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Bluetooth Enabled Home Automation Control System using Android Application

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Abstract: This article clearly shows the implementation of a Bluetooth Home Automation Control System using an android application for remote switching of electrical appliances such as lighting, fan, garage, door motor, power sockets, water-pump motor or any other load in homes, offices or industries. The android application in the mobile phone acts as a modem for the control of home appliances. The system used an Arduino microcontroller for signal processing, a Bluetooth module for receiving data from android smart phone with a Bluetooth terminal/switching application and relays as its major switching component. The use of android mobile phones is simple and on the increase, the researcher deem it necessary to take advantage of its Bluetooth technology. By using an android mobile phone with the necessary application, we can switch ON/OFF home appliances within the Bluetooth signal range of approximately 100m conveniently without stress or risk of electric shock. The Bluetooth Home Automation Control System as presented in this paper is most suitable for everyone especially the elderly and disabled as it ease the stress of to and from movement for manual control of appliances within the home environment. Proper authentication/protection is implemented in this project to prevent unauthorized users from accessing the appliances at home.
Keywords: Arduino Microcontroller, Home Automation Control System, Bluetooth module, Android Mobile Phone

INTRODUCTION

We are living in a digital era where wireless technology is becoming popular and very important for human comfort, especially in the areas of Telecommunication, Robotics, Instrumentation and Controls, Automobile, Artificial intelligence, etc. Home automation control system involves the use of any automating technology for the control of the household environment either by using Sensors and actuators through direct smart system or by using a smart phone from a remote location through wireless technology. Since android mobile phone is gaining more popularity worldwide, Bluetooth technology is becoming more useful nowadays as it is embedded in almost every home appliances.

Sriskanthan presented a Home Automation System that can control home appliances from a PC using Bluetooth [7]. Such system is not flexible and mobile because it cannot be controlled by the cell phone which is available at almost every household. This paper presents a low cost and flexible home automation system. The communication between the cell phone and the Arduino BT board is wireless and additional devices can be connected into the system with little modifications.

The Bluetooth Home Automation Control System presented in this paper uses a suitable Bluetooth Switching Application running on an android Operating System as the Graphic User Interface to send/receive commands wirelessly through the serial port to the Bluetooth module connected to the Arduino microcontroller for signal processing. Outputs of microcontroller are connected to respective relays for load switching. With this setup, a user can switch ON/OFF home appliances from any location within the home by just a tap of some buttons on the android phone. In a conventional home controlled setup, all circuits/components are wired to the same power supply cable through a home control panel/distribution board. Disadvantage of this setup is that it requires a stressful movement of the user from one point to the other for a manual switching with some risk of electric shock. This Bluetooth control system eliminates such disadvantage. Home automation are required for energy saving and remote monitoring and control. Raspberry Pi is an intelligent platform using which multiple appliance can be connected to each other and can be controlled from a longer range of distance [8]. Study developed a low cost, secure, ubiquitously accessible, auto-configurable, remotely controlled solution using WiFi technology to connects system parts and system is highly reliable and efficient for the aged people and paralyzed person on a wheel chair.[9] [10].

LITERATURE REVIEW

R. Piyare and M. Tazil presented a "Bluetooth Based Home Automation System using Cell Phone" [3]. The design shows the Bluetooth connection status as a pop-up message/notification in just a few seconds duration on the user's phone. This is not an effective and reliable way of verifying the Bluetooth connection status. In this project, a steady and visible indicator lamp is embedded to show when Bluetooth is

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successfully connected to mobile device and it stays ON as long as Bluetooth is connected. With this setup, user can easily and quickly notice from distance when the Bluetooth Home Automation Control System is connected to a bluetooth device or not since the indicator is very visible to anyone from far or near. "Home Automated System using Bluetooth and an Android Application" was implemented by Abiodun E. Amoran, Ayodele S. Oluwole, Enitan O. Fagorola and R.S. Diarah[4]. In their design, ULN2003A Darlington Integrated Circuit(IC) was used as the relay driver circuit, unfortunately this can result to difficulty in fixing a particular IC pin output fault and high cost of replacing the whole IC. In this project presentation, transistors are used as relay drivers for easy access to individual output to relays for quick replacement in case of fault instead of using ULN2003A Darlington IC to avoid replacement of the whole IC in case of fault on any of the output pins.

