RADIO FREQUENCY BASED HOME AUTOMATION SYSTEM

By

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Abstract

The need for a remote control system that can control domestic appliances and various lighting points and sockets has often been a concern for users. At times users find it inconvenient and time consuming to go around turning their appliances on or off each time there is power outage or each time they are leaving the house for work. It has also often led to damage of appliances due to the fact that an appliance was not turned off before leaving the house. The Objective of putting up this project, therefore, is to design equipment that can facilitate a convenient and easy way of controlling our domestic appliances, lighting points and sockets especially in powering them, without always going to appliances physically by ourselves. This objective will be accomplished using various components which include a Microcontroller (Arduino) which acts as the backbone of the project together with other components.

Acknowledgements

Foremost, I would like to thank my wife for her inspiration, support to complete the undergrad degree and especially for her patience during this endeavour. I am indebted to Mr G. Manjengwa for his continuous guidance, encouragement, technical and inspirational support during the course of this project. I also would like to extend my deepest gratitude to my mother, and sisters for giving me encouragement, support throughout my life. I also would like to show my gratitude to the Applied Physics & Telecommunications staff for their guidance and mentorship.

Finally, I am gratefully to the Almighty Creator for the gift of life He breathed into us.

Declaration

I, ……..... hereby declare that I am the

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APPROVAL

This dissertation/thesis entitles "……

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by ……..……..meets the regulations governing the award of the degree of …….. of the Midlands State University, and is approved for its contribution to knowledge and literal presentation.

Supervisor …….

Date …….

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CHAPTER 1

1.0 Introduction

1.0.1 Background

The concept of “automation” has existed for many years. It began with a student connecting two electric wires to the hands of an alarm clock in order to close a circuit of a battery and light bulb. Later, companies developed automated systems of their own to control alarms, sensors, actuators and video cameras and, in so doing, created the first automated buildings[1]. This project will focus on rf based home automation system. Nowadays the industry has many electrical devices which are manually switched which requires manpower to control, if manpower increases maintenance costs also increases and this is one of the drawbacks of industry. So to avoid such type of drawback we should need some wireless controlling systems and one of wireless communication system is RF (Radio frequency) communication system among others. RF communication system is very cheap and very easy to implement. This is not only used in industry but also used for domestic purposes. Home appliances can also be controlled using RF remote. Some persons who are unable to walk to switch board which includes the elderly and the cripled need this type of project because you can switch ON/OFF load with remote, without moving away from your place [2].

Figure 1.1: An example of an automated home[3].

1.0.2 Background of the problem

The main objective in system is to control switching of appliances centrally in homes and industry. Currently in Zimbabwe automation is yet to be fully launched according to [4]. Most homes and industries are still using the conventional wall switches and appliances are being switched individually by switches near them. Appliances control: This module will deal with the controlling of hardware appliances using the electronic relay based switching circuit. Actual home appliances are connected to this circuit and the circuit will be then connected to the control circuit. It work as a middle ware between actual appliances and the computer.[5] Modern houses are gradually shifting from conventional switches to centralized control system, involving RF controlled switches [11]. The use of wireless automation reduce in the wiring required and this will reduce the cost and also increase efficiency in our systems at homes and industries. Electrical installations are the heart of every building, therefore intelligent building control absolutely ensures the safety and efficient control and eventually saves the electric power consumption and human energy.

1.0.3 Problem Statement

The need for a remote control alert system that can control domestic appliances and various lighting points and sockets has often been a concern for users. At times users find it inconvenient and time consuming to go around turning their appliances on or off each time there is power outage or each time they are leaving the house for work. It has also often led to damage of appliances due to the fact that an appliance was not turned off before leaving the house.

1.0.4 Aim

To develop a RF based home automation system that will make life easier in homes and also in industries.

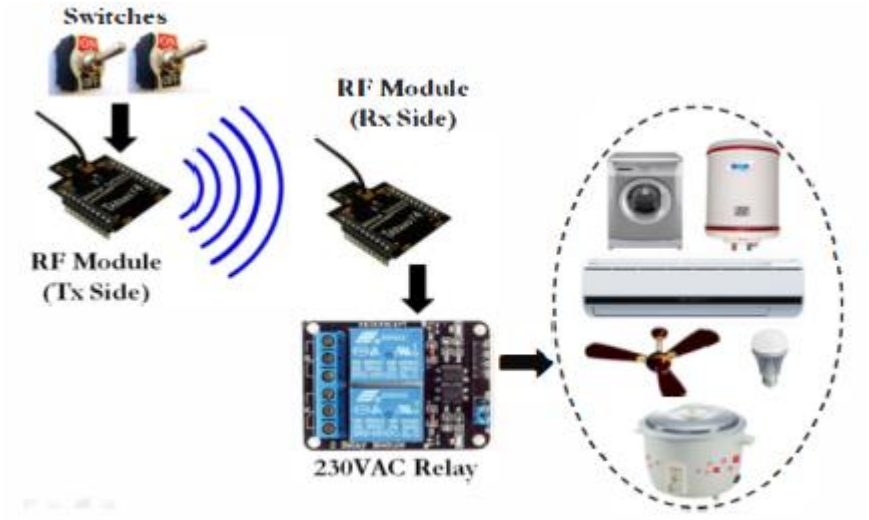

Figure 1.2: RF based home automation [11].

1.0.5 Objectives

To design an equipment that can facilitate a convenient and easy way of controlling our domestic appliances, lighting points and sockets especially in powering them, without always going to appliances physically by ourselves.

1.0.6 Justification

Saves time, It is no secret that today's world is busier than in days past. If you are like most people, you are constantly running from place to place, working to accomplish everything on your never-ending "to-do" list. Because of the high-tech nature of a home automation system, you never have to worry about running home to open the door for your children after school or making a quick stop at home in order to adjust household items. In short, you easily save precious time and experience more daily productivity [6].

The ease of putting our appliances, lighting points and sockets on or off has made it necessary to develop this system in order to control our appliances, lighting points and sockets from a central point using a remote control. The issues of always forgetting our appliances ON when leaving the house has often caused fire outbreak and explosion in homes and this is another reason that led to designing and construction of this project [7].

Give homeowners the power to fuse together their entertainment, lighting, temperature control, and security into a single console.

In tandem with ZIMASSET cluster 3 which is on infrastructure and utilities and cluster 4 on value addition and beneficiation, the success of the project will easy the government's goals on economic turnaround.

The success of the project will be ear marked by homes and industry, hence this will be a milestone on the MSU motto on commercialization of technology.

1.0.7 Scope

The researcher will research on ways and components which might be used to come up and develop a RF based home automation to be used in homes or industrial applications.

1.0.8 Hypothesis

Presently, conventional wall switches located in different parts of the house makes it difficult for the user to go near them to operate [11]. In order to achieve this, a RF remote is interfaced to the microcontroller on transmitter side which sends ON/OFF commands to the receiver where loads are connected. By operating the specified remote switch on the transmitter, the loads can be turned ON/OFF remotely through wireless technology. This circuit utilizes the RF module (Transmitter/Receiver) for making a wireless remote, [12] which could be used to drive an output from a distant place. RF module, as the name suggests, uses radio frequency to send signals. These signals are transmitted at a particular frequency and a baud rate [8]

