

# DESIGN AND CONSTRUCTION OF A VOICE CONTROL AUTOMATION SYSTEM

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## ABSTRACT

System automation is a trending research area in the 21st century considering its important role in our daily lives. The main importance of an automated system is the fact that it reduces human stress and error. There has been a sudden shift from the normal switches to the remote based control switches in recent times. Presently, conventional wall switches located in different parts of the house makes it difficult for operation more especially the elderly and physically challenged people. Technological advancement has made it easier and necessary that every human being should own a mobile smart phone. Applications are being developed on Android systems that are useful in various ways. Another upcoming technology is natural language processing which enables the command and control of systems using voice. This research work presents a Micro Controller-based Voice Control Automation System using Android Smartphone. This system can enable users to have absolute control over every appliance in the house using their voices. The control circuit consists of an Arduino Uno microcontroller, which processes the user commands using voice via android smartphone which is installed with 'AMR voice' application. The relay controls the switching of devices while the Bluetooth Module shares signal data having establish a wireless connection between the microcontroller and the smartphone.

**Keyword:** - Voice Control Automation, Arduino Uno Microcontroller, Relays, Android Smartphone, Bluetooth Module.

## 1. INTRODUCTION

The use of remote control for the operation of home appliances is on increase owing to its ease of use and comfort. The concept of controlling appliances using human voice is interesting. Many researchers have worked in this area and findings have been presented on how to remotely control appliances. Some of them used internet, wireless technology to communicate and control appliances. Others used remote, computers etc, for controlling the appliances. The main aim of our system is to build a perfect companion for someone to be at home or in his/her office and control electronic appliances using voice. It's a Bluetooth and GSM technology system based that can accept voice as direct commands and process them. The system is reasonably cheap, easy to configure and easy to use. The users should be able to control all the appliances from any point in their home or office by establishing a wireless control via Bluetooth. The proposed scheme in this paper can produce an integrated portable system that can wirelessly control two or more appliances. We demonstrate a system that can be integrated as a single portable unit and allows the user to wirelessly control home electrical appliance by turning them ON and OFF accordingly. The voice command conveyed to the control unit is been converted to binary sequence by the microcontroller which switches the load ON/OFF as desired. The microcontroller unit takes command and performs the required decision.

The proposed system has various applications in different places. Although, but for the purpose of this paper, its application is limited to that of electric bulb and fan.

## 2. REVIEW OF RELATED EMPIRICAL STUDIES

### 2.1 Implementation of Internet of Things for Home Automation

K. Mamata, *et al.* [1] presented a paper on the implementation of Internet of things for home automation. The paper focused on IoT coverage that can establish connection between various objects such as digital cameras, tablets, sensors, smart phones etc and equally establish transfer of huge amount of data and information. The paper also covers cloud-based computing that could easily enhance connection of other things for easy access at a given time and place. The authors illustrated sensing as a service on cloud by using certain applications like Augmented Reality, Agriculture, Environment monitoring etc. with a presented prototype model. The society needs novel solutions for the management of complex Internet of Things. The model is capable of ensuring safety and security because of the use of Wi-Fi Wireless Equivalent Privacy (WEP) and Wi-Fi Protected Access (WPA) in the design.

### 2.2 Hand Gesture Based Home Automation for Visually Challenged:

M. Smitha, *et al.* [2] published a paper on hand gesture-based home automation for visually challenged. The designed system is targeted at making life comfortable for the visually handicapped people in operation of home appliances. They have used MEMS (Micro electromechanical Systems) accelerometer which is used to sense the accelerations of a hand in corresponding three perpendicular direction that is (x y z) and also the use radio frequency to convey signals to wireless protocol. The hand and the received gestures are compared by the gesture stored in the microcontroller. The home appliances are controlled if the corresponding gesture matches with the templates. The designed device is also recommended for the aged people.

However, making the system automated without the use of gesture would be more appropriate. The desire to have the gesture stored in the microcontroller is fading up gradually. These days, such applications are embedded in android applications.