Design of Bluetooth home automation control system must be implemented at low cost, it should be simple and user friendly. Jolan Baccay Sy and Shaik Irfan also came up with the presentation of "Bluetooth Based Automation System using Android App"[2]. In their design, Liquid Crystal Display (LCD)-an electronic display module was embedded to display either when the load is ON or OFF. This is a good idea but they didn't consider the fact that Bluetooth home automation control system will not be suitable or mounted at too low heights to have a clear view of the LCD display if this system is to be implemented at residential homes. For the purpose of safety and unauthorized access, systems like the Bluetooth home automation control units and other conventional control boards at homes are mounted at certain heights for clearity of vision to LCD screen and prevention from dust, therefore LCDs may not be necessary to keep implementation at low cost. In this project, clear and visible load indicator lamps are implemented to show the status (ON/OFF) of the various load outputs. This will save cost, allow system flexibility and make usage easier for user. When the microcontroller gets a command from a Bluetooth device, it sends the signal to the relay drivers to trigger the corresponding relay and get a loop supply from the load line to indicate on the load indicator lamps.

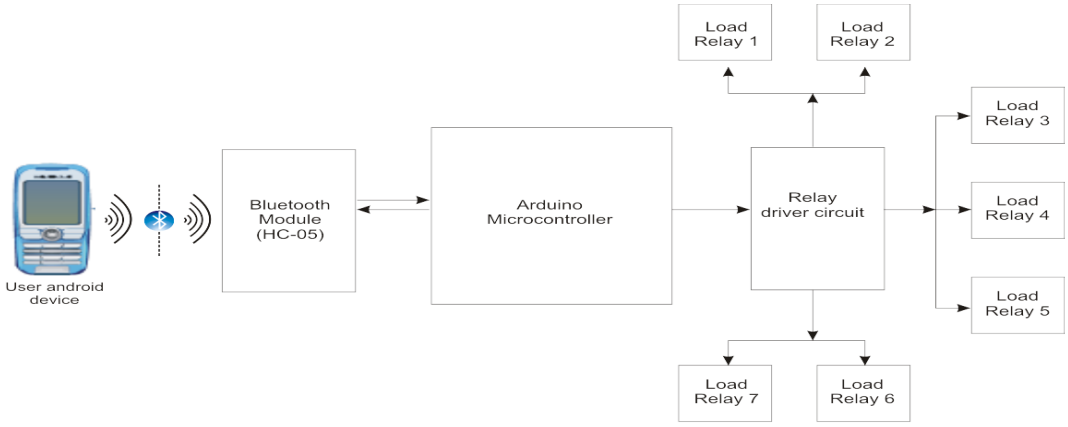

Figure 1. Block diagram of Bluetooth Home Automated Control System.

Figure 2. Home control using Android phone

MATERIALS AND METHODOLOGY

The Bluetooth Home Automation Control System presented in this paper uses the software and hardware approach to achieve it successfully. The hardware part comprises the various components as shown in Fig.1 above and will be explained subsequently while the software part was based on an android application with a maximum of 104 switch buttons available online and an Arduino Integrated Development Environment (IDE) for writing codes onto the microcontroller. The Arduino uses codes written in C or C++ programming language to control the function of the entire process of the Bluetooth control system. In this design, User enters a command by tapping a button on his android device, through Bluetooth connection, the Bluetooth module receives the command entered by the user and sends that command to the Arduino microcontroller via serial port (TXD on Bluetooth module) for processing. The microcontroller receives, read and compare the command to the set codes written on the Arduino Uno, if the command matches the set codes, a corresponding output pin goes high, this high state triggers its relay

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through the relay driver and the relays switch the supply line to the respective loads. The entire system comprises the following hardware components:

Power Circuit: The power section comprises of electronics component configured to convert AC voltage to a regulated DC voltage for a smooth operation of the system. The main four blocks of the power circuit are:

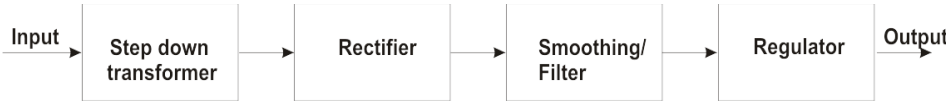
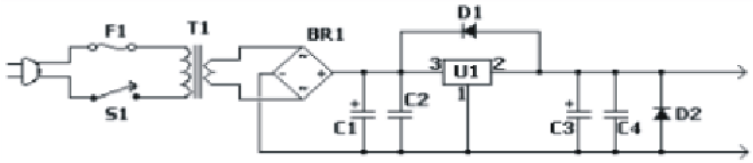


Figure 3. Showing block diagram of power circuit



C1 = 2200uF 35V Electrolytic Capacitor
C2,C4 = 0.1uF Ceramic Disc Capacitor
C3 = 10uF 35V Electrolytic Capacitor
D1,D2 = In4007, BR1 = 2A 30V Rectifier
U1 = Lm7809, T1 = 12V 1.5A , F1=2A 240V, S1 =2A SPST

Figure 4. Circuit Diagram of Power circuit

Step Down Transformer: this steps down 220vac to a required ac level without changing the frequency which is 50Hz here in Nigeria.

Rectifier circuit: this circuit is a combination of diodes arranged in such a manner that converts AC into DC voltage.

Smoothing/Filter: this comprise of capacitor used to convert the pulsating dc signal from the rectifier into pure dc signal, without distortion for proper regulation.

Regulator: the regulator is an integrated circuit (LM7809) used to give a constant output voltage regardless of input voltage changes.

Bluetooth Module: The module used in this design is HC-05 Bluetooth module. It receives commands sent by the user through an android phone. The HC-05 accept 3.3v logic levels and operates on 3.6v to 6v. This module can work up to the range of approximately 100metres at 2.4 GHz.

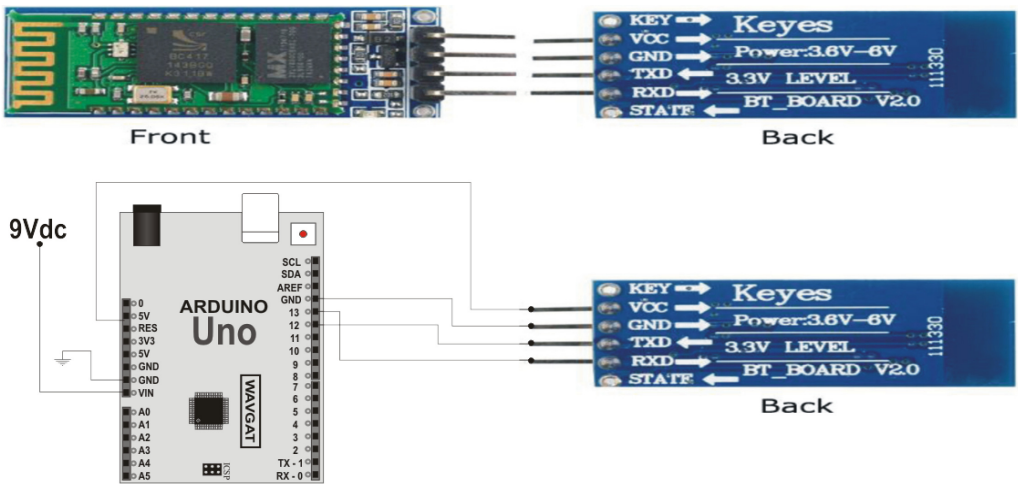


Figure 5. Bluetooth Module and Connection

Arduino Microcontroller: The microcontroller used in this project is an arduino Uno R3 microcontroller board based on the ATmega328P. Its recommended input voltage is 7Vdc to 12Vdc, 3.3V logic levels with DC current per I/O pin as 20mA and 50mA for DC current of 3.3V pin [1]. The arduino microcontroller receives data from the Bluetooth module, process it and send it as output to the relay driver circuit. Software serial configuration was used for arduino pin 13 and 12 serving as TXD and RXD respectively.

