to Arduino compatible boards, but also, with the help of 3rd party cores, other vendor development boards. The Arduino IDE supports the languages C and C++ using special rules of code structuring.

In our Arduino is used to code for PIR sensors so that the lights only turn on when there are pedestrians or vehicles on the road and remain off otherwise. We have also used Arduino for coding our NodeMCU which is used to monitor voltage and charging state of battery wirelessly.

Figure 3-25: Arduino Logo [31]

5.2.2. Proteus Design Suite

The Proteus Design Suite is a proprietary software tool suite used primarily for electronic design automation. The software is used mainly by electronic design engineers and technicians to create schematics and electronic prints for manufacturing printed circuit boards.

It is a Windows application for schematic capture, simulation, and PCB (Printed Circuit Board) layout design. It can be purchased in many configurations, depending on the size of designs being produced and the requirements for microcontroller simulation. All PCB Design products include an auto router and basic mixed mode SPICE simulation capabilities.

We have used this software to design the circuit for our project for simulation and testing purpose. First we have made the layout. Then after the design layout in Proteus we shift to ARES so that we can print it on PCB board.

Figure 3-26: Proteus Design Suite Logo [38]

5.2.3. Android Studio

Android Studio is a official integrated development environment (IDE) for Google's Android operating system, built on JetBrains' IntelliJ IDEA software and designed specifically for Android development. It is available for download on Windows macOS and Linux based operating systems. It is a replacement for the Eclipse Android Development Tools (ADT) as the primary IDE for native Android application development.

We have used Android Studio to develop an app to monitor our system.

Figure 3-27: Logo of Android Studio [39]

CHAPTER 4

DESIGN AND IMPLEMENTATION

CHAPTER 4

DESIGN AND IMPLEMENTATION

4.1. Architecture Design of Smart Street Light System

This project of "Smart Street Light System" comes in the category of Hardware -Software Integration. The project can be best understood by flow chart and block diagram. Our project has two parts, in the first part we are trying to minimize wastage of electricity by detecting motion on the road by means of PIR sensors. In the second part we are generating electricity by means of piezoelectric sensors and storing this electricity in a battery.

4.2. Development Plan

Designing and development are the most important aspects of a project especially when it comes to FYP. So the basic timeline which was followed during the development of our project is given below:

Figure 4-1: Project Development Timeline

4.3. Comparison of Sensors

The below table shows the comparison between two types of sensors which were suitable for our design.

Table 4-1: Comparison of Sensors [6]

	PIR	Ultrasonic
Coverage	• Line of sight • Field of view can be adjusted by user via a Fresnel lens • Range of 6-40m	• Covers entire space (volumetric) • Field of view cannot be adjusted by user • Coverage area of 50-200m^2
Highest sensitivity	Motion lateral to the sensor	Motion to and from the sensor
Indoor/Outdoor use	Indoor and outdoor	Indoor
Compatible applications	• Smaller enclosed spaces • Spaces where the sensor has a view of the activity • Outdoor areas	• Typically ceiling mounted • Open spaces • Spaces with obstacles • Spaces with hard surfaces
Incompatible application characteristics	Low motion levels by occupants, obstacles blocking sensor view, within 2-3m from HVAC air diffusers or other heat sources	High ceilings, high levels of vibration or airflow, open spaces that require selective coverage

We consider PIR technology to be most suitable for our application. Although ultrasonic sensors are more sensitive and have greater coverage and range, they are not suited for outdoor applications and will consequently have a high false detection rate. The false detection rate is the main cause that we did not use dual technology (both PIR and Ultrasonic Sensors) for this purpose.

The chosen sensor is packaged for indoor use and so the casing needs to be modified for outdoor applications. This would allow us to optimize detection for cars and people while meeting the required regulations for ingress protection.

4.4. PIR Sensor Specification

After selection of sensors we have tested PIR sensor to find its range which is 6m - 7m and input and output voltage. Input voltage is 4V-12V and output voltage is 3.3V. Power consumption of 65mA.

Table 4-2: PIR Sensor Specifications [7]

PIR Sensor Specifications	
Input Voltage	4V - 12V
Output Voltage	3.3V
Power Consumption	65mA
Sensitivity	110 x 70 degree
Range	6m - 7m
Operating Temperature	-20 to +80 degrees

4.5. Comparison between Bulbs

The below table shows the comparison between various lights bulbs that exist.

Table 4-3: Comparison of Bulbs [8]

	Incandescent	CFL	LED
Approximate cost per bulb	$1	$2	$8 or less
Average lifespan	1,200 hours	8,000 hours	25,000 hours
Watts used	60W	14W	10W
No. of bulbs needed for 25,000 hours of use	21	3	1
Total purchase price of bulbs over 23 years	$21	$6	$8
Total cost of electricity used (25,000 hours at $0.12 per kWh)	$180	$42	$30
Total operational cost over 23 years	**$201**	**$48**	**$38**

As it is evident from the above table that why we have chosen LED light bulbs. Their initial cost is high but the operational cost over the period of 23 years is less and their average life span is more and they consume less power as compared to CFL and Incandescent. We will use DC voltage to power the light bulbs instead of AC. We can also power the lights using AC voltage but for this purpose we only need an inverter to convert the DC voltage to AC voltage. For this purpose we will add the inverter after the battery as the battery in our case stores DC voltage [3].

4.6. Methodology

First of all the piezoelectric sensors are connected with each other in series and parallel and placed under a tile or a sheet of metal. As people walk on it a certain amount of pressure is applied on the sensor due to this pressure AC voltage will be generated. Amount of voltage that is produced by piezoelectric sensor will depend on the pressure applied either by the weight of the moving vehicles or by the weight of people walking on it. Due to sensitivity of the sensor, the output voltage will keep on fluctuating. This fluctuating voltage is given as an input to the full wave rectifier circuit that converts AC voltage into DC voltage. This DC voltage is then stored in a rechargeable battery. A direct connection can be given from the battery to the load in case of a DC load. The battery can then be connected to an inverter in case of an AC load.

Here we can give this to the LDR sensor which helps in the automatic control of street light. When it is full dark, the sensor activates the street light. During day time the LDR begins to reduce the brightness and the street light is completely off once the sun rises completely. PIR sensor is used to detect movement on the road i.e. lights will turn ON only when there are vehicles or pedestrian on the road during the night.

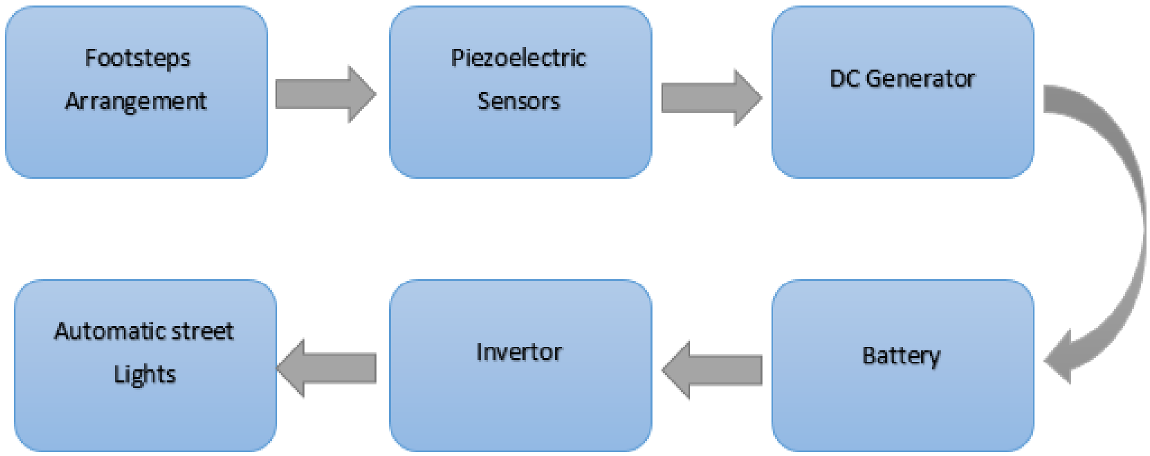

Figure 4-2: Proposed Block Diagram

In order to explain the flow chart we will consider the two phases of our project. In the first phase or part of our project we will be generating electricity by means of piezoelectric materials. A basic diagram to demonstrate this is given below.

