# DEVELOPMENT OF A BLUETOOTH-BASED HOME AUTOMATION SYSTEM USING ARDUINO

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# DEVELOPMENT OF A BLUETOOTH-BASED HOME AUTOMATION SYSTEM USING ARDUINO

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the Requirements in
Research 3

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## ABSTRACT

Technology has advanced significantly to the point that it has revolutionized the way we live. It helps reduce work, causing our lives to become more convenient. This paper presents the implementation of a more affordable and efficient home automation system which can be accessed on a mobile application through Bluetooth technology (HC-05) by utilizing an Arduino microcontroller (Arduino Uno R3). The devices and appliances connected to the system can be accessed through the mobile application, which sends the command to Arduino through Bluetooth. The Arduino controls the components connected to the system and was programmed with the Arduino programming language by using its Integrated Development Environment (IDE).

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# INTRODUCTION

## Background of the Study

People have been gaining interest in home automation systems these recent years. Home automation refers to the automatic control of your household appliances or devices, such as lighting and fan systems, through the use of a mobile device. Home automation systems are used to improve the experience of comfort, convenience, and quality of life of certain individuals. By being able to control appliances through a mobile device, they can reduce the human labor that is normally needed inside the household (Asadullah & Raza, 2016). However, most of the popular home automation systems cost a great amount of money due to the materials and the labor required to install them inside a home. Hence, reputable companies such as Google and Amazon have provided low-cost alternatives by producing portable devices that can also control smart devices the same way as a home automation system does. These devices however still have limited abilities in controlling smart devices. Because of this, people have resorted to using another low-cost alternative, which is by using Arduino. Arduino is an open-source electronics platform used to create interactive electronic objects (Arduino, n.d.). With the use of its hardware and software, people have developed home automation systems that are similar to the expensive alternatives. There still lies the problems on the features required such as the type of network connection and the controller that will be the most convenient for the user.

## Objectives of the Study

This project aims to develop a cheap home automation system alternative that uses an Arduino board as its microcontroller to automate devices connected to the board. The specific tasks required in doing the project are as follows:

- To test the wireless connectivity of the HC-05 Bluetooth module
- To test the sensitivity of the MQ2 Gas Sensor
- To build and program the circuit and test the system as a whole

## Significance of the Study

This project can help in developing a technology that can improve homeowners' experience of comfort inside the household. This project can help other people like hobbyists or engineers in creating their own home automation systems. This can also help those people in understanding the concept of home automation systems. The project can help in providing ideas and mechanisms on how to automate every device that they are interested in. Lastly, this project can give knowledge on the uses and function of an Arduino board which can lead other researchers or engineers in creating projects that can help improve the quality of life in the world with an Arduino board as one of the main components.

**Scope and Limitations of the Study**

Among the variety of Arduino boards, this project will utilize the use of Arduino Uno R3 board as the main circuit board of the system. The Arduino board will be programmed using Arduino's own programming language and IDE. The mobile application will be developed using the MIT App Inventor 2. The mobile application will only be available for Android devices. The system will be using a Bluetooth connection for the wireless control of the system.

## REVIEW OF RELATED LITERATURE

Automation performs an increasingly vital role in daily experience and the global economy. Engineers strive to combine automated devices with mathematical and organizational tools to create complex systems for a rapidly expanding range of applications and human activities (Malik & Bodwade, 2017). An internet-based home automation system focuses on controlling home electronic devices irrespective of whether someone is inside or outside of the house. (Das et al., 2016).

The home automation system that Chandramohan et al. (2017) developed constitutes an automatic lamp, fan, and AC control. It utilizes light-dependent resistors and temperature sensors and uses Wi-Fi connectivity for mobile control. Wadhwanni et al. (2018) also built their own home automation system that is composed of flex sensors for controlling the appliances, an accelerometer for automatic controls of a door, a magnetic sensor for lock breaks alert, and a flame sensor for fire alert. They also used Wi-Fi connectivity for mobile monitoring and control. Shinde et al. (2017) on the other hand used GSM for monitoring through SMS and both IR and Bluetooth connectivity for mobile control. Their home automation system is composed of only light bulbs that can be controlled through a mobile application that is developed using the MIT App Inventor. All of the said home automation systems use Android as their OS for the mobile app.

A survey of different home automation systems shows that there are various kinds of technologies used to implement this type of system. All the proposed systems have been presented and compared in this paper which reveals some merits and demerits of the systems (Malik & Bodwade, 2017). The objective of this literature review is to compare

and determine the best and most convenient way to access the home automation system, and what modules and microcontrollers are most suitable for a home automation system. In the survey, a Bluetooth-based home automation system is found to be secure and low-cost and can be applied for controlling devices that are connected to the main circuit board.

Other researchers have also tried to use other means to connect to the home automation system, such as Zigbee and BlueTooth. Das et al. (2016) used Bluetooth Module HC-05 to transmit the set of instructions to the Arduino through which the Arduino generates the set of output signals which, in turn, controls different devices via drives. Shah et al. (2017) utilized PIC24F Microchip microcontroller to use as coordinator and PIC18F Microchip microcontroller to use as End device, to access the home automation system through Zigbee.

A study by Asadullah & Raza (2016) compared home automation systems with different types of communication techniques and network connectivity. It featured Wi-Fi and Bluetooth as one of the types of network connectivity. It has been found in the comparison that Bluetooth costs less and has a higher communication rate compared to Wi-Fi. However, the limited range of approximately 10 meters is said to be one of the main disadvantages of Bluetooth as opposed to Wi-Fi connectivity.

# METHODOLOGY

## Procurement of Materials

There were 2 ways of procuring the materials needed for the project: by purchasing them through walk-in stores in Iligan City, Lanao del Norte and through online shopping platforms.