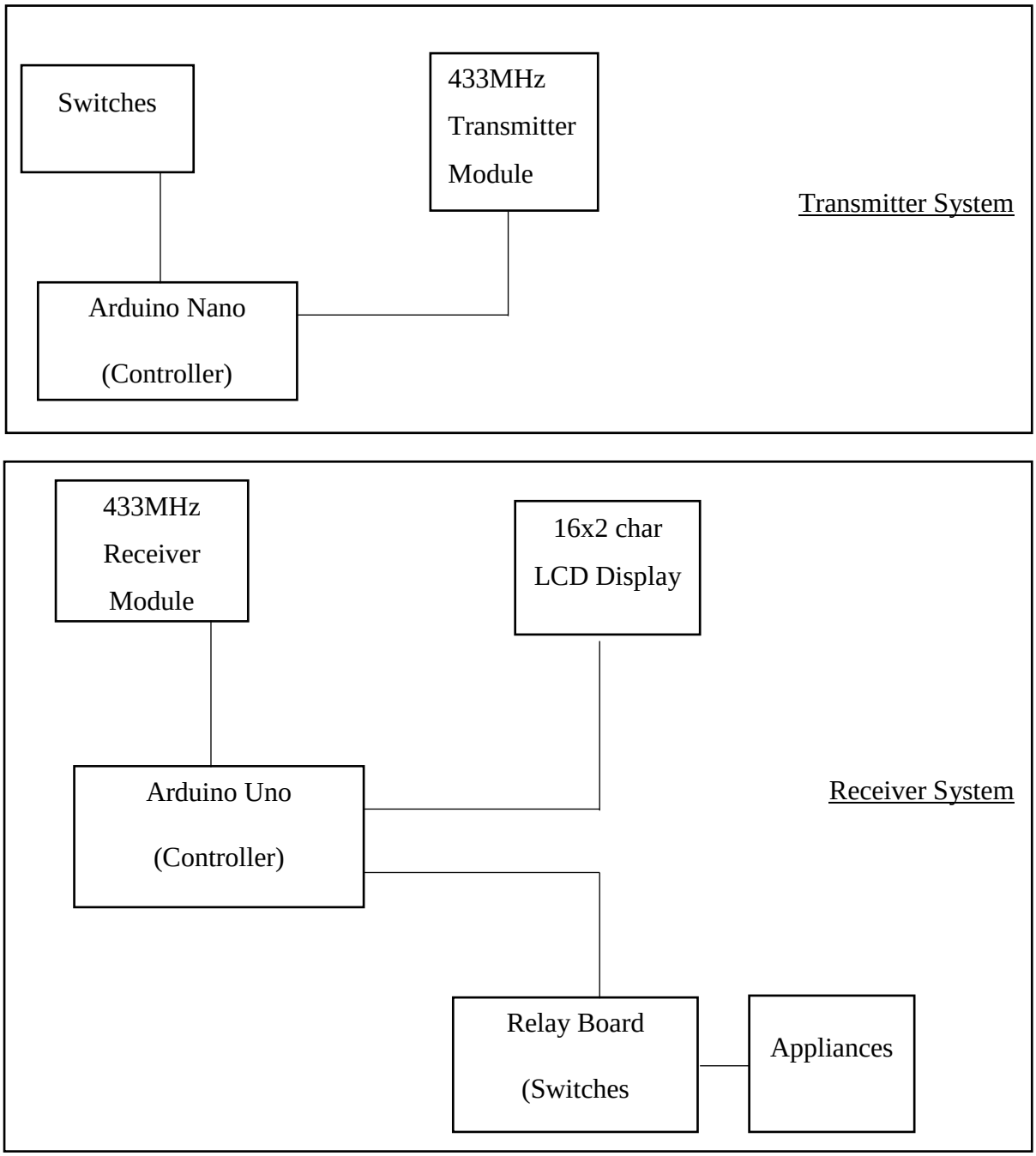

Figure 1.3: Block diagram of the system prototype

1.0.9 Challenges faced

Proprietorship: Many of the systems (TV, stereo, surveillance camera, etc.) mentioned in the examples are proprietary and as such each have their own programmatic interface that control them, or none at all. Thus to obtain a system able to handle the examples, the buyer has to seek out a home automation vendor that specializes in custom home automation solutions and likely has to buy a whole range of appliances that the vendor is endorsing. This introduces a high cost due to the amount of work required to realize these systems. High cost means that

home automation is less likely to become a common household system, unfortunate for both home automation vendors and households [9].

1.0.10 Delimitations

- The research is focused to this study only.
- The research is to be done within a time period of 6 months only.
- The review of literature for the research is limited on RF based home automation.
- The research will provide solution to the current challenges.

1.0.11 Dissertation Outline

Chapter 1 serves as the introductory chapter where I tried to relay the concept and acceptable reasons why the project should be implemented for the intending user of the work. Thus, showing the block diagram of the design and a scope of diagram for the entire project design.

Chapter 2 deals with the literature review where it will be discussing the origin of this project design. In the origin of the project, we will be looking at what brings about the rf home automation in our day to day activity and how the idea of designing this project comes about.

A description of the Project is also given where the two sections of the project are discussed and the various components contained in the sections also mentioned.

Chapter 3 treats the methodology of this project design. It comprises of the information gathering, the components and devices used in the course of designing this project will be analysed to know their basic means of operation and how they will help in putting up this design, system design approach; the possible way to tackle the project design from scratch, bottom-up; it will treat how the practical detail was gotten before considering about the general principle of the system design, choice of design system and the system flow chart.

Chapter 4, Results and analysis- This chapter give an in-depth analysis of the data gathered in *Chapter 3* so as to come up with statistical results which can be used to give conclusive results *and possible solutions.*

Chapter 5, Summary and conclusion of the design will be presented. It will be looking at the problems encountered in designing the project and possible solutions to them. From the problems and solutions of this work, the suggestion for further improvement will be stated [10].

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CHAPTER 2: Literature review -Theoretical Aspects

2.0 Introduction

The previous chapter illustrated the problem background and the objectives of the research. This chapter helps the designer to gather and examine the related information concerning the design of a RF based home automation system. This research will also include the shortfalls of the previous inventions, parameters and materials to be in cooperated throughout the design process. By so doing, a broader and informed decision pertaining to the design can be arrived and be implemented.

2.1 Alternate system designs

2.1.1 Internet of Things (IoT) based home automation system

Internet of things (IoT) a scenario in which objects, animals or people are provided with unique identifiers and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction [1].

Internet of things is also called internet of objects. The aim of the IoT is that enable things to be connected anytime, anywhere with anything and anyone [2]. The IoT will generate a self-motivated network of Billions or Trillions of wireless identifiable “things” The new rule for the future is going to be ‘Anything that can be connected, will be connected and the connected devices talking to each other’ [3,5].

When IoT is used in home automation one is able to communicate with the system over the internet from anywhere so long there will be online. The phone, computer, PDA etc will communicate with the system via the Wi-Fi module and the system will trigger the switches of appliances by the use of a relay module hence communication with the system is achieved remotely via the internet.

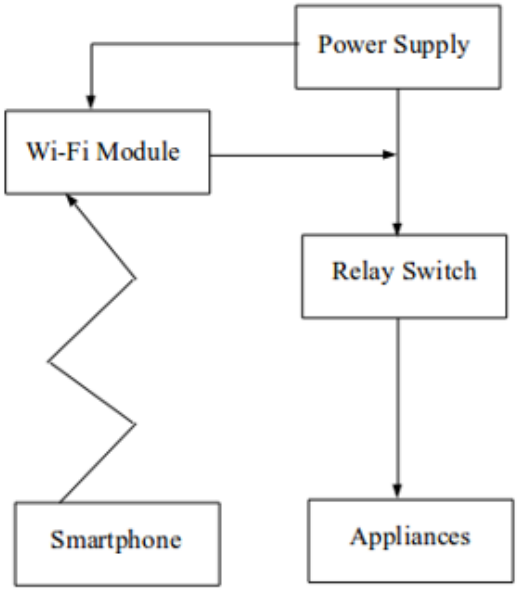

Figure 2.1: Block diagram for IoT based home automation

Advantages and Disadvantages of IoTbased home automation

Advantages	Disadvantages
• Stand alone • Low-cost • Flexible • Easy to operate • Better scalability and flexibility • Simple and low cost • Android compatible smart phone app	• Loss of privacy and security as information is prone to attack by hackers online. • As devices from different manufacturers will be interconnected, the issue of compatibility in tagging and monitoring crops up • The IoT is a diverse and complex network. Any failure or bugs in the software or hardware will have serious consequences. • Our lives will be increasingly controlled by technology, and will be dependent on it [4].

2.1.2 Bluetooth based home automation

First Bluetooth module connected to the phone by the Bluetooth. Bluetooth phone already have an application to provide the interference between mobile and the Bluetooth module. According to [6] using the application, the mobile send the command signal to microcontroller by the Bluetooth. Bluetooth and relay IC is connect to the microcontroller by its pins according to [7]. The relay is connected to the load by its pins. When microcontroller receives the command from mobile, it operate the load.

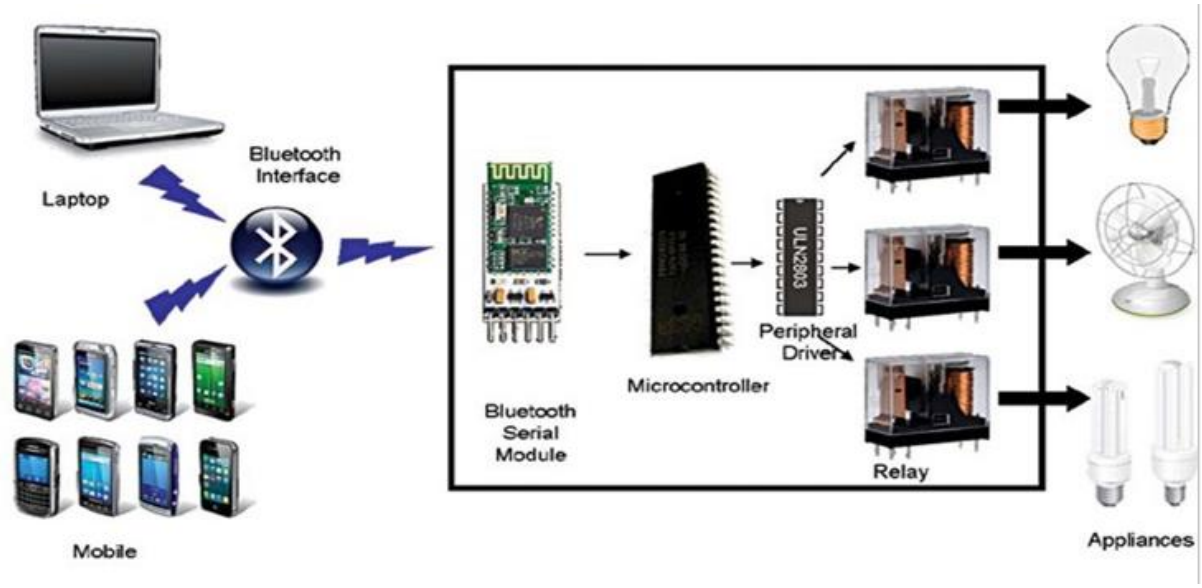

Fig 2.2: Bluetooth based home automation system [8].