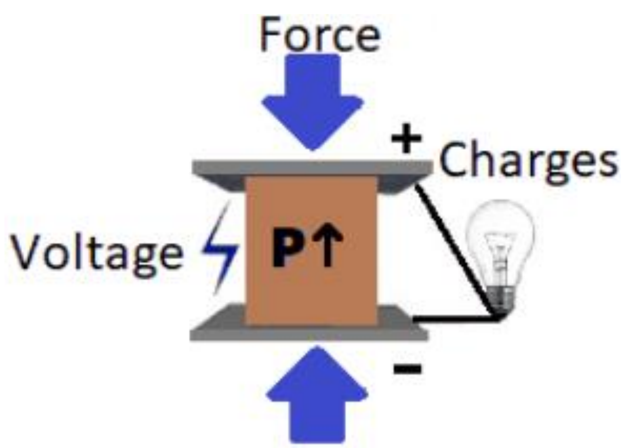

Figure 4-3: Piezoelectric sensor basic description

The figure shows that the senor has positive and negative charges and when force is applied on it then voltage is produced but as this voltage is not as high to directly power a bulb so we will use this voltage to charge a battery. The force in this case comes from the pedestrians walking or running on the footpath as we have explained earlier that the piezoelectric sensors are placed beneath the tile so when someone walks on the footpath then force is exerted on these sensors which then produces voltage. This voltage is used for charging the 12V battery. We are using piezoelectric sensors to produce electricity as it is a non-conventional source of energy production and it is environment friendly.

The charging of battery while walking can be illustrated by the figure shown below which shows that pressure of pedestrians walking on the footpath charges the battery which in turn is utilized for powering the lights.

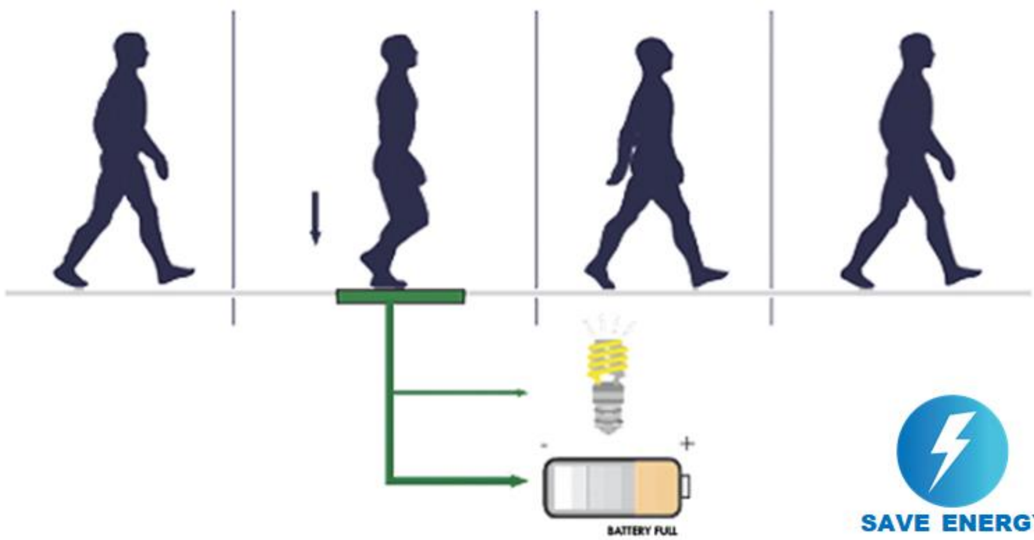

Figure 4-4: Charging of Battery

As we have to minimize usage of electricity so we are using PIR sensor to detect motion so the lights will only turn on when there are pedestrians or vehicles on the road and remain off otherwise. LDR is used to detect presence or absence of light so light remains off during the daytime and even during night street lights only turn on when there is some kind of motion on the road.

The battery charges during the daytime and also at night and is only consumed when required by the people.

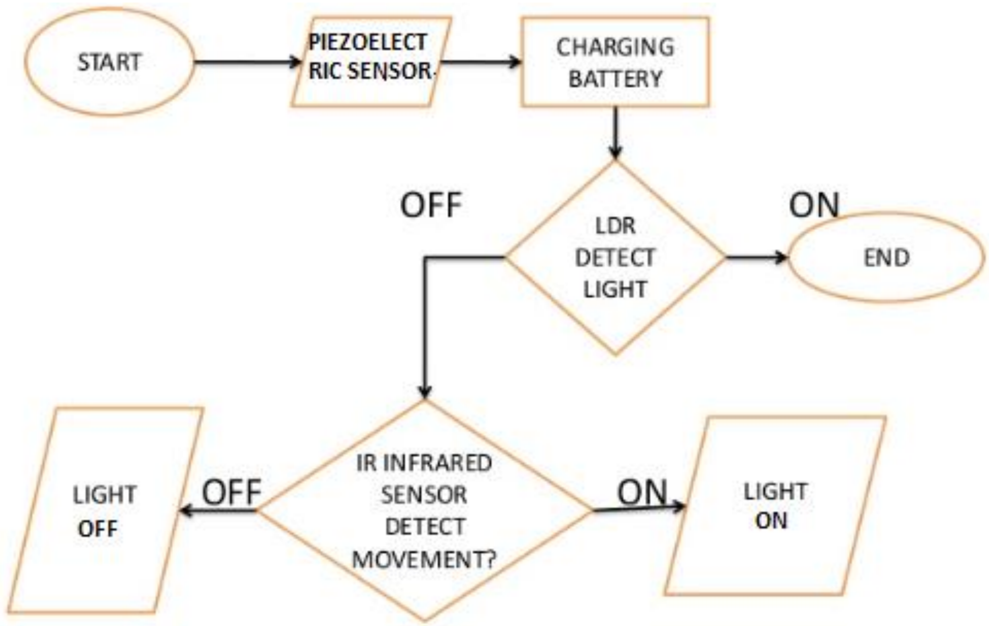

Figure 4-5: Flow Chart of Proposed Solution

4.7. Tile Designing

4.7.1 Arrangement of Sensors

For designing the prototype for Smart Street Light System we will have to design the tile first. In designing the tile, we have to arrange the sensors beneath the tile in a way that generates maximum output voltage. There are many ways to increase the output of a piezo material.

1. Connecting them in a series combination: this will increase the voltage output but won't be able to increase the current as significantly, as these materials are not linear (with linear I mean V vs I graph).
2. Connecting them in parallel combination: this will increase the current output but the voltage won't increase much significantly.

3. In order to get a good V as well as I output, we have used the series-parallel combination.

The below figure shows how the sensors will be arranged in series-parallel combination. The voltage produced will be AC voltage which will be converted to DC by means of a rectifier.

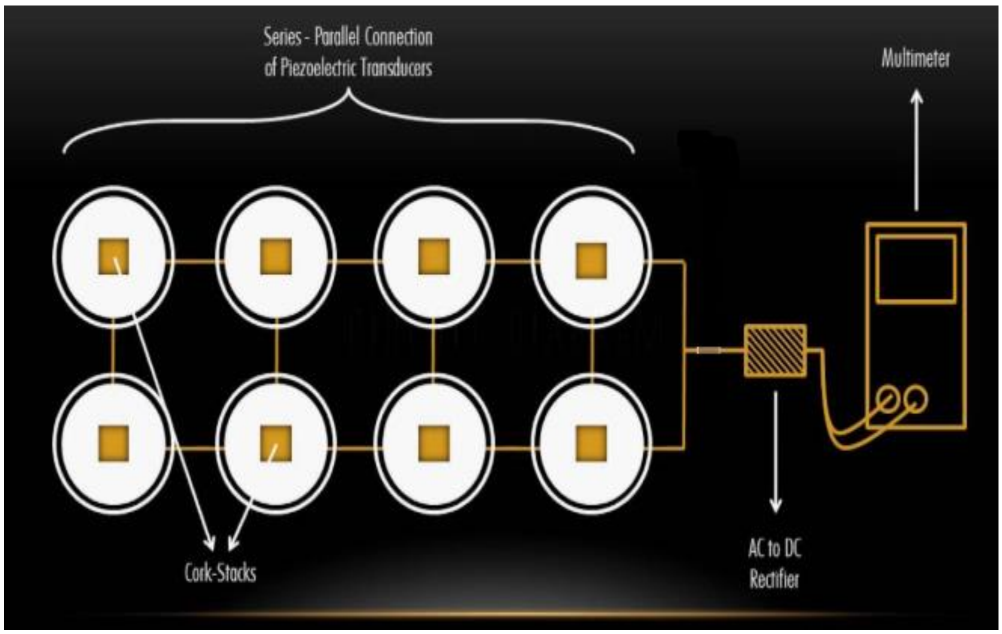

Figure 4-6: Arrangement of sensor

4.7.2 Tile Design and Specification

For the prototype the specifications of the tile are: its length is 24 inches and its width is 10 inches.

As we are designing a prototype so we have made a small tile. The external view of the tile is shown below.

Figure 4-7: External View of Tile

As discussed earlier, the sensors are arranged below the tile in series and parallel combination. For the prototype of this project we have arranged 12 sensors beneath the tile. We have made three groups of four sensors each. The four sensors are parallel to each other and the three groups are in series with each group containing 4 sensors.