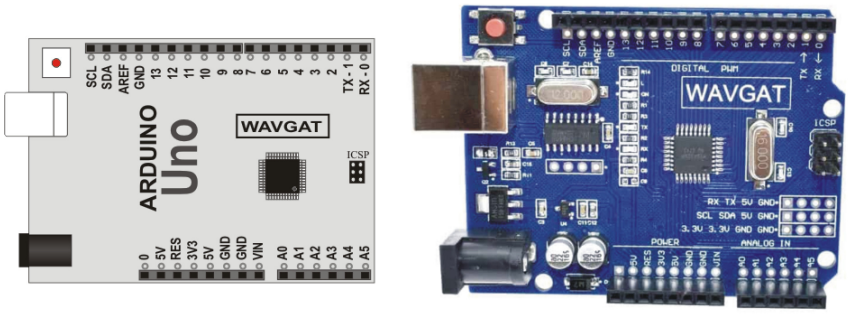


Figure 6. Arduino Uno Microcontroller Module

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Relay Driver: The relays are powered by a driver circuit of individual BC337 general-purpose NPN transistors with a minimum gain of 630 and can switch loads of up to 45v at 800mA.

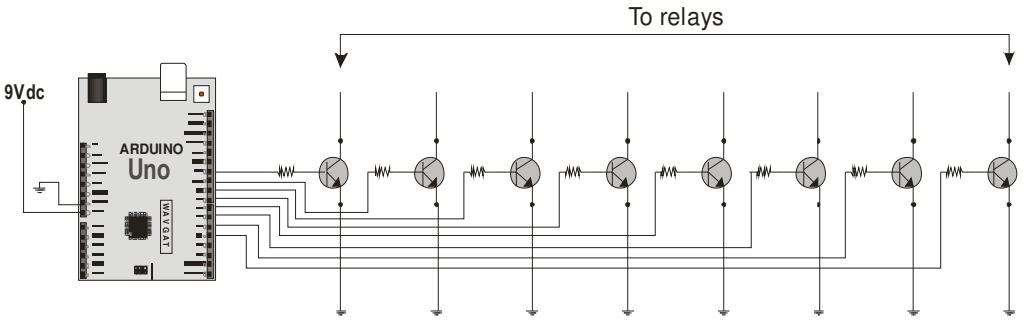

Figure 7. Relay Driver Circuit

Relay Switch: Relays are electromechanical device with normally open/normally close contacts used for switching in an electrical circuit. It has both coil ratings and switch contact ratings. The relays used here are 9Vdc relays with AC contact rating of 220VAC, 10A. It switches ON/OFF the loads to the main 220VAC supply line when triggered by the driver circuit. A general Relay is mechanical switch, its contact is closed when a current flows through it [6].

