JIMMA UNIVERSITY

INSTITUTE OF TECHNOLOGY

FACULTY OF COMPUTING AND INFORMATICS

DEPARTMENT OF COMPUTER NETWORKING

REDUCING CONSUMPTION OF ENERGY IN HOME CAUSED BY LIGHT BULBS THROUGH GSM NETWORK

A THESIS SUBMITTED TO THE FACULTY OF COMPUTING AND INFORMATICS OF JIMMA UNIVERSITY IN PARTIAL FULLFILMENT FOR THE DEGREE OF MASTER SCIENCE IN COMPUTER NETWORKING

BY

Nigatu Tamene

Principal Advisor: - Esmael Kedir (PhD)

Co-Advisor:- Mr. Berhanu Megersa (MSc)

July, 2023

Jimma, Ethiopia

JIMMA UNIVERSITY

INSTITUTE OF TECHNOLOGY

FACULTY OF COMPUTING AND INFORMATICS

DEPARTMENT OF COMPUTER NETWORKING

REDUCING CONSUMPTION OF ENERGY IN HOME CAUSED BY LIGHT BULBS THROUGH GSM NETWORK

As member of the board of examining of the MSc thesis open defense examination of the above title, we members of the board (listed below), read and evaluate the thesis and examined the candidate.

Name	Responsibility	Signature	Date
Mr Gemechu Birhanu (MSc)	Chair person		
Esmael Kedir (PhD)	Principal Advisor		July 13, 2023
Mr. Berhanu Megersa (MSc)	Co-Advisor		July 12, 2023
Ketema Adere (PhD)	External Examiner		September 04, 2023
Mr. Nahil Kebede (MSc)	Internal Examiner		

July, 2023

Jimma, Ethiopia

Declaration

I, Nigatu Tamene, declare that this thesis entitled: “Reducing Consumption of energy in home caused by light bulbs through GSM Network” is my original work. I have undertaken this research work with the guidance and support of the research advisors. This research has not been submitted for any degree or diploma program in this and any other institutions and that all sources of materials used for the thesis has been duly acknowledged.

NigatuTamene

This thesis has been submitted to the department for examination with our approval as university advisor:

Principal Advisor	Co-Advisor
	
Esmael Kedir (PhD)	Mr. Berhanu Megersa (MSc)

Acknowledgment

The one above all, I would like to say thank you to Almighty God who has given me the strength to endure all the difficulties and challenges of life. Next to that I would like to thank to principal advisor Dr. Esmael Kedir and Co-advisor Mr. Berhanu Megersa for their endless patience and giving me insightful ideas and support during my work. Finally, I would like to express my sincere thank all those who have contributed to this work in one way or another.

Table of Contents

List of Abbreviation

GSM – Global System for Mobile Communication

SMS – Short Message Service

EEU – Ethiopian Electric Utility

CEPT - European Conference of Post

And Telecommunication

ETSI - European Telecommunication

Standard Institute

IoT – Internet of Things

WPAN – Wireless Personal Area Network

Wi-Fi – Wireless Fidelity

ISDN – Integrated Service Digital Network

SDO – Standard Development Organization

TDMA – Time Division Multiple Access

SIM – Subscriber Identity Module

USB – Universal Serial Bus

CPU – Central Processing Unit

LED – Light Emitted Diode

PWM – Pulse Width Modulation

I/O – Input/output

AC – Alternative Current

DC – Direct Current

GND – Ground

KB – Kilo Byte

SRAM – Static Random Access Memory

EEPROM – Electrical Erasable Programmable

Read Only Memory

UART – Universal

TTL – Transistor – Transistor Logic

IDE – Integrated Development Environment

NO –Normally Open

NC – Normally Closed

DSM – Demand Side Management

EMS – Energy Management System

AT – Attention

PCB – Print Circuit Board

ISIS – Institute of Software Integrated System

ARES – Advanced Routing and Editing Software

IC – Integrated Circuit

IEEE – Institute of Electronic and Electrical Engineering

List of Figures

List of tables

Abstract

The general objective of this study is to design controlling mechanism that prevents wastage of excessively consumed energy due to light bulbs in home using GSM Network. GSM module was used for receiving SMS from user's mobile phone that automatically enable the controller to take the action such as to switch ON and OFF the light bulbs. The system used SIM900 GSM Module which allows users to effectively control light bulbs from wherever by sending SMS (Short Message Service) to the device. ATmega328 microcontroller which is embedded in Arduino Uno board, which was used to communicate with SIM900 GSM Module and the relay module to carry out the ON/OFF operations received from user's mobile phone. The software used to this system Arduino IDE to write the codes which makes the communication with microcontroller; programming language C, and the Proteus software is used to simulation. When a user sends an SMS to the controller at home or at work, the system is stimulated. The microcontroller units automatically control the light bulbs by turning the gadget ON or OFF in response to receiving the SMS command. The system has been successfully developed and it could provide effective mechanism in controlling the light bulbs efficiently as result the excessively wastage of power is reduced. This research provides a modern approach to our society to control the light bulbs and improves the traditional method of switching. The evaluation indicates that as the user perform successfully; it reduces monthly bill payment by more than 50% from the previous consumption. The system has evaluated in different ways, the first one is measuring the performance of the system in terms of speed and the second evaluation is undertaken using assessment and collecting data from the user to show the effectiveness of the method. As indicated from simulation result, the execution time of the system is very fast when the commands are sent from user to take action & the time taken to perform the action is very minimum seconds/milliseconds/.The assessment result indicated that, when the user implement this method in their home, they reduce wastage of power highly and as result they minimize monthly bill payment by half of the earlier payment.

CHAPTER ONE

INTRODUCTION

1. Background of the Study

In Ethiopia, there are over 110 million people, and 46% of them exclusively utilize electricity for daily functions like lighting and food preparation. 80% of the populations live in the rural area of the country; those people have no sustainable energy supply(Getie, 2020). The development of a country depends on the consumption of electric power and the quality of life depends on the electric power infrastructure. As the number of populations increase, the number of residence and different institutions are increase and also consumption of energy similarly increase. Power is one of the main infrastructures for those organizations and for human to live. Producing electrical energy constantly is world's major problem and in some countries this problem is very serious that peoples not get electricity to their basic need like TV, fans, house lights (Undre etal., 2014)

In modern world, energy is one of the most necessary commodities and needs to human life and found in every human residence area as well as in every working area. Without energy anything cannot be done since all things depends on it. Because electrical energy is widely used as a necessity for humans the main driver of economic progress, and a crucial component of the modern economy. But most of the time the usage of energy in our society's home or on working area not consider its insufficiency and due to this wastage of energy will be happen. Even after the task is finished, the user cannot switch off the device to save energy. But energy saving is an important issues of everyday living to reduce wastage of energy.Therefore nowadays energy consumption and especially providing energy saving mechanism are hot issues to research.

As we know, to save electric power, almost all users in home or in office are disremember to make switch off the light when they go out from the home or office and when they go in to the rest at night. Numerous advancements have been made in automating various work parts to save on manual labor as a result of the rapid advancements in wireless communication technology made possible by the usage of microcontrollers (Kesav & Rahim, 2015).

The convenience and flexibility that mobile communication provides have made it one of the fastest expanding areas of telecommunications over the previous year, during which wireless communications saw an exponential growth era and became a crucial component of modern civilization (Gu & Peng, 2010).

Now communication takes place relatively fast, easier through the usage of cell phones. A cell phone's function is not limited to calling and texting; it can be used for various functions. Cell phones have become a necessity in people lives; communication and entertainment are all possible with smartphones.

The proposed method in (C. K. Das, M. Sanaullah, 2009) enables users to control their home appliances and systems from anywhere using a cell phone.RemoteControl technologies are frequently employed to operate residential electrical items remotely(Olawale Adepoju et al.,2017). GSM technology's benefits in cellular communications offer a potential remedy for such remote controlling activities. GSM and SMS technology can be used to control light bulbs from remote places. As the technology grows; SMS technology has been widely accepted as part of medium of communication.

The purpose of using SMS is to provide broadest coverage at a lowest price. So the use of SMS would enable in controlling the electrical device at home from long distance and low in maintenance and free from any physical geographical boundary(Ahab et al., 2010).

Currently, people use electrical energy as one of the main source of power to operate any electrical device or appliance. Most of the time people turn on the light for 24 hours per day when they are away from home and leaving the light turn on continuously, this lead to wastage of energy(Ahab et al., 2010).

Thus this research is proposed to provide a mechanism to the home owner to optimize the modern usage of electric power and helps to them to reduce extra consumption of power by controlling light bulbs remotely using mobile phone through SMS using GSM network.

1.1. Statement of the Problem

Energy is one the most important commodity to our society modern life. However due to lack of energy supply in a country, not all our society attain power for lighting purpose. But in contrary the society which attained power in home is not used power in efficient and effective manner by minimizing the operating time of the bulbs to save energy.

Sometimes the light bulb is “on” without making service and without the presence of anyone in home as well as working area.This improper utilization of power in home or organization leads to extra wastage of energy.The present light controlling system depends on the residents’ manual control for switching off & on the device.But users have a tendency to forget turning off the light when they go out from the home due to residents’ behavior and lack of awareness for energy saving practices. Due to this lighting is left on continuously without anyone in home leads to energy wastage and as result unnecessary load in monthly bill payment on home owners. To improve this problem we have to provide best, comfortable, and cost efficient strategies for users to control their home light bulbs using wireless communication technology through their hand cell phone.

1.2. Research Question

The main research questions in this study are:-

- What is the drawback of the usual controlling approach?
- What are the appropriate& cost efficient wireless communication technologies?
- What are the best strategies for users to save unreasonably consumed energy by light bulbs in home?

1.3. Motivation

The reason that motivate to do the research in the area of power consumption especially in home or organization, today wastage of electricity cannot improved. Most of the time in home or office, the electric light is operating for a long time in a day and night even after the work is completed. As result extra wastage of electricity will be occurred and monthly payment is overloaded. In addition to that, the conventional system presents in house or office to switch OFF/ON the device is not near from the operating area of the owner. Due to this, most of the time the user cannot control the bulbs by turning off the light because the user may tired in hard work. So, due to the above mentioned problem the researcher motivated to solve problem.

In (Saari et al., 2019) discussed about the saving of energy, in the modern world, energy saving has become an important issue, in almost every aspect of life. On the other hand, the wide spread of wireless communication is increasing day by day, this has motivated to use mobile phones to remotely control household appliances particularly light bulbs by sending SMS. This research contributes to home owner in controlling the light bulb without worrying the distance wherever the mobile network is available.

1.4. **Objective of the study**

1.4.1. General Objective

To develop effective controlling mechanism using GSM network for home owners to prevent excessively consumed energy due to light bulbs in home.

1.4.2. Specific Objective

Specific objectives of the research are:-

- To identify the effects of usual light controlling technique
- To identify the appropriate& cost effective wireless communication technologies.
- To develop a mechanism that helps for home owners to control their home light bulbs.
- To evaluate the system

1.5. Significance of the Study

As successfully implemented the proposed work will return the following benefits. These are:-

An extra wastage of electric energy is minimized, the operating time bulbs in home are minimized& increase life time of light bulbs, monthly payment of bill is reduced, users get the appropriate and comfortable mechanism to control the light bulbs, users can control thelight bulbs from outside of the home, reduce the complaint of users related with monthly payment of EEU.Since the monthly bill payment is comes to the user is the monthly reading of the bill. But from that reading the home owner may use some of that and some of them are wasted energy. So, according to the reading, the bill payment may increase over. During this time the home owner goes to EEU to provide complain. But when the owner install this system on his home and control the extra wastage energy, then monthly bill reduce as a result no complaint is provides to EEU office.

1.6. Scope (Limitation and Delimitation) of the Study

The scope of this thesis is limited in designing the energy controlling mechanism to minimize consumption of electric energy with Arduino microcontroller by integrating with GSM wireless network to send message via mobile phone. The thesis is focused on controlling light bulbs in home as result extra wastage of energy caused by light bulb is reduced. The other home electric appliances such as fun, air-conditioner, stove, divider and others are not concerned.

1.7. **Organization of the thesis**

This thesis has organized in the following manner. This paper has organized into five chapters. The first chapter described previously contains the introduction part of the proposed work. Second chapter provides literature review. This chapter contains the basic concepts about wireless technologies related to GSM technologies. Under chapter three describes the methods which are implemented in conducting this work. Chapter four provides simulation of the desired work. Finally, conclusion and recommendations were provided in chapter five.

CHAPTER TWO

LITERATURE REVIEW

2.1. Overview of Wireless Network

One of the fastest-growing areas of information technology is wireless networks. The versatility of wireless networks has led to their adoption by businesses, educational institutions, and residences, making them an essential part of contemporary life (Mewada, 2016). Due to the ease and flexibility it offers, mobile communications is one of the areas of telecommunications that is growing at the fastest rate. Mobile communication systems have rapidly increased both their user bases and the range of services they provide over the past 20 years (Mewada, 2016).

The Global System for Mobile (GSM) is a specification for second-generation cellular systems. According to Mewada (2016), it is the first cellular system to specify network-level services and architecture in addition to digital modulation. The majority of people today use mobile phones as one of their main forms of communication, and SMS is the method of choice for mobile phone users due to its affordability and usefulness. As a result, SMS technology is shared by all mobile network service providers.

The history of the GSM protocol dates back to 1982, when the CEPT (European Conference of Posts and Telecommunications Administrations; standardization organization) decided to create a Group Special Mobile (the original source of the term GSM) to create a set of shared standards for a potential pan-European cellular mobile network. It was not decided then whether it will be analogue or digital.

The European Telecommunication Standard Institute (ETSI), which took over the project in 1988, produced the initial proposals in 1991 (GSM phase 1), consisting of 130 documents totaling more than 5000 pages. The name was also changed to Global System for Mobile Communications during this year. GSM was formally introduced in Europe in 1992, and by the end of 1993, 1 million individuals had signed up for the service.

2.2. Wireless Technologies to Monitor and Control lighting

The crucial communication technology necessary to create lighting systems is covered in these sections. Zig-Bee, Bluetooth, and GSM modules are some of the wireless technologies covered in this section.