The first material that the researchers tried to procure was the Arduino Uno board as it is the most important material in this project. It was purchased on an online shopping platform called Shopee. The Arduino board came in a learning kit that also contained other necessary materials for the project. Specifically, those were: the (1) LED lights, (2) solderless breadboard, (3) jumper wires, and (4) buzzer. After procuring those materials, the researchers started to search for the sensor and modules in Iligan City. Unfortunately, those materials were not available in every electronics store that the researchers went into. Due to the unavailability of those materials, the researchers opted to purchase the following materials on Shopee: (1) HC-05 Bluetooth Module, (2) MQ2 Gas Sensor, and (3) 8-Channel 5V Relay Module. The light bulbs, fans, terminal blocks, and flat cord were purchased in an electronics store. For the plywoods, the researchers used the unused plywoods that are found in their homes.

## Mobile Application Development

The mobile application was created through the use of MIT App Inventor, a visual programming environment that allows us to build functional mobile applications for

Android phones for free. The switches were created by arranging the command blocks in a way that it sends a code to the microcontroller when turned on.

The mobile application is able to send commands to the Arduino Uno with the use of the Bluetooth Extension of MIT App Inventor. The blocks were arranged so that when switch 1 is turned on, it sends the uppercase 'A' to the microcontroller, and the lowercase 'a' when switch 1 is turned off. When switch 2 is turned on, it then sends the uppercase 'B' to the microcontroller, and the lowercase 'b' when turned off. This goes on until switch 6, and up to the letter 'F' since 6 devices were connected to the system. The 3 lightbulbs were connected to switches 1-3, and the fans were connected to switches 4-6. On the bottom part of the mobile application, there is a button which the user can use to manually turn off the buzzer. When the button is pressed, it sends the uppercase ‘G’ to the microcontroller. The Arduino Uno then interprets that command and interacts with the appliances depending on the code and the circuit of the system.

The Graphical User Interface (GUI) design was also created by utilizing the functions of the website. The layout extension of the website provides a user-friendly interface that is convenient for designing the application and the arrangement of the switches. The six switches were separated into three rectangles, with each rectangle having two switches each, one for the lightbulb and another one for the fan.

**Testing of HC-05 Bluetooth Module**

In testing the HC-05 Bluetooth module, the researchers connected the Bluetooth module to the Arduino Uno board first. In this test, the signal strength of the Bluetooth connection will be collected. The method in getting the signal strength of the Bluetooth is

through its Received Signal Strength Indicator (RSSI) value. The researchers also used a third-party mobile application called Bluetooth Signal Meter that was published by Edgar Garcia Leyva. This mobile application can detect Bluetooth connections and get their intensity signal or their RSSI value. The setup for this test consists of 4 different ranges/distances from the Bluetooth module. First, the close range (0-1 m), then the mid range (1-4 m), then the long range (4-8 m), and lastly the limit range (8-12 m). In each range, the RSSI value of the Bluetooth module will be collected. This is to measure how well the Bluetooth module can be used as the wireless connection for the home automation system.

**Testing of MQ2 Gas Sensor**

For the testing of the MQ2 Gas Sensor, the sensor was first connected to the Arduino board. The testing utilized Arduino's own serial monitor in order to read what the sensor is able to read in the atmosphere. Different gases are tested. The unit equivalent in Arduino of the different gases as the sensor sensed them was recorded. These were done in order to get the sensitivity threshold that will be used for the system.

**Hardware / Building the Circuit**

The Arduino Uno board is powered by an AC-DC 9V adapter through the port. Electronic parts were connected using jumper wires. For the HC-05 Bluetooth module, the VCC pin is connected to the 5v pin, the TX and RX to digital pins 0 and 1 respectively, and the GND pin to the GND pin of the Arduino Board. For the gas sensor, the VCC pin

is connected to the 5v pin, the GND pin to the GND pin of the Arduino board, and lastly the analog pin to the A0 pin of the Arduino board. For the buzzer, the positive terminal is connected to digital I/O pin 13, and the negative terminal would be connected to the GND pin of the Arduino board. The 8-channel 5v Relay Module is powered by an AC voltage source. Each light bulb and fan is connected to a channel of the relay module. The digital I/O pins used for each channel are pins 2, 4, 7, 9, 11, and 13. The GND pin of the relay module is connected to the GND pin of the Arduino board while the VCC pin is connected to the 5v pin.

**Software / Programming**

The program of the home automation system was coded using the Arduino programming language and the Arduino Integrated Development Environment (IDE). There are 2 major parts in the program.

At the top of the code for the program is the assignment of the digital I/O pins to their respective variable names for easy readability. The first major part is the block of code that runs only once the moment the Arduino board is powered on. In that particular code block, the following are the tasks to be done by the system. First is the setting of data rate to 9600 bits per second which is the default data rate for HC-05 Bluetooth transmission. Next is the configuring of the digital I/O pins of the light bulbs and fans to behave as an output and setting their starting voltage to 0V.

The second major part of the program is the block of code inside the loop function. The code inside this block is executed in a loop that will not stop unless the Arduino board is powered off. For the light bulbs and fans, the program will first find for a signal from

the Bluetooth module. The program will then read the value of the signal from the Bluetooth module. In this system, the signal can be received by the Bluetooth module from the mobile controller using the mobile app that was developed. If there is no input from the mobile controller, then the Bluetooth module will receive a null signal. However, if a command is given by the mobile controller, the Bluetooth module will receive the command and the program will read the signal from the Bluetooth module. The program will then control the device that is connected to the certain digital I/O pin that corresponds to the command read by the program. While these are all happening, the Gas sensor also senses the amount of gases and smoke around it at the same time. If the amount of gas reaches the set sensitivity threshold, it will make the buzzer ring.

**Building of Housing Prototype and Installation of Home Automation System**

The housing prototype was built using plywoods. Three 1x3 ft and four 1x1 ft plywoods were used. After assembling the plywoods, three cube rooms were formed. In each cube room, one fan is placed at the ceiling of the room while one light bulb is placed at the floor of the room. The gas sensor is placed at the ceiling of the middle room. The circuit is placed at the back of the housing. Holes were drilled on the plywoods to give allowance for the wirings.