### 2.3 Bluetooth Based Wireless Home Automation System Using FPGA:

B. M Krishna, *et al.* [3] presented a paper on the Bluetooth based wireless Home automation system using FPGA. They primarily focused on Bluetooth technology. The authors were able to control all appliances connected to the FPGA board using android smart phone and Bluetooth module HC-05. The advantages of the system include less human stress for the aged and physically challenged persons, and it's also time saving and energy efficient. A higher performance Home automation control system is recommended for future work.

### 2.4 Design of an Intelligent Voice Controlled Home Automation System

S. Sonali, *et al* [4] proposed a research work that undertakes the design of an intelligent voice-controlled home automation system with the aim of ensuring automatic control of electrical home appliances. The designed work composed of Microcontroller (Arduino), Bluetooth module, relay boards and power source. The designed work is capable of ensuring automated control of all appliances in the home conveniently without stress by the user, especially the disabled and the aged people who are physically incapacitated.

However, the research work did not clearly show the circuit and schematic diagrams. Also, the coding of the Microcontroller (Arduino) was not captured which makes the work difficult to comprehend.

## 3. BACKGROUND OF STUDY

These days, technology has gone digital which makes modern electronics devices to be remotely controlled. The designed and constructed home automated system as presented in this paper has the ability to conveniently control home appliances such as fan, bulb etc without stress by talking to them. This research is titled "Voice Control Automation System" using Arduino and a Bluetooth module which enables a user to control appliances through voice commands sent to an Android application. The instructions are sent orally to the android application which

passes the command to the Arduino microcontroller wirelessly through Bluetooth. We have interfaced the Arduino to the main circuit. This circuit has total of 2 relays. The user can connect relays to various electronic appliances.

The conventional switches have been transformed to central control system in modern houses and offices. Presently, conventional wall switches located in different parts of the house or office makes it difficult for the user to go near them to operate. It appears more difficult for the elderly or physically handicapped people to do so. Remote controlled voice automation system provides a most modern solution with smartphones.

### **3.1 Statement of problem**

In the present day, robotization is getting the chance to be particularly essential with the true objective of advancing our life condition. The voice-controlled automation system offers a present-day way of life in which an individual gets the chance to control his entire house or office appliances.

Many research works have been carried out in this area. However, there has been no clarity as regards the circuit and schematic diagrams of the systems in the literature as well as coding of the microcontroller (Arduino) for comprehensive understanding.

### **3.2 Aims and Objectives of the Study**

The aim and objectives of this research work is to design, implement and develop a reliable and scalable prototype of a well detailed “voice control automation system” that will remotely switch ON/OFF any household or office electronic devices, such as bulbs, fans, television etc, using a microcontroller, voice dial on phone via Bluetooth based Android application.

### **3.3 Significance of Study**

Largely, home based automation is one of the research areas in recent times with the purpose of accommodating vital software applications that provide comfort and security as the essential needs for the aged and handicapped people. Scalability of the research work would be considerably easier as the device can be used in every building that uses electrical appliances and devices.

### **3.4 Scope of Study**

Though, this proposed system has its various applications in different places, but for the purpose of this paper, its application is limited to that of electric bulb and fan.

## **4. THEORETICAL FRAMEWORK**

In this paper, a Bluetooth wireless technology as a wireless means of communication is used. An android based application is installed on the smart phone which has inbuilt interface that has the ability to centrally control individual electrical appliances. The Bluetooth module receives the command from mobile phone and passes to the Arduino and from the Arduino to the relay circuit. The main purpose of using Bluetooth wireless technology is to provide the desired range and feasibility.

The microcontroller device with the Bluetooth module and relay circuit needs to be attached to the bread board. The microcontroller is instructed to switch ON/OFF an appliance when the android base application “Smart Voice” is launched. After getting the instruction through the Bluetooth module, the microcontroller gives the signal to the relay board [5]. The application first searches for the Bluetooth device. The voice recognizer is launched if the application finds the appropriate available Bluetooth. The audio signal is converted to a string having read the voice by the application. A value is produced for each appliance and sent to the microcontroller. A signal is sent to the parallel port for the purpose of activating the relay circuit when the input data is read and decoded.