2.2.1. Bluetooth

It is a wireless technology that transmits information quickly and over a short distance between phones and other portable devices. It operates in the 2.45 GHz range of frequencies. The advantage of Bluetooth is that it uses little power (just 0.3mW). But compared to other wireless communication methods, Bluetooth's range is quite limited, only reaching 30 feet (10 meters).

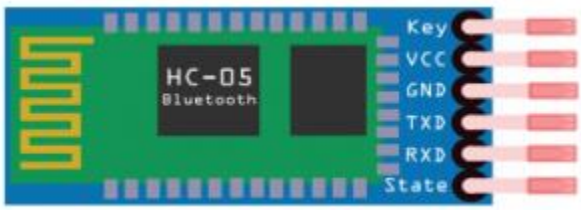


Fig.2.1.Image of Bluetooth

2.2.2. Zig-bee Technology

For communication between numerous devices in the WPAN (Wireless Personal Area Network), Zig-bee is a wireless communication technology that operates on protocol IEEE 802.15.4 at frequencies of 868 MHz, 902-928 MHz, and 2.4 GHz (Attachie et al., 2021).

It increases information transmission from one device to another device by utilizing digital radio. This form of communication technology is favored since it is inexpensive, requires little maintenance, and uses less power. Additionally, Zig-Bee technology is chip, effective, and user friendly. Zig-bee is not secure compared to Wi-Fi technology, though. And in comparison to GSM technology, it only covers a short distance (10-100m).

Fig.2.2.Image of Zig-bee technology module

2.2.3. GSM: Global System for Mobile communication

The second-generation cellular system standard known as GSM was created to address the fragmentation issues of the first-generation cellular networks. GSM was the world's first cellular system to define digital modulation, network device designs, and services.

For brand-new cellular radios and other personal communications equipment, it is currently the most extensively adopted standard worldwide. The GSM (Group Special Mobile) committee took on the task of developing a uniform mobile communication system for Europe using the 900 MHz band. The Global System for Mobile Communications has lately replaced GSM as the moniker for marketing purposes. In 1991, it made its debut on the European market.

One of the most well-liked and commonly utilized digital cellular telecommunications systems today is the GSM system. Due to the increasing quantity and demand for GSM subscribers, the GSM wireless communication technology has become increasingly popular in the field of mobile telecommunications. It is the most basic form of communication and basically requires no additional network construction because to worldwide GSM roaming and strong network capabilities (Amin & Khan, 2014).

A digital cellular communications system is the Global System for Mobile communications. It was created to establish a uniform mobile phone standard for Europe, but it has gained widespread acceptance quite quickly (Pawar & Pawar, 2012). It was intended for GSM to work with ISDN services. The second generation (2G) mobile system marked the beginning of digital communication technologies in the 1990s. The availability of higher quality voice services to the general public distinguishes second generation systems. Second generation systems benefited from the cellular concept, which enables several users to simultaneously use scarce radio resources without interference.

The most well-known 2G system is called the Global System for Mobile Communication. Standard creation Organizations (SDOs) offer the required structure for the creation of standards in the telecommunications environment (Le Bodic, 2005). The technologies that enable the realization of telecommunication network technologies and services are defined or identified in these standards, which are technical publications. The main objective of SDOs is to develop and sustain widely accepted standards that would permit the introduction of alluring services across interoperable networks (Le Bodic, 2005).

The GSM standard was developed by the European Telecommunication Standards Institute (ETSI) to describe protocols. The cellular networks are digital, second generation (2G). First-generation (1G) cellular networks are replaced by it. Globally active GSM is an open, digital cellular network. It is narrowband time division multiple access (TDMA) technology. It is not only used voice calls; it is also used for data computing and sending text messages.

(Gu & Peng, 2010) Highlights the assessment of GSM, one of the most extensively used second generation wireless cellular systems worldwide, for wireless communication. Based on the GSM standard, one of the most widely used cellular systems.One of the most popular GSM service is the Short Message Service (SMS). This service allows SMS subscribers to exchange short text messages. SMS are the most common and economically affordable service and it is used for both receiving and sending text message. SMS is based on transferring information via GSM network and a single text message can include up to 160 characters (Amin & Khan, 2014).

2.3. Services and Features of GSM

A communication services held by any system are defined as a group of communication capabilities that a service provider offers to the subscriber who sees this group of services worth paying for. The services of GSM are classified either telephone service or data services. They divide in to three main classes are telephone service, Bearer service and supplementary services. All of these services are digital in nature and not available in analog mobile networks.

- Telephone Services – includes regular telephony and emergency calls
- Bearer Services – gives the user the capacity required to transmit signals between certain access points.
- Supplementary Services – are defined as additional features to both telephone service and bearer services.

One of the most remarkable features of GSM is the Subscriber Identity Module (SIM), which is a memory device that stores information such as the subscriber; identification number, the networks and countries where the subscriber is entitled to service, privacy keys, and other user-specific information.

2.4. Wireless Technology with Respect to Area of Coverage to Controland Manage Light Bulbs

As described above, there are different wireless communication technologies implemented before to manage and control home appliance remotely. But all those technologies have its advantage and disadvantages. When we see their limitation, Bluetooth and Zig-bee, they cover very short range to control light bulbs far from home. But when we talk about GSM, the GSM covers a broad area and globally roaming facility and network capability. And it is not require building additional network. More over one of the most popular GSM service is SMS. This service allows SMS to exchange short text message and SMS are the best common and economically affordable service.

2.5. Energy Consumption

In early 1870s, the time when gas lamps were the most popular source of energy, there existed gas meters to compute the energy consumed(Patel et al., 2019). Currently conventional meters use kilowatt-hour as the standard unit of measurement. Energy consumption is a major issue in the modern world. The primary factor for excessive power usage in homes, businesses, and institutions is ineffective power monitoring and control methods (Mukendi & Adonis, 2017).

Energy consumption can be measured through its environmental impact and usage; the measure of the amount of power consumed by the load side of an electrical circuit is termed energy consumption(Patel et al., 2019).As presented by (Kumaresan et al., 2020), the usage of electrical consumption is measured through the electrical meter which is provided by the government. But these energy meter is does not measure the wasted electrical energy. It reads only the consumption utilized.

The maximum power that a load can consume is equal to the total power generated by the source minus the power lost in the transmission line. The researcher also cited, the reading of bill reads once in the period, but this creates error since it involves human intervention. So, he proposes metering system to measure consumption energy by eliminating fallacies and dishonest behavior. Its system promote paperless environment where the meter update directly sent to the user via SMS. The system implemented using Arduino microcontroller and GSM.

2.5.1. Factors Contribute to Consumption of Energy in Residence/organization

Energy was used for different purpose in home or institution for their daily operation. Without power the daily operation in home of in working area can't be easily completed and simplified. But with help of power whether for cooking food, heating, lighting in home or for performing different office job in organization was made easily. So, we have used the provided power regularly by saving energy. The home owner must save energy by controlling their home light bulbs.

As described by (Molla, 2022),most people without doubt tend to leave their home lights on when leaving their homes resulting in energy wastages and inefficiencies. Most of the time, energy was excessively consumed by irregular usage of power in home/office. In home, due to negligence, disremember, living habit /understanding how power bill impact on economy/, the type of light bulb appliance used, the number of appliances in home, the time of usage and others reasons are contribute to excessively consumed power. In working area /office/, typically carelessness and forgetting to turn OFF the bulb when they finished their work and they get out from office after work time is finished.

2.5.2. Impacts of Wastage of Energy Caused by light bulbs to home owners

As described above the factors that contributes to the excessive consumption of energy in home or work places due to lighting leads the home owners to negative impacts. As described in (Sena, 2014) negligence with regard to leaving lights on can lead to shocking electricity bills, wastage of more needed electric energy and shorter life span of electrical devices.

Some of mostly sounded impacts on home owners due to unbalanced usage of power in home increased monthly bill payment due to highly increased reading, replacing the power device when it burned due to performing operation for ling time and maintenance cost. Generally, the home owners are economically impacted and they disturb their plan.

2.6. Energy Management

Since energy is a vital resource for sustaining life and boosting social welfare, sustainable development depends on having a sufficient and dependable supply of energy. To save energy, one must use it intelligently, efficiently, and without producing unnecessary waste.

Saving energy has the potential to lower energy costs, improve comfort, and raise environmental value.

According to Saad et al. (2014), participation in DSM (Demand Side Management) programmed, greater customer awareness, the usage of an EMS (Energy Management System), and efficient home appliance design are the main variables in smart home energy management. Energy management systems are utilized to control items like lighting since unnecessary power consumption happens during the day and while people are not in a class (Molla, 2022).

According to Bagus et al. (2020), one way to enhance energy control and achieve effective, efficient, and sustainable energy use is through energy management. Customers may better comprehend how much energy is used by the appliances in their homes thanks to the automatic energy meter placed by the smart system, which replaces the standard energy meter (Kumaresan et al., 2020).

2.7. Related work

This part offers a review of earlier research that is relevant to the study we propose in order to learn more about the GSM control system now in use.

(Patel et al., 2019) presented a system that would send users updates on their energy consumption via SMS utilizing GSM. This eliminates the need for human intervention in the generation of bills and meter readings. That indicates that the system automatically generates bills and notifies users of updated meter readings. The systems' operations update the amount of power that has already been consumed, produce monthly bills, and alert the user.

The study outlined in Undre et al. (2014) a method of managing energy consumption that is based on GSM. Each consumer receives an equal share of the available electrical energy under this scheme. Energy is provided evenly to each consumer up to a set wattage. However, if a consumer exceeds the allowed level of usage, the system will send a signal to that consumer to turn off the power. Electricity is distributed evenly among all consumers by means of this mechanism. When a consumer uses more electricity than is allowed by the system, an alarm message is sent to them.

The suggested system in (Hussien et al., 2021) was created for government institutions to utilize IOT to save electricity. The device is awakened in this system to begin running at its predetermined start and end times. In other words, the device is built to activate at the designated time. If the gadget continues to operate after its scheduled time, the system notifies the institution manager. The system was created utilizing an Arduino Mega as the primary controller and GSM for sending notifications. The timing of the device's operation is determined in terms of day and night. The system issued a notification to the management when the device was still in use after the predetermined amount of time.

Energy conservation, as explained by Zhao et al. (2013), is an essential strategy for raising effectiveness. To track the energy use of sizable buildings like supermarkets, government buildings, and hospitals, an online energy monitoring system was developed.

The development of a building energy consumption platform to improve energy efficiency and even the development of a protection system for the electrical safety of the building were both examined in (Aravind et al., 2013). When a consumer uses more electricity than is necessary in this work, the system will send out signals via an alarm circuit.

The study recommended by Rafique et al. (2018) energy metering system to control the amount of energy used. The system enables customers to control their electricity consumption. When reading meters, the technology prevents human error. GSM and Arduino technology are both incorporated into the system's architecture. With the help of this approach, reading the updated consumption in a month is done with less labor and with less chance of error.

2.8. Summary of the Related Work

Electric power plays a significant part in the growth of the nation because it is so essential for daily life at home and the proliferation of enterprises. As a result, numerous academics are working to design and create a system to control energy use.

At the moment, wireless connectivity is crucial for remotely and automatically operating the light bulbs. Researchers have created a system that uses GSM to manage electricity by transmitting commands from a mobile device to a microcontroller, which then executes the command.

Numerous of the researchers cited above use GSM-based energy monitoring to regulate monthly energy consumption of home appliances, monthly energy metering mechanisms, equally distribute energy to consumers, and design systems to specify the operating time of the appliance, which is the beginning and ending time of the light. The primary objective of the overall research strategy described above is to decrease the amount of electricity used at home and at the office. They make use of wireless technology, including Zig-bee and others. However, these wireless technologies have drawbacks of their own.

In contrast to GSM technology, Zig-bee utilizes an internet connection, making it insecure and only capable of travelling a short distance. However, our research offers a mobile network-based method for reducing energy waste by managing household light bulbs. Our system is committed to having a reliable control system that is based on an Arduino Uno board. As a result, the system will be very scalable and cost-effective. The user turns the device "ON" when he wants to start working and "OFF" when he is finished. Before power is used, the user can control the light bulbs.

Therefore, in this project, we had to develop a system that would let a user transmit a command through his phone to his home light bulbs utilizing the GSM network. As a result, the user conserves energy before it is wasted unnecessarily. In fact, I've already suggested a few GSM-based energy management strategies. Their understanding of energy consumption includes the discovery of energy metering mechanisms and the management of energy theft mechanisms; these mechanisms aid users in avoiding reading errors and avoiding human involvement. Our suggested method, however, must limit additional energy wastage.

