# Design and Implementation of a Microcontroller Based Home Automation System

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**Abstract**

*Technology is a never ending process. To be able to design a product using the current technology that will be beneficial to the lives of others is a huge contribution to the community. This paper presents the design and implementation of a low cost but yet flexible and secure cell phone based home automation system. The design is based on a stand-alone Arduino BT board and the home appliances are connected to the output ports of this board via relays. The communication between the cell phone and the Arduino BT board is wireless. This system is designed to be low cost and scalable allowing variety of devices to be controlled with minimum changes to its core. Password protection (mobile phone password) is being used to only allow authorized users from accessing the appliances at home.*

**Keywords: Arduino Uno, Bluetooth module, Relays and Cell phone.**

## I. Introduction

A common definition of Home Automation is of an "electronic technology to integrate devices and appliances so that the entire home can be monitored and controlled centrally as a single machine (Pragnel et al. 2000). Another term that describes the same technology is "domotics", which derives from the Latin word domus, meaning home and "informatics" meaning the study of the processes involved in the collection, categorization, and distribution of data (Shiu, 2006).

However, since this technology is still very much in flux, other terms also used in the literature with equivalent meaning are: "smart home", "smart house", "digital home" or electronic home". Home automation is a principle which came into being due to unlimited possibilities it can offer. A lot has been done pertaining this theory with completely diverse methods at different times and places. The evolution of wireless technologies has offered so many opportunities to the scholars and researchers at large to go further into exploring different methodologies (Nisar et al., 2011).

Wireless communication has been used in industrial applications for more than 40 years (Ibrahim et al., 2009). Among the first applications was used in wireless control of Automated Guided Vehicles (Garlapti and Kassim, 2015). Using a wireless solution in industries Increases mobility eliminates expensive and maintenance-heavy transmission media such as flexible cables, swivels, etc. Overcoming large and problematic zones has to achieve fast and efficient installation and commissioning. Ensure personnel safety in hazardous areas (for instance, when needing to climb in a crane) by offering a control possibility from a further distance than can be the case with a cable.

Now with the embedded Bluetooth technology, digital devices form a network in which the appliances and devices can communicate with each other. Today, home automation is one of the major applications of Bluetooth technology (Piyare and Tazil, 2011). Operating over unlicensed, globally available frequency of 2.4GHz, it can link digital devices within a range of 10m to 100m at the speed of up to 3Mbps depending on the Bluetooth device class (Maditsha, 2017) and (Amirah et al., 2014). With this capability of Bluetooth; we propose a home automation system based on Bluetooth technology.

A relay is used to control the home appliances with the Arduino. The relays used in this system are 4 pin relays. The relays are normally in the closed state. For our use-case, we want to turn on the bulb only when we send a signal from a smartphone. That's the reason we connect the load on the NO (Normally Open) terminal, so that when the relay is triggered from the Arduino, the contact brush flicks from NC to NO terminal, thereby completing the circuit to electromagnetic induction.

There are few issues involved when designing a home automation system. The system should be scalable so that new devices can easily be integrated into it. It should provide a user- friendly interface on the host side, so that the devices can be easily setup, monitored and controlled. This interface should also provide some diagnostic services so that if there is any problem with the system, it can be tracked down. Moreover the overall system should be fast enough to realize the true power of wireless technology. Finally the system should be cost effective in order to justify its application in home automation.

## II. System Design

**Design Requirement:**

**Software:**

i. Arduino IDE; for programing the microcontroller
ii. Arduino Bluetooth 4CH: Bluetooth android app.

The Arduino IDE software was necessary for programing the microcontroller to perform the task of receiving and executing commands. The Bluetooth 4CH application was to enable communication between the mobile phone and the Arduino through the Bluetooth module attached to the Arduino.

**Hardware:**

i. Arduino Uno (microcontroller)
ii. Bluetooth module (hc-05)
iii. Relays (5v)
iv. Tumbler switches
v. Vero-board
vi. Jumper wires

**Hardware Architecture**

This home automation system consists of two main hardware components: the cell phone and the Arduino - BT board. The cell phone hosts the application which enables the user to access the home appliances and also the control commands for the appliances. This Bluetooth application communicates with the Arduino through the Bluetooth module and sets up an ad-hoc communication protocol between the two devices, which allows controlling the behaviour of the Arduino - BT board. Figure 1 shows the block diagram of the home automation system.