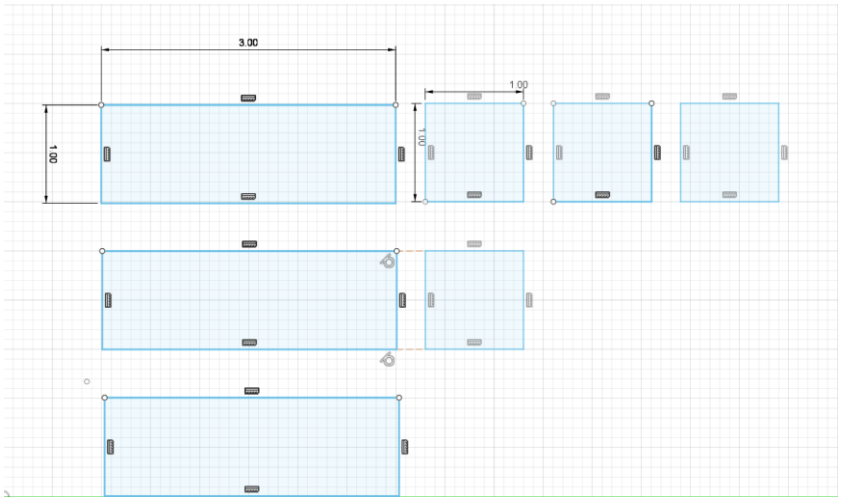


*Figure 1.1* Dimensions of the plywood cutouts (in meters) for the housing

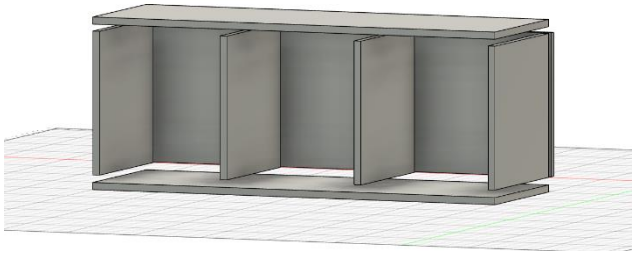

*Figure 1.2* Diagram of the assembly of the cutouts for the housing of the system

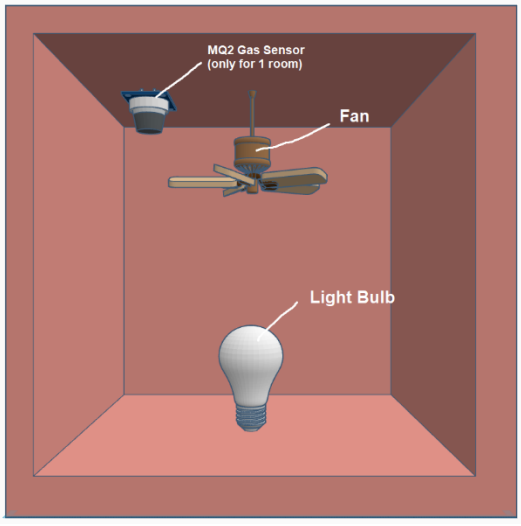


*Figure 2* Placement of the devices in each cube room

**Testing of the Home Automation System**

In testing the fully-assembled home automation system, the researchers made use of a functionality test for the system. The researchers used the same setup from the testing of the HC-05 Bluetooth module where the Bluetooth connectivity was tested in different ranges. In the functionality test, it will also be using the same four different ranges which are the close range (0-1 m), the mid range (1-4 m), the long range (4-8 m), and the limit range (8-12 m). In each range, all combinations of devices will be attempted to be turned on using the mobile application controller developed. The devices that function were noted as the test is replicated in each range.