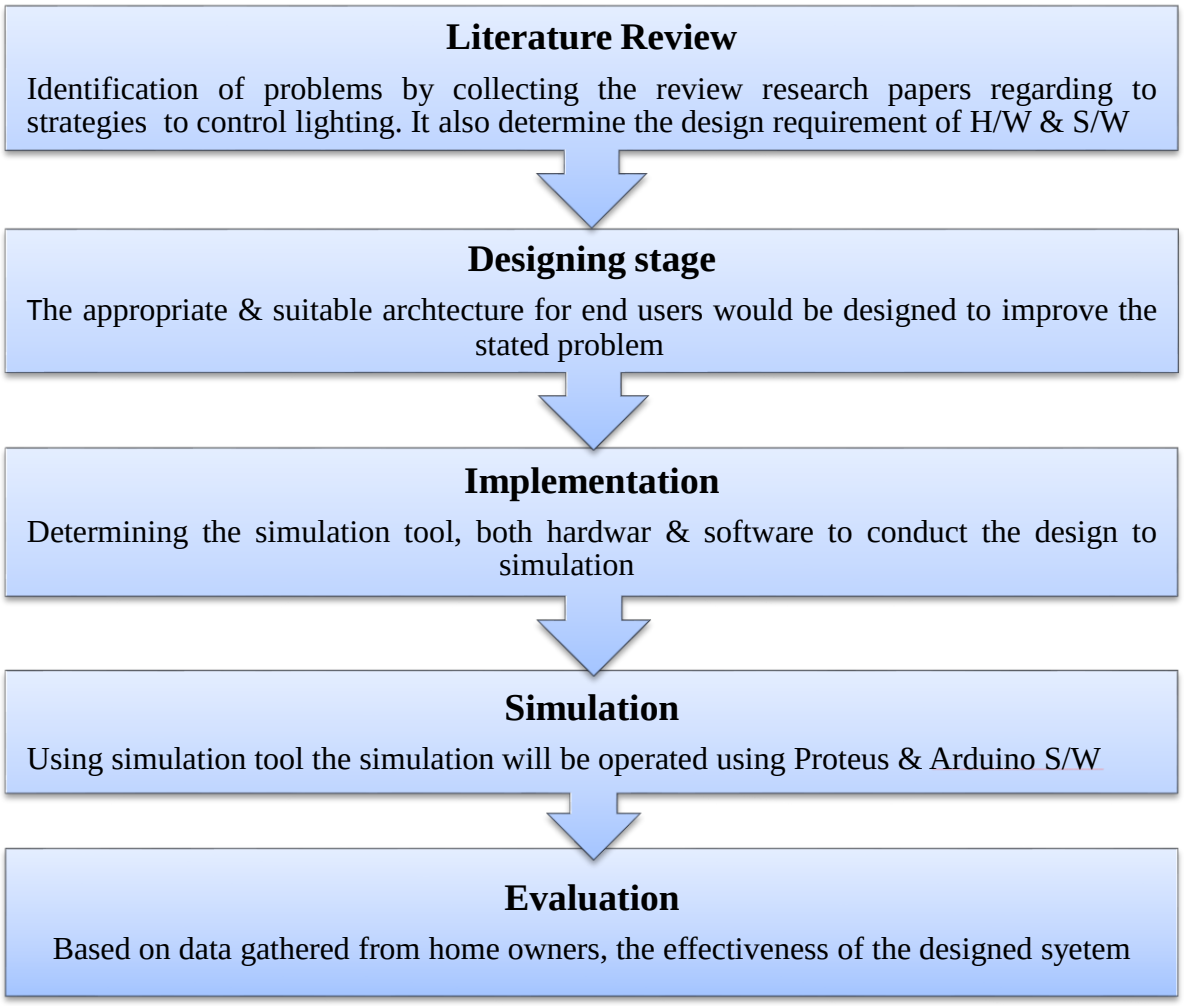
Through the system, the user can control the light bulb using his mobile phone by sending SMS messages to the microcontroller, which serves as the system's primary controller. As a result, the user can take a break and exert less effort. Additionally, energy was conserved by stopping the light bulb from completing extra tasks. Controlling this energy waste has the effect of reducing monthly bills and providing financial gains to the customer.

CHAPTER THREE

METHODOLGY

3.1. Introduction

The suggested method for creating this system is to use an Arduino microcontroller-based control system that gets its instructions and orders from a cell phone through a GSM network to carry out and execute the supplied directives and control the light bulbs. Therefore this chapter describes how to develop and conduct this research paper. The methods used when conducting this thesis consists of the following five stages.



3.2. System Design

The study's goal was to develop a microcontroller-based light bulb control system that would reduce energy waste. GSM (Global System for Mobile communication) module that receives messages was used to do this. The hardware components for implementing the planned system are a mobile phone, GSM module, microcontroller, relay, and lamp. The hardware architecture is made up of the standalone embedded system, which is based on the Arduino Uno microcontroller.

A mobile station that controls and issues commands to the device and a microcontroller unit that oversees the device and processes data from the mobile station make up the system's main two components. Since it is the system's central processing unit and handles data sent to and received from mobile stations. The block diagram used to design the system is shown in the following figure.

3.3. Diagram of the Proposed System

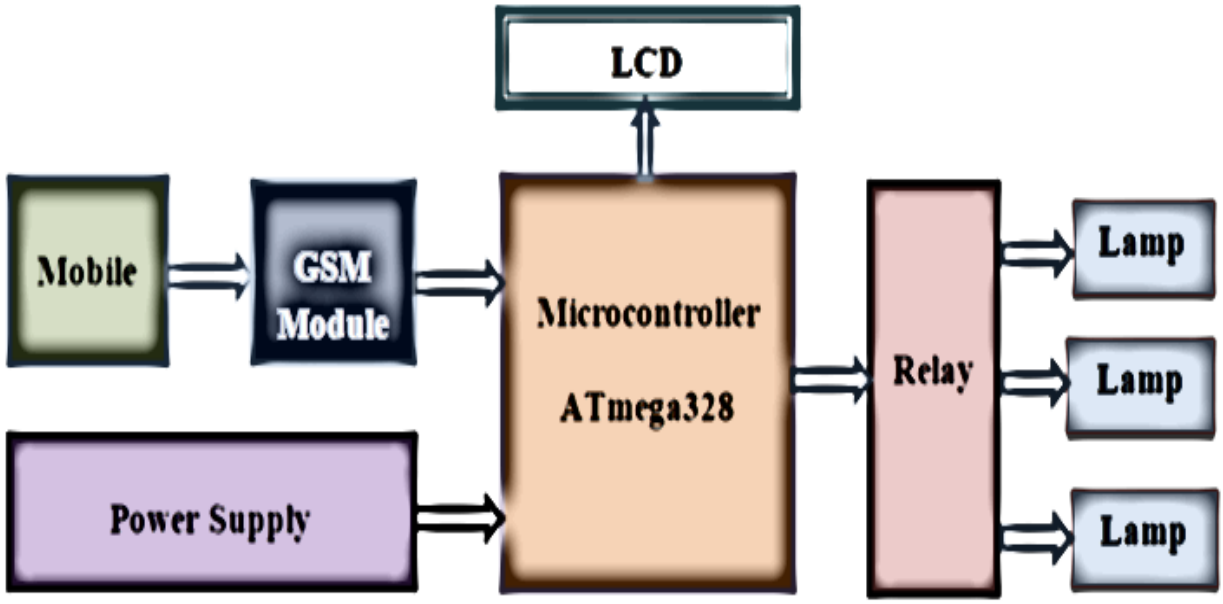
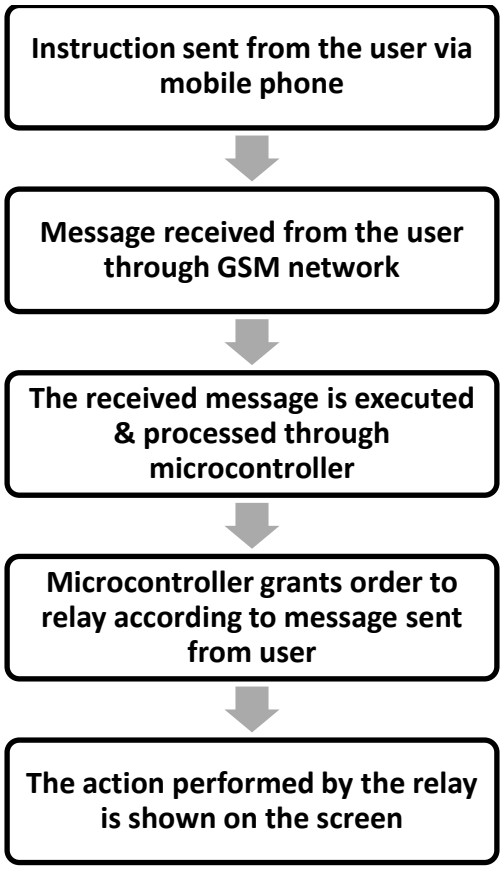


Fig.3.1. Block diagram of the proposed system

The first mobile phone serves as the transmitting section from which the subscriber sends text messages containing instructions and directives to the next mobile station using GSM technology, which is based in the area where our control system is. When using a GSM modem, SMS messages are the primary form of communication between the user and the system. The received message SMS is initially stored in the phone's SMS subscriber identifying module memory before being removed and properly processed by the microcontroller to carry out a specific task.

Relay circuits are used to switch various appliances connected to the interface, and a lamp is used to show whether the microcontroller is functioning properly. The system consists of two parts. Autonomous embedded system with hardware and software that can manage and watch over electrical appliances Bulbs creates the hardware architecture by sending SMS messages with directives. Using a cell phone, the technology allows the user to remotely monitor and operate a light bulb. As seen below, the system was enabled when the user sent commands specifying whether to turn on or off the bulbs. Fig. 32 shows the system's intended operation..



3.4. Implementation

3.4. Software and Hardware Description

3.4.1. Hardware

The block diagram for the light bulb controller can be seen in the related graphic. Building blocks make up the bulk of this diagram. The GSM (Global System for Mobile) module, Arduino Uno microcontroller, power supply, relay, and lamp are among them.

3.4.1.1. Mobile Phone

Each SIM-equipped mobile phone has a unique number where communications can be made. According to O.Olawale Adepoju et al. (2017), the method of communication is wireless, and the mechanism relies on GSM (Global System for Mobile communication) technology. Mobile is one of the communication tools used in this work to send messages to the controller. In this scenario, the user instructs the system to turn on the light bulbs via SMS.

It offers services including voice and data transfer. Short Message Service (SMS), a telecommunications system that enables the delivery of brief (160 characters or fewer) text messages, is used for data transfer. The majority of digital mobile phones have access to it. Mobile phones that can connect to devices like computers and microcontrollers via protocols like AT command can deliver SMS messages. Our design, as shown in the figure, is based on this potential mobile phone feature.

Fig.3.3. Mobile Phone

3.4.1.2. GSM module

A piece of hardware known as a GSM module (Fig. 3.4) connects to a remote network using the GSM mobile telephone standard. It is a modified Global System for Mobile communication module that tracks wireless radiation (SMS) using short message service. GSM modules are necessary for many communication devices that use the GSM (Global System for Mobile Communications) technology. A GSM module is a chip or circuit that will be used to create communication between a mobile device or computer and a GSM system. The GSM cellular mobile phone network allows for the placement of calls since the GSM module was created expressly to connect to the crucial control module. Because the service provider supplies the GSM module SIM, the consumer can utilize any network of his choosing.

Fig.3.4. GSM Module

3.4.1.3. Arduino/Arduino Uno (Microcontroller)

Arduino is a versatile hardware and software-based open source electronics prototyping platform. It is a complex device built on the ATmega microcontrollers from Atmel. The Windows, Macintosh OS X, and Linux operating systems all support the Arduino software. But the majority of microcontrollers can only run Windows. The Arduino Uno, on the other hand, is a microcontroller board made by Arduino and is based on the Atmel ATmega328 microcontroller. The word "Uno" is Italian for "one," and the Uno board is the most recent in a line of USB-based Arduino boards that serve as the platform's benchmark.

A microcontroller is an integrated circuit that has a CPU core, memory, and programmable input/output peripherals (Kumaresan et al., 2020).The Arduino-Uno microcontroller is a type of integrated circuit that manages some or all of the operations of an electric device, such as a household appliance, and includes a microprocessor, memory, and related circuitry.

The suggested system uses it to process user input (messages), as well as to give peripherals the required control signals. A wide range of products and machinery, including embedded systems in toys, power tools, office supplies, implanted medical devices, and automobile engines, are automatically controlled by microcontrollers. An open-source platform for prototyping is Arduino.

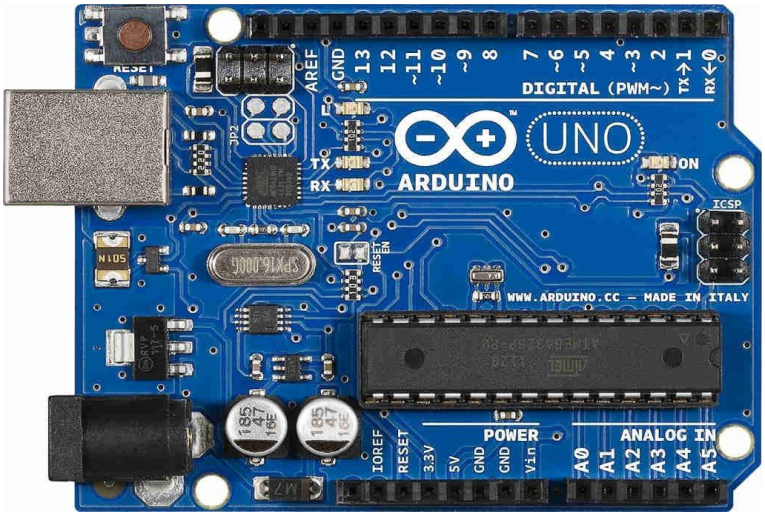


Fig 3.5.The Arduino Uno board which uses microcontroller ATmega328 onboard.

The main board is an Arduino, and the ATmega328 microcontroller on it serves as the primary controller to handle the circuit as needed. It is a well-known open source microcontroller-based kit for building interactive tools and digital devices that can communicate with switches, LEDs (Light Emitted Diodes), and other devices.

The Arduino Uno Board is depicted in Figure 3.5 and is made in Italy by Arduino. Both an external power supply and a USB connection are options for powering it. As shown in figure 5, pins 0 through 13 are 14 digital input/output pins, and pins A0 through A5 are analog input pins. Additionally, the pins denoted by a ""sign can be utilized as PWM output pins. It is an open source electronic platform built on simple-to-use hardware or software.

It offers a programmable board with input and output capabilities for the external environment. One type of ATmega328-based microcontroller board is the Arduino Uno.

3.4.1.3.1. Main Components of Arduino Uno

- Digital I/O pins – It has 14 pins (0 - 13) – used to send & receive signal
- Analogue input pin – It has 6 pins (0-5) – used to receive analog value
- ATmega328 microcontroller – which is the heart or brain of an Arduino
- Reset button – to reset ATmega328 microcontroller
- USB port – to transfer or upload the sketches to Arduino& to communicate with Arduino
- Power connector – to plug the cable
- TX/RX pins – it shows light when Arduino and computer communicate.

All these can support the microcontroller for further operation by connecting this board to the computer. The power supply of this board can be done with the help of an AC to DC adapter, a USB cable, otherwise a battery.

3.4.1.3.2. Pin Configuration of Arduino Uno

- Power Supply

A power supply is a device that changes the wall outlet's AC current into the DC current needed by electronic circuits. With the aid of a USB cable or an additional power source, Arduino Uno can be powered. As seen in the image below, the external power supplies (Fig. 3.6) typically consist of an AC to DC adapter or a battery (Fig. 3.7).

