Project I: Internet of Things (IoT) based Home Security System

Introduction

IoT (Internet of Things) is a network of interconnected devices embedded with sensors and software that enable them to collect, exchange, and act on data. These devices can connect to the internet and communicate with each other, enabling automation, efficiency improvements, and new services across various industries and everyday life. One such use of IoT is in Home Security Systems. This project aims to create an IoT-based ecosystem that detects intruders and other discrepancies at the door of a home with the help of sensors, and thereby alert the owner of potential risks. In order to create a successful IoT-based ecosystem, the following components were considered:

1) Devices and Sensors: These are the physical objects equipped with sensors to collect data (motion, status of the door etc)
2) Connectivity: IoT devices use various communication protocols to transmit data to the cloud or other devices.
3) Data Processing: Data collected by IoT devices is processed and analysed either locally on the device or in the cloud to derive meaningful insights.
4) Cloud Infrastructure: IoT platforms often rely on cloud computing services to store, process, and analyse vast amounts of data generated by devices.
5) Applications and Services: IoT data is used to create applications and services that improve efficiency, productivity, and convenience across various industries and everyday life scenarios.

This project makes use of sensors and Arduino Uno board in order to create an ecosystem. Furthermore, the various communication protocols were studied and can be used to integrate into the ecosystem as further scope. This report discusses, in detail, about all the components used, their role in the ecosystem and the results obtained while implementing the hardware components.

Components

- Hardware
    - Arduino Uno R3
    - Vibration Sensor
    - PIR Sensor
    - Bluetooth Module
    - Ultrasonic Sensor
    - Magnetic Reed Switch
    - Radio Frequency Identification (RFID)
    - Buzzer
    - Resistors
    - Breadboard
    - LED Lights
    - Jumper Wires
- Software
    - Arduino IDE
    - Bluetooth app: Arduino Bluetooth Controller

Working

This IoT ecosystem works with the help for four different sensors which include: Vibration Sensor, Passive Infrared (PIR) Sensor, Magnetic Reed Switch, Radio Frequency Identification (RFID) and Ultrasonic Sensor.

The Arduino Uno R3 is a microcontroller board based on the ATmega328P. It features 14 digital input/output pins, 6 analog inputs, and a USB 2.0 type-B connection for programming and power. The board operates by reading inputs (like light on a sensor), processing the data, and controlling outputs (like turning on an LED). It's widely used for prototyping and educational purposes in electronics and programming.

Figure 1.1: Arduino Uno R3

A vibration sensor detects and measures the intensity and frequency of vibrations in machines, structures, or environments. It converts mechanical vibrations into electrical signals for analysis, allowing for monitoring of equipment health, structural integrity, and operational efficiency in various industries. In this ecosystem, the vibration sensor detects motion at the door.

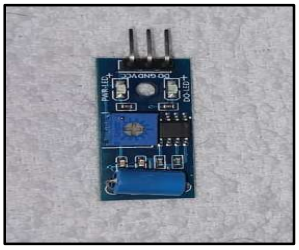


Figure 1.2: Vibration Sensor

Figure 1.3: Passive Infrared (PIR) Sensor

A PIR sensor detects motion by sensing changes in infrared radiation emitted by objects in its vicinity. It is commonly used in security systems, lighting controls, and automatic door systems to detect movement and trigger actions such as turning on lights or activating alarms. In this ecosystem, the PIR sensor also senses motion.

The ecosystem also used Ultrasonic Sensor. An ultrasonic sensor uses high-frequency sound waves to measure distances and detect objects without physical contact. It emits ultrasonic pulses and calculates distances based on the time it takes for the pulses to bounce back. Therefore, this sensor is used in this project to detect objects and interferences as well as measure the distance.

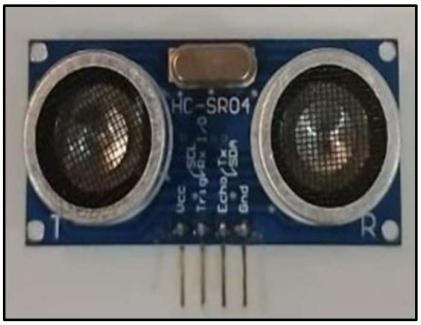


Figure 1.4: Ultrasonic Sensor

This project makes use of a Bluetooth module, which is a compact electronic device that enables wireless communication between electronic devices within short distances. Bluetooth module facilitates wireless data transmission and communication between devices like smartphones, tablets, laptops, and microcontrollers. It uses Bluetooth technology to establish a short-range, low-power wireless connection. This helps for the user/owner to

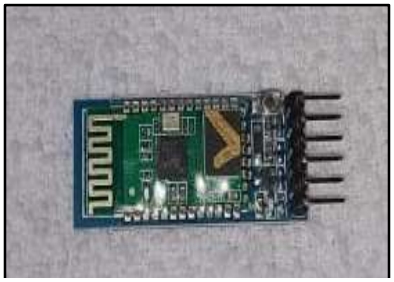


Figure 1.5: Bluetooth Module

operate the system with the help of an app on their phone, making the system very convenient and reliable.