Bluetooth has always been a popular technology to be used in combination with mobile devices such as phones. In the past Bluetooth was mainly used for wireless transmission of audio and direct communication between phones and computers. With the introduction of the power-friendly version Bluetooth Smart or Bluetooth Low Energy (BLE) it has opened up a multitude of possibilities to create Internet of Things (IoT) devices that can directly connect to your smartphone [10] and that can run on batteries for several months or even years. Focus is been made on Bluetooth Smart devices and the implications of choosing Bluetooth Smart on the interactions with the user [11].

Advantages and Disadvantages of Bluetooth based home automation

Advantages	Disadvantages
• Quick response is achieved. • Easy to maintain and repair.	• This system is not capable of displaying the feedback status of the

• Design is efficient and low cost. • Power consumption is low. • Controlling electrical devices wirelessly • Saves electricity. • We can control appliances from any place round the room.	devices being operated. • Number of electrical appliances that can be controlled by this circuit is limited. • The range is limited (up to 15m).

2.1.3 Infrared

[12] Studies about infrared to make an introduction to infrared technology, applications in the home, classroom, workplaces and beyond. Infrared technology increasingly present in mainstream applications, but there is several disadvantage by using the method, receiver and transmitter must be almost directly aligned. Main problem is the signal will lose if blocked by common material, people wall, plant and etc.

2.2 Problems of the current systems

The need for a remote control alert system that can control domestic appliances and various lighting points and sockets has often been a concern for users. At times users find it inconvenient and time consuming to go around turning their appliances on or off each time there is power outage or each time they are leaving the house for work. It has also often led to damage of appliances due to the fact that an appliance was not turned off before leaving the house [13]. It is tiresome and at times boring to go around the house switching on or off appliances in different locations of the house hence people tend to ignore some appliances either left on or off. This is a hazard which needs to be addressed immediately to alleviate accident occurrences in homes and work places.

2.3 Components used for the system

For the project to be result oriented and versatile, the researcher also looked into the functions and behavior of various components. So, thorough knowledge about the functionality of

components was required hence interrogations pertaining these was needed. For remote communication, there are many technologies used as mentioned above in Chapter 2.1. Radio frequency based home automation was chosen for this project due to the availability of RF modules on the market easily and also to the following advantages;

- This circuit helps in controlling the home appliances from a remote place.
- One circuit can control up to eight different appliances directly and further the equipment can be grouped using a multiplexer, several other devices can be controlled.
- Cost involved for making and operating the circuit is minimum.
- Low power requirement and maintenance cost is zero.

2.3.1 Remote Controller

One of the earliest examples of remote control alert was developed in 1893 by Nikola Tesla. With the invention of Relays previously in 1835 by Joseph Henry it became possible to use remote controls to drive other devices. This is because of the ability or relays to serve as a switch that can control devices when energized by electricity. Again with the invention of Integrated Circuits like 555 timers and Microcontrollers, more functionality was added to whole concept of Remote control alert [9].

The first remote intended to control a television was developed by Zenith Radio Corporation in the early 1950's and made use of wire to connect to the television set. The remote — unofficially called "Lazy Bones" — used a wire to connect to the television set. To improve the cumbersome setup, a wireless remote control alert was created in 1955. The remote called "Flashmatic" worked by shining a beam of light onto a photoelectric cell. Unfortunately, the cells did not distinguish between light from the remote and light from other sources. The Flashmatic also required that the remote control be pointed accurately at the receiver. In 1956 Robert Adler developed "Zenith Space Command", a wireless remote. It was mechanical and used ultrasound to change the channel and volume. When the user pushed a button on the remote control it clicked and struck a bar, hence the term "clicker". Each bar emitted a different frequency and circuits in the television detected this noise. The invention of the transistor made possible cheaper electronic remotes that contained a piezoelectric crystal that was fed by an oscillating electric current at a frequency near or above the upper threshold of

human hearing, though still audible to dogs. The receiver contained a microphone attached to a circuit that was tuned to the same frequency. Some problems with this method were that the receiver could be triggered accidentally by naturally occurring noises, and some people, especially young women, could hear the piercing ultrasonic signals. There was even a noted incident in which a toy xylophone changed the channels on these types of TVs since some of the overtones from the xylophone matched the remote's ultrasonic frequency.

The impetus for a more complex type of television remote control alert came in the late 1970s with the development of the Ceefax teletext service by the BBC. Most commercial remote controls at that time had a limited number of functions, sometimes only four: next station, previous station, and increase or decrease volume. This type of control did not meet the needs of teletext sets where pages were identified with three-digit numbers. A remote control to select teletext pages would need buttons for each number from zero to nine, as well as other control functions, such as switching from text to picture, and the normal television controls of volume, station, brightness, colour intensity and so on. Early teletext sets used wired remote controls to select pages but the continuous use of the remote control alert required for teletext quickly indicated the need for a wireless device. So BBC engineers began talks with one or two television manufacturers which led to early prototypes in around 1977-78 that could control a much larger number of functions. ITT was one of the companies and later gave its name to the ITT protocol of infrared communication. In the early 1980s, when semiconductors for emitting and receiving infrared radiation were developed, remote controls alert gradually switched to that technology which, as of 2006, is still widely used. Remotes using radio technologies, such as Bose Audio Systems and those based on Bluetooth also exist.

By the early 2000s, the number of consumer electronic devices in most homes greatly increased. According to the Consumer Electronics Association, an average American home has four remotes. To operate a home theater as many as five or six remotes may be required, including one for cable or satellite receiver, VCR or digital video recorder, DVD player, TV and audio amplifier. Several of these remotes may need to be used sequentially, but, as there are no accepted interface guidelines, the process is increasingly cumbersome. Many specialists, including Jakob Nielsen [13], a renowned usability specialist and Robert Adler, the inventor of the modern remote, note how confusing, unwieldy and frustrating the multiplying remotes have become.

Most modern remote control alert systems for appliances use infrared diode to emit a beam of light that reaches the device or equipment.

Therefore the concept of remote control is further expanded in another form by applying it in a circuit that is used to power many appliances automatically by pressing buttons on the remote control.

2.3.2 Arduino microcontroller

Arduino is an open-source electronics platform based on the Atmega microcontroller chips. Arduino boards are able to read inputs both analog and digital and they can write to outputs. There are different types of arduino modules in terms of physical sizes, processor power and memory. In this project arduino types used are arduino nano and arduino uno. The arduino nano are shown in figure 3.7 and 3.8 respectively. Key advantages of the arduino are as follows:

- It is an open source design so it has a large community of people using it and troubleshooting it hence it's easy to find help troubleshooting projects.

- The arduino plugs straight into computer USB port and registers on a PC as a virtual serial port.

- It has very convenient power management and built-in voltage regulation. It can be connected to an external power source of up to 12v and it will regulate it to both 5v and 3.3v. It can be powered directly from a USB port without any external power.

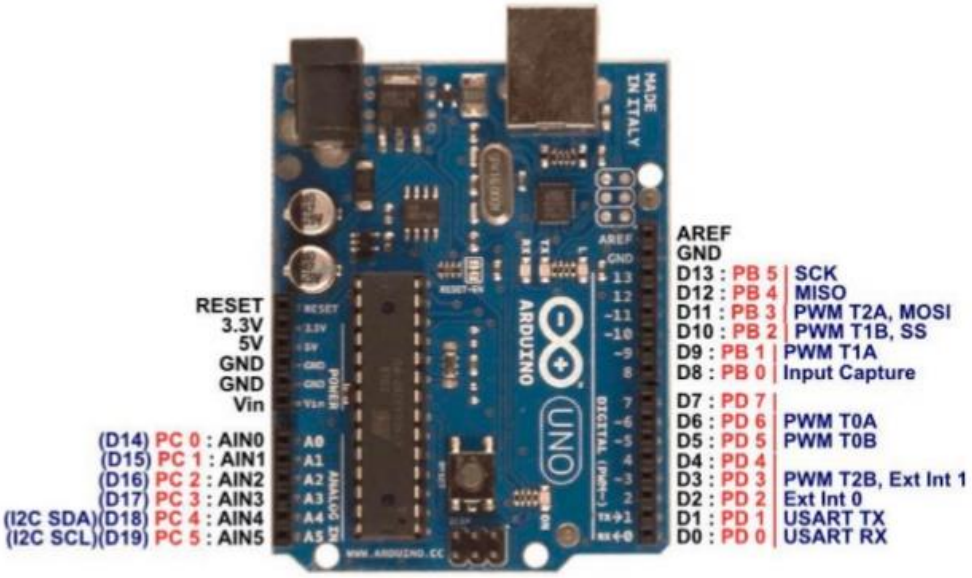

Figure 2.3: Arduino uno [15].

2.3.3 Relay switch

A relay is an electrically operated switch. Current flowing through the coil of the relay creates a magnetic field which attracts a lever and changes the switch contacts. The coil current can be on or off so relays have two switch positions and they are double throw (changeover) switches.

Relays allow one circuit to switch a second circuit which can be completely separate from the first. For example a low voltage battery circuit can use a relay to switch a 230V AC mains circuit. There is no electrical connection inside the relay between the two circuits; the link is magnetic and mechanical.