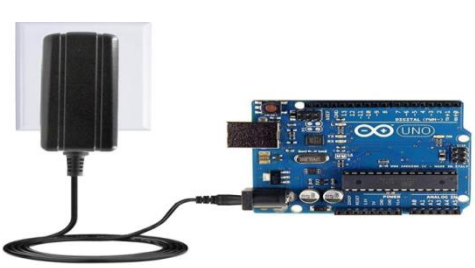


Fig.3.6. External Power supply

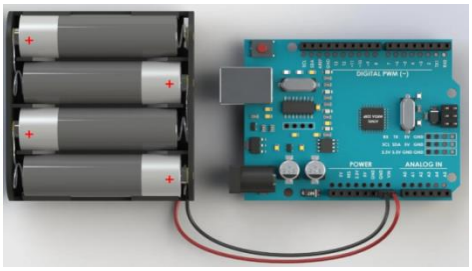


Fig. 3.7. Battery

The Arduino board can be connected by placing the adapter into the Arduino Uno's power port. Similar techniques can be used to connect the power connection's V in pin and GND pin to the battery cables.The recommended voltage range is 7 to 12 volts.

This is because using more than 12V could cause the voltage regulator to overheat and harm the board, and using less than 5V could make the board unstable. Therefore, 7 to 12 volts is the optimum voltage range. Pin for input/output: With routines like pin Mode (), digital light ON(), and Digital light OFF(), the Arduino's 14 I/O put digital pins can be used for input and output.

TX/RX Pin: These pins are used to transmit and receive message and they shows when Arduino and computer communicate to each other.

Memory: This Atmega328 Arduino microcontroller's memory has 1KB of EEPROM (Electrical Erasable Programmable ROM), 2KB of SRAM (Static Random Access Memory), and 32KB of flash memory for storing code.

The Arduino Uno ATmega328 provides UART TTL - serial communication, which is available on digital pins like TX (1) and RX (0). Two LEDs that are located on the board flash when data is sent over USB. The Arduino board's ATmega328 microprocessor can be programmed using the IDE and the Arduino programming language (Integrated Development Environment).

3.4.1.3.3. Features of Arduino Uno

The basic features Arduino Uno are the following

- It has14 digital input/output pins
- Each input and output pins 40mA DC
- It has 6 analog pins
- It has 5V operating voltage
- The recommended input voltage ranges from 7V-12V
- The input voltage range from 6V-20V
- Flash memory is 32KB

3.4.1.4. Relay

Relays are components that open or close connections to activate other electric controls. By opening and closing contacts in another circuit, it regulates one electrical circuit. A relay is an electromagnetic device that is used to electrically isolate two circuits and connect them magnetically, as seen in the diagram below.

The relay in Fig. 3.8 basically acts as a switch control that can be switched on and off using electromagnetism and a low-voltage signal. When necessary, it is utilized to stop the supply of the load.

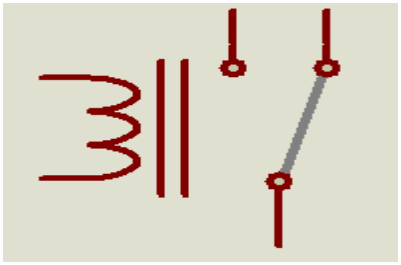


Fig.3.8. Relay

They are really useful tools that let you switch between completely independent circuits. They are widely used as an interface between electronic circuits with low voltage and electrical circuits with very high voltage. A relay switch's input and output can be divided into two parts. A magnetic field is created when a very little voltage from an electrical circuit is applied to the input section's coil. This voltage is known as the operating voltage.

Relays that are frequently used come in a variety of operating voltage configurations, including 6V, 9V, 12V, and 24V. However, we want to use a 12 volt relay. Contactors that connect or disengage mechanically make up the output section. There are three contactors in a basic relay: a normally open (NO), a normally closed (NC), and a common (COM). The COM is attached to NC in the no input condition. The relay coil energizes and the COM changes contact to NO when the operating voltage is applied. By using proper combination of contactors, the electrical circuit can be switched on or off.

3.4.1.5. Load

Any component that consumes electrical energy and transforms it into another type of energy is referred to as a load. We are utilizing a bulb in this clever energy-saving technique. The lamp

will be ON or OFF depending on the output signal from the Arduino. A standard light-emitting element called an electrical lamp is used in many circuits, primarily for illumination. Electric lights are things that use electricity to produce visible light. According to Wikipedia, it is the most prevalent type of artificial lighting and is crucial to modern society since it provides indoor illumination for homes and offices as well as outdoor lighting for activities throughout the evening and at night.

Fig.3.9. Lamps

3.4. Software

3.4.1. Arduino IDE (Integrated Development Environment)

A text editor for writing code, a message area, a text console, a toolbar with buttons for basic operations, and a series of menus are all included in the Arduino Integrated Development Environment (IDE), often known as the Arduino Software. It simplifies the process of developing code and publishing it to the board. It connects to the Arduino hardware to upload applications and communicate with them. Using the Arduino IDE, computer programs are called sketches. These illustrations are produced in a text editor, and then saved as files with the.ino extension. Text replacement and text searching options are available in the editor.

The message area reveals issues and offers feedback when saving and exporting. The terminal displays text produced by the Arduino Software (IDE), together with additional data including complete error messages. In the bottom right corner of the window, you can see the configured board and serial port. Using the toolbar buttons, you may create, open, and save sketches, validate and upload programs, open the serial monitor, and more.

3.4.2. Proteus PCB Design and Simulation Software

From concept to finished design, Proteus is an all-inclusive platform for product creation. Proteus is simulation software that can model components and draw desired circuits. It is a collection of software that includes tools for designing circuit boards, simulating designs, and schematics.

There are two primary packages in Proteus. They are ARES (Advanced Routing and Editing Software) and ISIS (Institute of Software Integrated System). The software used to generate schematics and carry out live circuit simulations is called ISIS.

By allowing for live interaction, the simulation offers real-time simulation. ARES is used for designing PCBs. Along with the planned PCB and components, it has the capacity to show output in three dimensions. The product's 2D drawings can also be created by the designer. The library of ISIS contains a range of materials. Sources, signal generators, measurement and analysis tools, such as oscilloscopes, voltmeters, and ammeters, probes for real-time circuit parameter monitoring, switches, displays, loads like motors and lamps, discrete components, such as resistors, capacitors, inductors, and transformers, digital and analog integrated circuits, semi-conductor switches, relays, microcontrollers, processors, sensors, and more are all included.

ARES provides PCB design services with surface mount and through entire packages, up to 14 inner layers. It contains the imprints of many types of discrete components, including as integrated circuits (IC), transistors, headers, and connectors. The PCB Designer has access to both automatic and manual routing options. It is possible to transfer the schematic that was created for the ISIS.

3.4.3. Simulation implementation Flowchart

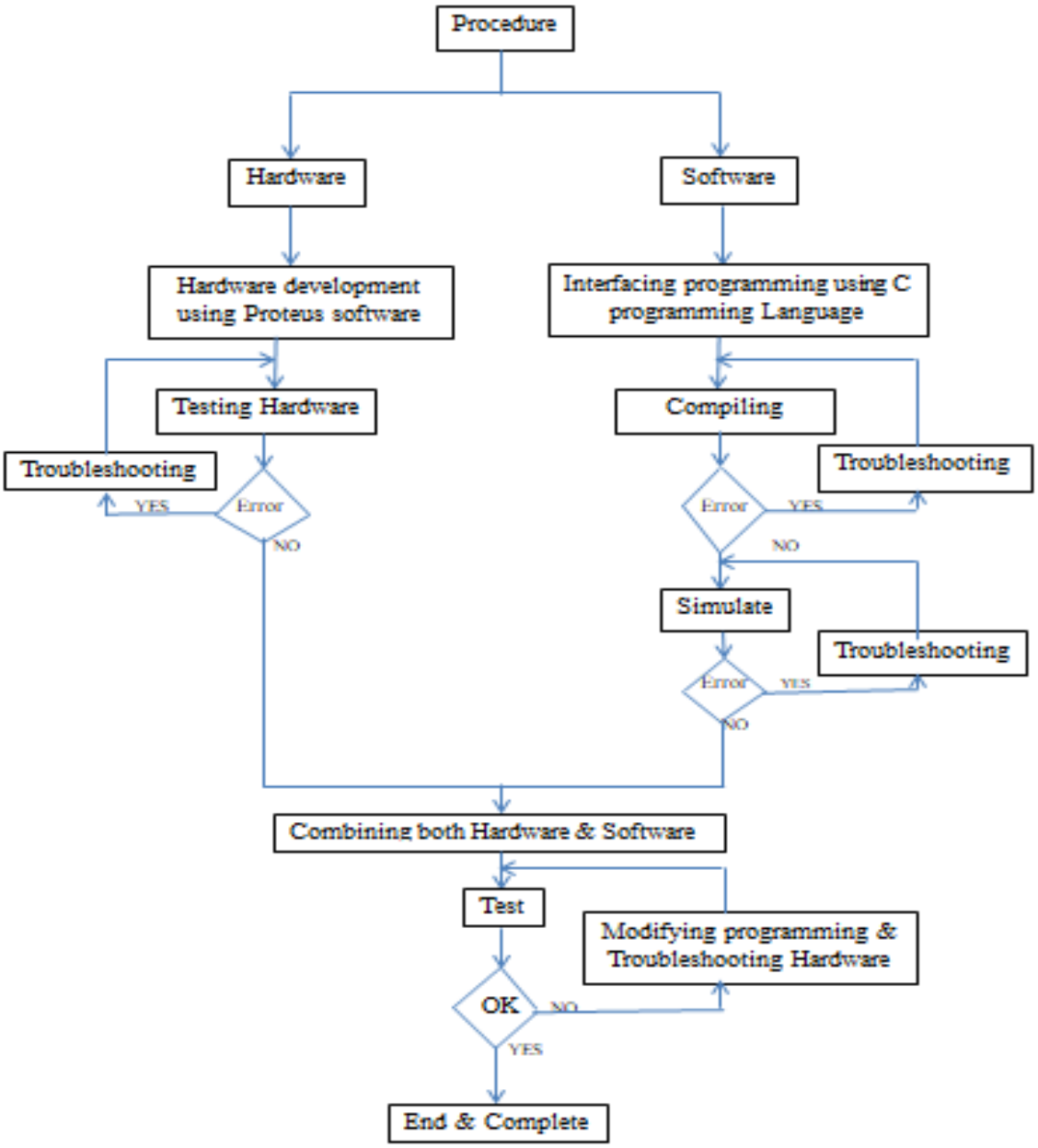


Fig.3.10. Simulation Implementation Flow chart to control light bulbs

CHAPTER FOUR

SIMULATION

4.1. Introduction

This chapter presents the implementation of the system that describes how the system goes to be done and how the materials are integrated to each other. The connection of each component would be described and shows the systems' activity when land to the ground. The simulation shows that combination of the selected hardware and software and how the consumers manage their home light bulbs to save power based on the commands.

4.2. Used Tools

In the previous section, we describe the two main parts of the system namely hardware architecture and the software that was used to implement in this study. The design of the system was implemented using C programming language, Proteus simulator software and Arduino IDE as shown below. Since Arduino IDE is open-source software used to write, compile, debug and upload programs to Arduino boards. The format that the system used to communicate each other is written in C program as shown below.

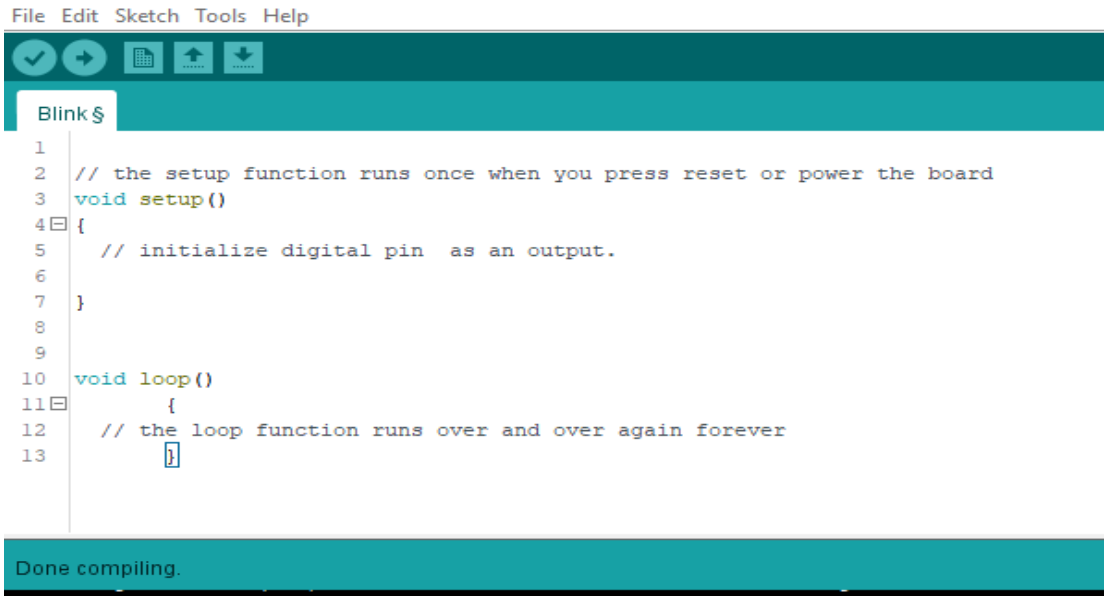


Fig.4.1.Arduino IDE

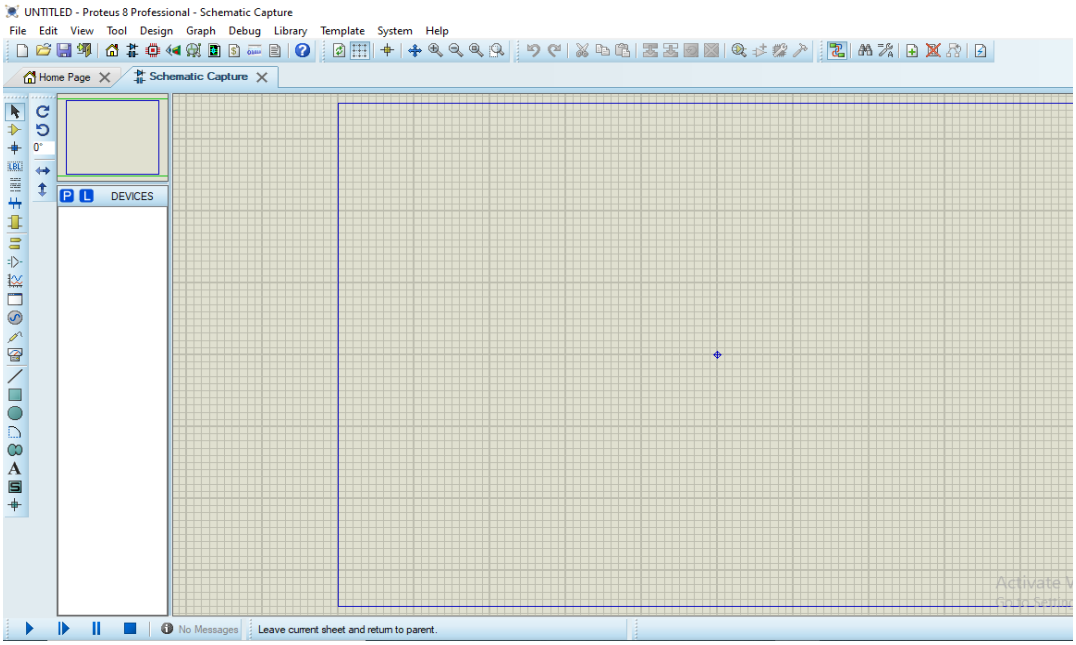


Fig.4.2. Proteus Simulator

4.3. Circuit Connection

4.3.1. Connecting GSM module with Arduino

As we know, there are different ways to implement remotely manage light bulbs in home, such as, managing using internet based, or managing using GSM module. The electronic device or light bulb or lighting system is managed remotely using the GSM module especially using SMS which is our study focus on.

