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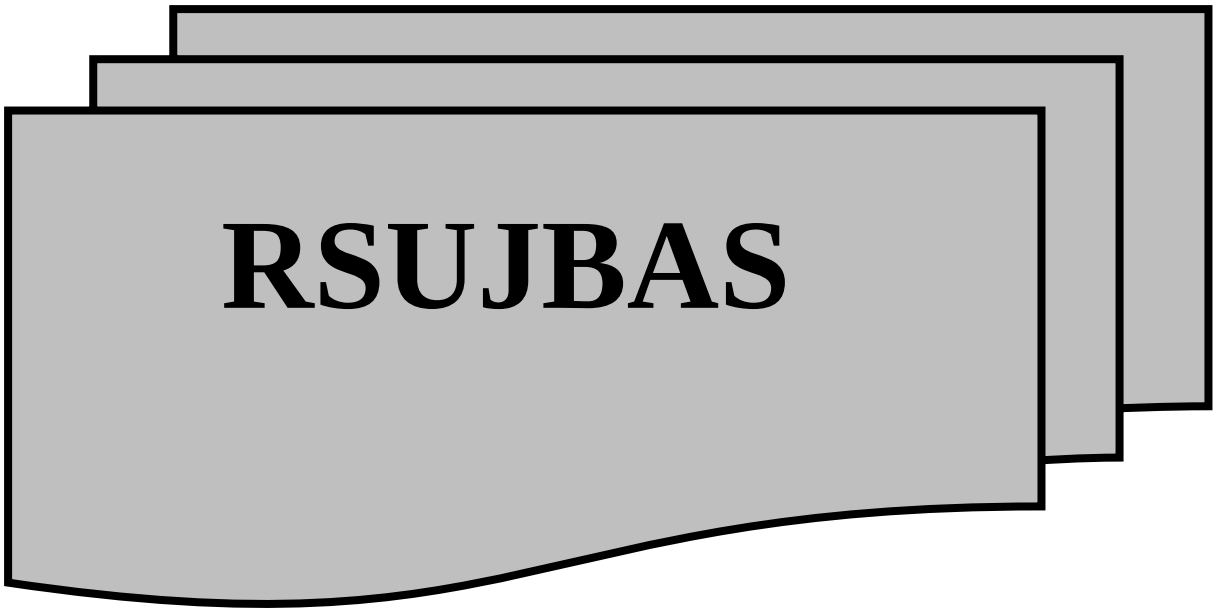

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The acknowledgment of people, grants or funds should be brief.

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A BLUETOOTH ENHANCED SMART HOME AUTOMATION SYSTEM USING ARDUINO BOARD

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ABSTRACT:
In this paper, a smart home automation system, using an Arduino board with Bluetooth being remotely controlled by any Android Operating System smart phone, was developed. A Bluetooth module is interfaced to the Arduino board at the receiver end while on the transmitter end, a Graphical User Interface (GUI) application on the cell phone sends ON/OFF commands to the receiver where loads are connected. By touching the specified location on the GUI, the loads can be turned ON/OFF remotely through this technology. The loads are operated by Arduino board through opto-isolators and thyristors using triacs. The smart home automation system was experimentally proven to work satisfactorily by connecting sample appliances to it and the appliances were successful controlled from a wireless Mobile device. The smart home automation using Arduino UNO makes the system more flexible and provides attractive user interface compared to other home automation systems. The Bluetooth client was successfully tested on a multitude of different mobile phones from different manufacturers, thus proving its portability and wide compatibility.

Keywords: ***Bluetooth, Arduino board, Automation, Smart home***

INTRODUCTION

Nowadays, we have remote controls for our television sets and other electronic systems, which have made our lives real easy. One might have wondered about home automation which would give the facility of controlling tube light bulbs, fans and other electrical appliances at home using a remote control. This system is super-cost effective and can give the user, the ability to control any electronic device without even spending for a remote control, but just a smart-phone. With the help of this system, one can control his/her home appliances from the mobile phone within the range of Bluetooth, (Francis, *et al.,* 2018).