The coil of a relay passes a relatively large current, typically 30mA for a 12V relay, but it can be as much as 100mA for relays designed to operate from lower voltages. Most ICs (chips) cannot provide this current and a transistor is usually used to amplify the small IC current to the larger value required for the relay coil. The maximum output current for the popular 555 timer IC is 200mA so these devices can supply relay coils directly without amplification.

Relays are usually SPDT or DPDT but they can have many more sets of switch contacts, for example relays with 4 sets of changeover contacts are readily available. For further information about switch contacts and the terms used to describe them please see the page on switches.

Most relays are designed for PCB mounting but you can solder wires directly to the pins providing you take care to avoid melting the plastic case of the relay.

The supplier's catalogue should show you the relay's connections. The coil will be obvious and it may be connected either way round. Relay coils produce brief high voltage 'spikes' when they are switched off and this can destroy transistors and ICs in the circuit. To prevent damage you must connect a protection diode across the relay coil. [14]

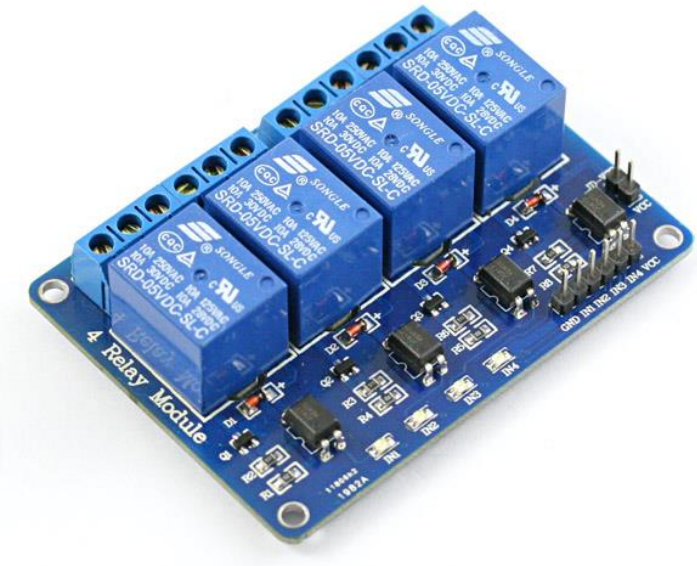

Figure 2.4: Four way relay module[16]

2.4 Project description

This project is basically a device used to control our domestic appliances, lighting points and sockets. It is a remote control alert based system which is used to power our appliances, lighting points and sockets ON or OFF.

The project consists of two sections which are; the transmitting side and the receiving side. The receiving side consists of a power supply section, a microcontroller and relays. Relay board provides isolation [14] between the arduino controller that operates at 5V DC and the connected appliances that operate at 220V AC. It also houses the RF module.

The transmission side is a smaller component which is inform of a hand held component powered by usb 5v. The transmission side also has a microcontroller (Arduino nano) which coordinates the various button inputs. The last major component contained in the transmitter

side id the RF sender which transmits signals received from the input buttons to the receiving side of the system. This transmission is accomplished wirelessly through the RF sender on the Transmitter section.

2.5 Use of project

This Project is intended generally for everyone and especially for users of various domestic appliances including lights, fans, televisions etc. This project will be used to power any of these appliances at any desired time.

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CHAPTER 3: Methodology

3.0 Introduction

The Radio Frequency (RF) based home automation system is fully described in this chapter. All the software and the hardware components are explained in detail. The system consists of two parts which are a remote transmitter and receiver that are communicating with each other via radio frequency modules which generate at a frequency of 433MHz. The main objective of this system is to enable a user to be able to switch (ON/OFF) appliances like lights, fan, water pump, geyser etc. remotely without having to go to the switch nearby the appliance [1].

3.1 Hardware and software development

3.1.1 System structure

The RF based home automation system described in this document consists of two subsystems to achieve the stated objective of being able to control the status of appliances remotely. The two parts are the hand held RF remote controller and the fixed controller which is the receiver of the signal that is sent by the remote. The remote controller comprises of tact switches mounted on a custom made PCB, an Arduino Nano and a 433MHz transmitter module. The receiver comprises of an Arduino Uno which is the central controller that is connected to a 16x2 character LCD for displaying the status of each appliance, a 433MHz receiver module which receives a signal from the RF remote controller, a 4 channel relay board that switches the relatively higher voltage appliances connected to the system. The different appliances in a home are represented by using AC light bulbs for the demonstration of this prototype.

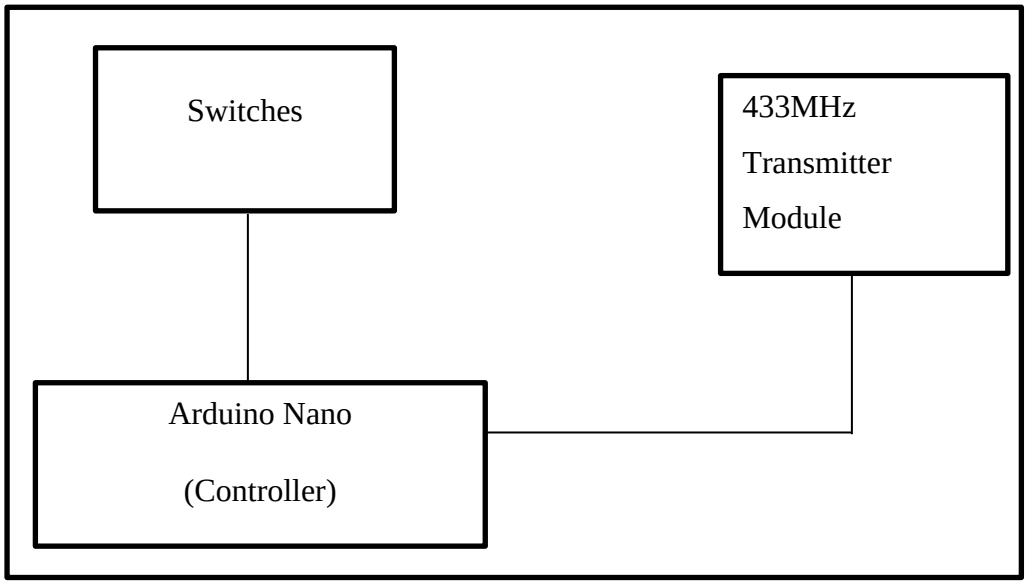

Figure 3.1: Block diagram of the remote controller

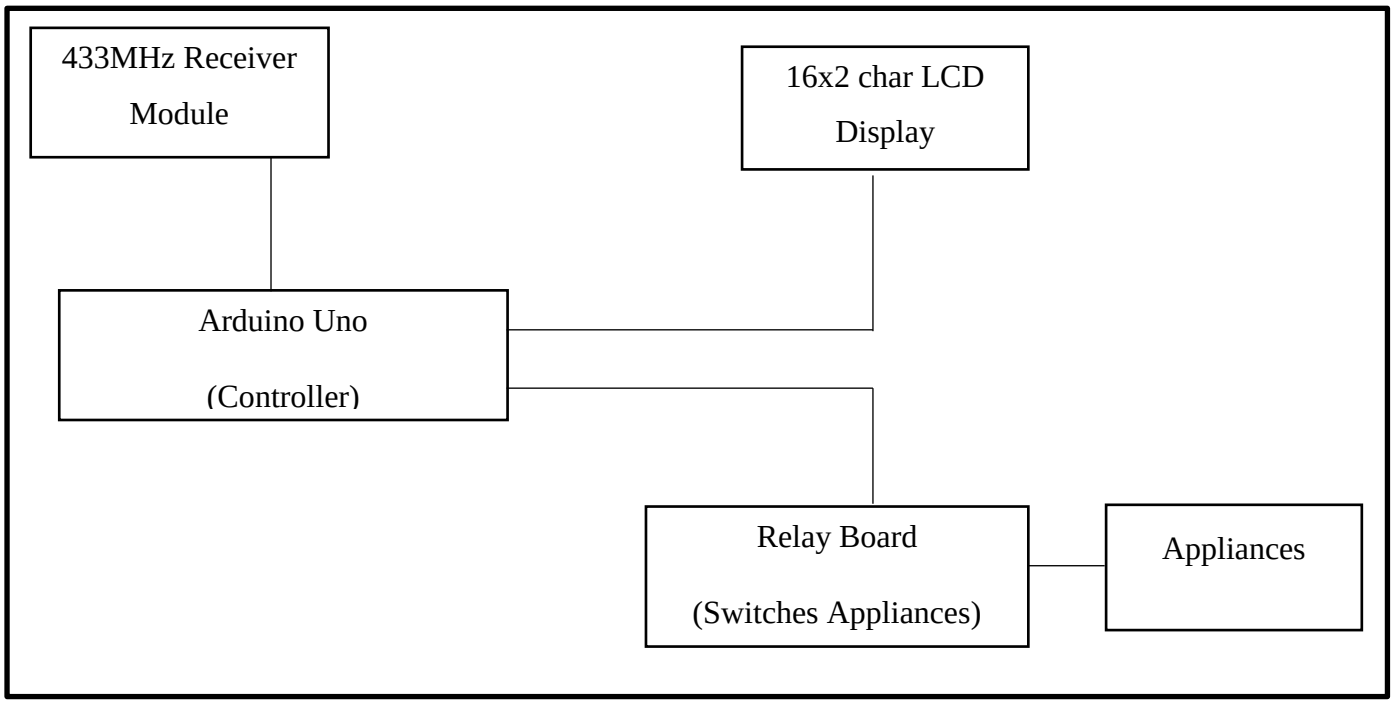

Figure 3.1: Block diagram of the receiver circuit

3.1.2 Design of the remote controller

The switches on the remote controller are configured as shown in the Figure 3.3 diagram. The configuration is such that the switch is active high, meaning when it is not pressed the input pins to which the switches are connected to the arduino are grounded through the 10K resistor. This means that the digital input to the arduino controller is low. When the switch is