Figure 4-8: Internal View of Tile

4.8 Motion Detection Circuit

For motion detection we have used PIR sensor. We have used this sensor to detect the motion of vehicles and pedestrians on the road so the street lights only turn on when they are needed and remain off otherwise. We are trying to do this as large amount of energy is wasted as the lights remain on throughout the night and there is no check on them. This could also be done using image processing by installing cameras but that is a costly process as the cameras that are required to do such image processing are expensive as they should be very efficient so that no cars are missed and lights turn on for each and every vehicle or person otherwise the rate of street crimes may increase if there is complete darkness. Image processing is also a tough job as it requires machine learning and detecting moving objects by that is complex and it requires complicated programming.

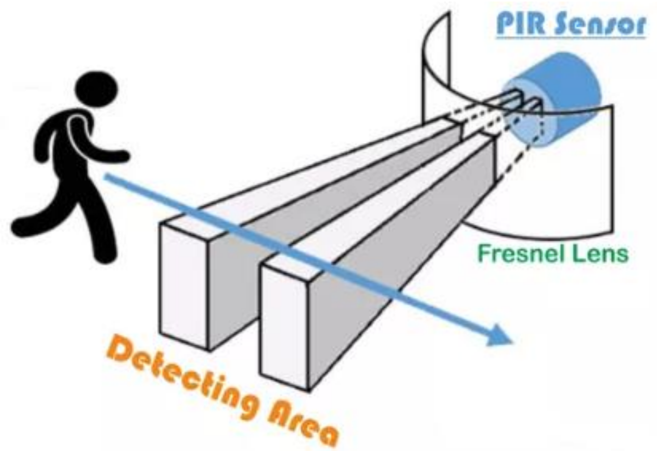

Figure 4-9: Working of PIR Sensor

The above diagram shows the working of PIR sensor. The PIR sensor itself has two slots in it, each slot is made of a special material that is sensitive to IR. The lens used here is not really doing much and so we see that the two slots can 'see' out past some distance (basically the sensitivity of the sensor). When the sensor is idle, both slots detect the same amount of IR, the ambient amount radiated from the room or walls or outdoors. When a warm body like a human or animal passes by, it first intercepts one half of the PIR sensor, which causes a positive differential change between the two halves. When the warm body leaves the sensing area, the reverse happens, whereby the sensor generates a negative differential change. These change pulses are what is detected.

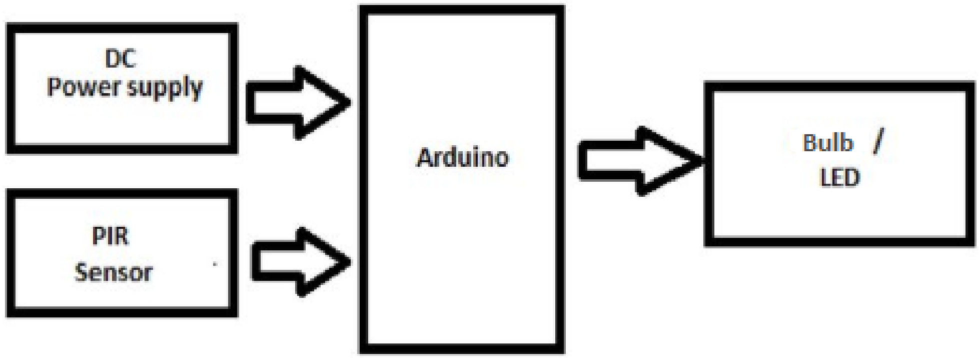

Figure 4-10: Block diagram for Motion Detection

The block diagram above explains the basic functioning of our project. The Arduino board can be supplied with power either from the DC power jack (7 - 12V), the USB connector (5V), or the VIN pin of the board (7-12V). Supplying voltage via the 5V or 3.3V pins bypasses the regulator, and can damage your board.

In this project we will use DC power supply to operate Arduino using a DC power jack. The DC power supply will be provided to Arduino by the same 12V battery which was used by the street lights and charged by the energy produced by the force applied by the pedestrians walking on the footpath.

The PIR sensor will detect motion and its output will be feed to the Arduino. The bulb will turn on or off depending on the output of the PIR sensor. If the PIR sensor detects motion then the light will turn on otherwise it will remain off as in the daylight.

4.9 PCB Designing

For PCB Designing we know that there is no Arduino device available in proteus so we have to install the library of Arduino so that we can then access it from pick devices. The Arduino library in proteus is shown below.

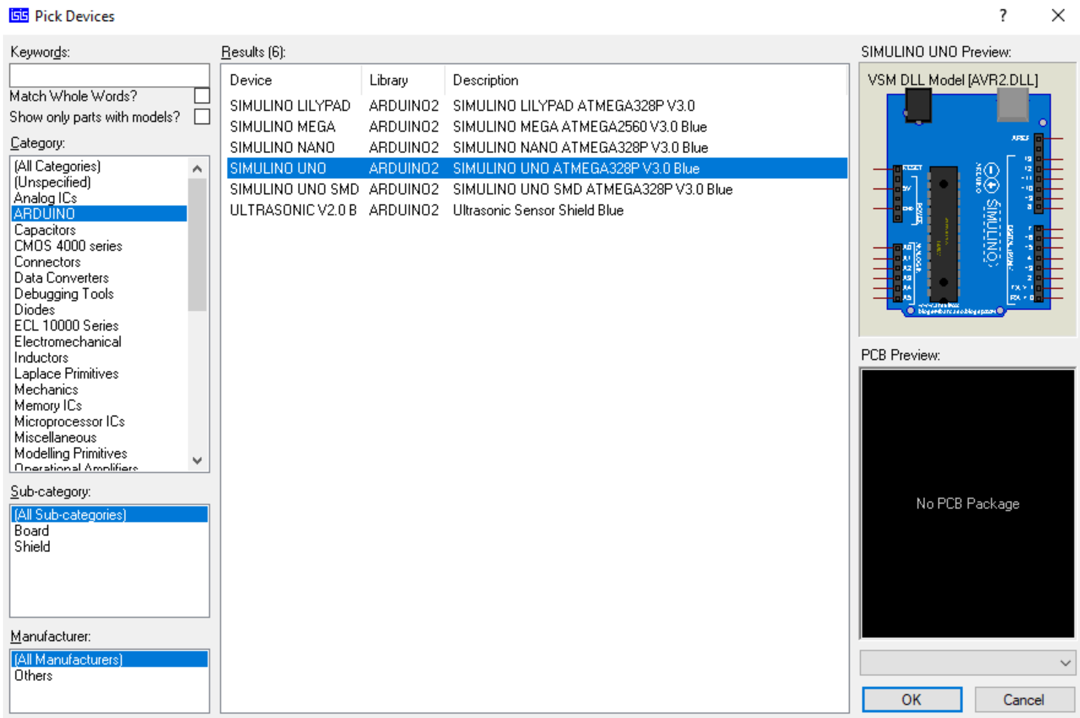

Figure 4-11: Arduino Library in Proteus

Now that the Arduino library is installed but its PCB package is not available and we need its PCB package for the PCB layout in ARES. The PCB package is shown below.

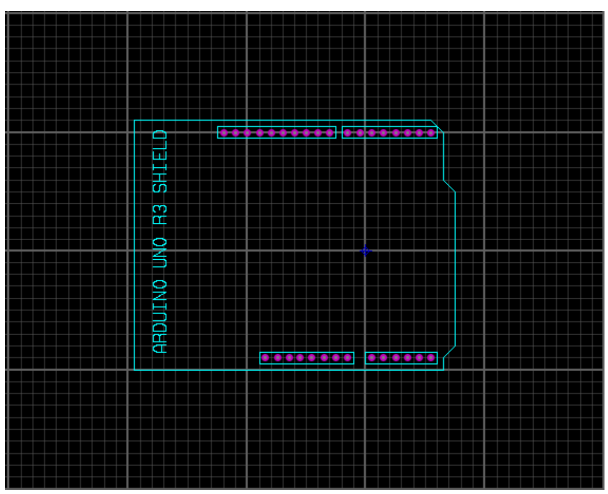

Figure 4-12: PCB Package of Arduino

This PCB package is required to make the circuit in ARES so that when we print the circuit on the PCB board then we would know the exact place where to drill.

After the printing of circuit on PCB board, holes were drilled on the PCB board in order to place the components and then soldering was done. The complete PCB board is shown below.

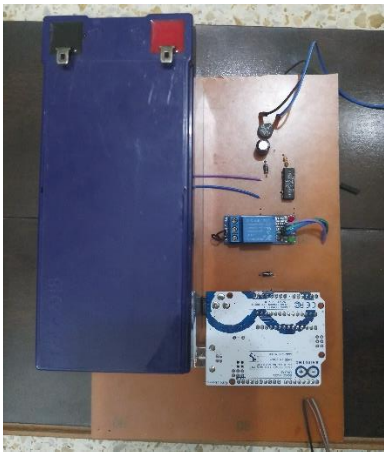

Figure 4-13: PCB Design

4.10 Pole Designing and Development

In designing the pole, we have to keep in mind the dimensions of street light system which are common in various parts the world.