A smart home refers to a residence equipped with a communication network, high-tech household devices, appliances, and sensors that can be remotely accessed, monitored, and controlled and that provide services responding to the residents' needs (Chadil, *et al.,* 2017). Although the widespread diffusion of high-speed Internet in the late 1990s provided the opportunity for the home network business to grow, it was not until the late 2000s that smart homes began to be installed, which is when smart phones were popularized. Initially, a smart home was defined using various names, such as a home network, a digital home, home automation, and an intelligent home. In the mid-2010s, it has been leaning towards a combination of Internet of Things (IoT) and a situation-aware smart home (Dickey, *et al.,* 2019).

However, as the existing discussions are abstract, a fundamental understanding is necessary to characterize smart home automation system. In addition, past studies have conducted an empirical analysis on a specific group, but the popularization of smart home systems now requires more general discussions for diverse user classes, (Jan, *et al*., 2014).

The need to design a system that can allow complete multiple tasks, with the touch of a button, or simple voice commands prompted this research. Pre-programmed scenes make life a breeze – whether it's getting everyone up and out in the morning [blinds up, radio on], entertaining guests [lights dimmed, playlist on], or bedtime [down lights off, blinds closed]. Pre-set Scenes simplify your routine. With smart home technology that activates temperature control, one will never come home to a too hot or cold house again. Smart home automation can also be used to stream music and video throughout the house. And in the middle of the night, sensors can automatically turn lights on at a low level and provide safe and energy efficient passage. One cannot manage what you can't measure. Put your connected home to work and keep energy use in check, with automated alerts.

Use home automation to reduce heating and cooling requirements with blinds that automatically close when the temperature reaches a certain point. Sensors and timers can ensure lights are not left unintentionally on, and an 'all-off' scene switches everything off when not required.

Smart home technology allows the user to electronically access home security. Cameras from anywhere and can alert you when sensors detect strange movements. If you are away from home, blinds and light switches can be programmed to operate as if the house was occupied.

A smart doorbell with camera can be linked to your smart device. See who is knocking or use the intercom to talk without opening the door, or even being home. The benefits of Smart home can never be over-emphazed. Thus the need for this research.

In this research, a smart home automation system that will remotely switch on or off any household appliances connected to it, using a microcontroller, voice dial on phone, or Bluetooth based android application is presented. The research is to implement a low cost, reliable and scalable home automation using a microcontroller to achieve hardware simplicity, low cost short messaging service for feedback and voice dial from any phone to toggle the switch state.

REVIEW OF RELATED LITERATURE

Gebhardt, *et al*. (2017) proposes a home automation Security System called Smart-Eye using General Packet Radio Service (GPRS). Smart-Eye also uses a central controller, to which many individual home controllers are connected. The system alerts the homeowner by mobile phone using GPRS and the user can view the home using live camera feeds. The system uses a Rabbit-Core Module to connect an electrical appliance in the home to the home system, usually a PC. Each home system is connected to a central server. Rabbit Core has an IP address, so each device connected to it can be identified and operated via mobile phones using GPRS. The user sends device management commands to a central server. The home system reads the command from the central server, called home polling, and makes the changes needed to a device. When a device changes state, the home system, usually a PC sends the change of state of the device to the central server. The user's mobile will read the change from the central server, called mobile polling. The mobile user is provided with a home plan and places where each piece of equipment is kept in their home. The proposed research gives importance to communication and network setup rather than security. It mentions intrusion detection, but no concrete parameters identifying intrusions are mentioned.

The work of Alheraish (2014) shows the implementation of a home automation system using Bluetooth. They use a host controller implemented on a PC, which is connected to a microcontroller-based sensor and device controllers. The researchers even built a new protocol on top of the Bluetooth software stack, called Home Automation Protocol (HAP), to make the communication between devices possible. The device controller is connected to electronic devices through the I2C Bus. The system allows more than one device controller to be connected to the host controller.

Kim *et al.* (2019) also proposes a home automation system using Bluetooth that can be accessed remotely through GPRS. The researchers use a cellphone equipped with Bluetooth connectivity as a host controller and a GSM modem that provides Internet connectivity. Home devices are fitted with Bluetooth communication adapters so that they can communicate with the host controller phone via Bluetooth. The paper discusses remotely controlling and updating home devices along with fault diagnostics and detection. The work also talks about providing an electronics user manual on the phone using Bluetooth and Internet. Bluetooth looks like an attractive communication technology for creating smart homes. It is cheap, easy, and quick to

set up. People are already familiar with the technology. The hardware required for establishing Bluetooth communication is readily available.