### **4.1 Android Based Phone**

Android mobile phones use operating system based on Linux Kernel and recently advanced by google with a special interface suitable for direct manipulations. The android operating system (OS) that uses touch input command that is

compatible with real world activities such as pinching, tapping, swiping, virtual key board etc. Android platform is used in this design because of its huge global applications and user interface friendliness [6]. Android phone applications are usually written in java programming language with the help of software development kit (SDK). The voice recognizer which is an in-built feature of Android phones is used to build an application which the user can automate control of appliances in house or office. The research is realized with the help of an Android based application known as the “AMR Voice” which can be downloaded from an open source website using Google search. The application uses Google voice recognition system for speech recognition.

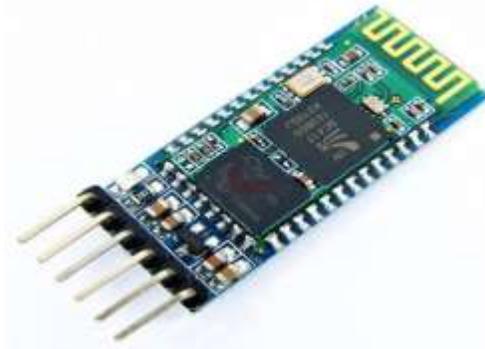


**Fig-1: AMR\_Voice Application Interface**

## 4.2 Bluetooth

The means of wireless data exchanging over a short distance is termed Bluetooth technology. It uses short wavelength UHF radio frequency from 2.4 to 2.485Ghz range. It's applicable to mobile devices and personal area networks (PANs) [7]. The Bluetooth module being used allows us to transmit and receive signals [6]. In this design, the transmitted text received by serial port of the Arduino microcontroller is sent by the Bluetooth through the android smart phone.

There are so many Bluetooth modules available in the market, but HC-05 Bluetooth module is used in this design. It is a serial port protocol module that is user friendly with a coverage range of 9m depending on the level of environmental interference. Serial port Bluetooth module is fully qualified Bluetooth V2.0+EDR (Enhanced Data Rate) 3Mbps Modulation with complete 2.4GHz radio transceiver and baseband. HC-05 is a CMOS technology single chip Bluetooth system with adaptive frequency hopping feature (AFH). It connects automatically to the last device on power as default with a slave default baud rate of 9600 and pairing pin code of “1234” as default [8]



**Fig-2:** HC-05 Bluetooth Module

#### 4.3 Microcontroller (Aduino)

Arduino has been used for different engineering projects and applications. The Arduino software is very simple to use for beginners, yet flexibly adequate for advanced users. It runs on windows, Linux and Mac. There are numerous types of microcontrollers obtainable under Arduino family for physical computing and engineering, they include; Arduino Nano, Arduino Uno, Lilypad Arduino, Red Board, Arduino Mega and Arduino Leonardo. But for the purpose of this research, Arduino Uno is used because of its cost effectiveness and functionality.

The Arduino Uno is a 14digital input/output pins microcontroller board based on ATmega328p. it has USP connection port, 16Mhz ceramic resonator, a power jack, 6 analog input and ICSP header, and a reset button [9]. It contains everything needed to support the microcontroller. It can be connected to a computer using a USB cable or powered with an AC-to-DC adapter. The Arduino circuit acts as an interface between the software part and the hardware part of the system [5].

A microcontroller is a single integrated circuit meant to perform a particular task. Arduino Uno microcontroller is used in this design to ensure signal supply to the relays and also receive signal from the HC-05 Bluetooth module. It takes 5V dc power supply.