As we described in the previous section, SIM900 GSM module acts as the mediator between the microcontroller and the mobile station. It is responsible for the communication between them. The user's message to control the lighting reached to microcontroller is using GSM network. The communication between Arduino and GSM is serial; therefore we supposed to use serial pin of Arduino (Rx and Tx).

To communicate both Arduino and GSM serially, the receiver (Rx) and transceiver (Tx) of Arduino and GSM should be connected directly. That is Rx of GSM is should be connect with Tx of Arduino and Tx of GSM should be connect with Rx of Arduino. And to make negative volt, both Arduino's and GSM module's GND should be connected. But in this research work, we have used virtual terminal by assuming mobile phone to write text message as SMS.

Since we have discussed before mobile phone is one of the feature of this work to send text message to GSM, so we use virtual terminal as mobile phone to write text message on it.

Therefore, we connect Rx and Tx pin of Arduino is with this virtual terminal of Tx and Rx as shown in the figure. In our code we have used Arduino's Pin 2 as Rx (receiver) and pin 3 as Tx (transceiver). So to make the communication between Arduino and GSM, Arduino's pin 2 is connected to Tx of GSM module and Arduino's pin 3 is connected to Rx of GSM module as shown in figure.

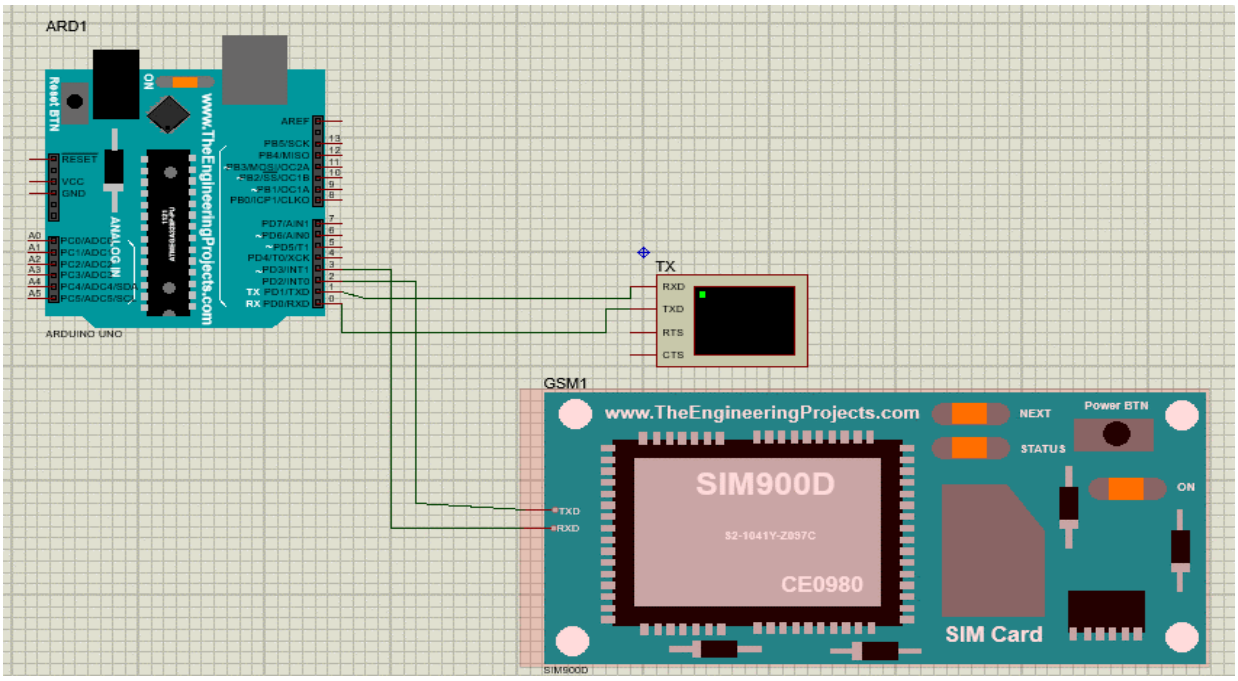


Fig.4.3.The Circuit Connection of GSM module and Arduino

4.3.2. Connection of Arduino with Relay

A switch that is electrically operated by an electromagnet is called a relay. Two sides make up the relay. As shown in the diagram below, one side is connected to the high voltage device, and the other is connected to the Arduino. In the connection of Arduino and relay, three Arduino's pins (4, 5 & 6) are connected with three relays. Pin 4 is connected with relay one (RL1), pin 5 is connected with relay two (RL2) and pin 6 is connected with relay three (RL3).

And each relays are connected with its corresponding light bulbs to control the bulbs as the order comes from the user. Each relay controls its corresponding light bulb.

Relay connections have both input and output pins. The input connections of relay are positive input which outs from Arduino and negative input (GND) which is from Arduino to relay.

The output connections of relay are three pins. These are NC (normally closed), common(C) and NO (normally open). From these pins, we connect the light bulbs on common and normally open pins. Since our aim is controlling the light by “switching off” the light bulbs. So to switch off the bulbs we should connect with common and normally open pins. Unless and otherwise if we connect the bulbs with normally closed pin, the light may “switch on” anytime.

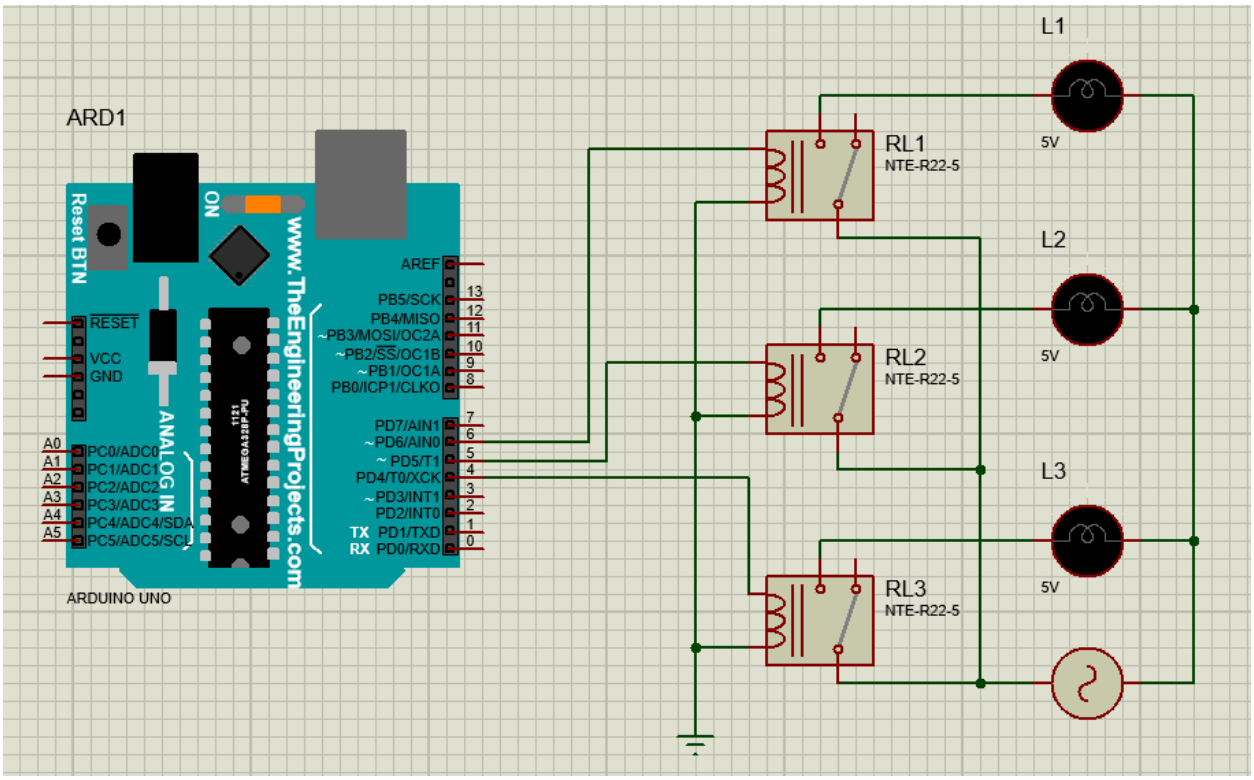


Fig.4.4. Connection of Arduino and Relay

The above figure shows that, the output interface of the system, in which the output of the command that comes from the user is shown whether turn ON or OFF the light. The system was programmed such that it receives commands to turn ON or OFF certain Light which were attached to the output section indicated in the above picture. The importance of this research is that the houses hold appliances such that light bulbs can be source of energy saving if this SMS controller system is installed in the home. This enables the user to remotely switch OFF these light bulbs during unused time such as during the day when the user is probably at work or out of home.

As indicated in the above diagram, there are three relays are connected with Arduino. Relay one (RL1) is connected with lamp one (L1) which is room one light bulb and controlled by R1, relay two (RL2) which indicated in the middle of the circuit that assigned to room two and controlled by R2. And finally relay three (RL3) is connected with lamp three which assigned to room three and controlled by R3. According to the user interest or commands sent from him, these relays are takeaction by doing the light bulb whether "turning on" or "turning off" the wanted home electric Light.

4.3.3. Connecting Arduino with LCD

As we know the LCD screen is used to indicate the status of the order comes from the Arduino whether to turn on or turn of the light bulbs in home. Since the LCD uses a parallel interface, the microcontroller must simultaneously manipulate multiple interface pins to control the display.

The interface on LCD consists of the following pins: RS (register select) pin that controls where in the LCD's memory we are writing data to, R/W (read /write) pin that selects reading mode or writing mode, An Enable (E) pin that enables writing to the registers, and 8 data pins (D0-D7). The states of these pins (high or low) are the bits that we are writing to register when we write, or the values we reading when we read. As we describe in the previous chapter, Arduino have 14 pins (0-13). From these Arduino pins, we connect 6 pins (from pin 8-13) with LCD data pins as shown below from the circuit connection.