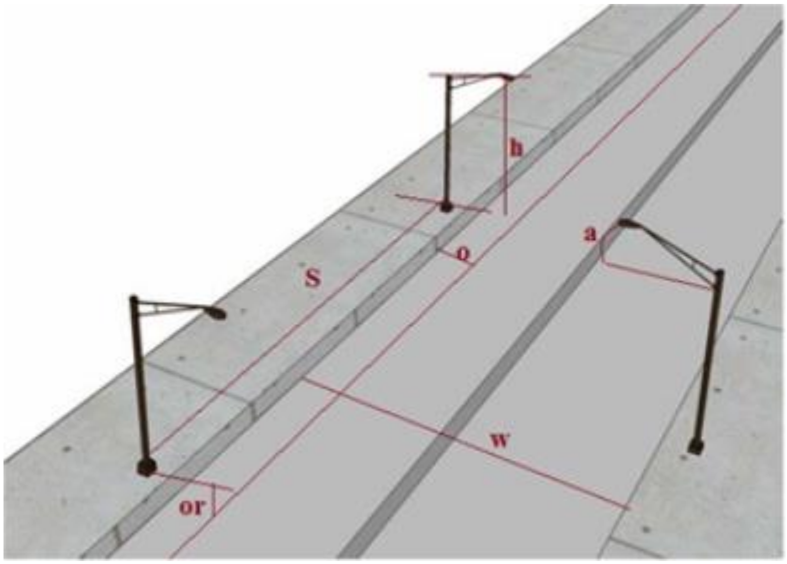

Figure 4-14: Road Dimensions

Technically, the distance between two street lamps should be 29 meters. This is defined by calculations of pole heights and other factors. Intention of keeping a standard distance is to maintain good illumination on streets. But at many places in PCB the istance between two lamps is as much as 50 meters [4].

The streetlight mounting height was 25ft (7.6 m) [5].

As we know that the width of the road varies from area to area so in order to calculate the distance between the street light poles we have the following calculations.

Road Details: The width of road is 11.5 Foot.

Pole Details: The height of Pole is 26.5 Foot.

Luminaire of each Pole: Wattage of Luminaries is 250 Watt, Lamp output (LL) is 33200 Lumen, Required Lux Level (Eh) is 5 Lux, Coefficient of Utilization Factor (Cu) is 0.18, Lamp Lumen Depreciation Factor (LLD) is 0.8, Lamp Lumen Depreciation Factor (LLD) is 0.9.

Space Height Ratio should be less than 3.

Calculation:

$$Spacing\ between\ each\ Pole = \frac{LL \times CU \times LLD \times LDD}{Eh \times W} \quad \textbf{(4.1)}$$

Spacing between each Pole = (33200×0.18×0.8×0.9) / (5×11.5)

Spacing between each Pole = 75 Foot.

Space Height Ratio = Distance between Pole / Road width

Space Height Ratio = 3. Which is less than define value.

Spacing between each Pole is 75 Foot.

Required Illumination Level for Street Light (L) is 6 Lux per Square Meter.

Luminous efficacy (En) is 20 Lumen per Watt.

Required Street Light Area to be illuminated (A) is 1 Square Meter.

We are designing a prototype so we can’t use the original dimensions of the road as this is not possible. The diameter of our pole is 0.7 inches and its height is 15.5 inches.

We will place the PIR sensor on the pole. It will placed at a height of approximately 4 feet so that the sensor only detects humans and does not detect animals like cats and dogs which are on the street cause if it starts to detect their motion then the lights will be on unnecessarily. If the sensor is placed at this height i.e. four feet then animals won’t be detected as their height is approximately 2ft-2.5ft and as the PIR sensor is placed at a height of four feet so it won’t detect animals and only humans and cars will be detected.

4.11 Wireless Connection with NodeMCU

We have also used NodeMCU v1.0 in this project to wirelessly connect Smart Street Light System to the server. Actually, we are using this to monitor our system and to check whether the battery is charging or not. By doing this we can find faults in our project like if the sensors are damaged or battery isn’t charged due to less number of people or battery needs to be changed for any reason.

We have coded NodeMCU using Arduino IDE to show whether battery is charged or not and also show its exact voltage.

4.12 Making the App

First we have made the login page for our application which is “Smart Street Light System”. By this login page only authentic users can view the information. The login page is shown.

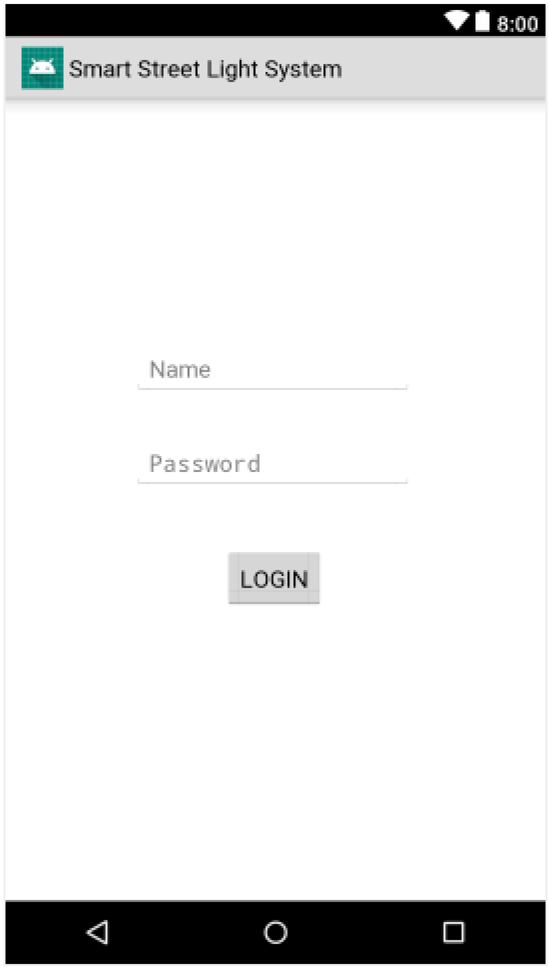

Figure 4-15: LOGIN Page

We have used firebase to create our database.

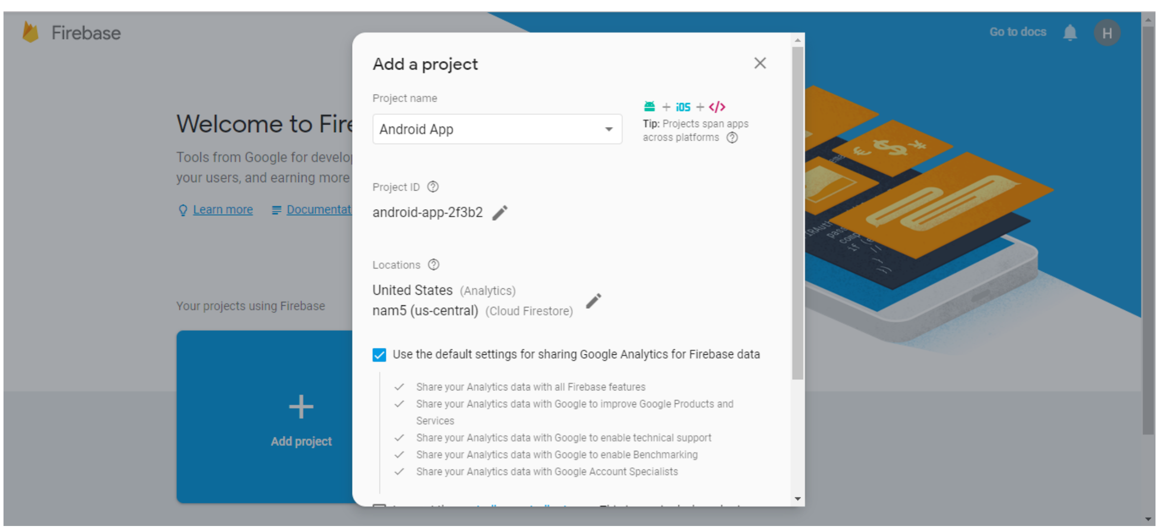

Figure 4-16: Adding our Project

We will be using real time database in locked mode.