Alkar and Buhur (2015) proposed a home automation system using SMS. The proposed system detects illegal intrusions at home and allows legitimate users to change the passkey for the door and control lights in the home. The illegal intrusion into the home is identified by monitoring the state of the home door, which is done using Light Emitting Diode (LED) and infrared sensors. The passkey to the door can be any 4 digits, which can be set either by using the keypad or by using SMS from a registered user's mobile number. A user can control the lights in their home remotely using SMS from their registered mobile number; by turning the lights on in different rooms at random intervals of time, one can give the impression that the home is occupied, even when it is not.

Sumino *et al.* (2020) also proposes an SMS-based home automation system. The system has a Java application running on the phone. Legitimate users can log in to the application using their username and password, and can select the building/floor/room/device that they wish to remotely control along with an appropriate action from the list of available user actions. The Java application will compose the appropriate SMS message and send it to the home's GSM modem. The GSM modem will receive the SMS message, decode it, and pass it to the home network to perform the action specified. The researchers used a 4-digit passkey and facial recognition for security.

Ramamurthy *et al.* (2010) proposed a home security system using GPRS. The work uses a webcam to stream video and pictures of the home to its owner's mobile through GPRS. The webcam detects movement by comparing frames for differences, including light intensity. Video streaming in the proposed work is done using the home Internet connection, not the GSM modem.

Zhang *et al.* (2015) describes video camera surveillance using the GPRS facility in mobile phones. The camera is triggered when an intrusion is detected or the door bell is rung. The system identifies intrusions with an infrared sensor. In the case of a doorbell, the system calls the homeowner and establishes voice communication with a live video feed between the visitor and the homeowner. When an intrusion is detected, an email is sent to the user along with a picture, most likely of the intruder. Upon receiving this email, the user can start monitoring the video feed on his phone.

The work of Chesti *et al.* (2019) allows a user to read and change the status of the devices at home using a preregistered mobile number using GPRS. The proposed system doesn't allow external devices to connect directly to the home devices. When a legitimate device with the correct phone number tries to connect to the home environment, a connection is established between the virtual home which mirrors the current state of the home devices and user, acting like a honeypot. The commands issued by the user are analyzed, and if they don't pose any harm to the home devices then the command is applied to the real devices at the home. When an emergency situation arises, like an intrusion or a fire, the intelligent devices at home initiate a communication between the home and the user via telephone, text message, or email that is

called "phone-out-only." The reverse never happens – a user never initiates direct communication with the home devices.

Malik *et al.* (2019) implemented a home automation system using Internet for enabling remote home access and infrared technology for device communication within the home. The researchers use a PC to perform the task of a web server, database, and interface. They use an RS232 module as a communication interface. The user interface is also developed by researchers and made accessible through the Internet. The work proposes the use of SSL certificates to ensure the authenticity of the web server.

The SSL certificate proposed by the authors is relatively secure, but there are still issues like SSL certificate stealing, certificate authority hacking, and fake certificate authorities. User authenticity is ensured using a username and a password, which is an area of security concern, as discussed earlier. Wi-Fi communication technology has a lot of advantages: low installation cost, easy to deploy and install, decent communication range, scalable technology, high bandwidth, and low power consumption. AES encryption offers good security. Moreover, repeaters can be used to extend communication range. Wi-Fi is an ideal choice of communication for automating an already-existing home without altering the existing architecture. Besides, the communication is wireless so it improves the aesthetics of the home. All these factors make Wi-Fi an ideal choice for wireless communication among researchers.

Faisal *et al.* (2018) proposes an Internet-based home automation system. Their work uses Wi-Fi to enable communication between different devices and the server at home. A user can login using a username and password and control the devices at home. In their work, the researchers use a PC as a web server. The PC also has built-in Wi-Fi communication capabilities and a communication module that enables communication between the home devices and the server PC. The home devices are connected to the server via Wi-Fi by a hardware interface module. Security is improved in the proposed system by blocking access to a login page for some time after successive failed login attempts. This protects the system from brute-force attacks and dictionary-based attacks. The system is still vulnerable to browser vulnerabilities and social engineering.