pressed the circuit from the 5V supply is closed such that current will flow into the digital input of the arduino controller. It happens that the current flows into the digital input pin instead of the 10K resistor through to ground because current choses a path with less resistance and the digital input of the arduino has less resistance compared to the 10K resistor. This configuration is done for all the four buttons which are inputs for the on and off signal to the arduino. The problem of switch bouncing which is bouncing between the mechanical contacts to produce a rapidly pulsed electrical signal instead of a low to high signal is solved by programming a delay before instruction is executed in the code. A pictorial depiction of the remote is shown in figure 3.4. The configuration of the push buttons is mounted on a printed circuit board (PCB). The switches of appliance 1 to 4 are connected to digital pins 2,3,4 and five of the arduino module as shown on figure 3.4. The remote controller has the 433MHz transmitter connected to pin 10 of the arduino configured as digital output.

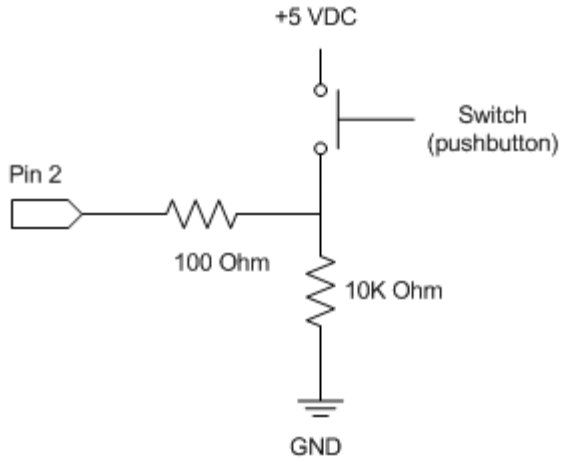

Figure 3.2: Push button configuration for the switch.

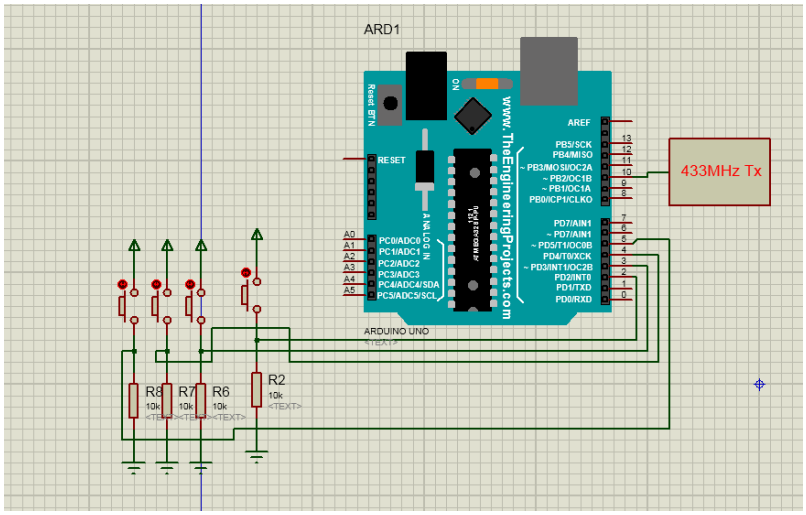

Figure 3.3 Full schematic of the remote controller

3.1.3 Design of the receiver circuit

The receiver circuit which directly controls the appliances connected to it consists of a 433MHz RF receiver module, a Liquid Crystal Display (LCD), and a 4 channel relay board which provides isolation [2] between the arduino controller that operates at 5V DC and the connected appliances that operate at 220V AC. The LCD provides information to the user on the screen [3] about which appliances are switched on or switched off. The pictorial depiction of the receiver circuit is shown in figure 3.5 with four light emitting diodes (LEDs) representing the signals that will be sent to the relay board.

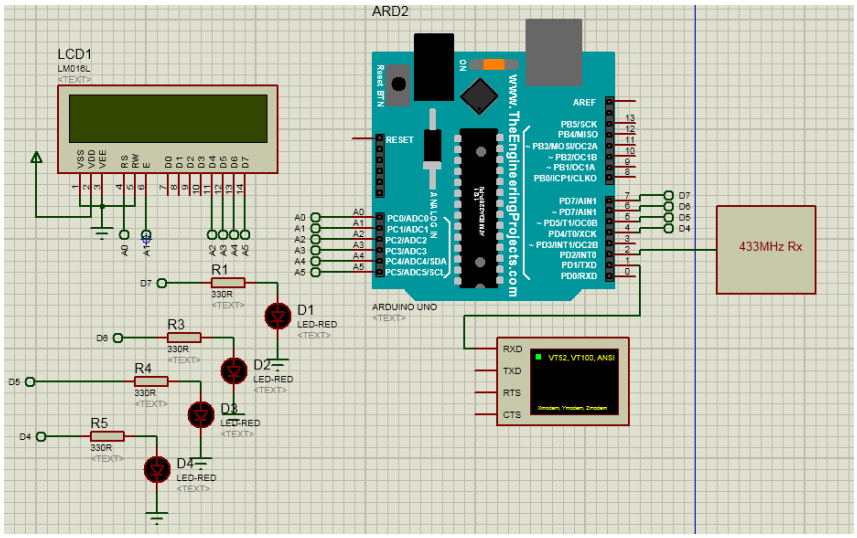

Figure 3.4: Full schematic of the receiver circuit.

3.1.4 Simulation of the whole system

Before the hardware was designed and connected, a simulation is done to ensure that the program code and hardware works as expected. The project was simulated in software made by Labcenter Electronics called Proteus and the version used in this case is Proteus 8.5. The Proteus simulation is shown in figure 3.6. As shown in the figure there are two separate parts which are the transmitter (remote controller) and the receiver (actual controller). The receiver has 4 buttons which are the switches for the appliances. When a button is pressed, a 24 bit value is sent to the receiver, upon receiving a valid signal the receiver checks what value it is and turns on or off the appropriate appliance depending on the code.

The LCD as shown displays which appliances (L1, L2,L3 and L4) are either ON or OFF. As seen in the diagram L3 is OFF and the signal to the relay is represented by the 3rd LED from the top which is ON. The reason why it operates in vice versa mode like that is because the actual relay used in the hardware is active low, which means that an appliance is turned on when the signal is low instead of high.

For debugging purposes a virtual monitor is connected to the TX pin of the arduino and the code is written such that each time a signal is received it shows the values of the variables toggle1 to toggle4. The values increment from 0 to 2 each time the same signal is received and rolls over to 0 from value 2. This enables the programmer to know if the programming as required. In other words the virtual monitor allows programmer to see what is happening

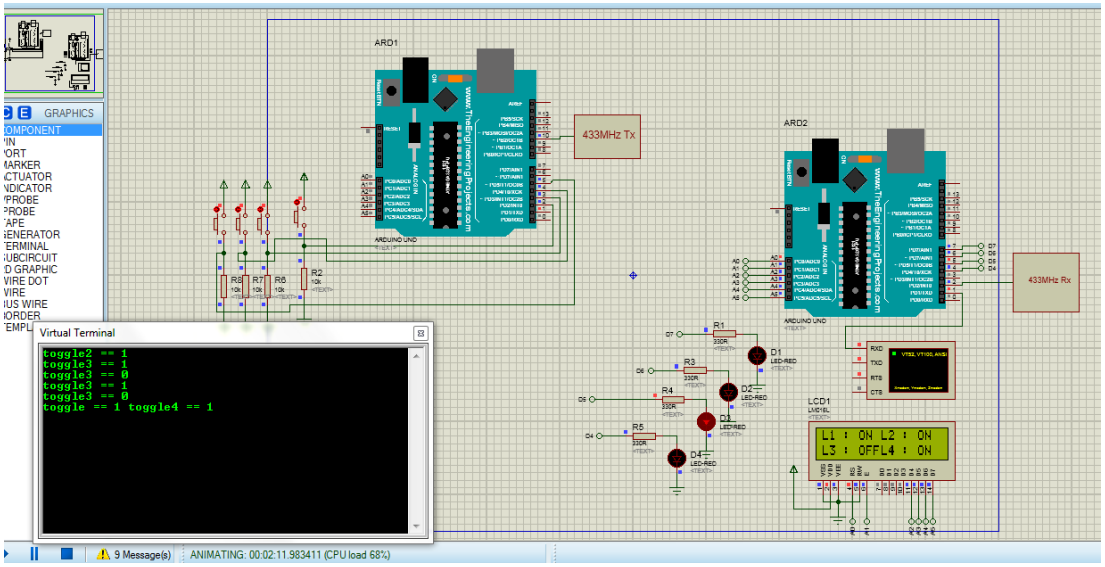

Figure 3.5: Simulation of the entire system.

inside the controller.