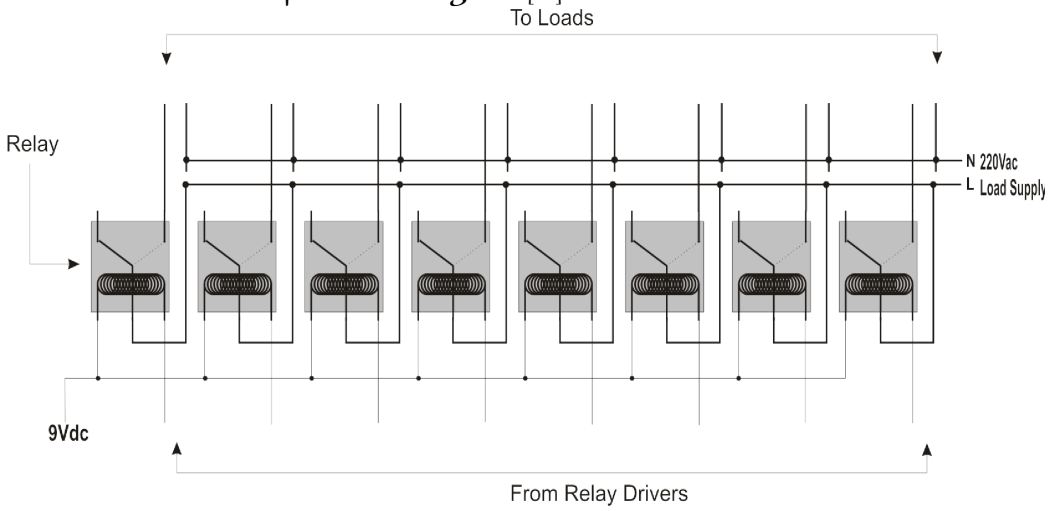

Figure 8. Relay Switch Circuit

CONNECTIONS

1 5V PIN and GND of microcontroller was connected to VCC and GND of Bluetooth module respectively.

2 RXD and TXD of Bluetooth module are connected to PIN 13 and 12 of Arduino microcontroller respectively
3 Pin 2 to Pin 11 of microcontroller are connected to the base of the transistors of the relay drivers through a 2.2k resistor. These pins are programmed as outputs.
4 9Vdc was connected to Vin of Arduino microcontroller while GND of dc power source is connected to GND of Arduino.
5 Emitter pins of all transistors are connected to ground(GND)