MATERIALS AND METHOD

Materials

The materials used for this research includes:

i. ARDUINO UNO with ATmega328p microcontroller
ii. 4 Channel relay (5v)
iii. Bluetooth module HC-06
iv. Power supply
v. Load (HOUSEHOLD APPLIANCE)
vi. Connecting wires
vii. Breadboard
viii. 9 v power supply
ix. Smartphone (Bluetooth enabled)

x. Arduino 1.6.9 compiler
xi. Android Studio IDE
xii. Android application

Key parameters of the system

Parameter	Value
CPU type	8-bit AVR
Performance	20 MIPS at 20MHz
Flash memory	32kb
SRAM	2kb
EEPROM	1kb
Pin count	28 or 32 pin: PDIP-28, MLF-28, TQFP-32 and MLF-32
Maximum operating frequency	20MHz
Number of touch channels	16
Hardware QTouch Acquisition	No
Maximum I/O pins	23
External interrupts	2
USB Interface	No
USB Speed	-

System Design and Implementation

The Arduino Software parts include the IDE and the ATMEGA328.

The Arduino integrated development environment (IDE) is across-platform application (forWindows,MacOS,Linux) that is written with the Java programming language. It originated from the IDE for the languages Processing and Wiring. It includes a code editor with features such as text cutting and pasting, searching and replacing text, automatic indenting, brace matching, and syntax highlighting, and provides simple one-click mechanisms to compile and upload programs to an Arduino board.

The ATmega328 is a single-chip microcontroller created by Atmel in mega AVR family (later Microchip Technology acquired Atmel in 2016). It has a modified Harvard architecture 8-bit RISC processor core.

Arduino UNO to ATmega328 pin mapping is achieved when ATmega328 chip is used in place of Arduino UNO, or vice versa. Fig. 1 shows the pin mapping between the two.

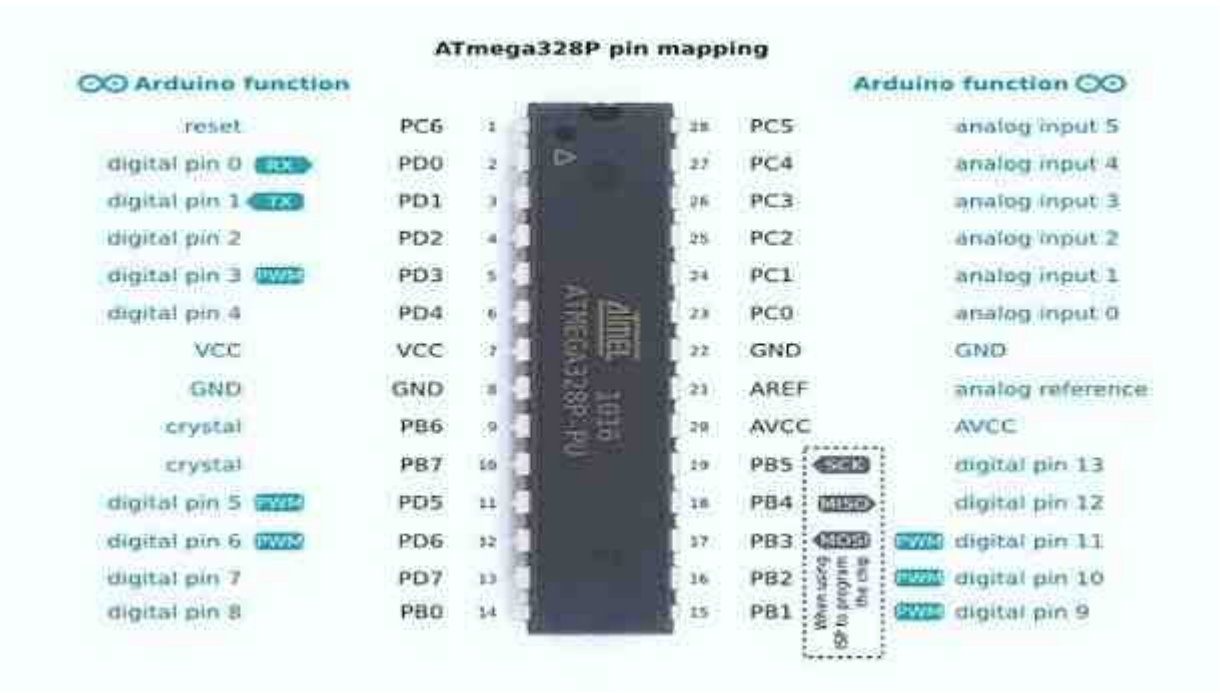


Figure 1: ATmega3228p pin mapping

HC-06 Bluetooth Module Circuit Connections

During power up the key pin can be grounded to enter into command mode, if left free it will by default enter into the data mode. As soon as the module is powered you should be able to discover the Bluetooth device as "HC-06" then connect with it using the default password 1234 and start communicating with it. The name, password and other default parameter can be changed by entering into the application. Fig. 2 shows the pin description of the Bluetooth modules.