3.1.5 The Program

The program for the system was written using the Arduino IDE using C programming language. A library for arduino called the RC switch was used to make communication between the RF modules. It makes the sending and receiving of the data relatively easy. The structure of the code is such that if a button is pressed a unique value which is 24 bit long including checksum is sent to the receiver. In the receiver if the 24 bit long value is valid it will compare with the values preprogramed in the controller. If the value matches any of the values then an instruction is executed depending on the value in the variable that counts if the button is pressed for the first or second time. The count variable for each appliance is such that it increments from 0 to 2 each time a key is pressed. The controller checks the value in this variable and turns the appliance ON when it is 1 and OFF when it is 2. This allows the use of one button to be used to switch one appliance either ON or OFF.

3.1.6 RF Modules

The modules used in this system are 433MHz Radio frequency transmitter and receiver modules. The modules used are relatively cheap and reliable.

A transmitter (or radio transmitter) is an electronic device which produces radio waves with the help of an antenna. A transmitter generates a radio frequency current applied to the antenna, which in turn radiates radio waves. A transmitter generates radio waves for communication, radar and navigational purposes [7].

A radio receiver is a device that receives radio waves and converts the information which is carried by them into a usable form. A radio receiver can be an integrated circuit (IC) within another device. An antenna intercepts electromagnetic radio waves and then converts them into alternating currents that are applied to the receiver, which extracts the desired information. A receiver uses electronic filters in order to separate the required RF signal from all the other signals and an electronic amplifier in order to increase the power of the signal. The receiver finally recovers the desired information through demodulation.
Specifications of the transmitter and receiver modules used in this system are as follows:

Transmitter:

- Working voltage: 3V - 12V.
- Working current: max Less than 40mA max , and min 9mA
- Resonance mode: (SAW)
- Modulation mode: ASK
- Working frequency: Eve 315MHz Or 433MHz
- Transmission power: 25mW (315MHz at 12V)
- Frequency error: +150kHz (max)
- Velocity : less than 10Kbps

So this module will transmit up to 90m in open area. [7]

Receiver:

- Working voltage: 5.0VDC +0.5V
- Working current:≤5.5mA max
- Working method: OOK/ASK
- Working frequency: 315MHz-433.92MHz
- Bandwidth: 2MHz
- Sensitivity: excel –100dBm (50Ω)
- Transmitting velocity: <9.6Kbps (at 315MHz and -95dBm) [8].

Figure 3.9 shows the transmitter (on the right) and receiver (on the left).

Figure 3.6: Transmitter and receiver modules [7].

3.1.8 Liquid Crystal Display (LCD)

The LCD used in this project is a 16x2 character LCD which means it can display 16 alpha-numerical characters in one row and it has 2 rows [3]. Figure 3.10 shows a 16x2 character LCD and its pin out configuration. The pin description is shown in the table below.

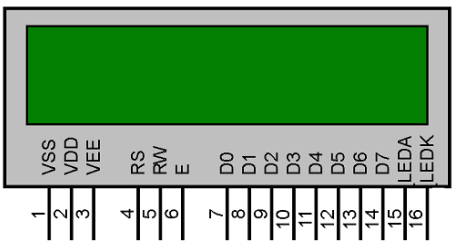

Figure 3.7: LCD Pin out [5].

Table 3.0: Description of the LCD pins [5].

Pin No	Function	Name
1	Ground (0V)	Ground
2	Supply voltage; 5V (4.7V – 5.3V)	Vcc
3	Contrast adjustment; through a variable resistor	V_{EE}
4	Selects command register when low; and data register when high	Register Select
5	Low to write to the register; High to read from the register	Read/write
6	Sends data to data pins when a high to low pulse is given	Enable
7	8-bit data pins	DB0
8		DB1
9		DB2
10		DB3
11		DB4
12		DB5
13		DB6
14		DB7
15	Backlight V_{CC} (5V)	Led+
16	Backlight Ground (0V)	Led-

3.1.9 Proteus 8 Professional

Proteus 8 Professional as mentioned above is simulation software that is used to test if the program and hardware will perform or operate as required by the programmer [6]. Libraries of arduino are added to the Proteus libraries folder in order to simulate the arduino since they are inherently built in libraries.

3.2.0 Arduino IDE

The arduino Integrated Development Environment (IDE) is the application that is used to write, compile and upload the program into the microcontroller of the arduino board [4]. Figure 3.11 shows a snippet of the arduino IDE with a program in it.

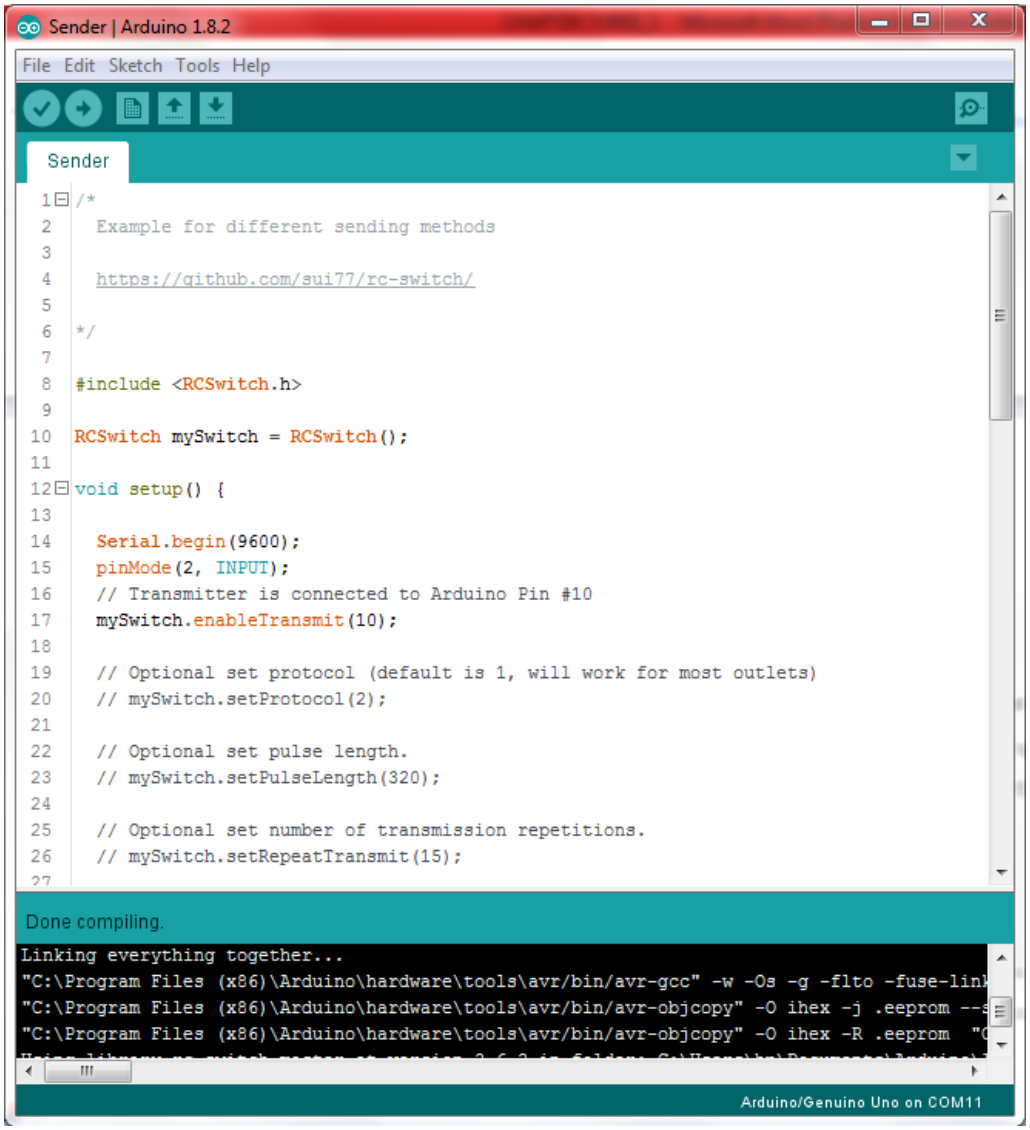

Figure 3.8: Arduino IDE with code written in it.

3.2.1 System flowchart

Before the program is written for both the remote controller and the receiver the system flow chart is designed to see how the program should execute optimally. The flow charts for both the transmitter and receiver are shown in figure 3.12 and figure 3.13.