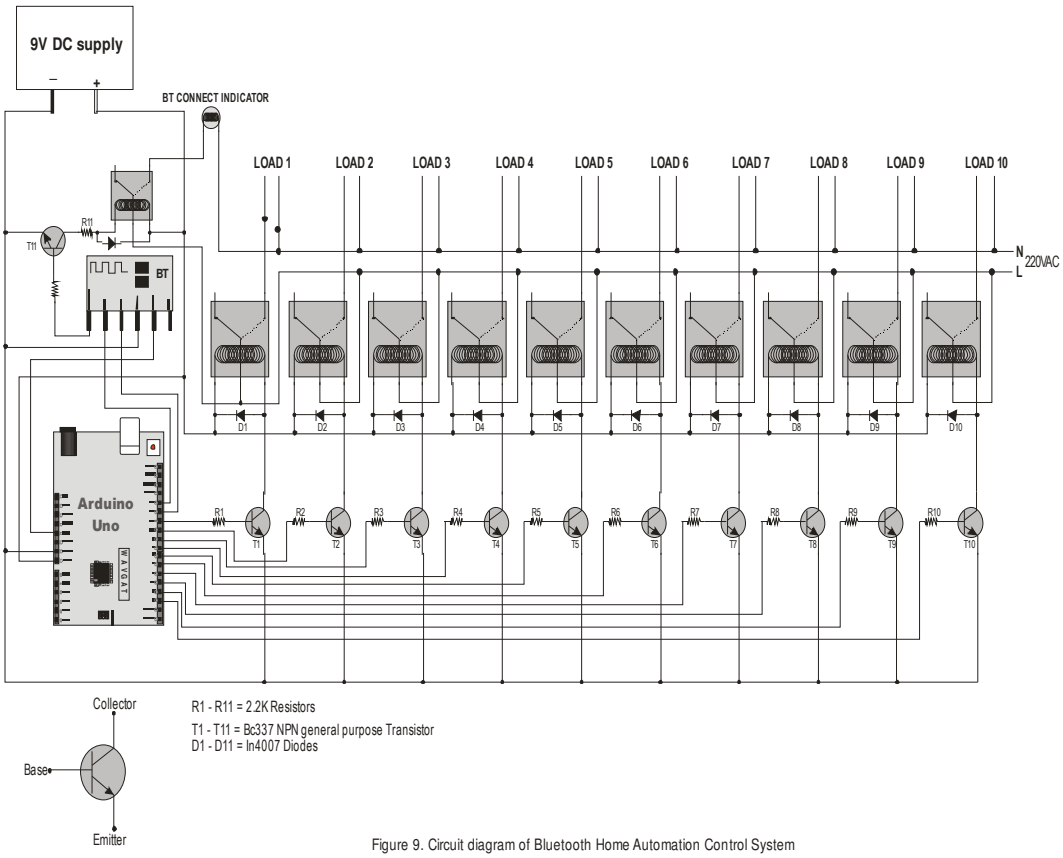

Figure 9. Circuit diagram of Bluetooth Home Automation Control System

SOFTWARE, APPLICATION AND IMPLEMENTATION

Arduino Integrated Development Environment (IDE):- Arduino IDE is an open source software that writes, compiles and uploads codes directly to the microcontroller. This software supports both C and C++ programming language. It is also used for debugging, editing, compiling and uploading code in its environment to physical hardware modules.

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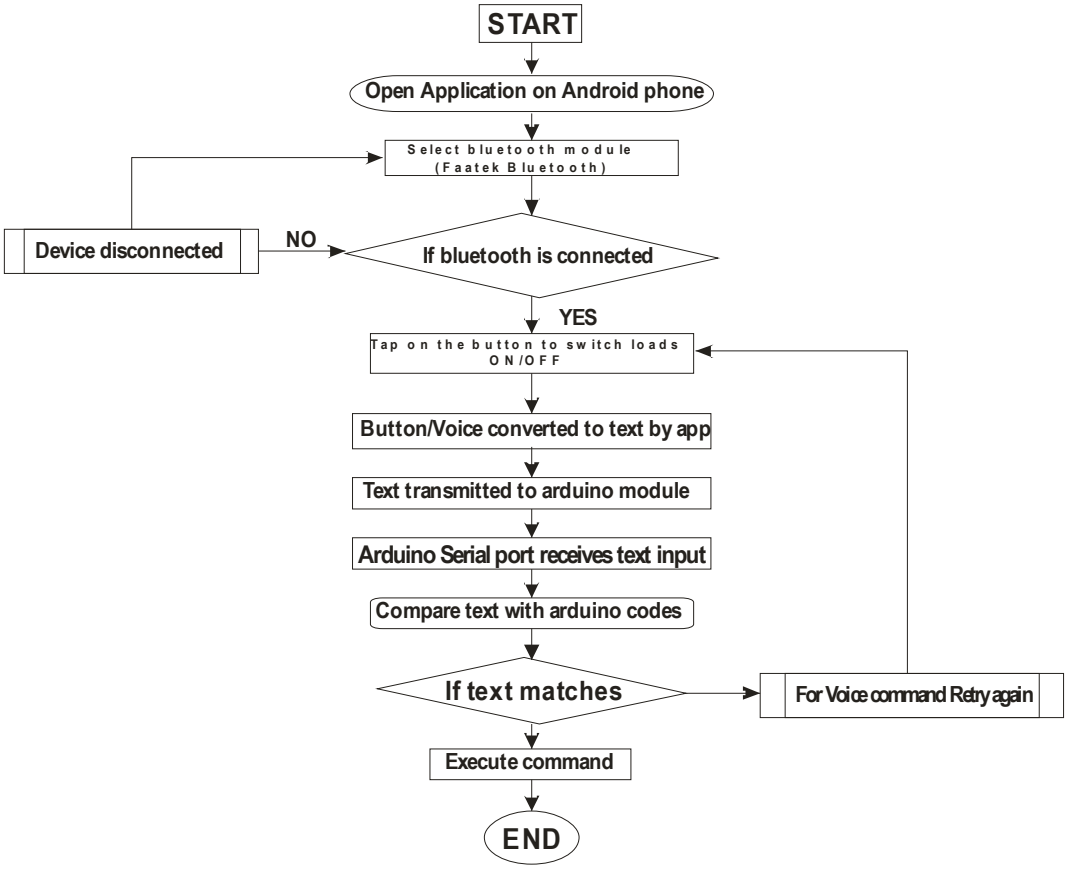


Figure 10. Operational flow chart of the Bluetooth Home Automation Control System

Android Application: - This project uses 'Bluetooth Switches' android application and can be located at https://github.com/yashx/Bluetooth-Switches. It contains a maximum of 104 control buttons of different layout/setup; either as a pushbutton (List), Pushbutton (Panel), Switch (List), Switch (Panel) or Voice Control (Beta) by which the system can be controlled through voice.