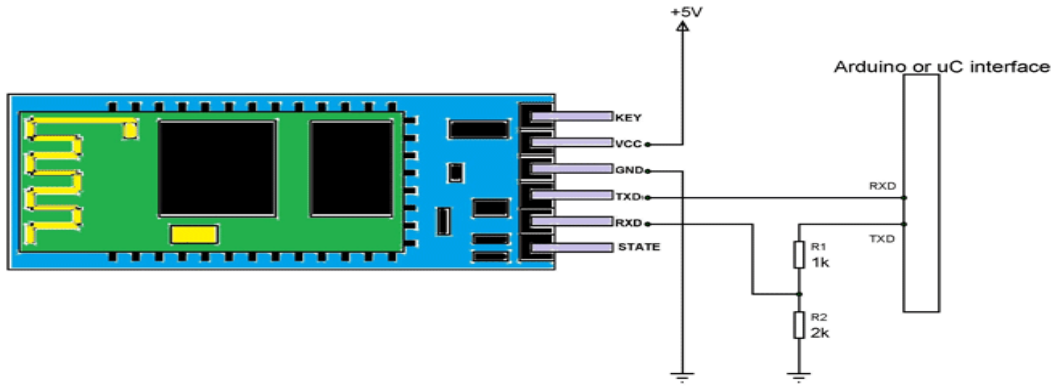


Figure 2: Pin Description of Bluetooth modules

HC-06 Bluetooth Module can Interface with Arduino UNO. HC-06 is a Bluetooth device used for wireless communication with Bluetooth enabled devices (like smartphones). It communicates with microcontrollers using serial communication (USART) as shown in Fig. 3. However we need to shift the transmit voltage level from microcontroller to RXD of HC-06 module.

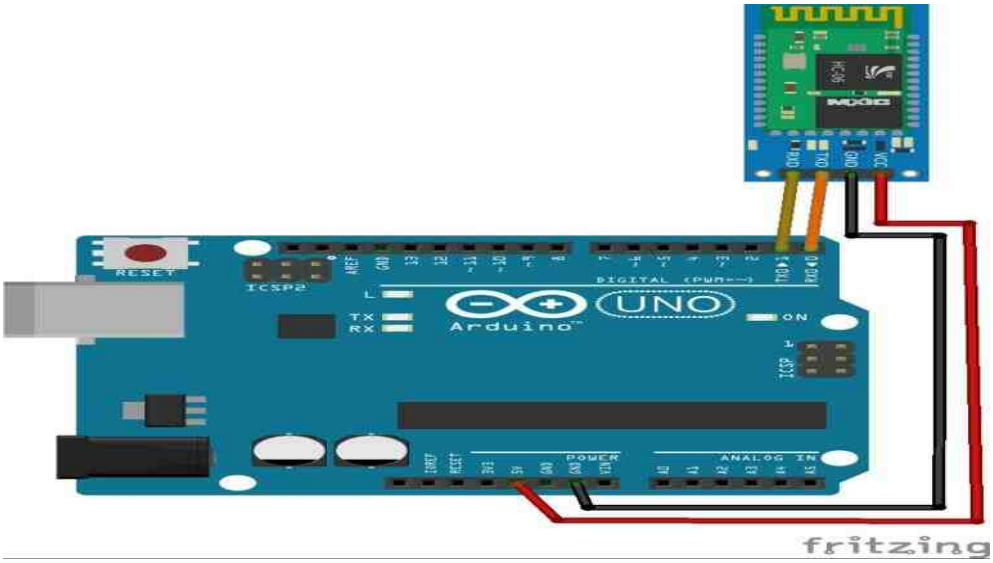


Figure 3: Bluetooth Module interfacing with Arduino UNO

A low cost and efficient smart home system is presented in our design. This system has two main modules: the hardware interface module and the software communication module. At the heart of this system is the Arduino Mega 626p microcontroller which is also capable of functioning as a micro web server and the interface for all the hardware modules. All communications and controls in this system pass through the microcontroller.