The text transmitted to the Arduino Uno serial port by the Bluetooth module is matched across various text combinations to switch the appropriate appliance ON/OFF. For example, to switch on a bulb the user needs to say “bulb on” and to switch it off he/she needs to say “bulb off”. The appliances are connected via the relay boards to pin numbers 4 and 7 of the Arduino Uno, but for this design, a two-channel relay device is used. The appropriate appliance is switched either ON/OFF if the matching text is detected to give the corresponding pin a high or low output signal.



**Fig-3** Arduino Uno Microcontroller

#### 4.4 Relay Boards

A relay is defined as an electromechanical switch. Historically, the first relay was used in long distance telegraph circuits as amplifiers, and they were also used in early computers to perform logical operations.

There are various kinds of relays operating at different voltages. A trigger voltage is always considered when circuits are designed.

When a circuit is built, the voltage that will trigger it has to be considered. In this paper, the relay circuit is used to turn the appliances ON/OFF. The high and low voltage signals received by the relay is supplied by the Arduino Uno microcontroller. The high and low voltage supplied to the relay to switch an appliance been connected signifies that the appliance be put ON/OFF respectively. The relay circuit drives two appliances in the voice controlled automation system as shown in figure 4. The number of loads to be connected to the relays can be modified as desired by the designer.



**Fig-4:** 5V DC Tongling Two (2) Channel Relay Module

#### 4.5 Jumper Wires

Jumper wire is used in the DC power Supply.

#### 4.6 Power Supply

The power supplies are designed to convert AC voltage mains electricity to a suitable DC voltage supply for electronic circuits and other devices. A power supply can be taken down into series of blocks, each of which performs a particular function. A regulated DC power supply refers to the DC power supply that maintains the constant output voltage irrespective of the fluctuations of the AC mains or load variations. The regulated DC output voltage is expected to be smooth and free from noise and ripples. It is suitable for all electronic circuits.