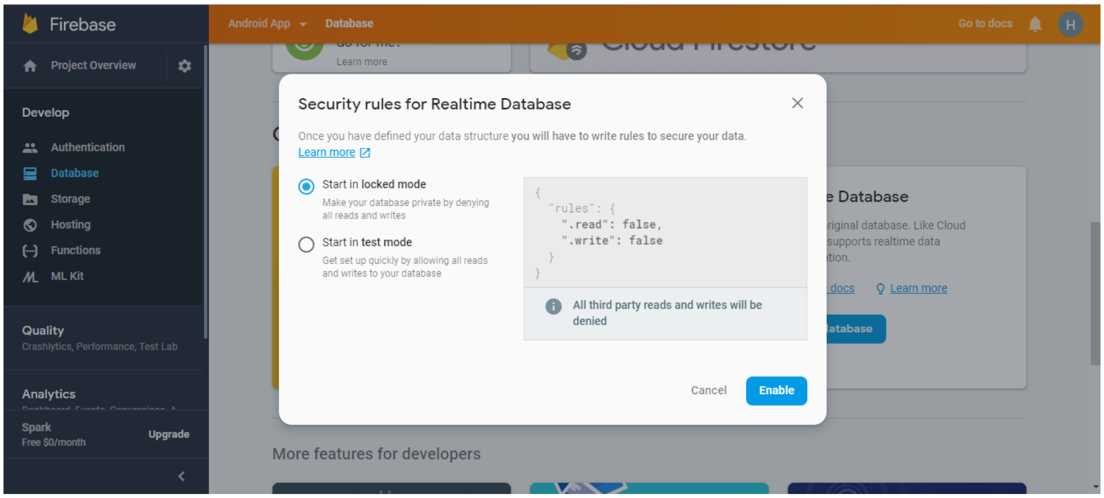

Figure 4-17: Setting the real Time Database

The basic layout of our app is shown in figure.

Figure 4-18: Layout of Application

CHAPTER 5

RESULTS AND ANALYSIS

CHAPTER 5

RESULTS AND ANALYSIS

5.1. Automation of Street lights

The street lights are controlled automatically i.e lights will turn on only when there are pedestrian or vehicles on the road otherwise remain off.

Figure 5-1: No pedestrian

Figure 5-1 shows that when there is no pedestrian or vehicle on the road lights will remain off because no movement is detected. Lights will turn on only when PIR sensor detects movement.

Figure 5-2 shows that only one light is turned on because PIR sensor detects only one movement.

Figure 5-2: Only one pedestrian

Figure 5-3: More than one pedestrian

Figure 5-3 shows that when there are more than one pedestrian and PIR sensors of both lights detect movement than both lights are turned on.

5.2. Movement Detected by PIR sensor

Figure 5-4 shows the movement detected by PIR sensor. It also counts the total number of people that passes through the road and then the street lights are turned on accordingly.

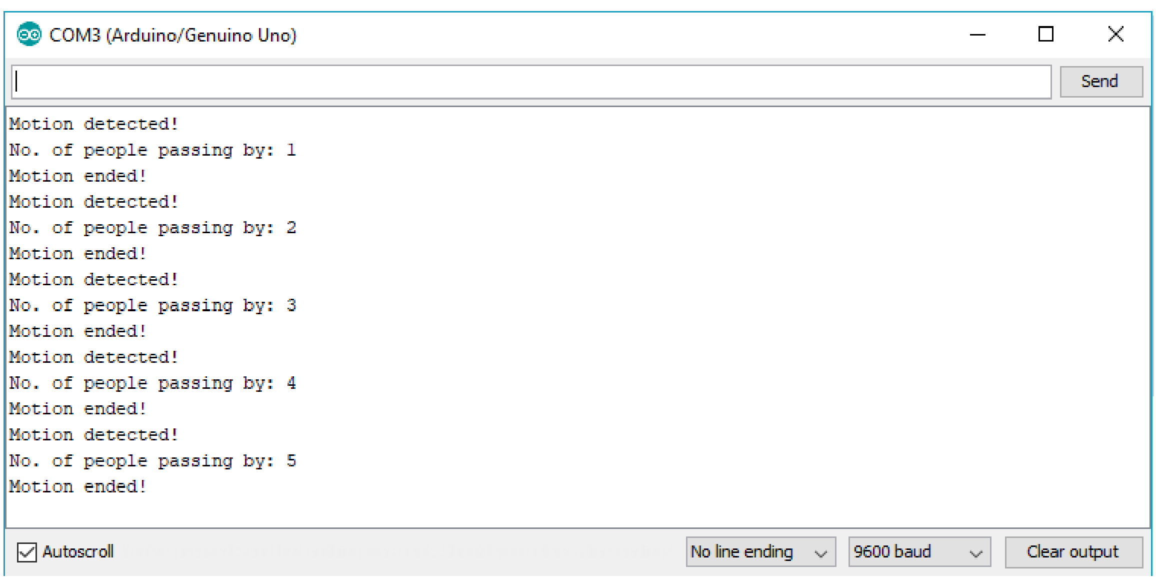

Figure 5-4: Movement detected by PIR Sensor

5.3. Voltage Generated by Piezoelectric Sensor

We have checked how much voltage is generated by piezoelectric sensor for testing purpose and displayed the results on serial monitor in Arduino software. The results are shown.

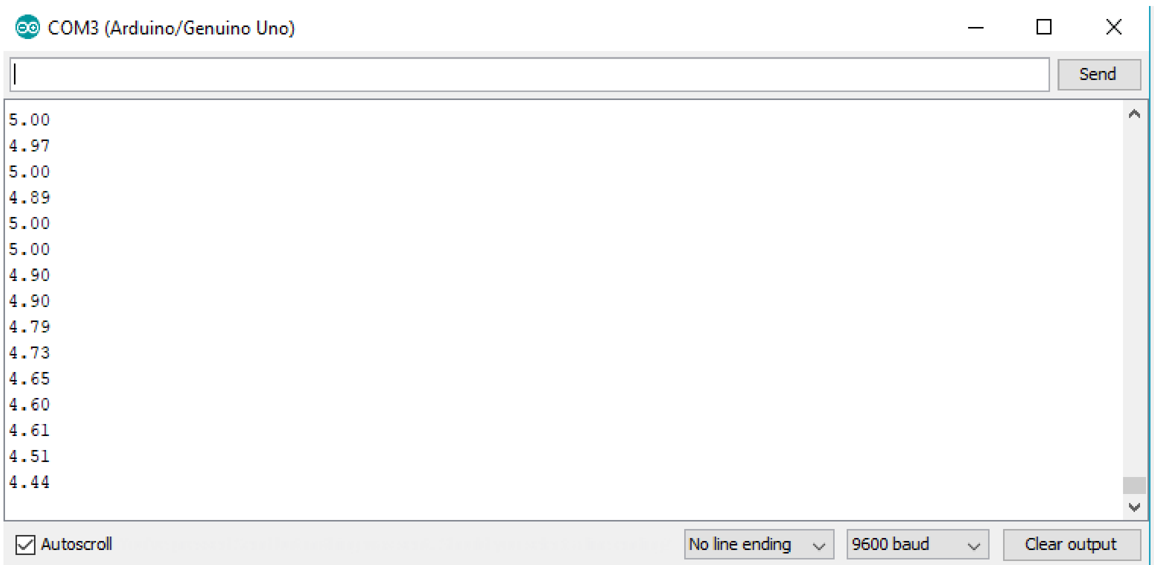

Figure 5-5: Piezoelectric Sensor Output Voltage

5.4. Calculation of Charging and Discharging time of the Battery

In ideal or theoretical case the charging and discharging time is calculated according to the following formula

$$Time = \frac{Capacity}{Current} \quad \textbf{(5.1)}$$

5.5. State of Charge of the Battery

Figure 5-5 shows the charging level of the battery. When battery gives 12.57 volts then it means it is fully charged, at 80% charging it gives 12.36V. Similarly it gives 12.15V at 60% charging, 11.94V at 40% charging and 11.73V at 20% charging.

Voltage	SOC
12.57	100%
12.36	80%
12.15	60%
11.94	40%
11.73	20%

Figure 5-6: State of Charge

5.6. Specifications and Results

- PIR Sensor Height = Approx. 4 ft.
- Total No. of Sensors = 12
- Minimum Voltage produced = 0.5 V
- Maximum Voltage produced = 5 V
- If Average Weight of Person = 50 kg
- No. of Steps Required to increase 1V Charge in Battery = 600 steps
- To Charge 12V Battery No. of Steps Required = 12 x 600 = 7200 steps

5.7. Wireless Connection with NodeMCU

For the connection of NodeMCU to Arduino IDE software to upload the code we first have to install the board and then its driver which is CH340 for this NodeMCU.

In this project we are using NodeMCU to wirelessly monitor the charging of battery and whether it needs to be recharged or not.

The coding was done in Arduino software. The output in serial monitor shows that Wi-Fi is connected to NodeMCU and it assigns an IP address to the board which when entered in browser will give battery status and a button.