## RESULTS AND DISCUSSION

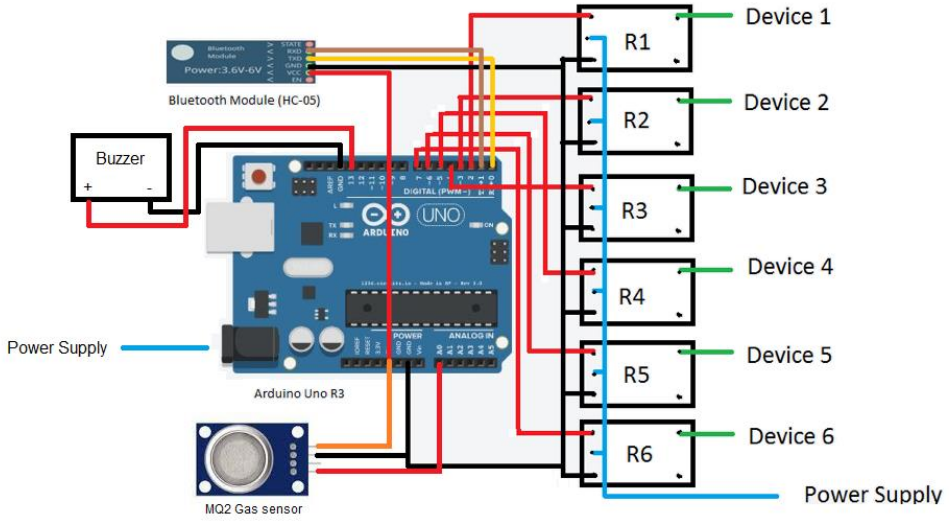


*Figure 3* Circuit diagram of the Home Automation System

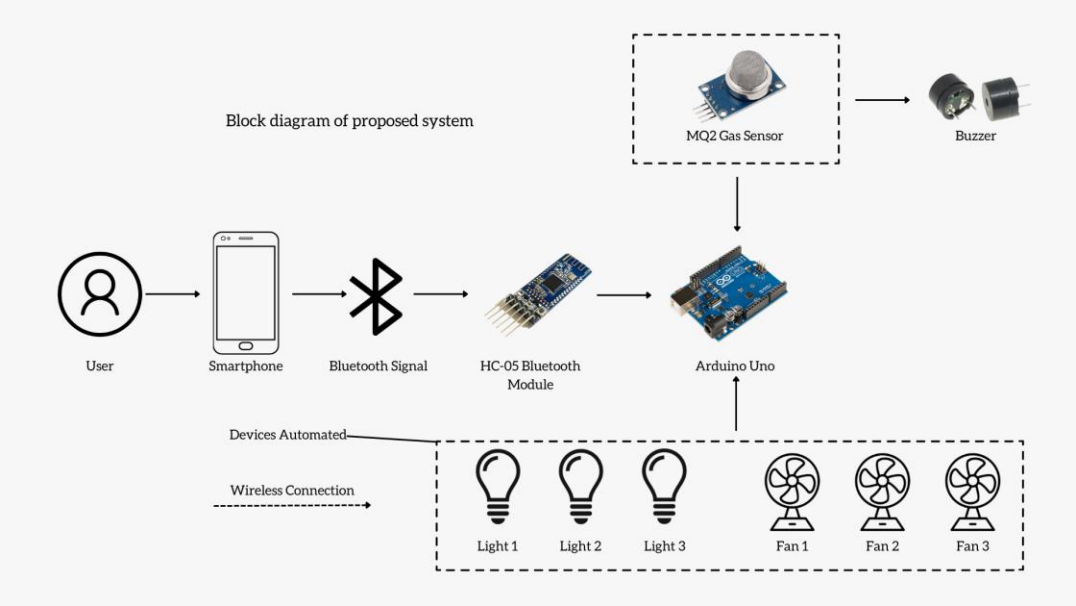


*Figure 4* Block Diagram of the Home Automation System

The developed home automation system behaves in a way that when a user sends a command, whether it is to turn on a light bulb or turn off a light bulb, the mobile controller used (smartphone in this project) sends out a Bluetooth signal to the HC-05 Bluetooth

module. The Bluetooth module then sends instructions to the Arduino board based on the signal received. If the command given by the user was to to turn on light bulb 1, then Arduino turns on the light bulb 1 that is connected to the board itself. See Figure 5 for the flow chart of the system where it shows the commands the user can give to the Arduino board.

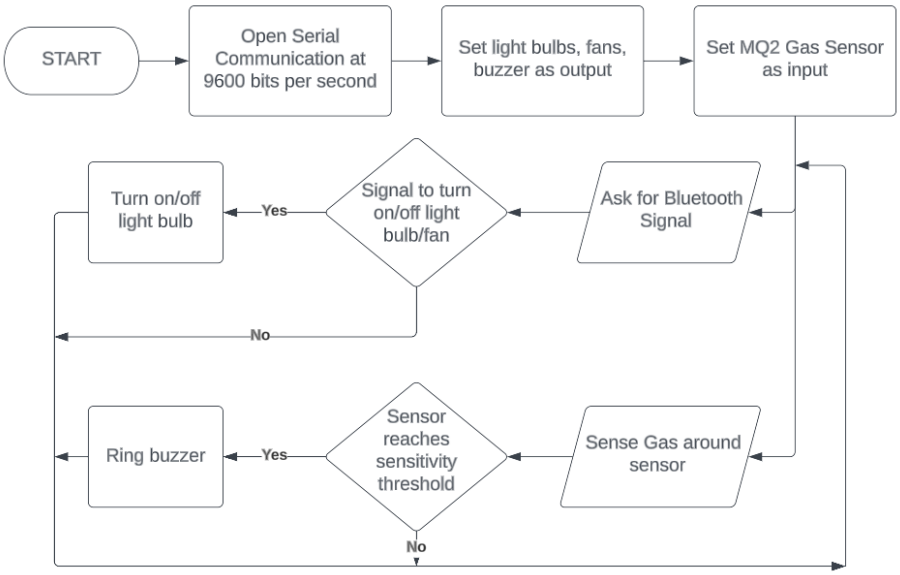


*Figure 5* Flow Chart of the Program

Before evaluating the functionality of the home automation system, the signal strength of the HC-05 Bluetooth module and the sensitivity of the MQ2 gas sensor were first tested. After that, a functionality test was performed on the fully-built home automation system.

**HC-05 Bluetooth Module Testing**

The HC-05 Bluetooth module was tested by measuring the signal strength of the Bluetooth module at certain distances. Using the mobile application Bluetooth Signal

Meter, the following RSSI values, measured in decibels per milliwatt (dBm) were collected from the test:

| | Close Range | | Mid Range | | | Long Range | | | | Limit Range | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **0m** | **1m** | **2m** | **3m** | **4m** | **5m** | **6m** | **7m** | **8m** | **9m** | **10m** | **11m** | **12m** |
| **Reading #1** | -33 | -49 | -52 | -78 | -76 | -78 | -88 | -89 | -86 | -82 | -87 | -86 | N/A |
| **Reading #2** | -29 | -46 | -54 | -76 | -72 | -85 | -84 | -82 | -78 | -87 | -84 | -87 | N/A |
| **Reading #3** | -34 | -53 | -56 | -69 | -83 | -83 | -85 | -84 | -77 | -93 | -89 | -87 | N/A |
| **Reading #4** | -31 | -46 | -60 | -77 | -77 | -86 | -84 | -83 | -79 | -86 | -87 | -88 | N/A |
| **Reading #5** | -28 | -47 | -62 | -79 | -79 | -85 | -83 | -88 | -80 | -84 | -90 | -86 | N/A |
| **Average** | -31 | -48.2 | -56.8 | -75.8 | -77.4 | -83.4 | -84.8 | -85.2 | -80 | -86.4 | -87.4 | -86.8 | N/A |

*Table 1* Returned Signal Strength Indicator (RSSI) values measured in dBm

A greater negative value of RSSI indicates a weaker signal. As the distance between the receiving device and the Bluetooth module increases, the weaker the signal gets as observed from the table. The average RSSI values of the distances in the close range and mid range indicate that the signal strength in these distances are strong, unlike the distances in long range and limit range which have reached the 80 dBm mark indicating that a weaker signal can be received in these distances. Upon reaching the 12 meter distance, the mobile application used in determining the signal strength of the Bluetooth module was not able to detect a Bluetooth connection to the module anymore, which indicates that the Bluetooth module is only able to provide wireless connection for up to 12 meters in distance.