### 5. SYSTEM ANALYSIS AND DESIGN

#### 5.1 Figures and Diagrams

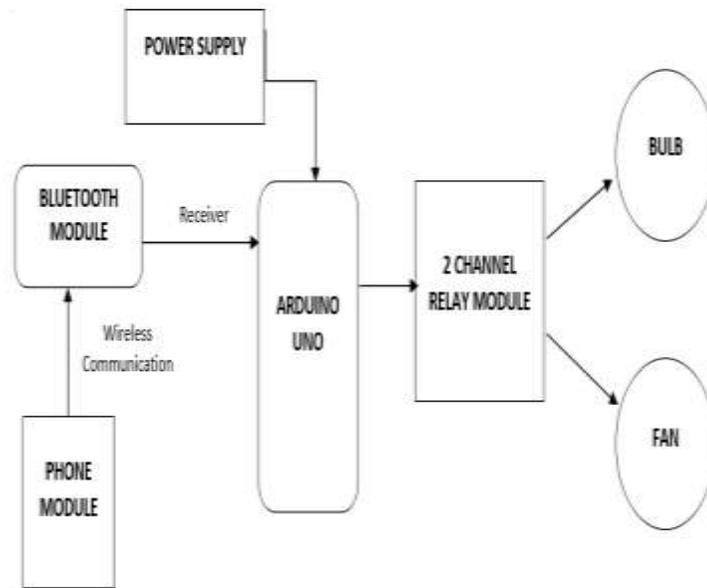


Fig-5: System Block Diagram

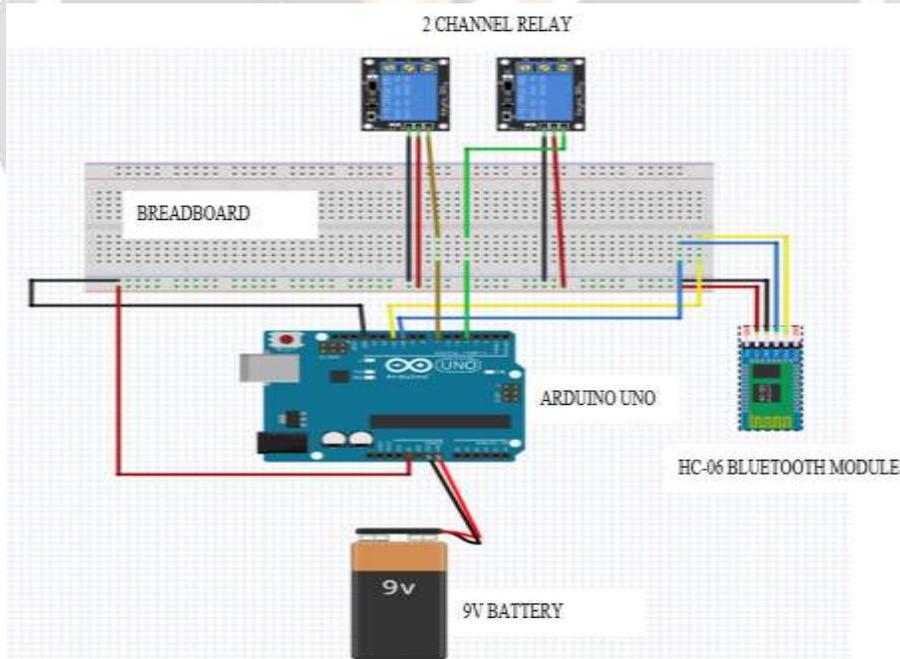


Fig-6: System Circuit Diagram

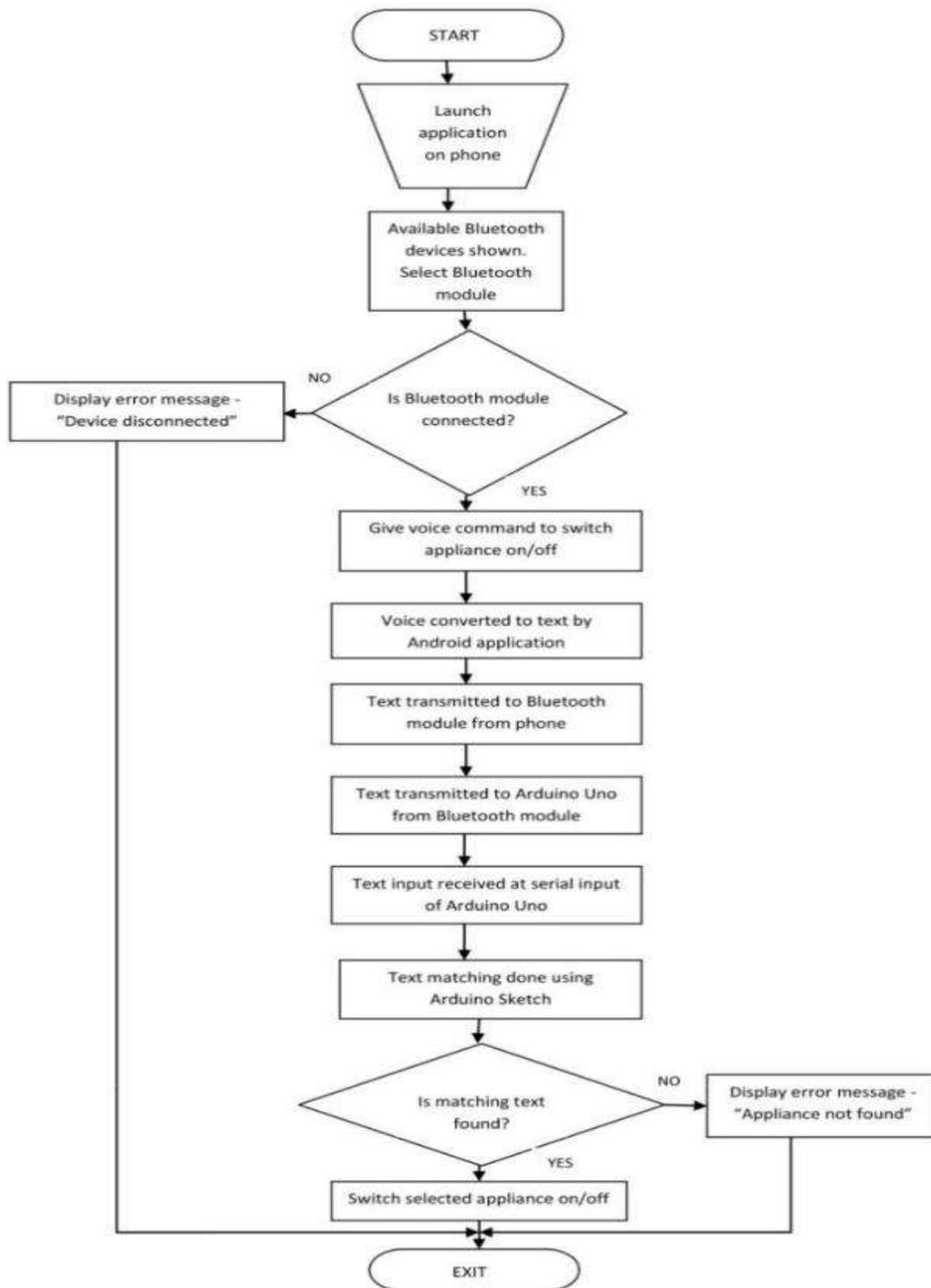
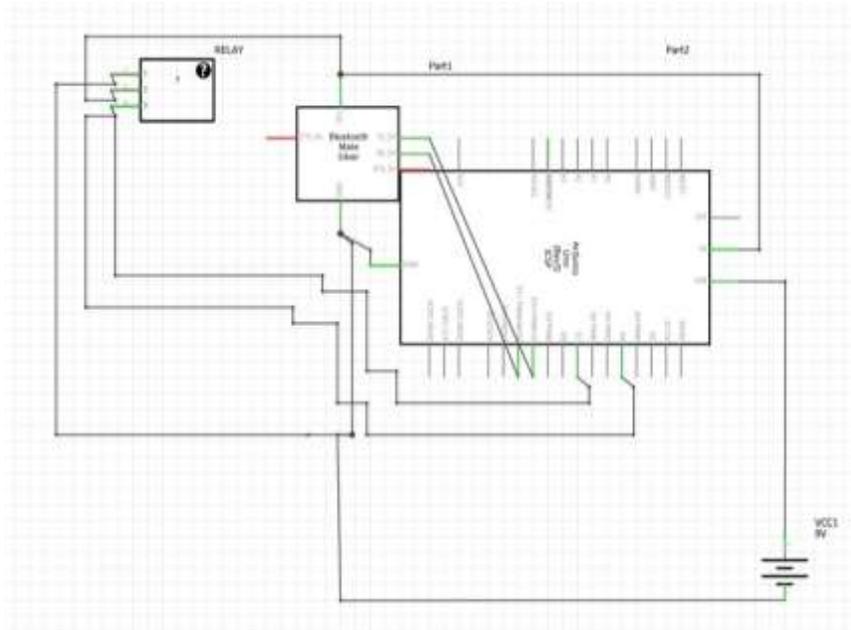


Fig-7: System Flow Chart [4]



**Fig-8:** System Schematic Diagram

## 5.2 Working Principle of the System

The above components are used to implement the system. The core component of this system is the Arduino Uno which has a microcontroller that is, Atmega 328p. Atmega 328p has a 32KB flash, it is needed to burn a boot loader and download Arduino sketches. The ISP program controller is used to programmed the boot loader. A 9V adapter power supply serves as input supply to the Arduino voice control system. The relays connected to the Arduino Uno output pin serves as switches to the loads.

Android is a Linux kernel based mobile operating system developed by Google. Android phones have an inbuilt feature called 'voice recognizer' which the user uses to control an appliance. For wireless communication system, a Bluetooth module HC-05 is used as a remote which is connected to the control unit for sensing the signals sent by the android voice application.