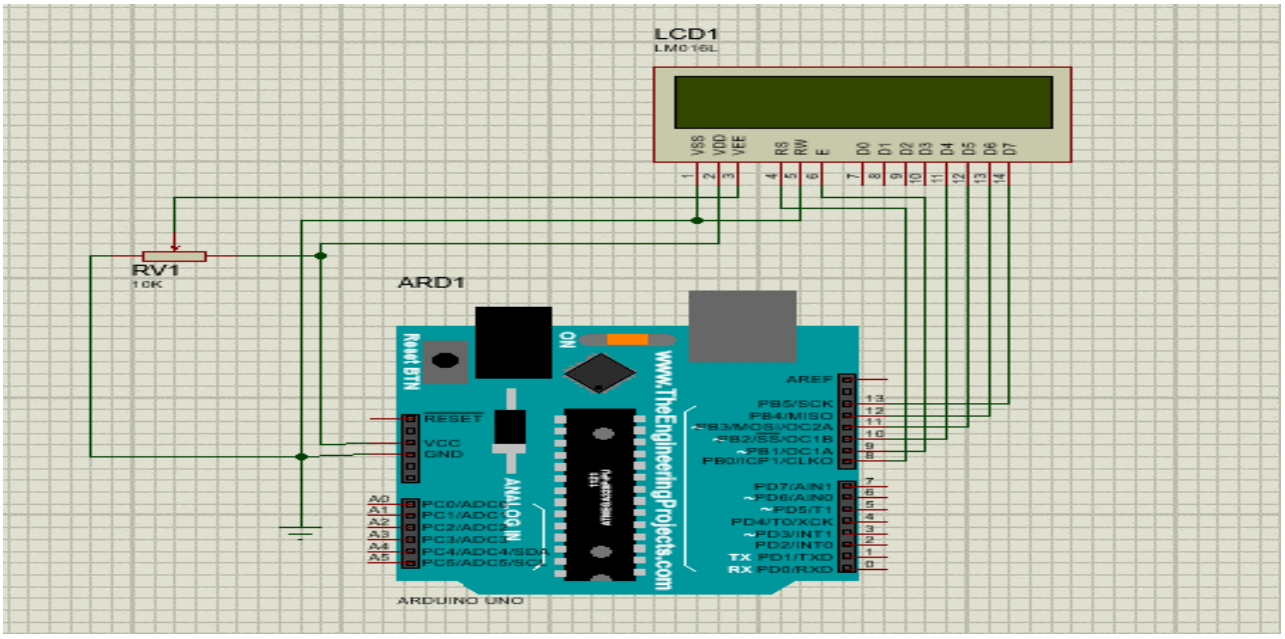


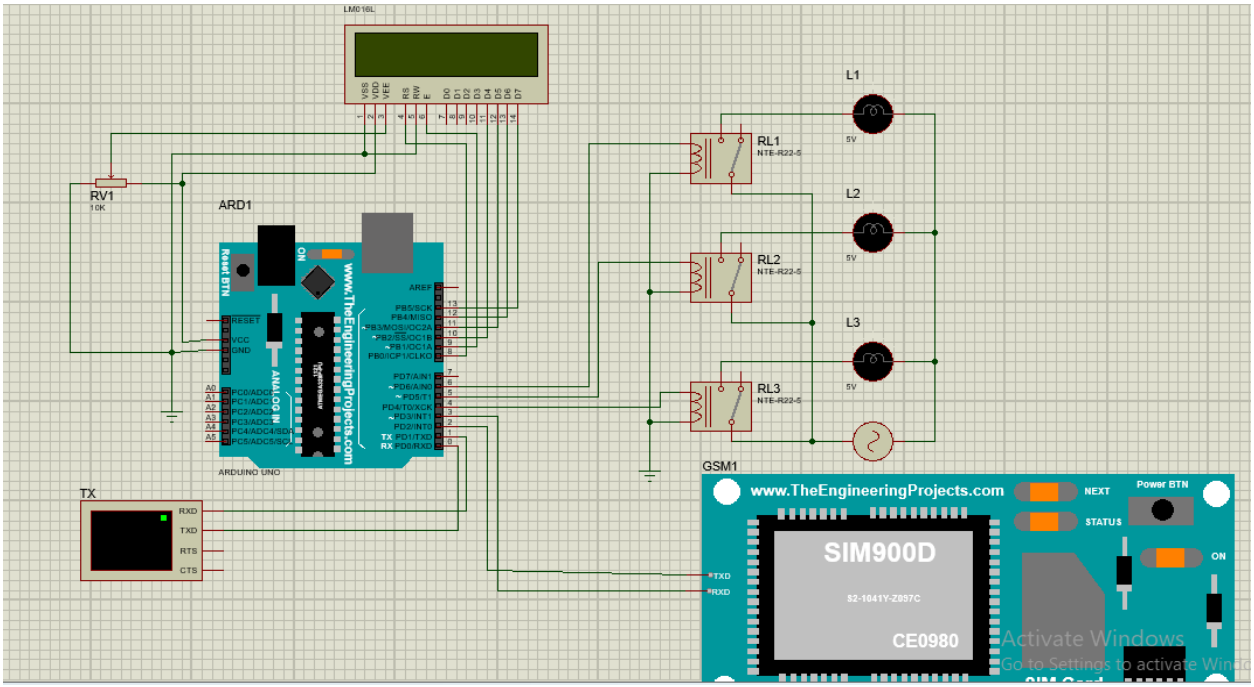
Fig.4.5. Connection of Arduino with LCD

As shown from the diagram, LCD data pins (D4-D7) connected with Arduino pins (from pin 10-13). It obtains 5V power and negative volt (i.e. GND) from Arduino. Potentiometer (variable resistor) is shown in above diagram is used to control the brightness of LCD whether to increase or decrease the brightness.

4.4. Overall Architecture of GSM Based Light Bulb Controlling System

The system architecture is the conceptual framework of the proposed GSM based light bulb controlling system in home. The system design is established on five structural features as each connection described in the above section. These consists of mobile phone (i.e. virtual terminal) is the first feature that serve as a controller for sending messages by cellular network connectivity. The wireless communication module that consists of GSM unit is the second feature of the system.

The GSM unit is accountable for communication between the microcontroller and the mobile phone. It is short message service based hardware for receiving and sending SMS information and commands. The third structure of the system is the data processing unit which is called Arduino Uno microcontroller. It acts as the brain of the processing units and it is responsible for coordinating, controlling and managing the communication inflow of all the connected hardware components. The fourth feature of the system is the relay switching module that utilizes three channels (that is bedroom light, Salon room light bulb and restroom light bulb) relay to initiate and disable the home light bulbs. These relays connected to the different room light bulbs through an electrical main. The last and the fifth feature of the system is the LCD screen that is used to show the process and the status of the lighting and used to show processes of the message that comes from the user whether to switch “on/off” the light.



The following Fig.4.6 shows that architecture of the system

4.5. Description of the Circuit Connection

The connection of GSM based light bulb controlling system look like the diagram above. In this system, the LCD is used for displaying the status of the home light bulbs which is directly connected to the Arduino in four pins. Data pins of LCD namely RS, EN, D4-D7 are connected with Arduino digital pin number 8-13.Since Arduino's Rx and Tx are codded as pin number 2 and 3, so Rx of GSM is connected to pin number 2 of Arduino, Tx of GSM is connected with pin number 3 of Arduino respectively. And we have used Arduino's Rx and Tx with virtual terminal. Since we assume virtual terminal as mobile phone, we connect Arduino's Rx and Tx with virtual terminal to us it as mobile phone. A GSM module is powered by 12 volt adapter. And 5 volt relays are used for controlling all light bulbs in home. Relays are connected with Arduino pin 4, 5, and 6 for controlling each light bulb.

The software parts used to simulation are using Proteus software that is to design the schematic diagram of the system and Arduino IDE used to write the code of the programming language. In this work, Arduino controls the whole process of the system. Here, GSM wireless connection is being used to control various light bulbs in different rooms of the house. To turn on and off the lights in various rooms, we send commands like "#A.Light on*" or "#A.Light off*."

Arduino sends a signal to relays to turn on or off the light bulbs after receiving the commands through GSM. Here, we utilized the prefix "#A" in the command string. The main command is indicated by this prefix, and the character "*" at the end of the string denotes the completion of the message.

When a user sends an SMS through his mobile device to the GSM module, GSM receives it and delivers it to the Arduino. The primary command is then extracted from the received string by the Arduino once it has read the SMS and stored it in a variable. Arduino then compares the string to a specified string. If the string and predefined string is matched, then the Arduino send signal to relays for turning ON or OFF the light bulbs. The result of the operation also prints or shows on LCD by using the appropriate commands like by saying room one/two/three/ light is ON or OFF according to the message comes from the user.

4.6.1. Simulation Result and discussion

The implementation of simulation is based on Proteus software and Arduino IDE. The connection of each device circuit is described in the previous section. The code of the program file used to initiate the system is hex file. This file is uploaded in to Arduino after compiling the program to start playing.

First we upload the GSM file from GSM library, then we open the program code and click on compiling button on top of the start menu and after a compilation is done, we copied the .hex file code from the of the program and past on Arduino. The following screen shoot image is the starting of simulation. “GSM BASED HOME LIGHT CONTROL SYSTEM” is shown on the screen at the beginning.

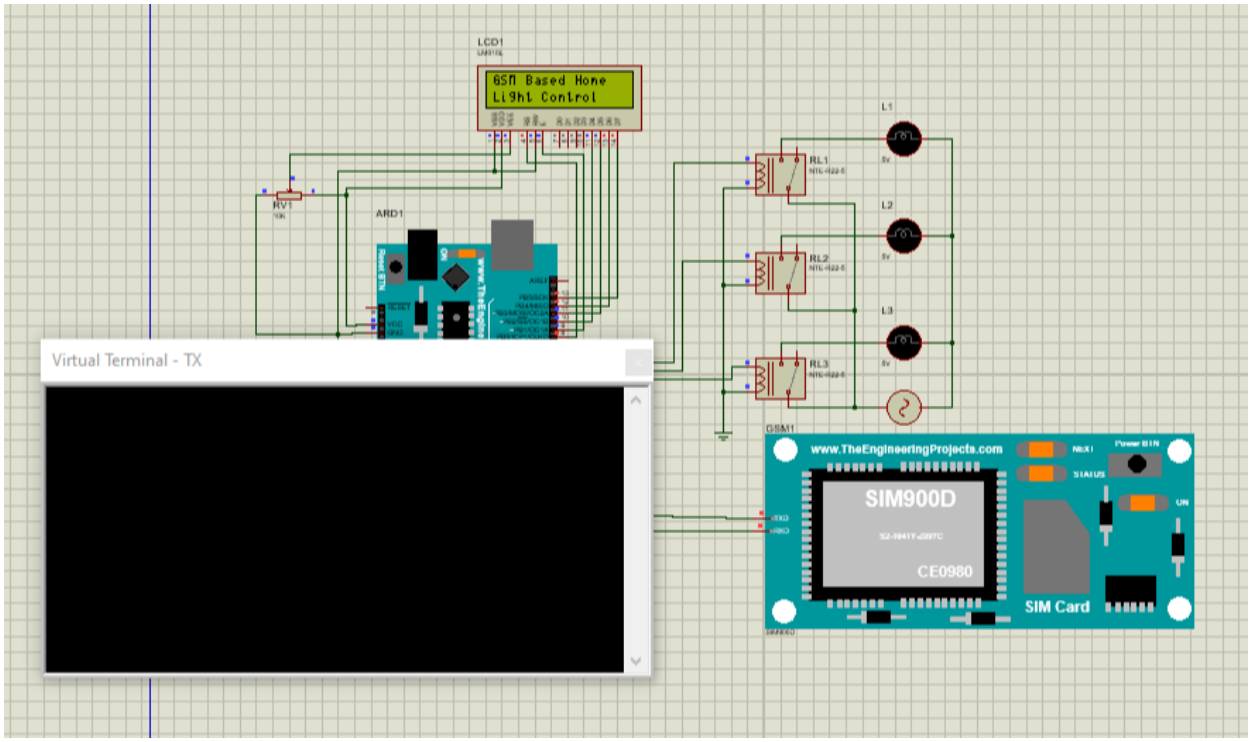


Fig.4.14.Screenshot image of the beginning of Simulation Result

After displayed the above title, each light bulb is controlled in the given command described next. To control the light the commands are written on the above black screen used as mobile phone.

The following table indicates that commands used to control the light bulbs.

Commands	Description
#A.l1 on*	to turn ON lamp 1
#A.l1 off*	to turn OFF lamp 1
#A.l2 on*	to turn ON lamp 2
#A.l2 off*	to turn OFF lamp 2
#A.l3 on*	to turn ON lamp 3
#A.l3 off*	to turn OFF lamp 3
#A.all on*	to turn ON all lamps
#A.all off*	to turn OFF all lamps

Table4.1. Commands to control the light

According to the above command we can control the light bulbs in home to save electric power. If the home owner wants to use light, he send a command as his interest whether lamp 1, 2 or 3.

If he want lamp one light, he send a command like this #A.l1on*. After a seconds lamp one light is turned ONN as indicated in the screenshot image below. Lamp one is ON

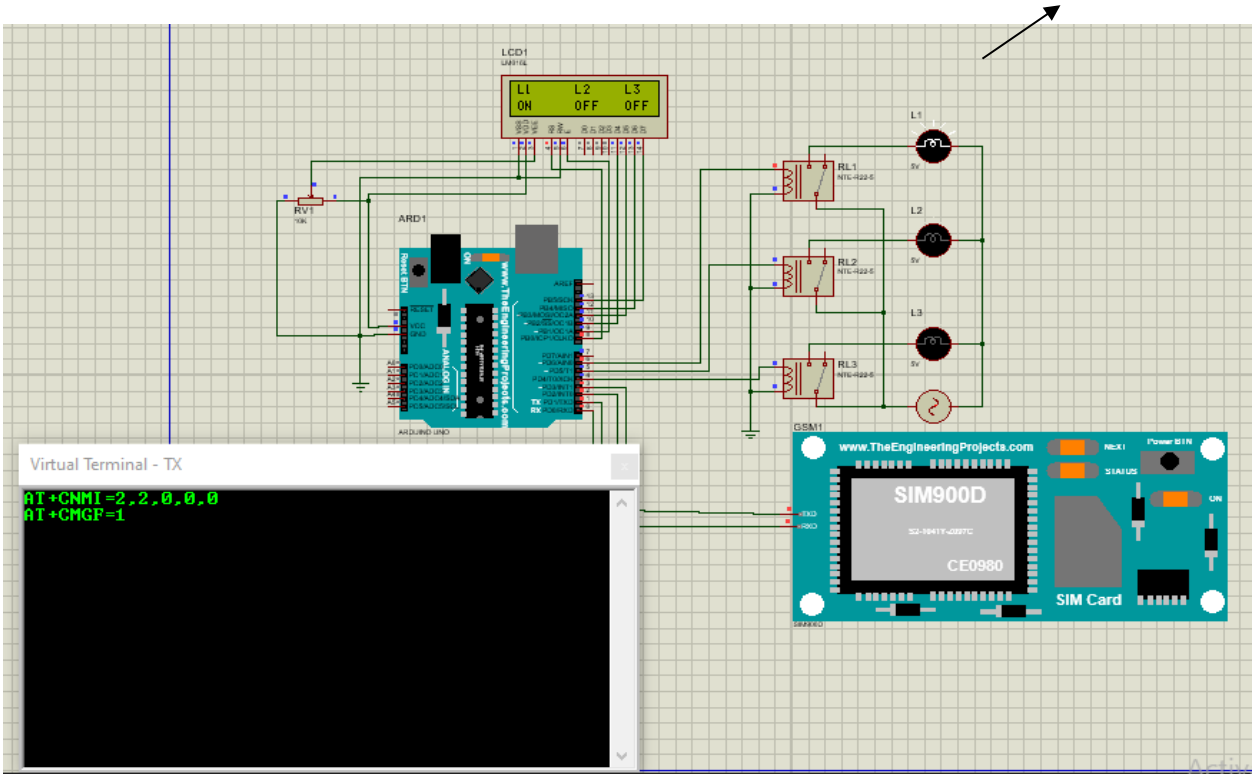


Fig.4.15.indicates that lamp one light is ONN

Similarly, if the home owner wants to turn off a lamp one, he sends command #A.l1off*. With the same the home owner wants to turn ONN or OFF all the light bulbs in the night time and he goes out the home, he should send the command #A.all on* and #A.all off*. The status of the bulb looks like the following picture.