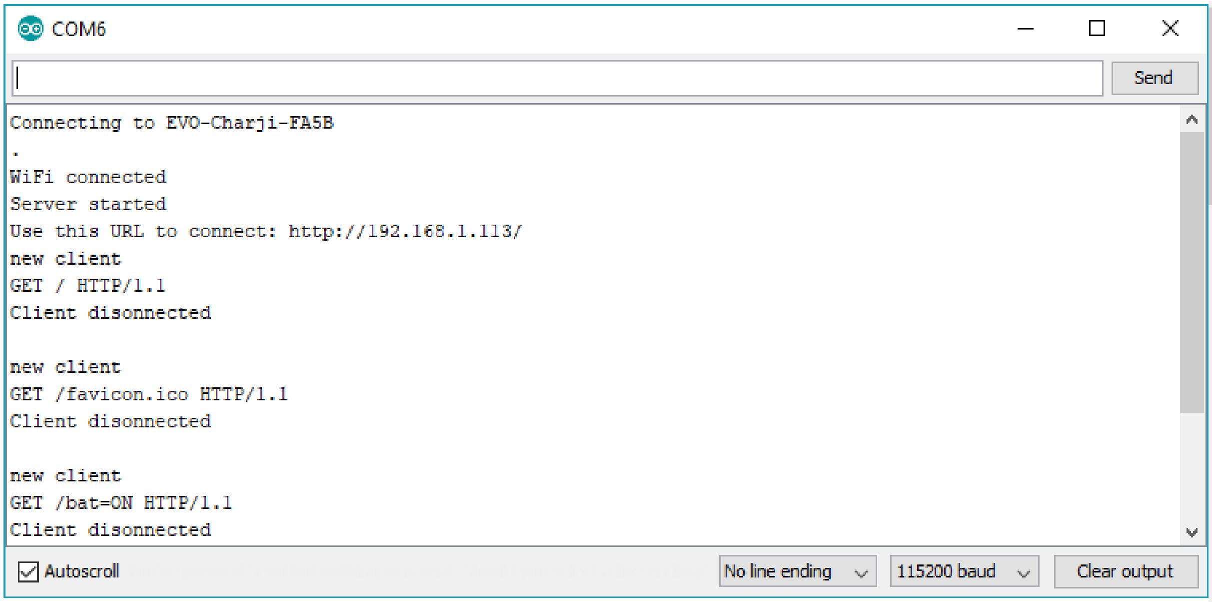

Figure 5-7: Serial Monitor Output

5.8. Displaying Battery Voltage on Server

The IP address when entered in browser as URL will give us the battery status and a button. The status button below when pressed will give updated results of battery voltage and charging state.

The IP address can be used both on laptop and on mobile phone. This is used to easily monitor charging of battery so that we can find out whether there are enough pedestrians on the road to charge the battery or we need to shift towards normal electricity connection and we can also find out if there is any fault in the connection or any component has been damaged.

When we connect to server the serial monitor also shows that client is connected and when client is disconnected.

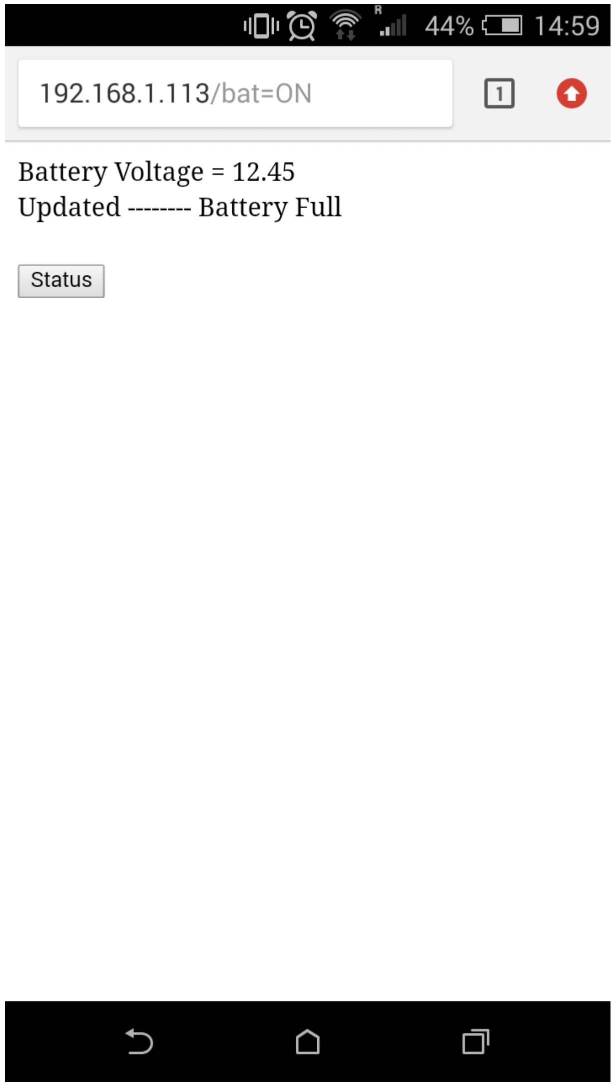

Figure 5-8: Battery Voltage displayed on phone

CHAPTER 6

CONCLUSION

CHAPTER 6

CONCLUSION

6.1. Summary

The project “Smart Street Light System Powered by Footsteps” provides a cost effective solution for electricity production in developing countries like Pakistan. Energy management will become easy due to the implementation of the automatic street light system. In rural areas implementing the system of energy generation by footsteps will help to resolve energy crisis problems faced by residents. This system will be used to power both AC as well as DC appliances. Better results can be obtained by implementing this system in crowded areas. Moreover Smart street light system will also reduce energy consumption. It turns the lights ON only when there are pedestrians or vehicles on the road otherwise lights remain OFF.

6.2. Accomplishments

Piezoelectric sensors are used to generate electric energy from the pressure applied by footsteps of pedestrians and this energy is stored into the battery. Hence, Street lights are powered by the energy generated by footsteps so there is no need to power street lights separately. DC lights are used instead of AC lights due to which cost of DC to AC conversion is eliminated. Street lights are controlled automatically i.e turn the lights ON only when needed and remain off otherwise. This system has reduced the consumption of electrical energy. So the smart street light system is a better solution for faster depletion of energy resources due to inefficient usage and wastage of these resources.

CHAPTER 7

ENHANCEMENT AND FUTURE WORK

CHAPTER 7

ENHANCEMENT AND FUTURE WORK

7.1. Future Work

Moving with the new & renewable energy sources, this system can be upgraded by replacing ordinary LED modules with the solar based LED modules. With utilizing the latest technology and advance sensors, we could serve the same purpose of automatically controlling the street lights much more effectively both by cost and manpower. The main objective of the project is to save the energy, and by doing so we would be able to lighten few more houses. This model could be implemented with few modifications as a source of revenue; as charging station for battery operated vehicles [11].

This system can also be enhanced by using internet of things technology. The Internet of Things (IoT) is a system of related computing devices, digital and mechanical machines, objects, people with unique identifiers and potential transfer of data over a network without human-to-human or human-to-computer interaction. Physical objects those are no longer disconnected from the virtual world, but can be controlled remotely through Internet services.

7.2. Solar based LED module

LED lights are used due to their high luminous efficiency and long life. Under the control of a DC charge controller, non-contact control automatically turns on the light at dark and switches off at daytime. It sometimes also combines with time controllers to set curtain time for it to automatically switch light on and off. These lights provide a convenient and cost-effective way to light streets at night without the need of AC electrical grids for pedestrians and drivers. They may have individual panels for each lamp of a system, or may have a large central solar panel and battery bank to power multiple lamps [12].

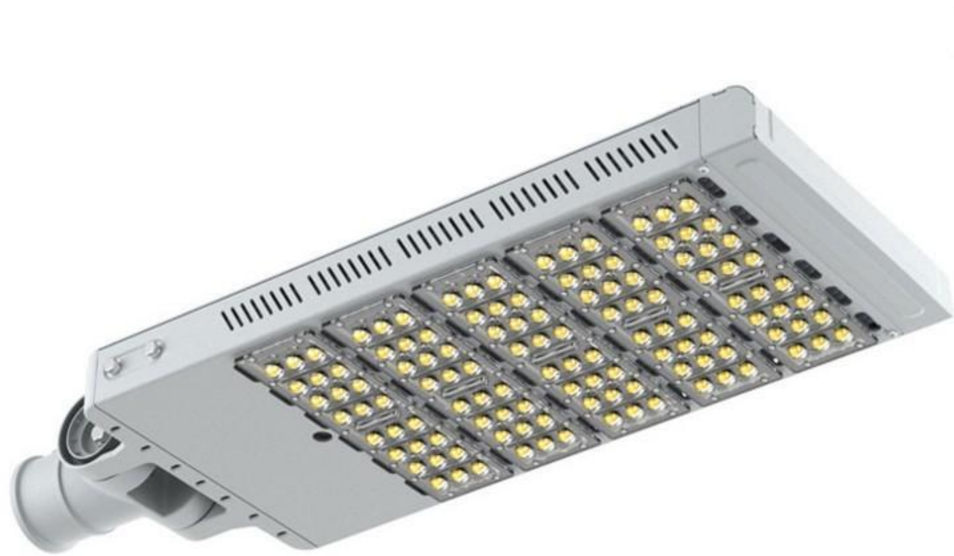

Figure 7-1: LED street light [12]

7.3. IoT based energy monitoring system

The Internet of Things has a vision in which the internet extends into the real world, which incorporates everyday objects. The IoT allows objects to be sensed or controlled remotely over existing network structure, creating opportunities for pure combination of the physical world into computer-based systems, and resulting in better productivity, precision and financial advantage in addition to less human involvement. This technology has many uses like Solar cities, Smart villages, Micro grids and Solar Street lights and so on. As Renewable energy raised at a rate faster than any other time in history during this era. The suggested system bring up the online presentation of the power usage of solar energy as a renewable energy. This monitoring is done through raspberry pi using flask framework. Smart Monitoring displays regular practice of renewable energy. This helps the operator to examine of energy usage. Analysis influences on the renewable energy usage and electricity concerns [13].