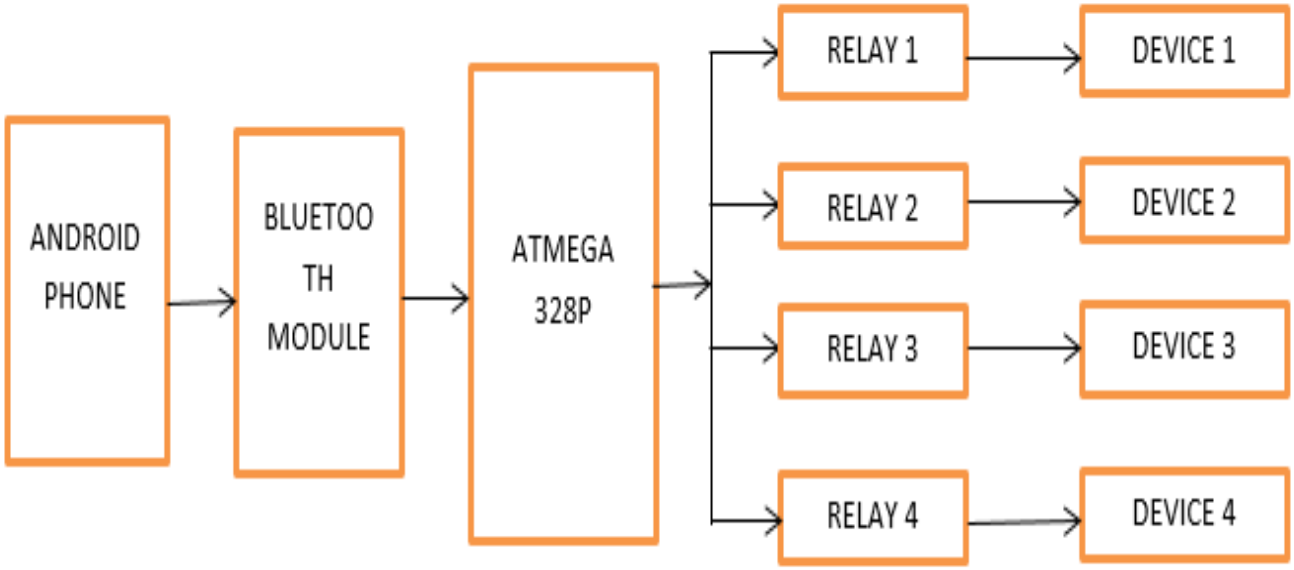


**Figure 1 Block diagram of the home automation system**

The Bluetooth antenna picks up the packets sent from the cell phone. Subsequently, these packets containing the appliance status commands are pipelined through ATmega328 microcontroller and the designed analogue circuitry according to the definition of each output. Different home appliances are connected to the digital output ports of the Arduino Uno board via relays to provide sufficiently high currents and voltage compatibility. The system circuit diagram as depicted in figure 2.

The microcontroller (ATmega328P**)** is a high performance yet low power consumption 8-bit AVR microcontroller that's able to achieve the most single clock cycle execution of 131 powerful instructions, thanks to its advanced RISC architecture. It can commonly be found as a processor in Arduino boards such as Arduino Fio and Arduino Uno.

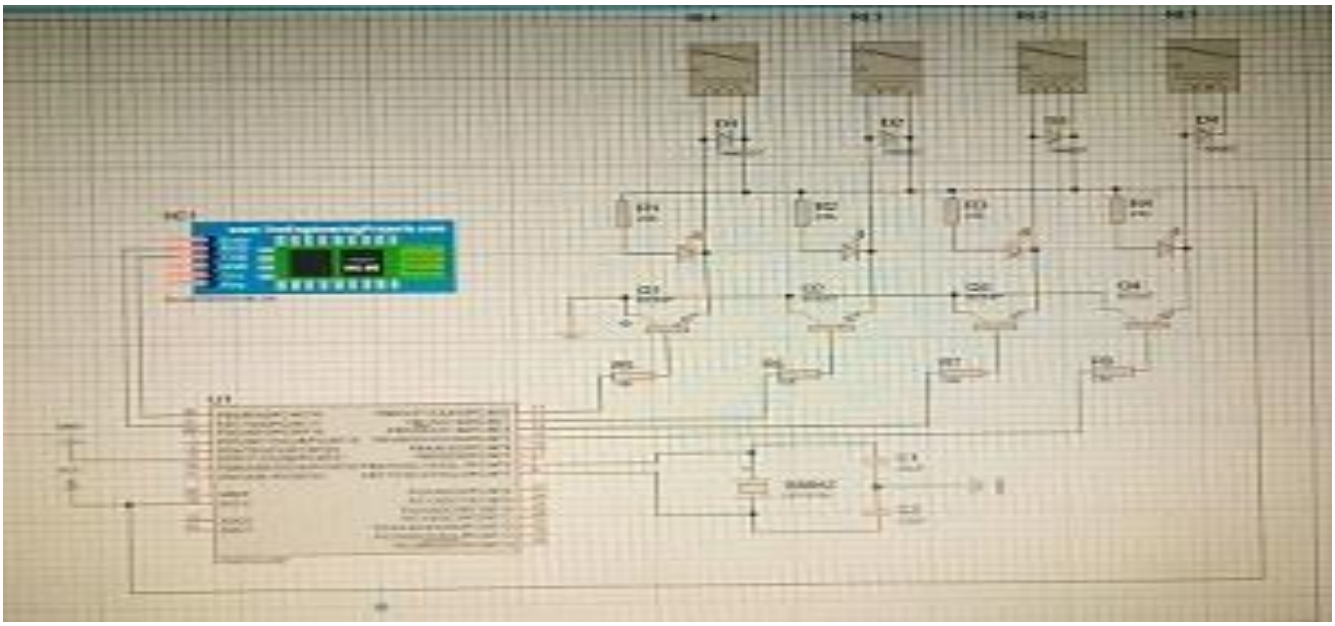

**Figure 2. System circuit diagram**

## III. Implementation

This paper is to lay the basic groundwork for controlling electrical loads using an Arduino controller and a smartphone. A communication medium between the user and the system is provided by the Bluetooth module, through a smartphone such as an Android and by sending a command from the smartphone. A person can send commands to the Bluetooth module through the Arduino's Bluetooth software application installed on the phone (Arduino Bluetooth 4CH).