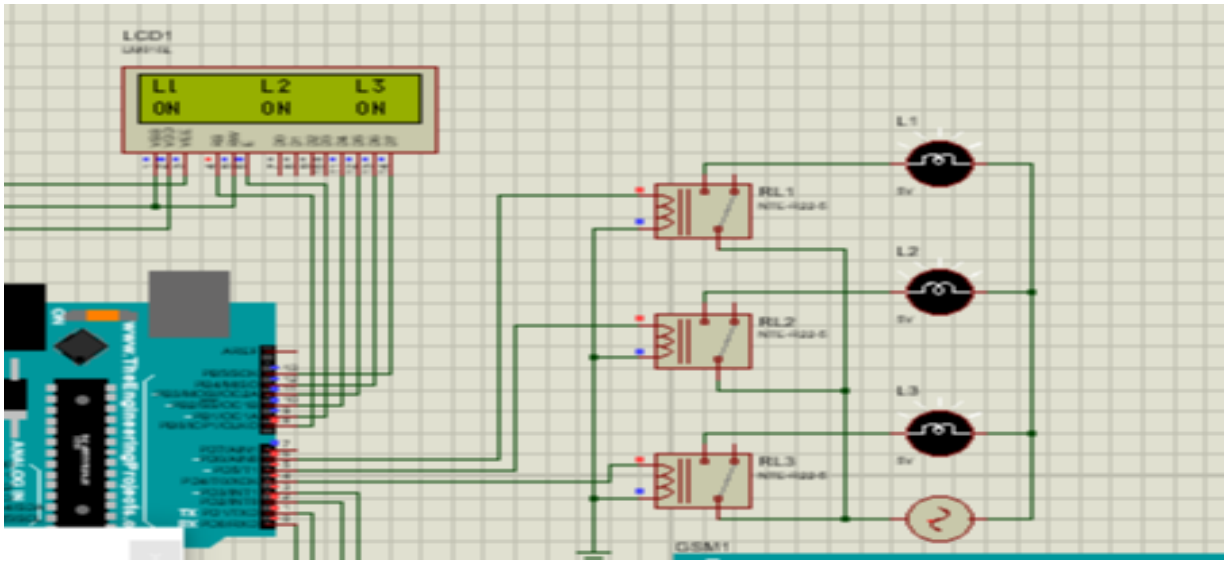


Fig. 4.16.shows that all light bulbs are “ON”

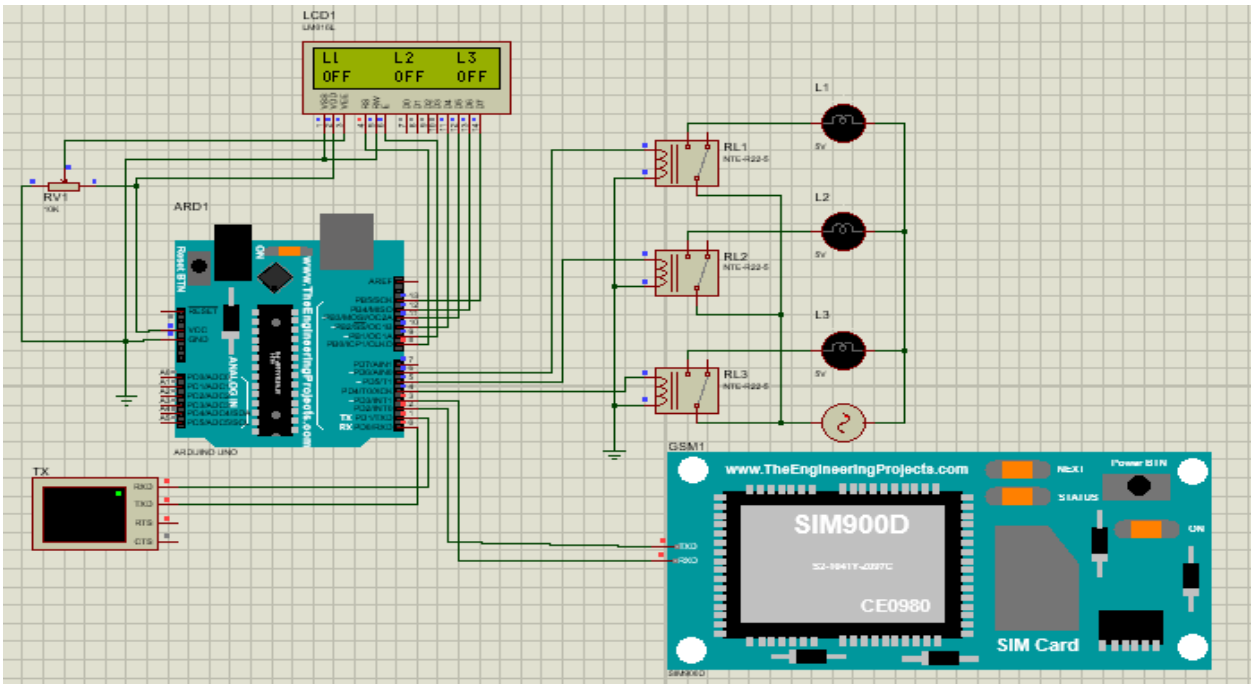


Fig.4.17. All the light bulbs are “OFF”

4.6.2. Comparison of the System with Recently Conducted work

Different authors are designed and implement a system that controls home electric appliances such as fun, air-conditioner, lighting and others to save energy using GSM network by integrating this network with different mobile applications. Researcher(Mrs Khin Ei Ei Khine et al..,(2019), Tamakloe & Kommey, (2022)designed and implement a system that controls residence power appliances using GSM technology by using android application through android mobile phone.

The application that used in those researchers is differ from our application. Various authors use android application through android mobile phone. It is limited to only smart phone users. However, it may not have smart phone in many of our society hand due to its highest cost. But we come to our designed solution, we use mostly founded mobile device in many home owners hand and cost efficient mobile device. That is the reason to say our system has cost effective and it used to all home owners.

Some the recently conducted research that is internet based, sensor based and smart phone android application based summarized with following section. Researchers (Mrs Khin Ei Ei Khine et al..,(2019), Tamakloe & Kommey, (2022), Nisar K & Ibrahim AAA (2018), Elvis Tamakloe& Benjamin Kommey,(2020).

No.	Title	Author/year	Used Technology	Findings
1	A smart home model using android application. Advances in Intell. Sys. and Comp	Nisar K & Ibrahim AAA 2018	ZigBee, Android smartphone, Arduino, Bluetooth	The developed system is capable to assist the physically challenged people to gain full access of their home appliances via ZigBee and Bluetooth and android based smartphone
2	GSM Based Home Appliance Control System	MrsKhinEiEiKhine et al., 2019	Arduino, GSM, Smartphone	Design and implement controlling system using GSM technology by using android application through android mobile phone
3	Smart Home Energy Management System Using GSM	G.Parameswaran et al.,2016	PIC microcontroller, GSM, PIR Sensor	Proposed a system to manage energy in residential building using PIC microcontroller and GSM
4	A Smart GSM-Based Home Electrical Appliances Remote Control System,	Elvis Tamakloe& Benjamin Kommey,2020	GSM, Smartphone	Implement GSM-based home energy remote control system that uses an embedded based station and mobile software application on a Smartphone

				to control electrical appliances from any location wirelessly.
5	GSM-Based Home Appliances Control System for Domestic Power Users	Effah E et al., 2016	Arduino Uno, GSM, PIR based motion detection	Design and implementation of a centralized remote lighting and appliances control system for smart home applications using GSM technology that generally reduces the cost of power consumption appreciably.
6	Development of GSM based home automation system using Arduino Uno Microcontroller	Okubanjo et al.,2021	Arduino Uno microcontroller Smartphone	Design and implement the system that optimizes the energy consumption of electrical appliances in the home and to enhance easy monitoring and controlling of electronic devices via smartphone.
7	Design and Implementation of Smart Home Energy Management System Based on GSM Network	Noor H. Saleh et al.,2017	Microcontroller, motion detection sensor	Design a system that consists of microcontroller connecting with home appliance & lighting through sensor.

4.6.3. Evaluation

4.6.3.1. Performance

Once the a system has developed to make service, then the performance the system should be measured in terms of speed and the effectiveness that gains to end user. The effectiveness of the designed system has measured by assessing and collecting data from the users. But when come to the performance of the system to express in terms of speed, we have to measure the execution of the system once the message sent from the user & by how fast the system execute and makes output/result indicated to the user as shown below.

The source code to measure the accuracy and the speed of the system is shown below.

Source code to measure accuracy is

```
{
float volts = digitalRead(vol);
vol = vol*5;
vol = vol/1023;
vol = vol*60;
int voltage = 220;
```

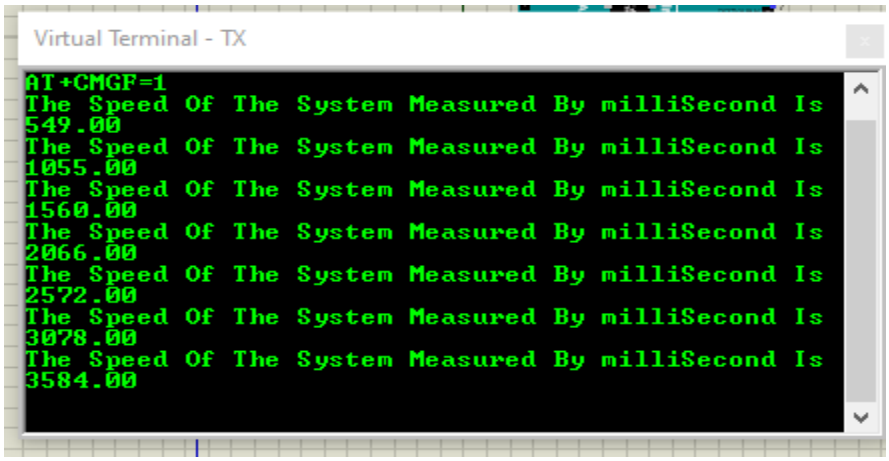
```
Serial.println("The Accurate Voltage Is:");
Serial.println(voltage),Serial.println("Volts");
delay(500);
  }
```

The output for accuracy is

Source code to measure speed

```
  {
floatTimeSinceStart = millis();
Serial.println("The Speed Of The System Measured By milliSecond Is :");
Serial.println(TimeSinceStart);
delay(500);
}
```

The output for speed is



As shown from the above result, the speed of the system is expressed in millisecond and this is below a second this show that how fast the system delivers the message once the user sent a commands.

4.6.3.2. Assessment of the existing mechanism

To show the effectiveness of the designed light bulb controlling mechanism, we have to evaluate by conducting survey in users' home by preparing questionnaire about the current usage of power in home. The survey was conducted in 111 home owners' residence by distributing questionnaire to those energy utilizers. From distributed paper, 84 male respondents and the rest 17 female respondent's data are collected.

To evaluate the extra wastage of energy per a day we have to identify the respondent's data by day time and night time. Based on the data obtained, the responses which indicates the lighting is 'ON' during the day time is 37 home owners leave their light bulb once they switch on and the rest respondents answer "NO" this indicates that they turned "off" after the used.

Therefore we have to focus on this data's of 37 respondents to evaluate the consumed power in two sessions (day and night). To obtain the consumed power, the average consumed Hrs. and the load/watt that user used and the number of lamp used in the day time on average would be calculated. Based on the respondents' data, the average wasted power Hr. in the day 6 and the number of lamp is 3. From 37 respondents, 15 users are using 40 watt bulb whereas the rest 22 users use 60 watt light bulb. So we have to use both type loads to obtain the consumed power.

To find the consumed power, we use the formula which is provided by the EEU. So according to EEU, the formula use to evaluate the monthly consumption power is

$$Monthly\ consumption\ in\ Kwh = load/watt \times no.of\ lumps\ used\ \times consumption\ hour/day\ \times 30\ days \div 1000$$

Based the data obtained from the respondent, the average Hr. is 5.67 which is approximately 6, the number of lump used is 3 and the loads are both 40 and 60 watt. Hence the monthly consumed power in day time for 40 and 60 watt light bulb users calculated as

$$40 \times 3 \times 6 \times 30 \div 1000 = 21.60\ kWh$$

$$60 \times 3 \times 6 \times 30 \div 1000 = 32.40\ kWh$$

The consumed power in the day time in 37 home owner's house is 54 kWh.

Next we have to find the power consumed in night time. According the collected data from user, the home owner that leave the light bulb having ‘ON’ after the they go to rest (sleep) at night is 53 home owners answer ‘YES’ and the other 48 peoples are not makes light 'ON’.

Based on the data, the average hour energy consumed is 4 and the number of lamp used on average is 4 and the load these 53 home owners used are both 40 (24 users) and 60 watt (29 users). Now we can calculate the monthly consumed power during night time with similar way in the above. Hence the monthly consumed power during night time for 40 and 60 watt light bulb users calculated as

$$40 \times 3 \times 4 \times 30 \div 1000 = 14.40\ kWh$$

$$60 \times 3 \times 4 \times 30 \div 1000 = 21.60\ kWh$$

This 36 kWh the result of consumed energy in a month during night time after the home owner went to rest to sleep. Then the wasted power during day time in a month is 54 kWh and during night time is 36 kWh. Therefore monthly consumed power per month is 90 kWh.

This finding indicates that the power is consumed excessively without making service due to uncontrolled utilization of power in a home. To calculate the cost payable per month, we have to use the EEU new tariff of consumption per kilowatt.

The new tariff from December 2014 E.C. indicated that from 50 - 100 kWh is calculated by birr 0.7670. Therefore monthly cost the user will pay is 69.03. This cost is additional cost of payment on the regular used payment.

Therefore the conclusion drawn from this result is that the user can attain economic benefit when they prevent wastage of energy by controlling the light bulbs using this improved strategy in home. The home owners not only gain economic benefit when monthly bill payment reduces but also unreasonable consumption of scarce resource (power) would be reduced.