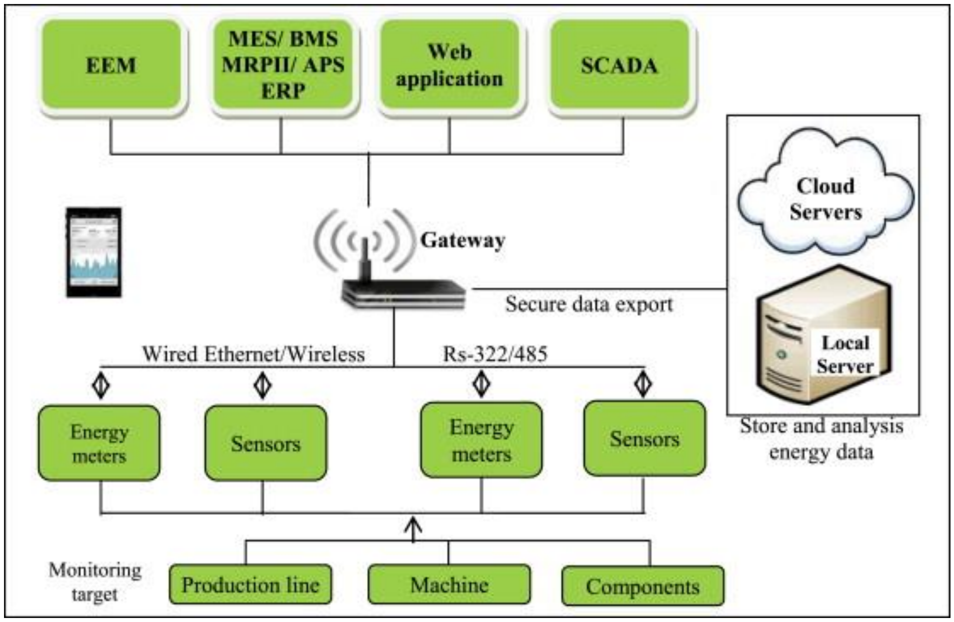

Figure 7-2 : IoT based Energy Monitoring System [7]

7.4. IoT based Smart Street Light Management System

The purpose of the streetlight controlling system by means of IOT is the preservation of energy by decreasing electricity consumption as well as to lessen the manpower. Streetlights are fundamental portion of any city because it helps improved night visualizations, safe roads, and disclosure to public zones but it ingests a relatively large amount of electrical energy. In the labor-intensive streetlight scheme lights remain on from sunset to sunrise with full power even when there is enough light accessible. This energy waste can be evaded by switching off lights inevitably. The hold back energy can be competently consumed for other tenacities like domestic, profit-making, conveyance etc. This can be attained using an IOT supported streetlight controlling system. The project utilizes LEDs which do not ingest an huge quantity of electricity to exchange the energy consuming outdated HID lamps. LEDs alongside the LDR enables the amount deviation which is infeasible with HID lamps. Since LEDs are reversing light bases it can radiate light in particular way thereby enhancing the effectiveness of the street lights. This method contains an supplementary DHT Temperature-Humidity measuring device. This delivers the precise temperature and humidity of a specific area. DHT11 is a compound measuring device that comprises of a standardized ordinal signal production of the temperature and humidity. It confirms high consistency and outstanding long-term constancy. This project is executed using a programmed Arduino board for giving the essential amount of light at numerous times. The anticipated work has conquered an improved performance relative to the present system.[14]

Figure 7-3 : IoT based Smart Street Light System [14]

7.5. Zigbee supported Automatic Street Light System

The main purpose is to make available remote-control system that can optimize management and efficiency of street light systems. It uses Zigbee-based wireless devices which support more effective street Lamp system management. It uses a sensor combination to control and guarantee the preferred system factors; the information is Transferred point by point using Zigbee transmitters and receivers and is sent to a control terminal used to check the state of the street lamps and to take appropriate measures in case of failure.

An XBee device can be configured as one of the following:

Coordinator – Creates a PAN1 and allows other devices to join the network. It is responsible for routing data and maintaining network security. Each PAN can have only one coordinator that selects a unique PAN ID and channel to operate on.

Router – Allows other routers and end devices to join the PAN. It may also assist in routing data.

End-Device – Must associate itself with a ZigBee PAN before it can transmit or receive data. It cannot route any data and must always communicate with the rest of PAN through its parent.

In the proposed design, each street light has an XBee2 module attached to its microcontroller for transmitting and receiving control signals. The nodes (lights) on a road are divided into clusters each consisting of routers and end devices. For example, a cluster formed under Router 1 is shown in Figure.

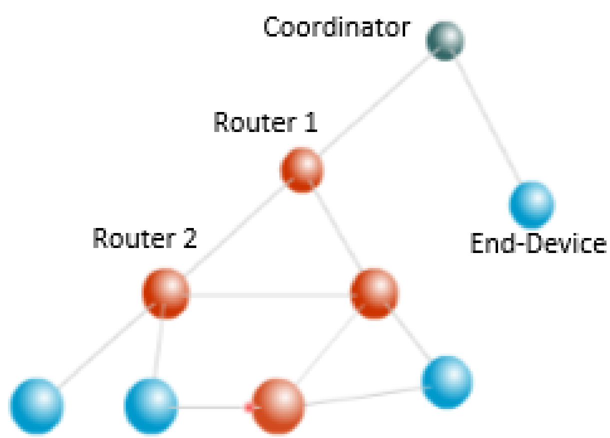

Figure 7-4: The Mesh Network [37]

As a vehicle moves along the road, entire clusters respond by adjusting their brightness as opposed to controlling individual lights. Hence, this makes the implementation of network easier because only a single control signal must be sent to head of the cluster which in turn forwards it to all the devices in the cluster. The cluster size is flexible and may contain any number of devices that have joined the PAN.

As shown in Figure, the XBee modules are connected in a mesh network topology to provide alternate routes for data packets in case of any node failure.

The ZigBee standard offers security by encrypting application data packets using 128-bit AES3 encryption and a network key chosen by the coordinator. The coordinator also acts as a trust center that is responsible for authenticating devices that join the network.

APPENDICES

APPENDIX-A

CODE FOR PIR SENSOR

```
int lamp = 8; // choose the pin for the RELAY

int inputPin = 4; // choose the input pin (for PIR sensor)

int val = 0; // variable for reading the pin status


void setup() {

pinMode(lamp, OUTPUT); // declare lamp as output

pinMode(inputPin, INPUT); // declare sensor as input

Serial.begin(9600);

}

void loop(){

val = digitalRead(inputPin); // read input value

Serial.println(val);

if( val== 1) {

digitalWrite(lamp,HIGH); // turn ON the lamp

} else {

digitalWrite(lamp,LOW); // turn OFF the lamp

}

}
```

CODE FOR PIEZOELECTRIC SENSOR

```
const int PIEZO_PIN = A0; // Piezo output


void setup()
{Serial.begin(9600);
}
void loop() {
// Read Piezo ADC value in, and convert it to a voltage
int piezoADC = analogRead(PIEZO_PIN);
float piezoV = piezoADC / 1023.0 * 5.0;
Serial.println(piezoV); // Print the voltage.
delay(250);
}
```