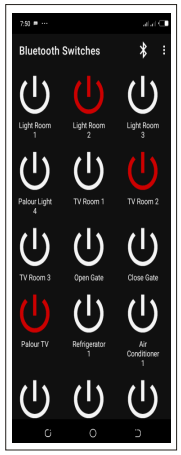
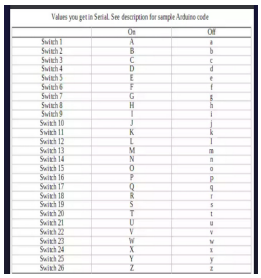


Figure 11. Android App User Interface with Buttons

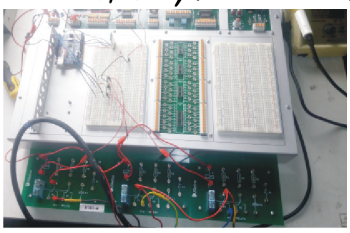


Values you get in Serial. See description for sample Arduino code

	On	Off
Switch 1	A	a
Switch 2	B	b
Switch 3	C	c
Switch 4	D	d
Switch 5	E	e
Switch 6	F	f
Switch 7	G	g
Switch 8	H	h
Switch 9	I	i
Switch 10	J	j
Switch 11	K	k
Switch 12	L	l
Switch 13	M	m
Switch 14	N	n
Switch 15	O	o
Switch 16	P	p
Switch 17	Q	q
Switch 18	R	r
Switch 19	S	s
Switch 20	T	t
Switch 21	U	u
Switch 22	V	v
Switch 23	W	w
Switch 24	X	x
Switch 25	Y	y
Switch 26	Z	z

Figure 12. Equivalent values sent by buttons over Serial communication to bluetooth module by the android phone.

TESTING, RESULT AND DISCUSSION



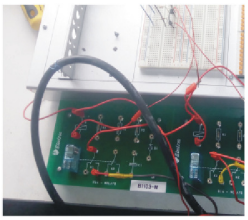


Figure 13. System Prototype under test

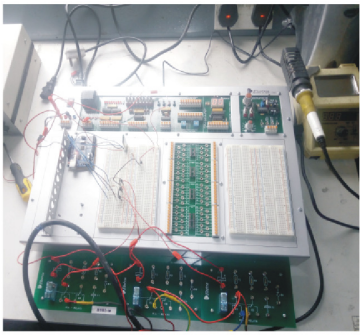


Figure 14. Writing Codes to the Arduino Microcontroller using arduino IDE on PC.

BUTTON No.	PROTOTYPE LOAD	DISTANCE
Load 1 ON Load 1 OFF	Working	10m
Load 2 ON Load 2 OFF	Working	20m
Load 3 ON Load 3 OFF	Working	30m
Load 4 ON Load 4 OFF	Working	40m
Load 5 ON Load 5 OFF	Working	50m
Load 6 ON Load 6 OFF	Working	60m
Load 7 ON Load 7 OFF	Working	70m

Table 15. System Responses under different test cases

CONCLUSION AND RECOMMENDATION

The Bluetooth Home Automation Control System presented in this paper is of minimal cost, easy to use, reliable and viable. This system, if implemented properly at homes, offices, industries, would give a complete

solution to the problems associated with manual switching as it offers zero risk of electric shock and eliminate the stress of to and fro movement, making it suitable for everyone, especially for the elderly and disabled. From the researcher's test and results, it shows that this system is simple, reliable and can be implemented to any home or office, especially if such plan is made from the initial stage of the home electrical installation design. To further the study of this system, it is recommended that Bluetooth home automation system be designed using an effective Radio Frequency Transceiver to create a wireless sensor network such that automated control of appliances can be achieved from a very far range of some kilometers.

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