CHAPTER FIVE

CONCLUSION AND FUTURE WORK

5.1. Conclusion

This thesis has been made in order to help the home owner to overcome the problem of extra wastage of energy caused by light bulb due to different reasons of the user. In this study, GSM based light bulb controlling mechanism using Arduino Uno microcontroller through SMS was presented. The system was designed to receive SMS from user mobile phone to the GSM module connected to the microcontroller. The main thing that motivates to work the research in this area is the usage of energy in community following that the daily extra wasting of energy caused by light bulb in home.

Because of irregular usage and poor control mechanism of lighting, home owners pay additional cost of the consumed energy to authorized body. GSM SIM900 module as SMS gateway, Arduino Uno, mobile phone (virtual terminal), LCD screen, and relay were integrated into GSM based light bulb controlling method to improve easy monitoring and controlling of light bulbs, as result save excessively consumed energy and minimize the cost of monthly bill.

In addition to this, the integration of this system has substantially improved the manual controlling of the light bulb to manage wastage of energy caused by light bulb in home. By using this system, the home owners reduce the operation time of the bulb as result the consumption of power also reduced; because of the user can control the bulb from everywhere using mobile phone through SMS. This research work is used to use energy timely in home and for the fact it is used for developing countries like our society. Because the availability of energy in our society obviously insufficient. Therefore using this system the home owners can control the light bulbs by switching-off power especially when the power is not needed and when they are out of home.

As we see the survey which is conducted on 111 users' home indicates that 90kWh in month energy will be excessively consumed without making service due to users improper controlling of light bulbs in home. As result home owners pay overload in addition to the used consumption.

The result from the evaluation shows that due to improper utilization of power, unreasonable consumption of power would be wasted and this results on home owners increases by half of the normal monthly bill payment.

Since the main objective is providing a mechanism that helps to home owners to reduce wastage of energy due light bulbs, therefore when home owners implement this system by controlling the lighting from unreasonable consumption, they get economically benefited and also they reduce unreasonable wastage of this scarce resource.

5.2. Future Enhancement

The main objective of this work is to reducing excessively consuming energy due to light bulbs in home using GSM network through SMS. The home owner manages their light bulbs by sending a command using his mobile device. But due the disadvantage of GSMs' limited data transfer, sometimes delay will occur when the user sent a command to the controller. So to improve this drawback, the researcher should use the advanced GSM network for future.

5.3. Recommendation

As shown result from the above comparison, the proposed system is not only the simplicity and conformability of the usage but also economically give benefit for users. Therefore, if home owners, organization owners are installed this system, they minimize the monthly cost of bill payment to EEU and reduce this scarce resource. And specially the EEU should give awareness and encourage their customer to use such system as result they reduce extra wastage of energy. This is because the summation of controlling many users home or organization wastage of energy provides power to the people they are not available power in home.

Reference

Ahab, M. H. A., Abdullah, N., Johari, A., & Kadir, H. A. (2010). GSM based electrical control system for smart home application. *Journal of Convergence Information Technology*, *5*(1), 33–39. https://doi.org/10.4156/jcit.vol5.issue1.4

Amin, A., & Khan, M. N. A. (2014). A Survey of GSM Technology to Control Remote Devices. *International Journal of U- and e-Service, Science and Technology*, *7*(6), 153–162. https://doi.org/10.14257/ijunesst.2014.7.6.14

Aravind, P. M., Kumar, P. N., & Vanitha, N. S. (2013). *GSM BASED AUTOMATIC TRIP CONTROL SYSTEM FOR ENERGY*. *2*(12), 7690–7695.

Attachie, J. C., Owusu, G., & Adu, S. O. (2021). Enhancement of Wireless Lighting Control System. *Journal of Electrical and Computer Engineering*, *2021*. https://doi.org/10.1155/2021/9287891

Bagus, I., Purwania, G., Kumara, I. N. S., & Sudarma, M. (2020). *Application of IoT-Based System for Monitoring Energy Consumption*. *5*(2).

C. K. Das, M. Sanaullah, H. M. G. S. and M. M. H. (2009). Development of a cell phone based remote control system: a an effective switching system for controlling home and office appliances. *International Journal of Electrical & Computer Sciences IJECS*, *9*(10), 37–43.

Getie, E. M. (2020). Poverty of Energy and Its Impact on Living Standards in Ethiopia. *Journal of Electrical and Computer Engineering*, *2020*. https://doi.org/10.1155/2020/7502583

Gu, G., & Peng, G. (2010). The survey of GSM wireless communication system. *Proceedings of ICCIA 2010 - 2010 International Conference on Computer and Information Application*, 121–124. https://doi.org/10.1109/ICCIA.2010.6141552

Hussien, N. A., Al-magsoosi, A. A. D., & Abed, F. T. (2021). *Monitoring the Consumption of Electrical Energy Based on the Internet of Things Applications*. *15*(07), 17–29.

Kesav, O., & Rahim, B. (2015). Automated Wireless Meter Reading System for Monitoring and Controlling Power Consumption. *Proceedings - 2014 IJES National Conference On Intelligence In Electronics And Communication Engineering (NCIECE ’ 15)*, *2*, 70–74.

http://www.ijrte.org/attachments/File/v1i2/B0208051212.pdf

Kumaresan, P., Prabukumar, M., & Barathkumar, E. (2020). SMART HOME: Energy Measurement and Analysis. *International Conference on Emerging Trends in Information Technology and Engineering, Ic-ETITE 2020*, 1–5. https://doi.org/10.1109/ic-ETITE47903.2020.ICETITE318

Le Bodic, G. (2005). Mobile Messaging Technologies and Services: SMS, EMS and MMS: Second Edition. In *Mobile Messaging Technologies and Services: SMS, EMS and MMS: Second Edition*. https://doi.org/10.1002/0470014520

Mewada, K. M. (2016). *A Survey on Latest Wireless Technologies 1*. *4*(1), 399–401.

Molla, T. (2022). Smart Home Energy Management System. *Research Anthology on Smart Grid and Microgrid Development*, *3*(Iceict), 1132–1147. https://doi.org/10.4018/978-1-6684-3666-0.ch051

Mrs Khin Ei Ei Khine | Mr Nay Soe Shwe | Mr Aung Myo Naing. (2019). GSM Based Home Appliance Control System. *International Journal of Trend in Scientific Research and Development (IJTSRD) International Journal of Trend in Scientific Research and Development*, *3*(5), 1675–1680. https://doi.org/https://doi.org/10.31142/ijtsrd26743

Mukendi, K. H., & Adonis, M. (2017). The development of a remotely controlled home automation system for energy saving. *Proceedings of the 25th Conference on the Domestic Use of Energy, DUE 2017, October*, 265–270. https://doi.org/10.23919/DUE.2017.7931853

Olawale Adepoju, F Ilori, Oluwumi Adetan, Kehinde Abiodun, O. B. (2017). Development of A GSM Wireless Control of Electrical Home Appliance. *International Journal of Scientific Research in Science, Engineering and Technology*, *Volume 3*(Issue 5), 317–320.

Patel, H. K., Mody, T., & Goyal, A. (2019). Arduino Based Smart Energy Meter using GSM. *Proceedings - 2019 4th International Conference on Internet of Things: Smart Innovation and Usages, IoT-SIU 2019*. https://doi.org/10.1109/IoT-SIU.2019.8777490

Pawar, A. S., & Pawar, A. S. (2012). Study of GSM network. *International Journal of Advanced Engineering Researsh and Studies*, *I*(Iii), 1–6.

Rafique, K., Shaikh, M. M., & Chachar, M. T. (2018). *Modeling of Arduino-based Prepaid Energy Meter using GSM Technology*. *January*. https://doi.org/10.14569/IJACSA.2018.090558

Saad, A., Ahmed, M. H., Salama, M. M. A., Saad, A., Ahmed, M. H., Salama, M. M. A., Al-sumaiti, A. S., Ahmed, M. H., & Salama, M. M. A. (2014). *Electric Power Components and Systems Smart Home Activities : A Literature Review Smart Home Activities : A Literature Review*. *5008*. https://doi.org/10.1080/15325008.2013.832439

Saari, M., Sillberg, P., Gronman, J., Rantanen, P., Jaakkola, H., & Henno, J. (2019). Survey of Applications for Apartment Energy Consumption Monitoring. *INES 2019 - IEEE 23rd International Conference on Intelligent Engineering Systems, Proceedings*, 283–288. https://doi.org/10.1109/INES46365.2019.9109517

Sena, G. B. (2014). *Kwame Nkrumah University Of Science And Technology College Of Engineering Department Of Electrical And Electronic Engineering Project Report On Gsm Based Automatic Energy Meter Reading By*.

Tamakloe, E., & Kommey, B. (2022). A Smart GSM-Based Home Electrical Appliances Remote Control System. *IPTEK The Journal for Technology and Science*, *33*(1), 1. https://doi.org/10.12962/j20882033.v33i1.12226

Undre, V. S., Dhole, R. N., Solanki, C. R., Pawale, S. R., & Thool, R. C. (2014). Advance energy management using GSM technology. *SCES 2014: Inspiring Engineering and Systems for Global Sustainability*, 0–3. https://doi.org/10.1109/SCES.2014.6880099

Zhao, L., Zhang, J., & Liang, R. (2013). Development of an energy monitoring system for large public buildings. *Energy & Buildings*, *66*, 41–48. https://doi.org/10.1016/j.enbuild.2013.07.007

Appendix

Source code for simulation

```
#include <SoftwareSerial.h>
#include<LiquidCrystal.h>
LiquidCrystallcd(8,9,10,11,12,13);
#define L3 4
#define L2 5
#define L1 6
#define rxPin 2
#define txPin 3
SoftwareSerialsim800 (rxPin,txPin);
int temp=0,i=0;
int led=7;
charstr[15];
Void setup ()
{
lcd.begin(16,2);
Serial.begin(9600);
pinMode(led, OUTPUT);
pinMode(L3, OUTPUT);
pinMode(L2, OUTPUT);
pinMode(L1, OUTPUT);
lcd.setCursor(0,0);
lcd.print("GSM Based Home");
lcd.setCursor(0,1);
lcd.print("Light Control");
```

```
delay(500);
lcd.clear();
lcd.print("LIGHT CONTROL");
delay(500);
lcd.setCursor(0,1);
lcd.print("System Ready");
Serial.println("AT+CNMI=2,2,0,0,0");
delay(500);
Serial.println("AT+CMGF=1");
delay(1000);
lcd.clear();
lcd.setCursor(0,0);
lcd.print("L1     L2    L3 ");
lcd.setCursor(0,1);
lcd.print("OFF    OFF   OFF ");
}
void loop()
{
lcd.setCursor(0,0);
lcd.print("L1     L2    L3 ");
serialEvent();
if(temp==1)
  {
check();
temp=0;
i=0;
```

```
delay(1000);
  }
}
voidserialEvent()
 {
while(Serial.available())
  {
if(Serial.find("#A."))
    {
digitalWrite(led, HIGH);
delay(500);
digitalWrite(led, LOW);
while (Serial.available())
      {
charinChar=Serial.read();
str[i++]=inChar;
if(inChar=='*')
      {
temp=1;
return;
      }
      }
    }
}
 }
void check()
{
```

```
if(!(strncmp(str,"l1 on",5)))
   {
digitalWrite(L1, HIGH);
lcd.setCursor(0,1);
lcd.print("ON    ");
delay(200);
   }
else if(!(strncmp(str,"l1 off",6)))
   {
digitalWrite(L1, LOW);
lcd.setCursor(0,1);
lcd.print("OFF    ");
delay(200);
   }
else if(!(strncmp(str,"l3 on",5)))
   {
digitalWrite(L3, HIGH);
lcd.setCursor(13,1);
lcd.print("ON   ");
delay(200);
   }
else if(!(strncmp(str,"l3 off",6)))
{
digitalWrite(L3, LOW);
lcd.setCursor(13,1);
lcd.print("OFF    ");
```

```
delay(200);
   }
else if(!(strncmp(str,"l2 on",5)))
   {
digitalWrite(L2, HIGH);
lcd.setCursor(7,1);
lcd.print("ON    ");
delay(200);
   }
else if(!(strncmp(str,"l2 off",6)))
   {
digitalWrite(L2, LOW);
lcd.setCursor(7,1);
lcd.print("OFF    ");
delay(200);
   }
else if(!(strncmp(str,"all on",6)))
   {
digitalWrite(L2, HIGH);
digitalWrite(L3, HIGH);
digitalWrite(L1, HIGH);
lcd.setCursor(0,1);
lcd.print("ON     ON    ON  ");
delay(200);
   }
else if(!(strncmp(str,"all off",7)))
```

```
    {
digitalWrite(L2, LOW);
digitalWrite(L3, LOW);
digitalWrite(L1, LOW);
lcd.setCursor(0,1);
lcd.print("OFF   OFF    OFF  ");
delay(200);
    }
    }
```

JIMMA UNIVERSITY
INSTITUTE OF TECHNOLOGY
FACULTY OF COMPUTING AND INFORMATICS
DEPARTMENT OF COMPUTER NETWORKING

This questionnaire is prepared for electric power users in home to collect data about the wastage of energy in home due to light bulbs and to evaluate the excessively consumed power. The main objective of collecting this data helps to the work of thesis to the partial fulfillment of Masters of degree in computer networking.

Part – One

Personal Information

User's Name - _____

Sex: Male ☐ Female ☐

Address: Region_____ Zone_____Wereda/City_____Kebele_____

Age: 25-30 ☐ 30-35 ☐ 35-40 ☐ 40-45 ☐ 45-50 ☐ Above 50 ☐

Education Level: Below Grade 10 ☐ Certificate ☐ Diploma ☐ Degree ☐ MA/MSc ☐

Occupation: Government ☐ Private ☐ Unemployment ☐

Part - Two

Users Information

1.	Do you have a light in your home?
2.	Do you have a light bulb/s will ON in day time
3.	In day time, for how much hours you use the lighting in your home (the duration)
4.	How many light bulbs are 'ON' during this time?
5.	The watt/load of the bulbs
6.	When you go to rest (sleep)
7.	Do you have a light bulb/s they perform light at night after you go to rest (sleep)
8.	If YES, When will be the light bulb/s are 'ON' (Duration)
9.	How many light bulbs are 'ON' during this time?
10.	The watt/load of the bulbs