Block Diagram

The Block diagram of the system is shown in Figure 4.

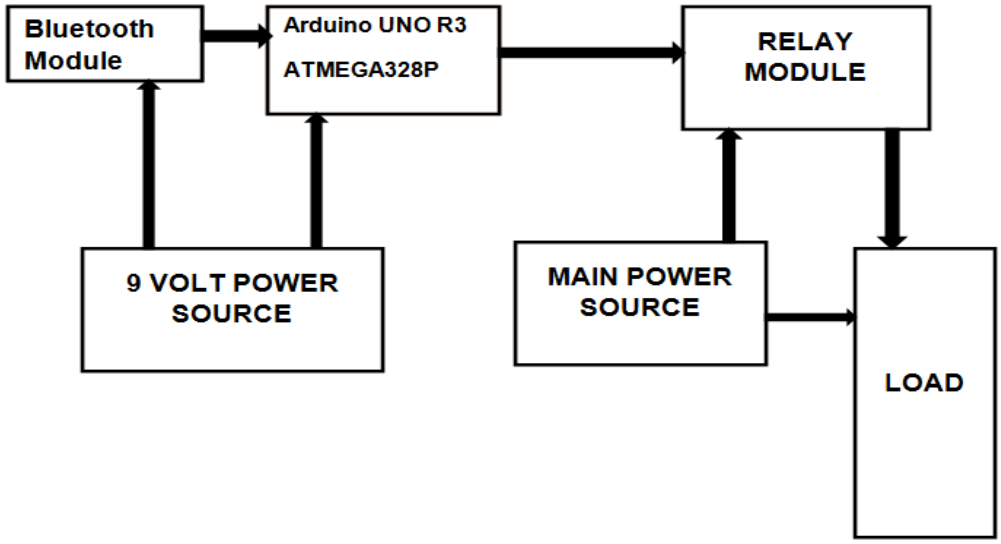


Figure 4: The Block diagram of the system.

Circuit Diagram

The Circuit diagram of the system is shown in Figure 5.