The Bluetooth module and relay circuit are connected to the microcontroller while the android based application is launched on the smart phone. The application can orally be instructed by the user to control an appliance either ON/OFF. The microcontroller sends signal to the relay board having received instruction through the Bluetooth module. The application first of all searches for the Bluetooth device to establish wireless connection. The voice recognizer is launched as soon as connection is established. The audio signal read from the voice is converted into string. Value is assigned to each of the appliances and fed to the microcontroller. The microcontroller decodes the sends data signal and activates the relays for appropriate loads switching.

## 6. CONSTRUCTION, TESTING AND RESULTS

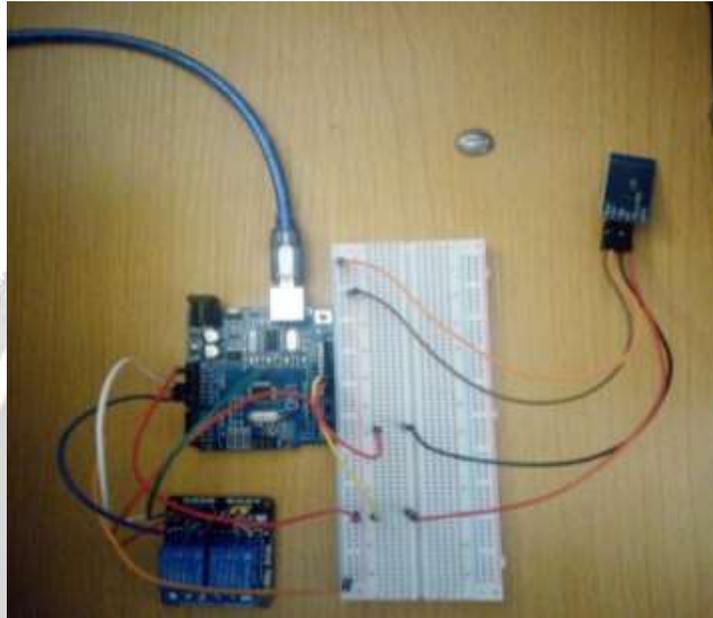
### 6.1 Construction and Testing

Bread board performance test and measurement were carried out for every stage. Some of the procedures carried out during constructions are:

- All components were mounted on their respective circuit position onto the bread board

- The microcontroller was mounted with due consideration to pin output to input as programmed, after which the microcontroller was programed and tested to be “OK”
- At the end of mounting components on the bread board, the overall system was tested and results measured.

The battery power supply of 9V was measured with a digital multi meter to ascertain the power available for the circuit. This was to ensure that the supply was enough to power the Arduino Uno. The laboratory implementation of Fig. 9 illustrates how the entire system was constructed.



**Fig-9:** Bread Board Diagram

**6.2 Results**

This device has been trained with several words. Each word is stored through programming the Arduino Micro controller making it possible to communicate with the relay to either switch ON/OFF any appliance connected to relay.

List of trained words using Bread Board for Testing is shown in Table 1.

**Table-1:** Trained words

Train words	Description
Bulb ON	BULB ON
Bulb OFF	BULB OFF
Fan ON	FAN ON
Fan OFF	FAN OFF

## 7. CONCLUSIONS

In this paper, we have successfully implemented a “Voice Control Automation System” made of three components which include; Bluetooth module HC-05, Arduino Uno Microcontroller and Relay Circuits. The main function of the Bluetooth module is to establish wireless link between the microcontroller and the android smart phone. The concept adopted in this paper can be used for controlling nth number of input control by simply increasing the number of relays. This paper proposes a low cost, secure, ubiquitously accessible, auto-configurable, remotely controlled solution which is reliable and flexible in order to control any load. The approach discussed in this project is novel and has achieved the target to control home appliances remotely using the Bluetooth technology to connects system parts, satisfying user needs and requirement. Hence, we can conclude that the required goal and objectives of “Voice Control Automation System” have been met. This research paper is relevant in so many automation applications in the areas of transportation, healthcare. process control, industrial automation, military, etc.