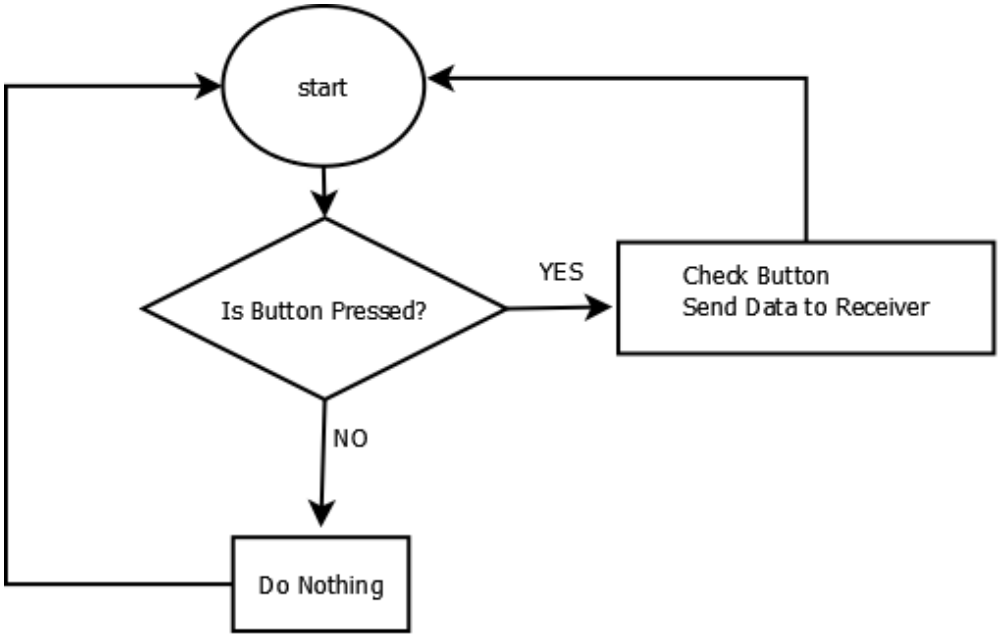

Figure 3.9: Flow chart of the transmitter (remote controller)

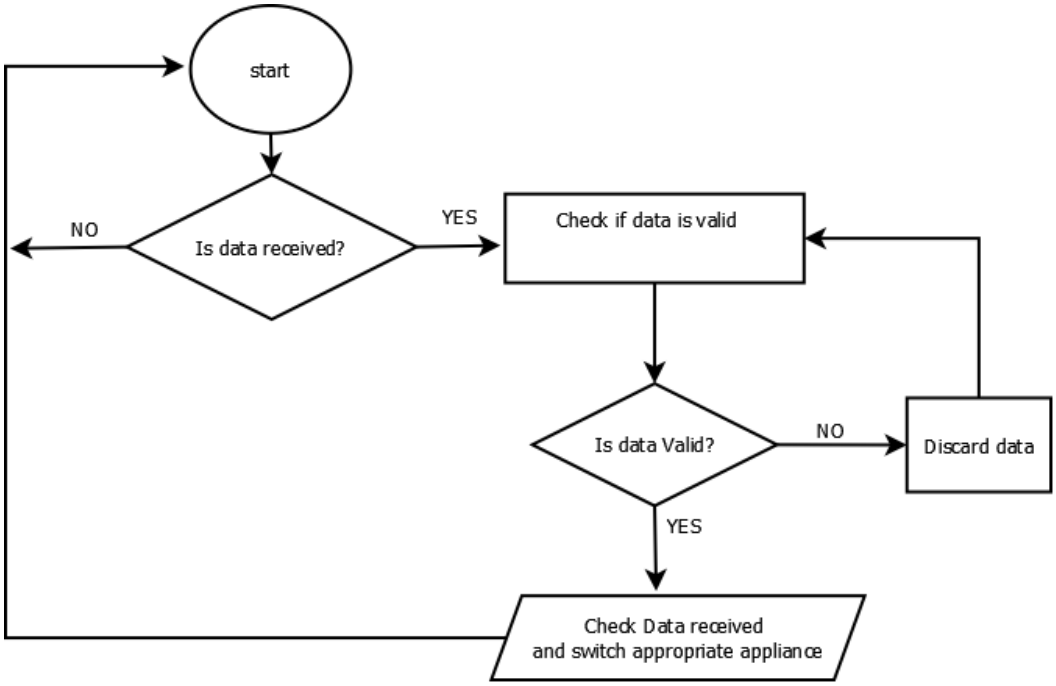

Figure 3.10: Flow diagram of the receiver program

3.2 Conclusion

The benefits of an automated solution was recognized from the start. The reason for making this choice of design is that it is programmable and can easily be modified. This reason, thus, makes it possible to improve on its features.

3.2 References

[1] Gurek, Alper et al. "An Android Based Home Automation System". *2013 High Capacity Optical Networks and Emerging/Enabling Technologies* (2013): n. pag. Web. 2 June 2017.

[2] Jiaqing, Qiao, Wang Zeyuan, and Liu Yan. "Design Of The Axie Relay Module". *2015 Fifth International Conference on Instrumentation and Measurement, Computer, Communication and Control (IMCCC)* (2015): n. pag. Web. 2 June 2017.

[3] Putman, Peter H. "An Overview Of TFT LCD Display Technology". *147th SMPTE Technical Conference and Exhibition* (2005): n. pag. Web. 2 June 2017.

[4] Barrett, Steven F. "Arduino Microcontroller Processing For Everyone! Third Edition". *Synthesis Lectures on Digital Circuits and Systems* 8.4 (2013): 1-513. Web. 2 June 2017.

[5] E. G., "LCD," *EngineersGarage*, 18-Mar-2017. [Online]. Available: https://www.engineersgarage.com/electronic-components/16x2-lcd-module-datasheet. [Accessed: 05-Jun-2017].

[6] "A Global Standard in Education," *Proteus in Education - Labcenter Electronics*. [Online]. Available: https://www.labcenter.com/education/. [Accessed: 05-Jun-2017].

[7] M. Rawashdeh, "RF 315/433 MHz Transmitter-receiver Module and Arduino," *Instructables.com*, 12-May-2016. [Online]. Available: http://www.instructables.com/id/RF-315433-MHz-Transmitter-receiver-Module-and-Ardu/. [Accessed: 05-Jun-2017].

[8] "http://ljournal.ru/wp-content/uploads/2017/03/a-2017-023.pdf," 2017.

CHAPTER 4: Results

4.0 Introduction

The design and implementation of the Radio Frequency based home automation system was carried out up to the level where demonstration was carried out using AC lights to represent the different appliances that a user may want to switch remotely to lessen the problem of having to walk to the wall switches especially for the elderly and the disabled. This chapter presents the results of the project.

4.1 Operation of the system

As proposed the implementation of the system was successful. The project has two subsystems which are the RF remote controller and the receiver which is directly connected to the actuators which are the relays that control the appliances connected to it in a normally open mode.

It was proposed that there would be a remote controller that has 4 switches that would be used to control 4 appliances via Radio Frequency communication protocol and a receiver system that would act on the received signal to turn ON and OFF the appliances. The project was carried out and upon completion a remote controller was made such that when one button is pressed it switches ON one the four different lights that are representing different appliances and when pressed again it switches the same appliance OFF, in other words the switch is digital toggle switch. All four switches worked as expected. Figure 4.1 and figure 4.2 shows the system being operated to switch the 4 lights representing different home appliances.

Figure 4.1: The RF home automation system working

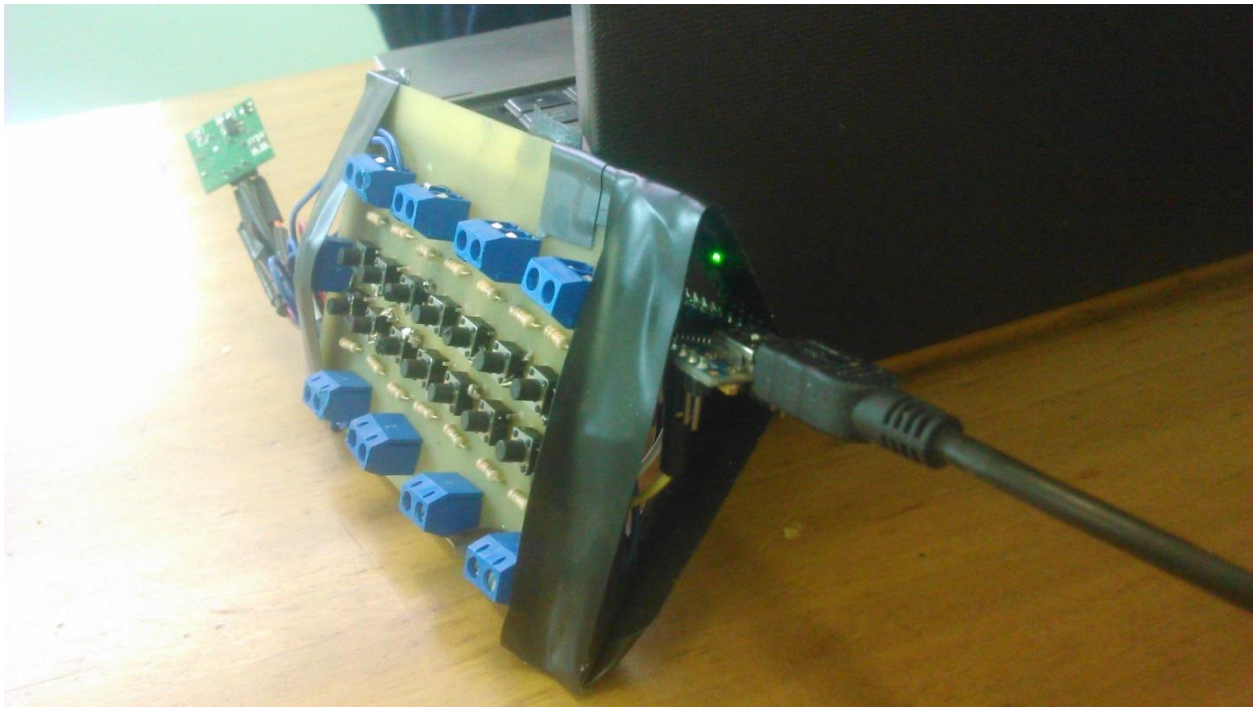

Figure 4.2: Remote controller to switch appliances ON/OFF

Table 4.1 below shows a summary of how the system operates.