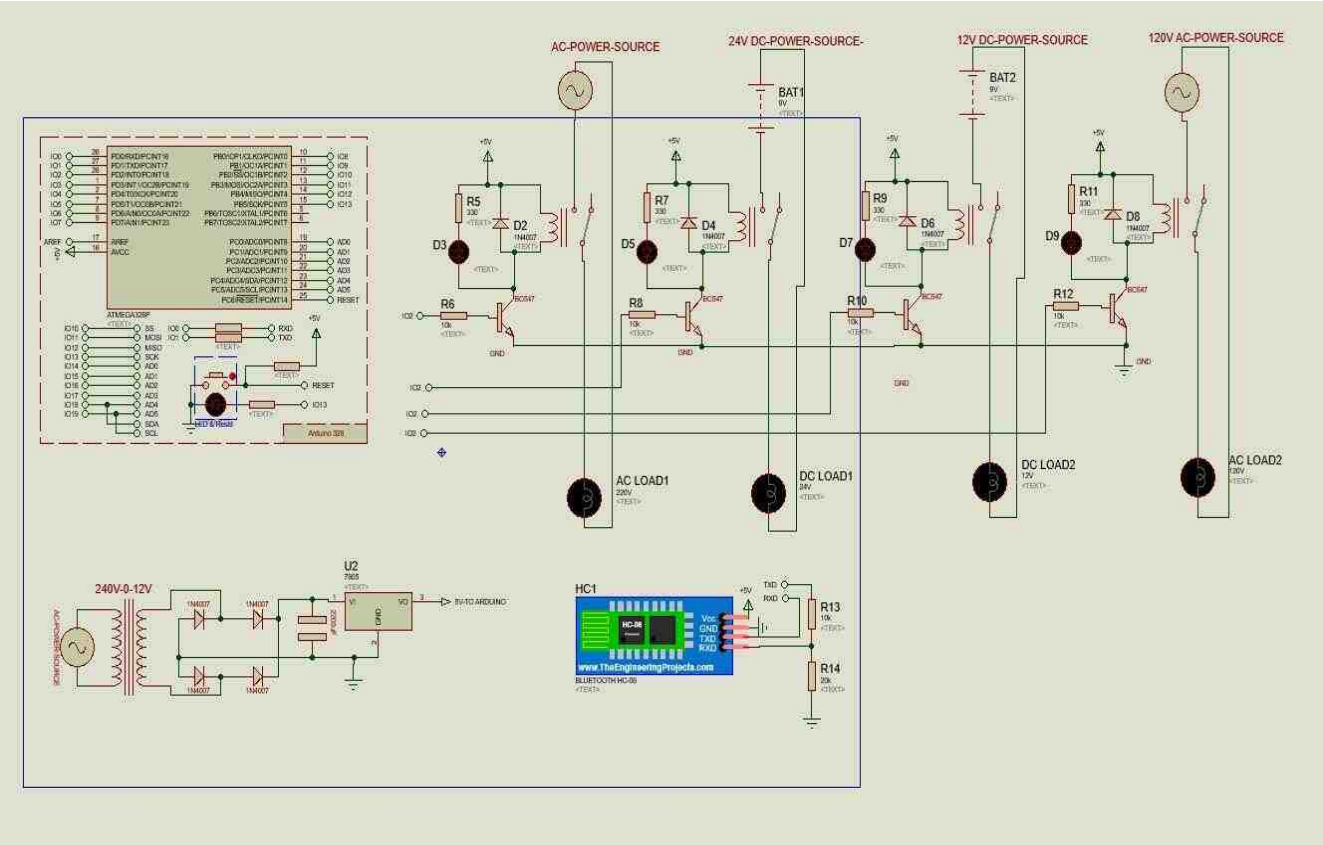


Figure 5: The Circuit diagram of the system

Implementation

The different components include a smart-phone or an Android mobile which should have the android app installed in it, Bluetooth receiver module – the project is connected to the smart-phone using Bluetooth technology, controller or the main processing circuit- In this project, Arduino UNO is the main controlling / processing unit, LCD Display – The liquid crystal display is optional but shows important messages like device status once command is received from Bluetooth, relay to control Devices – We have used 12volt single throw relays and output devices – For the demo purpose, we connected a DC devices to relay (12 volt DC bulb). One can connect any AC/DC devices to the remaining 3 relays.

Graphical User Interface (GUI)

The most important feature of our application is to hide several processes from the user while allowing some degree of interaction with the application. By using the GUI package, we were able to customize the application to include a variety of user interface elements such as text boxes, choice groups, alert messages, lists and command buttons. Figure 6 illustrates some designs for the graphical user interface.

Figure 6. Cell Phone GUI for controlling the home appliances

The system is secured for access from any user or intruder. The users are expected to acquire pairing password for the Arduino BT and the cell phone to access the home appliances. This adds a protection from unauthorized users. This system can be used as a test bed for any appliances that requires on-off switching applications without any internet connection.

The full functionality of the home automation system was tested and the wireless communication between the cell phone and Arduino BT was found to be limited to <50m in a concreted building and maximum of 100m range was reported to be applicable in an open range.