**MQ2 Gas Sensor Testing**

The MQ2 Gas Sensor was first exposed to normal air condition to know the analog value of the sensor when it is not exposed to any gases or smoke. It was then exposed to smoke and butane to test if the sensor is able to detect these gases.

| **Serial Monitor Reading (Analog Value 10-bit data)** | **Type of Gases** | | |
|---|---|---|---|
| | **No exposure** | **Smoke** | **Butane** |
| **Reading #1** | 30 | 213 | 812 |
| **Reading #2** | 29 | 226 | 886 |
| **Reading #3** | 28 | 213 | 926 |
| **Reading #4** | 27 | 178 | 913 |
| **Reading #5** | 26 | 184 | 712 |
| **Reading #6** | 25 | 193 | 800 |
| **Reading #7** | 24 | 198 | 845 |
| **Reading #8** | 23 | 196 | 891 |

| Serial Monitor Reading (Analog Value 10-bit data) | Type of Gases | | |
|---|---|---|---|
| | **No exposure** | **Smoke** | **Butane** |
| **Reading #9** | 22 | 242 | 959 |
| **Reading #10** | 22 | 233 | 961 |
| **Average** | **23.4** | **207.6** | **870.5** |

*Table 2* Sensor Analog Values of Detected Gases

As observed from the table, the MQ2 Gas Sensor was able to sense both smoke and butane based on the huge changes on the analog value compared to when it was not exposed to any of the two. The sensor was able to sense smoke with an average analog value of 207.6 units while it was able to sense butane with an average analog value of 870.5 units. Based on the data collected, the sensor can sense butane stronger than smoke. Although the detected smoke has a lower analog value compared to the detected butane, the analog value of the smoke is still greater than the analog value of the sensor when it is not exposed to any of the two. This means that the smoke was still detected by the sensor despite it having less analog values than butane.

**Home Automation System Functionality Test**

In testing the fully-built home automation system, a set of commands were given by a user. There are 13 commands in total in one trial, and these are: turning on, then off of the light bulbs and fans (since there are 3 each, there would be a total of 12 commands with this alone) and turning off the buzzer when the buzzer is set to ring. The accuracy of the system is given by the formula:

accuracy = number of commands executed / number of commands given

| Distance | Fan | | | Light | | | Gas Sensor | Number of Commands Given | Number of Commands Executed | Accuracy |
|---|---|---|---|---|---|---|---|---|---|---|
| | #1 | #2 | #3 | #1 | #2 | #3 | | | | |
| 0 m | / | / | / | / | / | / | / | 13 | 13 | 100% |
| 1 m | / | / | / | / | / | / | / | 13 | 13 | 100% |
| 2 m | / | / | / | / | / | / | / | 13 | 13 | 100% |
| 3 m | / | / | / | / | / | / | / | 13 | 13 | 100% |
| 4 m | / | / | / | / | / | / | / | 13 | 13 | 100% |
| 5 m | / | / | / | / | / | / | / | 13 | 13 | 100% |
| 6 m | / | / | / | / | / | / | / | 13 | 13 | 100% |

| Distance | Fan | | | Light | | | Gas Sensor | Number of Commands Given | Number of Commands Executed | Accuracy |
|---|---|---|---|---|---|---|---|---|---|---|
| | #1 | #2 | #3 | #1 | #2 | #3 | | | | |
| **7 m** | / | / | / | / | / | / | / | **13** | **13** | **100%** |
| **8 m** | / | / | / | / | / | / | / | **13** | **13** | **100%** |
| **9 m** | / | / | / | / | / | / | / | **13** | **13** | **100%** |
| **10 m** | / | / | / | / | / | / | / | **13** | **13** | **100%** |
| **11 m** | / | / | / | / | / | / | / | **13** | **13** | **100%** |
| **12 m** | x | x | x | x | x | x | x | **N/A** | **N/A** | **N/A** |

*Table 3* Functionality Testing / Command Accuracy of System

All distances (except for the 12-meter distance which is the distance at which the Bluetooth cannot be detected anymore) have reached a 100% accuracy on the commands given to the system by the user. This means that in all instances where the mobile controller was able to connect to the Bluetooth connection, all commands given by the user were executed by the fully-built home automation system.

# CONCLUSION

The development of a Bluetooth-based home automation system using Arduino is a significant contribution to the field of home automation and engineering as a whole. The result of the project offers a user-friendly, cost-efficient, and fully-customizable home automation system.

The creation cost of a home automation system has been significantly reduced with the use of free and easily-accessible platforms. After undertaking multiple tests, it has been proved that Arduino does its job in making the system work well, making it a suitable and more affordable replacement as a microcontroller for current home automation systems.

The findings of the study show that the project created was fully-functional, demonstrating the potential of Arduino and its open-source hardware and software that can be easily customized and accessed by anyone.

Overall, this research provides an approach for home automation that is not just suitable for the elderly and handicapped people but it is also beneficial in reducing human labour and saving energy with the help of devices and sensors automated.

## RECOMMENDATIONS

For future research works, it is recommended to use many different kinds of sensors to see the maximum potential Arduino can bring to developing home automation systems while still maintaining it to be a low-cost alternative. It is also recommended to try out different types of wireless communication such as Zigbee and Wi-Fi to compare their capabilities with each other. Finally, the researchers recommend to have a primary objective of helping people in need when doing projects such as this in order to provide service by making their lives more comfortable.