## 8. ACKNOWLEDGEMENT

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## 9. REFERENCES

- [1] K. Mamata, N. Kaimal, P. Jadhav and S. Adnan Rizvi. “Implementation of Internet of Things for Home Automation.” (2015).
- [2] M. Smitha, T. Avesha Rumana, P. Sutha. “Hand Gesture Based Home Automation for Visually Challenged” *International journal of Innovations in Engineering Research and Technology*, volume 2, issue 4, Apr-2015.
- [3] B.M Krishna, V.N Navak, K.R Reddy, B. Rakesh, P. Kumar, N. Sandhya “Bluetooth based wireless home automation system using FPGA” *Journal of Theoretical and Applied Information Technology*, Volume 77, Pp.411-420, 2015
- [4] S. Sonali, C. Shamik, T. Raghav, B. Ankita. “Design of an Intelligent Voice Controlled Home Automation System” *International Journal of Computer Applications*, volume 121, 2015, pp. 39-42, doi: 10.5120/21619-4904.
- [5] Abd, Mohamad, E. Mowad, A. Fathy, A. Hafez “Smart Home Automated Control System Using Android Application and Microcontroller” *International Journal of Scientific & Engineering Research*, Volume 5, Issue 5, ISSN, pp. 2229-5518, 2014
- [6] Y. Ming and S. Hao “Smart Living Using Bluetooth Based Android Smartphone” *International Journal of Wireless & Mobile Networks (IJWMN)* Volume 5, No. 1, 2013, doi: 10.5121/ijwmn.5105 65
- [7] B. Chakradhar, S. KrishnaveniI, and D. Naresh, D. “Bluetooth Based Home Automation and Security System Using ARM9”, *International Journal of Engineering Trends and Technology (IJETT)*, Vol. 4 Issue 9, 2013, Pp. 4053-4058
- [8] Datasheet Bluetooth to Serial Port Module HC05 Retrieved from: <https://www.electronicastudio.com/docs/istd016A.pdf> (Accessed: 10th April, 2020).
- [9] Arduino Uno Projects Retrieved from: <https://store.arduino.cc/arduino-uno-rev3> (Accessed: 10th April, 2020).

## 10. APPENDIX

### The Arduino programming code

```
#include <SoftwareSerial.h>

int relay1 = 7;

int relay2 = 4;

//variable for voice
```

```
String voice;

//bluetooth stuff

SoftwareSerial BT(10, 11); //TX, RX respectively

void setup() {
  BT.begin(9600);
  Serial.begin(9600);
  pinMode (relay1, OUTPUT);
  pinMode (relay2, OUTPUT);
  performFunction("reset");
}

void loop() {
  //checking for voice commands starts here
  while (BT.available()){ //Check if there is an available byte to read
    delay (10); //Delay added to make thing stable
    char c = BT.read(); //Conduct a serial read
    if (c == '#') {break;} //Exit the loop when the # is detected after the word
    voice += c; //Shorthand for voice = voice + c }
  if(voice.length() > 0) {
    Serial.println(voice);
    if(voice == "*fan on" )
    {
      performFunction("fan on");
    }else if(voice == "*bulb")
    {
      performFunction("bulb on");
    }else if(voice == "*fan off")
    {
      performFunction("fan off");
    }else if(voice == "*bulb off")
    {
      performFunction("bulb off");
    }
  }
}
```

```
    }  
    voice = "";  
  }  
  delay(150);  
}  
  
void performFunction(String command){  
  if(command == "fan on"){  
    digitalWrite (relay1, HIGH);  
  }else if(command == "fan off"){  
    digitalWrite (relay1, LOW);  
  }else if(command == "bulb on"){  
    digitalWrite (relay2, HIGH);  
  }else if(command == "bulb off"){  
    digitalWrite (relay2, LOW);  
  }else if(command == "reset"){  
    digitalWrite (relay1, LOW);  
    digitalWrite (relay2, LOW);  
  }  
}
```