Figures 7 and 8 shows the Screen shots of the designed system

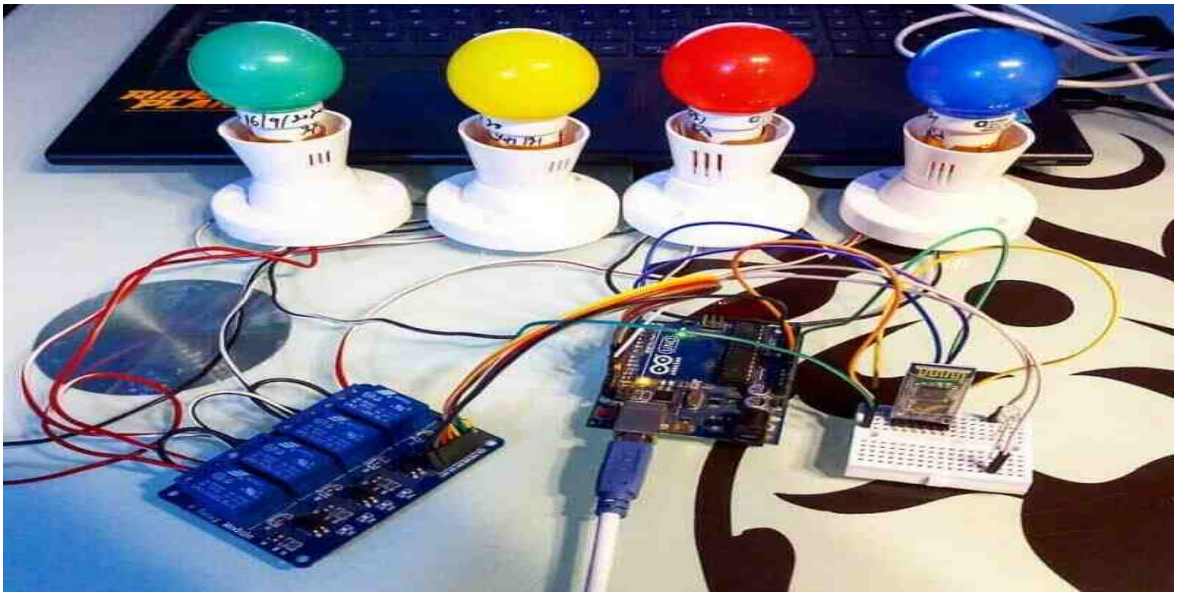
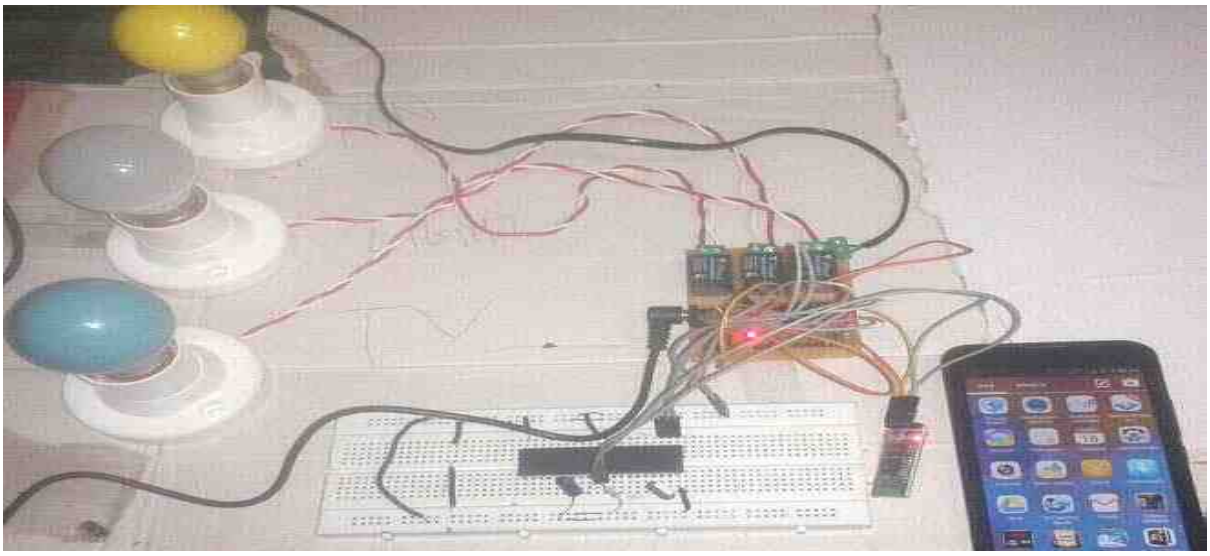


Figure 7: The Screen shots of the designed system



Figures 8: The Screen shots of the designed system using Cell phone

CONCLUSION

Arduino is designed to allow one execute code without all the fuss of dealing with an operating system since it does one thing at a time, it's easy to use. Smart Home Automation will show users how to make their homes automated using an android smartphone. It requires users to have no experience of android programming at all, as a free application is included. Using this android application, users will be able to control their lights, air conditioning, door locks, and more from their smartphones. This system uses Bluetooth to connect with our devices and control the various appliances in our homes. The smart home automation system has been experimentally proven to work satisfactorily by connecting sample appliances to it and the

appliances were successful controlled from a wireless Mobile device. The smart home automation using Arduino UNO makes the system more flexible and provides attractive user interface compared to other home automation systems. The Bluetooth client was successfully tested on a multitude of different mobile phones from different manufacturers, thus proving its portability and wide compatibility.

Conclusively, a low-cost smart home automation system has been successfully designed, implemented and tested.

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