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## APPENDIX A

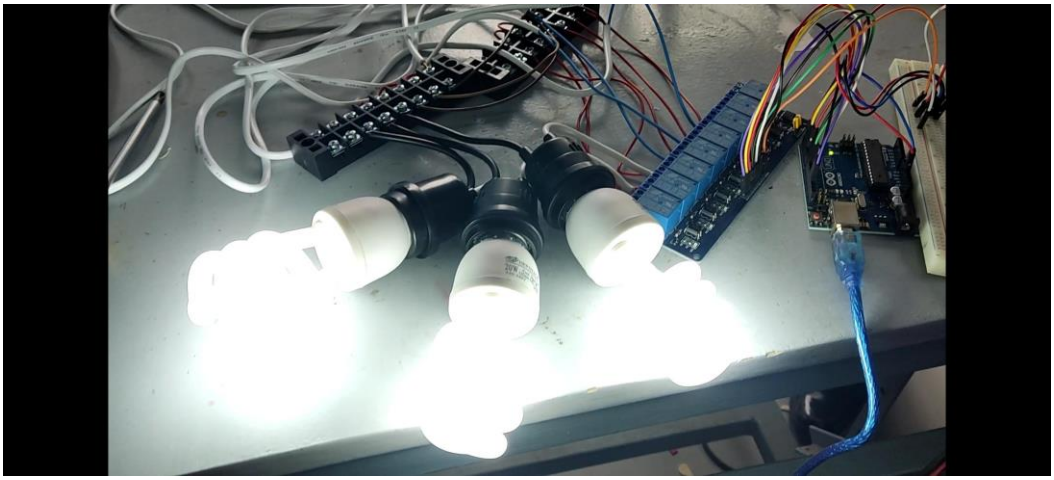

*Figure A.1* Image of Home Automation System Testing

*Figure A.2* Image of Testing the MQ2 Gas Sensor's Response to Smoke

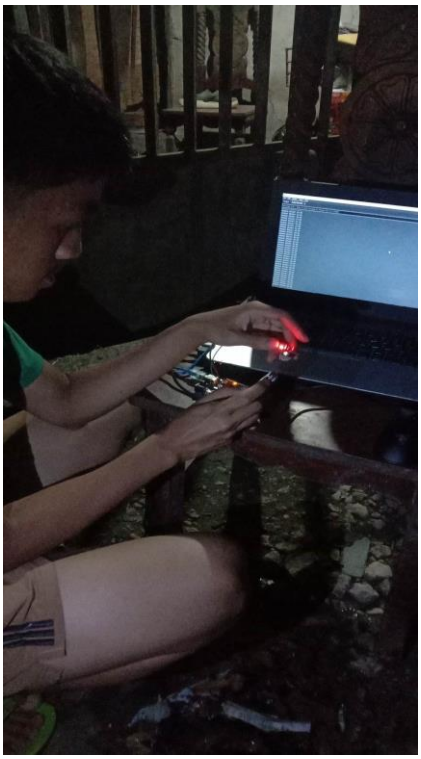

*Figure A.3* Image of Testing the MQ2 Gas Sensor's Response to Butane

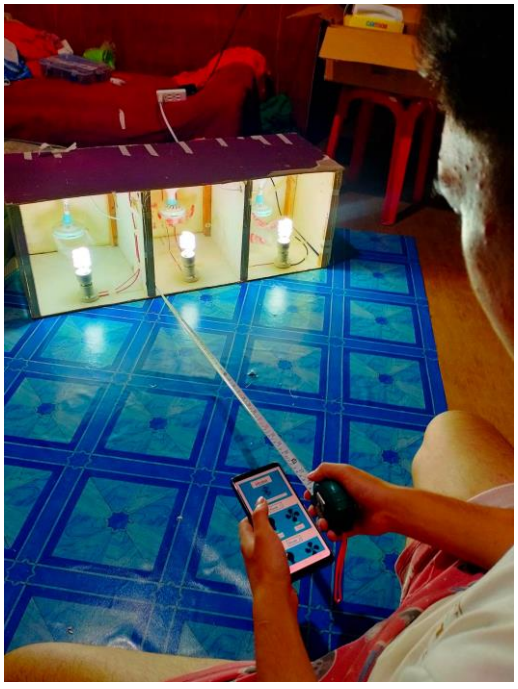

*Figure A.4* Image of Measuring the Reach of the System

## APPENDIX B

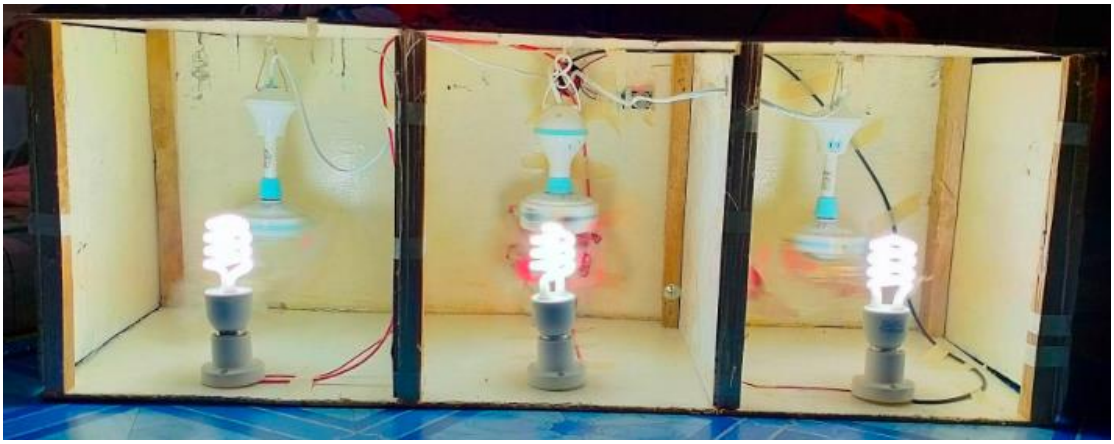

*Figure B.1* Front View Image of the Home Automation System with Housing

*Figure B.2* Back View Image of the Home Automation System with Housing

## APPENDIX C

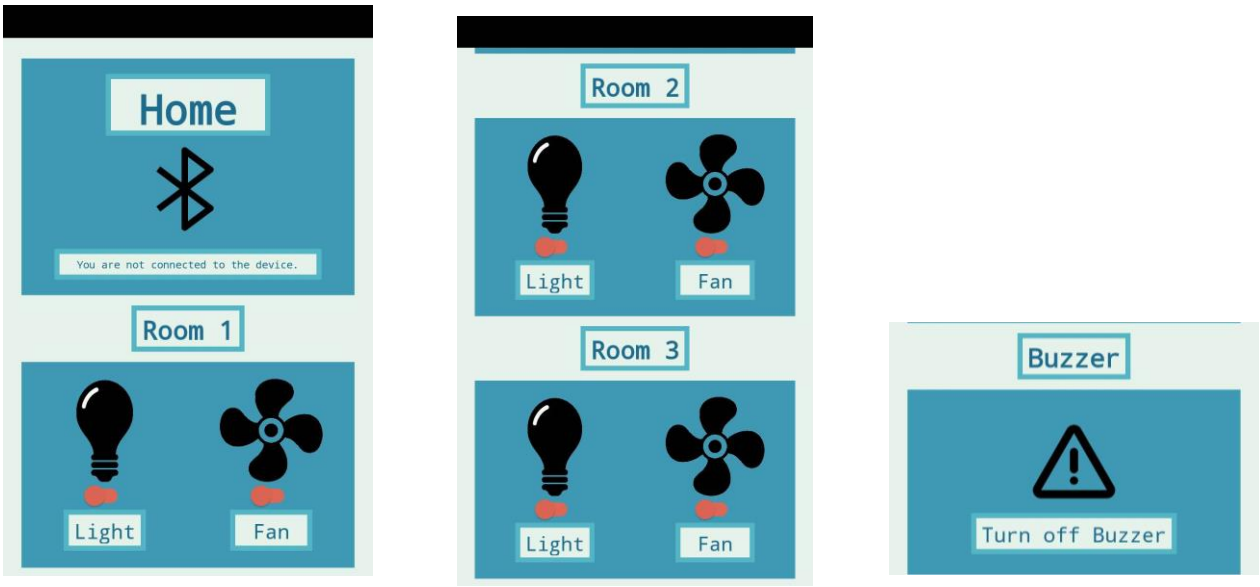


*Figure C.1* Images of the Arduino Home Automation System (AHAS) Application

# APPENDIX D



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# HC-05

## -Bluetooth to Serial Port Module

## Overview

HC-05 module is an easy to use Bluetooth SPP (Serial Port Protocol) module, designed for transparent wireless serial connection setup.
Serial port Bluetooth module is fully qualified Bluetooth V2.0+EDR (Enhanced Data Rate) 3Mbps Modulation with complete 2.4GHz radio transceiver and baseband. It uses CSR Bluecore 04-External single chip Bluetooth system with CMOS technology and with AFH(Adaptive Frequency Hopping Feature). It has the footprint as small as 12.7mmx27mm. Hope it will simplify your overall design/development cycle.

## Specifications

### Hardware features

- Typical -80dBm sensitivity
- Up to +4dBm RF transmit power