a. Breadboard Layout

The circuit was first implemented on a breadboard under the following procedure before soldering. The breadboard layout is as shown in plate 1.

1. Connect 5V and GND pins of Arduino to the bus strips on the breadboard as shown in the circuit diagram of figure 3.

2. To connect HC-05 module with Arduino, insert its 5V and GND pins to the bus strips on the breadboard. Note: In case HC-05 module supports 3.3V, please power it using the 3.3 V supply from Arduino.

3. Connect the TXD pin on the HC-05 module with the RXD pin (Pin 0) of Arduino.

4. TXD on HC-05: Transmit data from the Bluetooth transceiver.

5. Pin 0 on Arduino (RXD): Receive data on Arduino two-way by connecting these pins, we are establishing two-way communication between Arduino and HC-05, so that we can turn the device on/off with the command properly.

6. Next, as the receiver data lines on HC-05 are 3.3V tolerant, we need to convert the 5V input signal from Arduino into a 3.3 V signal. While it can be achieved easily through a bi-directional logic level converter, we're using a voltage divider to convert the 5V input signal into a 3.3 V signal.

7. Voltage Divider: Connect 1k ohm and 2.2k ohm resistors across the GND and TXD on Arduino, and we obtain the 3.3 V tolerant input directly from the intersection of the two resistors.

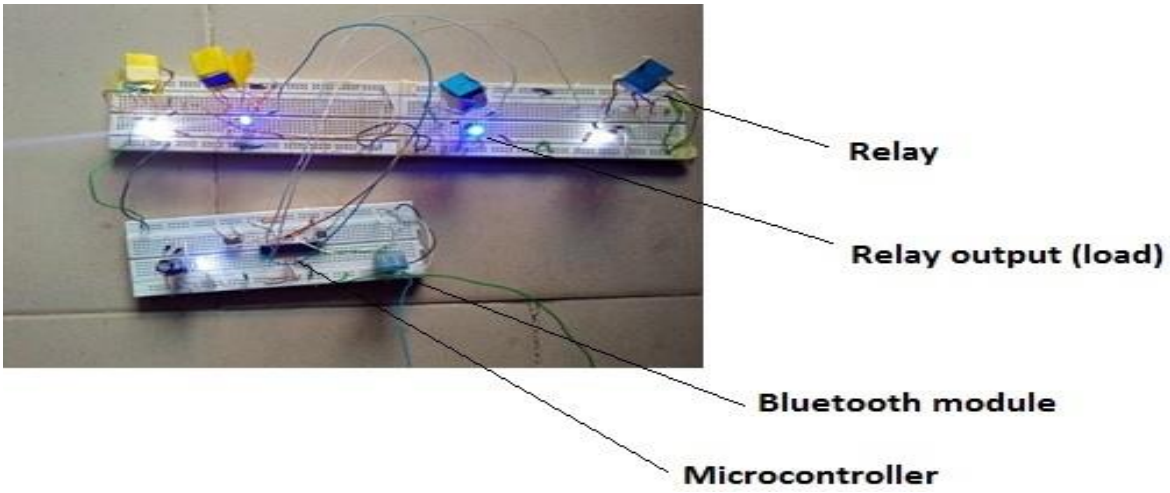


**Plate 1. Breadboard layout**

The system contain four relays for controlling four appliances simultaneously or otherwise. The four LEDs connected to the output of the relays serves as loads for demonstrating workability on breadboard.

b. Vero board layout

The last stage of the implementation process is vero board layout and soldering. The components were arranged on vero board and soldered for final packaging and testing. Plate 2 shows the vero board layout.

**Plate 2. Vero board layout**

## IV. Test and Result

The full functionality of the home automation system was tested and the wireless communication between the cell phone and Bluetooth module was found to be limited to 50m or less without line of sight (LOS), and up to a distance of 100m with line of sight between mobile phone and Bluetooth module. A 60w filament lamp was used for testing the system output, all the four outputs were tested using the lamp and the system successfully powered and controlled the lamp. The test set up is as depicted in plate 3.

**Plate 3. The home automation system under test**

## V. Conclusion

In this paper, we have explored how to control a lamp, fan, or any other electrical appliance in our space (homes) using an Arduino and a Bluetooth module. At the end, the device successfully control the connected load using a smartphone.

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