CODE FOR 2 PIR SENSORS

```
//Detects motion and count no. of people or vehicles detected
int ledPin = 13;            // choose the pin for the LED or pin to which bulb is connected
int inputPin2 = 4;          // choose the input pin (for PIR sensor)
int inputPin3 = 3;          // choose the input pin (for PIR sensor)
int pirState = LOW;         // we start, assuming no motion detected
int val2 = 0;               // variable for reading the pin status
int val3 = 0;               // variable for reading the pin status
int count = 0;
void setup() {
  pinMode(ledPin, OUTPUT);     // declare LED as output
```

```
  pinMode(inputPin2, INPUT);     // declare sensor as input
  pinMode(inputPin3, INPUT);     // declare sensor as input
  Serial.begin(9600);
}
void loop(){
  val2 = digitalRead(inputPin2);  // read input value
  val3 = digitalRead(inputPin3);  // read input value
  if (val2 == HIGH) {            // check if the input is HIGH
    digitalWrite(ledPin, HIGH);  // turn LED ON
    if (pirState == LOW) {
      // we have just turned on
      Serial.println("Motion detected!");
      // We only want to print on the output change, not state
      pirState = HIGH;
      count++;
      count=count++ ;
      Serial.print("No. of people passing by: ");
      Serial.println(count);
    }
  }
  else if (val3 == HIGH) {            // check if the input is HIGH
    digitalWrite(ledPin, HIGH);  // turn LED ON
    if (pirState == LOW) {
      // we have just turned on
```

```
      Serial.println("pin 3 Motion detected!");
      // We only want to print on the output change, not state
      pirState = HIGH;
    }}
  else {
    digitalWrite(ledPin, LOW); // turn LED OFF
    if (pirState == HIGH){
      // we have just turned of
      Serial.println("Motion ended!");
      // We only want to print on the output change, not state
      pirState = LOW;
    }
  }
}
```

CODE FOR WIFI CONNECTION TO NODEMCU

```
#include <ESP8266WiFi.h>

const char *ssid =  "EVO-Charji-FA5B";     // replace with your wifi ssid and wpa2 key
const char *pass =  "Q2G25mHk";

WiFiClient client;

void setup()
{
```

```
      Serial.begin(115200);
      delay(10000);

      Serial.println("Connecting to ");
      Serial.println(ssid);
      WiFi.begin(ssid, pass);
      while (WiFi.status() != WL_CONNECTED)
        {
          delay(500);
          Serial.print(".");
        }
     Serial.println("");
     Serial.println("WiFi connected");
}
void loop()
{
  }
```

CODE FOR BATTERY VOLTAGE MONITOR USING NODEMCU

```
#include <ESP8266WiFi.h>

const char* ssid = "EVO-Charji-FA5B";
const char* password = "Q2G25mHk";

int BAT= A0;              //Analog channel A0 as used to measure battery voltage
```

```
float RatioFactor=2.49;  //Resistors Ration FActor
WiFiServer server(80);

void setup() {
  Serial.begin(115200);
  delay(10000);
  Serial.print("Connecting to ");
  Serial.println(ssid);
  WiFi.begin(ssid, password);

  while (WiFi.status() != WL_CONNECTED) {
    delay(500);
    Serial.print(".");
  }
  Serial.println("");
  Serial.println("WiFi connected");
  server.begin(); // Start the server
  Serial.println("Server started");
  // Print the IP address on serial monitor
  Serial.print("Use this URL to connect: ");
  Serial.print("http://");    //URL IP to be typed in mobile/desktop browser
  Serial.print(WiFi.localIP());
  Serial.println("/");
}
```

```
void loop() {
  int value = LOW;
  float Tvoltage=0.0;
  float Vvalue=0.0,Rvalue=0.0;

  // Check if a client has connected
  WiFiClient client = server.available();
  if (!client) {
    return;
  }

  // Wait until the client sends some data
  Serial.println("new client");
  while(!client.available()){
    delay(1);
  }

  // Read the first line of the request
  String request = client.readStringUntil('\r');
  Serial.println(request);
  client.flush();

  // Match the request
```

```
if (request.indexOf("/bat=ON") != -1)  {
  ////////////////////////////////////Battery Voltage/////////////////////////////////
for(unsigned int i=0;i<10;i++){
Vvalue=Vvalue+analogRead(BAT);         //Read analog Voltage
delay(5);                              //ADC stable
}
Vvalue=(float)Vvalue/10.0;            //Find average of 10 values
Rvalue=(float)(Vvalue/1024.0)*5;      //Convert Voltage in 5v factor
Tvoltage=Rvalue*RatioFactor;          //Find original voltage by multiplying with factor
  ////////////////////////////////////Battery Voltage/////////////////////////////////
  value = HIGH;
}
// Return the response
client.println("HTTP/1.1 200 OK");
client.println("Content-Type: text/html");
client.println(""); //  do not forget this one
client.println("<!DOCTYPE HTML>");
client.println("<html>");
client.println("Battery Voltage =");
client.print(Tvoltage);
client.println("<br>");

if(value == HIGH) {
```

```
    client.println("Updated");
  } else {
    client.print("Not Updated");
  }
  client.println("--------");
  if(Tvoltage<=5){
    client.println("Battery dead OR disconnected");
    }
  else if(Tvoltage>5 && Tvoltage<=10){
    client.println("Need Imediate recharge");
    }
  else if(Tvoltage>10 && Tvoltage<=12){
    client.println("Recharge");
    }
  else{
      client.println("Battery Full");
      }
  client.println("<br><br>");
  client.println("<a href=\"/bat=ON\"\"><button>Status</button></a><br />");
  client.println("</html>");
  delay(1);
  Serial.println("Client disonnected");
  Serial.println("");
}
```

CODE FOR ANDROID APP

```
package com.example.smartstreetlightsystem;

import android.support.v7.app.AppCompatActivity;
import android.os.Bundle;
import android.util.Log;
import android.view.View;
import android.widget.Button;
import android.widget.TextView;

import com.google.firebase.database.DataSnapshot;
import com.google.firebase.database.DatabaseError;
import com.google.firebase.database.DatabaseReference;
import com.google.firebase.database.FirebaseDatabase;
import com.google.firebase.database.ValueEventListener;

public class MainActivity extends AppCompatActivity {
    FirebaseDatabase database = FirebaseDatabase.getInstance();
    DatabaseReference myRef = database.getReference();

    final DatabaseReference Bulbstatus1 = myRef.child("Bulb_1").child("status");

    final DatabaseReference Bulbstatus2 = myRef.child("Bulb_2").child("status");

    final DatabaseReference Bulbstatus3 = myRef.child("Bulb_3").child("status");

    Button b1;
    Button b2;
    TextView textView1;
    TextView textView2;
    @Override
```

```java
protected void onCreate(Bundle savedInstanceState) {
    super.onCreate(savedInstanceState);
    setContentView(R.layout.activity_main);
    b1 = (Button)findViewById(R.id.button1);
    b2 = (Button)findViewById(R.id.button2);

    textView1 = (TextView)findViewById(R.id.textView1);
    textView2 = (TextView)findViewById(R.id.textView2);
    //updateText(ledstatus1,textView1);

    Bulbstatus1.addValueEventListener(new ValueEventListener() {
        @Override
        public void onDataChange(DataSnapshot dataSnapshot) {
            // This method is called once with the initial value and again
            // whenever data at this location is updated.
            String value = dataSnapshot.getValue(String.class);
            Log.d("file", "Value is: " + value);
            textView1.setText(value);

        }

        @Override
        public void onCancelled(DatabaseError error) {
            // Failed to read value
            Log.w("file", "Failed to read value.", error.toException());
        }
    });

    b1.setOnClickListener(new View.OnClickListener() {
        @Override
        public void onClick(View view) {
```

```
            Bulbstatus1.setValue("ON");
        }
    });

    b2.setOnClickListener(new View.OnClickListener() {
        @Override
        public void onClick(View view) {
            Bulbstatus1.setValue("OFF");
        }
    });



}
}
```

APPENDIX-B

BUDGET

Project Hardware	Price in Rupees	Price in US Dollars
PIR Sensors	3x160=480	3.17
Piezoelectric Sensors	22x50=1100	7.26
Tile	1200	7.92
DMM	1400	9.24
Transformer	150	0.99
Battery	1350	8.91
Arduino uno	700	4.62
Bulbs	3x80=240	1.58
Acrylic Sheet Box	2500	16.51
Probe	250	1.65
Male to Female connector wires	180	1.19
Relay Module	250	1.65
Reed Relay	150	0.99
Copper Board	150	0.99
DC Pins	2x20=40	0.26
ESP8266	650	4.29
NodeMcu	700	4.62
Soldering Iron Bit	120	0.79
Soldering Iron	350	2.31

Rectifier	2x10=20	0.13
Paint	300	1.98
Pipe	2x100=200	1.32
Total	**12,480**	**82.40**

APPENDIX-C

LIST OF ABBREVIATIONS

LED	Light Emitting Diode
PIR	Passive Infrared
AC	Alternating Current
DC	Direct Current
USB	Universal Serial Bus
PCB	Printed Circuit Board
CFL	Compact Fluorescent Lamp
LDR	Light Dependent Resistor
IR	Infrared
HVAC	Heating Ventilation and Air Conditioning
DMM	Digital Multi-Meter
ICT	Information and Communication Technology
IOT	Internet of Things
SSL	Secure Sockets Layer
HID	High Intensity Discharge
AES	Advanced Encryption Standard
PAN	Permanent Account Number

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