- Low Power 1.8V Operation ,1.8 to 3.6V I/O
- PIO control
- UART interface with programmable baud rate
- With integrated antenna
- With edge connector

### Software features

- Default Baud rate: 38400, Data bits:8, Stop bit:1,Parity:No parity, Data control: has. Supported baud rate: 9600,19200,38400,57600,115200,230400,460800.
- Given a rising pulse in PIO0, device will be disconnected.
- Status instruction port PIO1: low-disconnected, high-connected;
- PIO10 and PIO11 can be connected to red and blue led separately. When master and slave are paired, red and blue led blinks 1time/2s in interval, while disconnected only blue led blinks 2times/s.
- Auto-connect to the last device on power as default.
- Permit pairing device to connect as default.
- Auto-pairing PINCODE:"0000" as default
- Auto-reconnect in 30 min when disconnected as a result of beyond the range of connection.

## Hardware

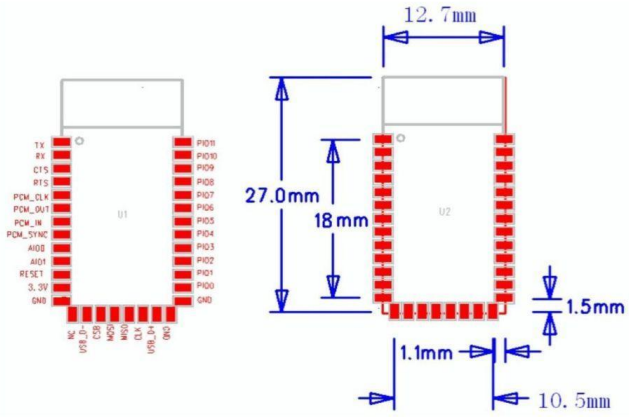





*Figure D.1* HC-05 Bluetooth Module Data Sheet

# MQ-2 Semiconductor Sensor for Combustible Gas

Sensitive material of MQ-2 gas sensor is $SnO_2$, which with lower conductivity in clean air. When the target combustible gas exist, The sensor's conductivity is more higher along with the gas concentration rising. Please use simple electrocircuit, Convert change of conductivity to correspond output signal of gas concentration.

MQ-2 gas sensor has high sensitity to LPG, Propane and Hydrogen, also could be used to Methane and other combustible steam, it is with low cost and suitable for different application.