Switch	1st Press	2nd Press	3rd Press	4th Press	Etc…
S1	Light ON LCD – L1: ON	Light OFF LCD – L1: OFF	Light ON LCD – L1: ON	Light OFF LCD – L1: OFF	…
S2	Light ON LCD – L2: ON	Light OFF LCD – L2: OFF	Light ON LCD – L2: ON	Light OFF LCD – L2: OFF	…
S3	Light ON LCD – L3: ON	Light OFF LCD – L3: OFF	Light ON LCD – L3: ON	Light OFF LCD – L3: OFF	…
S4	Light ON LCD – L4: ON	Light OFF LCD – L4: OFF	Light ON LCD – L4: ON	Light OFF LCD – L4: OFF	…

4.2 Challenges faced

Before the relay board that switches appliances was acquired LEDs were used to simulate the signal that would be sent to the relay and this worked well with all the power being supplied by the computer USB port. When the relay was connected instead of the LEDs the light bulbs could not switch despite the relay board being 5V because the maximum current supplied by the USB port is lower than that required by the relay board. It took time to figure this out but upon checking the datasheet the problem was rectified by using a different power source for the relay board that had a maximum current output of 1A. This rectification requires that the ground of the relay and that of the arduino be common so the arduino ground was connected to the relay ground.

CHAPTER 5: Conclusion

5.0 Introduction

The RF based home automation system was designed and implemented and it was a success. Pressing a switch on the remote controller toggles a light between ON and OFF and the LCD shows the status of each appliance such that the user does not need to go in each room to check whether appliance is ON or OFF rather the user just looks on the LCD.

5.1 Discussion

The RF home automation consists of two parts which are the remote controller that has buttons used to switch home appliances. Turning appliances ON and OFF is achieved by wireless communication between the transmitter and the receiver. When a button is pressed a 24 bit stream of data is sent via the 433MHz RF transmitter to the receiver. The receiver checks whether the data is valid and whether it matches any of the preprogrammed values. If it matches the value then an appliance is turned either ON or OFF depending on the current status. The arduino nano and arduino uno are the controllers of the remote controller and receiver respectively. The researcher observed that elderly people who have difficult in walking and disabled people have problems moving to and from the switches to turn appliances ON and OFF. This results in the appliances like geysers, lights or water pumps left ON unnecessarily thereby increasing the electricity bill. This system will enable the users to turn appliances either ON or OFF when necessary thereby reducing the electricity bill.

5.2 Recommendations for further research.

The implementation of the system was successful but further improvements can be made. The system uses 5V thus the RF modules are also powered by 5V but they can be powered by up to 12V to increase the range of transmission up to 90m on open space thus in an obstructed places like a house the transmission can be around 40m depending on the material that obstructs the path of the signal from the transmitter to the receiver. Another improvement that can be made is to make a remote that has indicators like LEDs to show immediately the status of the appliance thus a user does not need to move to a central location to check the status of the appliances.

5.3 Conclusions

[1] says that the most likely way of interfacing with devices in the future will be IP; it is more flexible, scalable and compatible. The biggest issue will be probably to make it usable and accessible to all kinds of users.

The results of this project are likely to be worthy of further analysis. The completion of a whole cycle of control between a remote device and the building will be critical for the success of the research; once control is achieved a meticulous study about how users and the system interact has to be done. It is important to clarify that this research does not exclude local control of home automation systems, it is simply focused on remote control as an important field for home automation in the future. To conclude, this research should help other researchers to achieve their goals with their future home automation projects and it will contribute positively to the E-Home community.

5.4 References

[1] S. Aurell, “Remote controlling devices using instant messaging,” *Proceedings of the 2005 ACM SIGPLAN workshop on Erlang - ERLANG 05*, 2005.

APPENDIX A

Remote controller code

```
#include <RCSwitch.h>

RCSwitch mySwitch = RCSwitch();

void setup() {

  Serial.begin(9600);
  pinMode(2, INPUT);
  // Transmitter is connected to Arduino Pin #10
  mySwitch.enableTransmit(10);



}

void loop() {



  if(digitalRead(2)){
  /* Same switch as above, but using decimal code */
  delay(600);
  mySwitch.send(5393, 24);

  }

  if(digitalRead(3)){
  /* Same switch as above, but using decimal code */
  delay(600);
  mySwitch.send(5394, 24);

  }

  if(digitalRead(4)){
  /* Same switch as above, but using decimal code */
  delay(600);
  mySwitch.send(5395, 24);

  }

  if(digitalRead(5)){
  /* Same switch as above, but using decimal code */
  delay(600);
  mySwitch.send(5396, 24);

  }

}
```

Receiver code

```
#define light1 7
```

```
#define light2 6

#define light3 5

#define light4 4


#include <RCSwitch.h>

RCSwitch mySwitch = RCSwitch();

// include the library code:

#include <LiquidCrystal.h>

// initialize the library with the numbers of the interface
pins

LiquidCrystal lcd(14, 15, 16, 17, 18, 19);

int toggle1 = 0;

int toggle2 = 0;

int toggle3 = 0;

int toggle4 = 0;


void setup() {

  Serial.begin(9600);

mySwitch.enableReceive(0);  // Receiver on interrupt 0 => that
is pin #2

  pinMode(light1, OUTPUT);

  pinMode(light2, OUTPUT);

  pinMode(light3, OUTPUT);

  pinMode(light4, OUTPUT);

lcd.begin(16, 2);

  // Print a message to the LCD.

  lcd.setCursor(0, 0);
```

```
  lcd.print("DAVID MATAGA  ");
  delay(2000);
  lcd.setCursor(0, 0);
  lcd.print("    RF HOME    ");
  lcd.setCursor(0, 1);
  lcd.print("   AUTOMATION  ");
  delay(2000);
  lcd.setCursor(0, 0);
  lcd.print("L1 :    ");

  lcd.setCursor(8, 0);
  lcd.print("L2 :    ");

  lcd.setCursor(0, 1);
  lcd.print("L3 :    ");

  lcd.setCursor(8, 1);
  lcd.print("L4 :    ");
  digitalWrite(light1, HIGH);
  digitalWrite(light2, HIGH);
  digitalWrite(light3, HIGH);
  digitalWrite(light4, HIGH);
}
void loop() {
  if (mySwitch.available()) {

    int value = mySwitch.getReceivedValue();
```

```
    if (value == 0) {
      Serial.print("Unknown encoding");
    }
if(value == 5393){
  delay(300);
  toggle1++;
if(toggle1 == 1){
      digitalWrite(light1, LOW);
Serial.print("toggle == 1 ");
                lcd.setCursor(5, 0);
                lcd.print("ON");
}
if(toggle1 == 2){
  digitalWrite(light1, HIGH);
  Serial.print("toggle == 0 ");
  lcd.setCursor(5, 0);
                lcd.print("OFF");
  toggle1 = 0;
  }
    }
if(value == 5394){
  delay(300);
  toggle2++;
               if(toggle2 == 1){
              digitalWrite(light2, LOW);
              Serial.println("toggle2 == 1 ");
```

```
                lcd.setCursor(13, 0);
                lcd.print("ON  ");
               }
           if(toggle2 == 2){
               digitalWrite(light2, HIGH);
               Serial.println("toggle2 == 0 ");
               lcd.setCursor(13, 0);
                lcd.print("OFF  ");
               toggle2 = 0;
               }
    }
if(value == 5395){
  delay(300);
  toggle3++;
              if(toggle3 == 1){
               digitalWrite(light3, LOW);
               Serial.println("toggle3 == 1 ");
               lcd.setCursor(5, 1);
                lcd.print("ON");
               }
           if(toggle3 == 2){
               digitalWrite(light3, HIGH);
               Serial.println("toggle3 == 0 ");
               lcd.setCursor(5, 1);
                lcd.print("OFF");
               toggle3 = 0;
               }
```

```
    }
if(value == 5396){
  delay(300);
  toggle4++;
               if(toggle4 == 1){
              digitalWrite(light4, LOW);
              Serial.println("toggle4 == 1 ");
                lcd.setCursor(13, 1);
                lcd.print("ON  ");
              }
          if(toggle4 == 2){
              digitalWrite(light4, HIGH);
              Serial.println("toggle4 == 0 ");
               lcd.setCursor(13, 1);
                lcd.print("OFF  ");
              toggle4 = 0;
              }
    }
    mySwitch.resetAvailable();
  }
}
```

APPENDIX B

List of components

Component	Value	Quantity
Arduino Nano	Nano	1
Arduino Uno	Uno	1
RF Transmitter Module	433MHz	1
RF Receiver Module	433MHz	1
LCD	16x2	1
Power supply	5V	1
Relay Board 4 channel	5V	1
Pushbutton switch		4