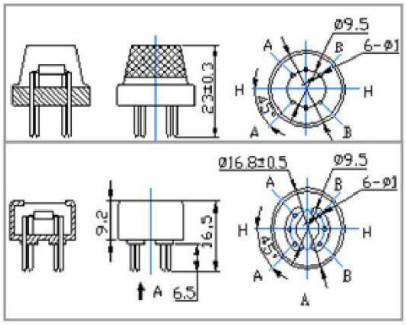
## Character

*Good sensitivity to Combustible gas in wide range
* High sensitivity to LPG, Propane and Hydrogen
* Long life and low cost
* Simple drive circuit

## Application

* Domestic gas leakage detector
* Industrial Combustible gas detector
* Portable gas detector

## Configuration

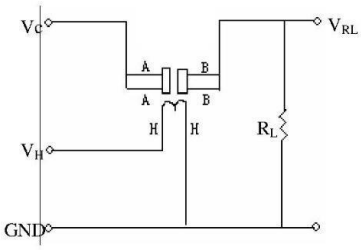



## Technical Data

| | | | |
|---|---|---|---|
| Model No. | | | MQ-2 |
| Sensor Type | | | Semiconductor |
| Standard Encapsulation | | | Bakelite (Black Bakelite) |
| Detection Gas | | | Combustible gas and smoke |
| Concentration | | | 300-10000ppm ( Combustible gas) |
| Circuit | Loop Voltage | $V_C$ | ≤24V DC |
| | Heater Voltage | $V_H$ | 5.0V±0.2V ACorDC |
| | Load Resistance | $R_L$ | Adjustable |
| Character | Heater Resistance | $R_H$ | 31Ω±3Ω（Room Tem.） |
| | Heater consumption | $P_H$ | ≤900mW |
| | Sensing Resistance | $R_S$ | 2KΩ-20KΩ(in 2000ppm $C_3H_8$ ) |
| | Sensitivity | S | Rs(in air)/Rs(1000ppm isobutane)≥5 |
| | Slope | α | ≤0.6($R_{5000ppm}/R_{3000ppm}$ $CH_4$) |
| Condition | Tem. Humidity | | 20℃±2℃；65%±5%RH |
| | Standard test circuit | | Vc:5.0V±0.1V；$V_H$: 5.0V±0.1V |
| | Preheat time | | Over 48 hours |

## Basic test loop

T




The above is basic test circuit of the sensor. The sensor need to be put 2 voltage, heater voltage（VH） and test voltage(VC). VH used to supply certified working temperature to the sensor, while VC used to detect voltage (VRL) on load resistance （RL） whom is in series with sensor. The sensor has light polarity, Vc need DC power. VC and VH could use same power circuit with precondition to assure performance of sensor. In order to make the sensor with better performance, suitable RL value is needed:

Power of Sensitivity body(Ps):

$Ps=Vc^2 \times Rs/(Rs+RL)^2$

Resistance of sensor(Rs): Rs=(Vc/VRL-1)×RL

**Sensitivity Characteristics**

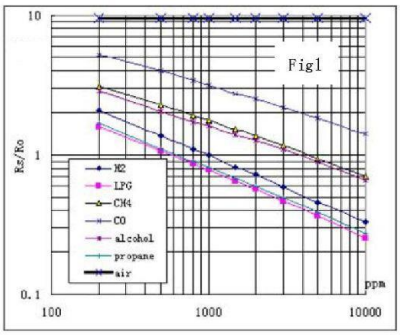



Fig.1 shows the typical sensitivity characteristics of the MQ-2, ordinate means resistance ratio of the sensor (Rs/Ro), abscissa is concentration of gases. Rs means resistance in different gases, Ro means resistance of sensor in 1000ppm Hyrogen. All test are under standard test conditions.

**Influence of Temperature/Humidity**

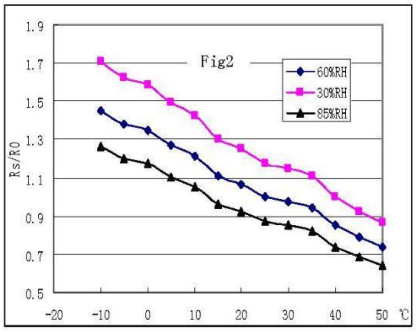
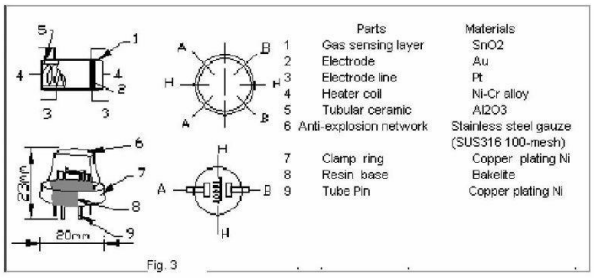



Fig.2 shows the typical temperature and humidity characteristics. Ordinate means resistance ratio of the sensor (Rs/Ro), Rs means resistance of sensor in 1000ppm Butane under different tem. and humidity. Ro means resistance of the sensor in environment of 1000ppm Methane, 20℃/65%RH

**Structure and configuration**




Structure and configuration of MQ-2 gas sensor is shown as Fig. 3, sensor composed by micro AL2O3 ceramic tube, Tin Dioxide (SnO2) sensitive layer, measuring electrode and heater are fixed into a crust made by plastic and stainless steel net. The heater provides necessary work conditions for work of sensitive components. The enveloped MQ-2 have 6 pin, 4 of them are used to fetch signals, and other 2 are used for providing heating current.

*Figure D.2* MQ2 Gas Sensor Data Sheet

## APPENDIX E

| List of Materials used in the System | |
|---|---|
| 1 | 3x Light Bulb |
| 2 | 3x Electric Fan |
| 3 | 3x Light Bulb Socket |
| 4 | Electrical Plug |
| 5 | 2x Terminal Block |
| 6 | Plywood |
| 7 | Flat Cord |
| 8 | Arduino Uno Board |
| 9 | HC-05 Bluetooth Module |
| 10 | MQ2 Gas Sensor |
| 11 | 8-Channel 5v Relay Module |
| 12 | Buzzer |
| 13 | Solderless Breadboard |
| 14 | Jumper Wires |

*Table E.1* List of Materials used in the System