Figure 1.6: Magnetic Reed Switch

A magnetic reed switch with plastic-covered wires and two positive-negative leads is a type of proximity sensor encased for protection. When a magnet approaches, the switch's internal reeds come together, completing the circuit between the positive and negative wires. This change in state can trigger an external device, like an alarm or light, indicating the presence of a magnetic field.

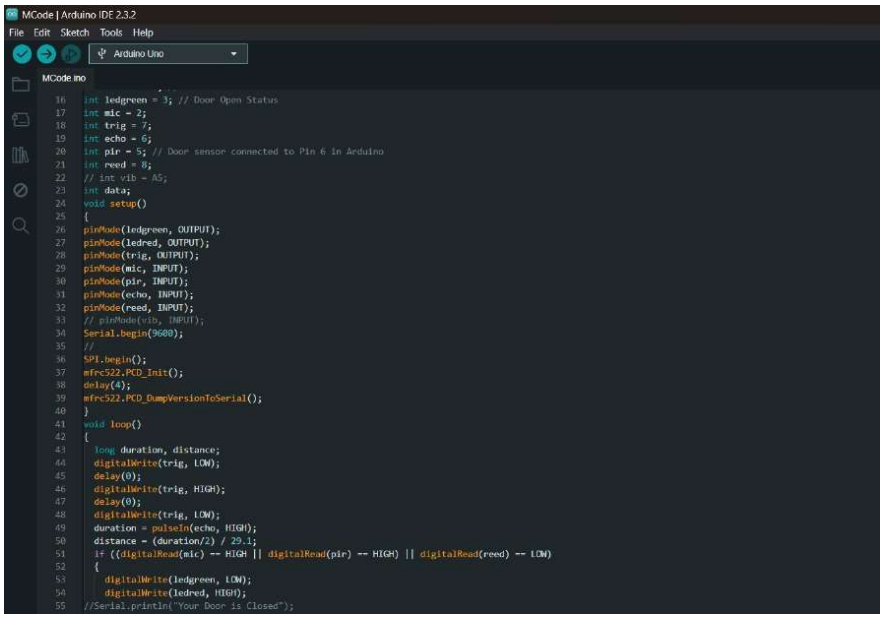
Figure 1.7: RFID System

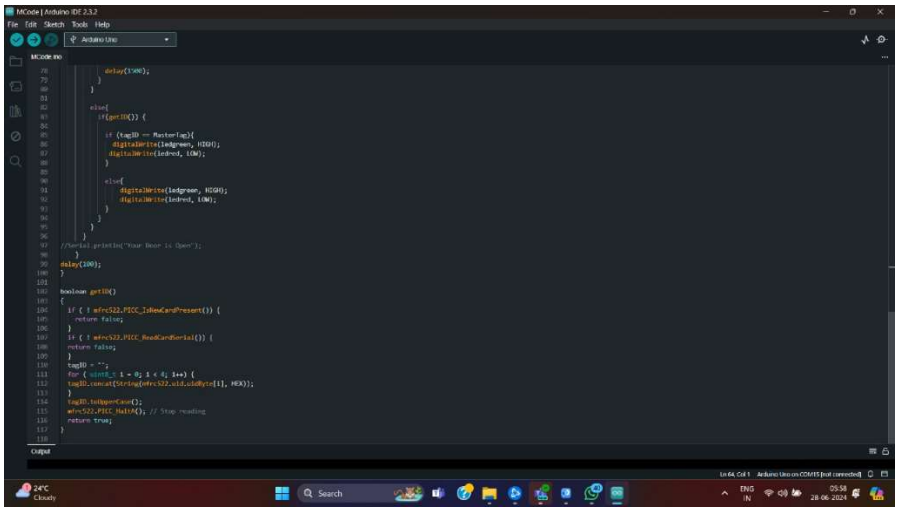
RFID (Radio Frequency Identification) is a technology that uses electromagnetic fields to automatically identify and track tags attached to objects. These tags contain electronically stored information. RFID systems typically consist of a reader device that emits radio waves to communicate with the tags, which then respond with their stored data. This technology is widely used in various applications such as inventory management, access control, and payment systems.

When there is a detection by any of the sensor, the owner is alerted with the help of LED lights as well as a buzzer system. The result part of this report will demonstrate the working of each individual sensor along with its output measures.

Code

The Arduino Uno board was processed with a code written in Arduino IDE software in order to instruct the system to operate. The code is shown in the figure below:





Block Diagram

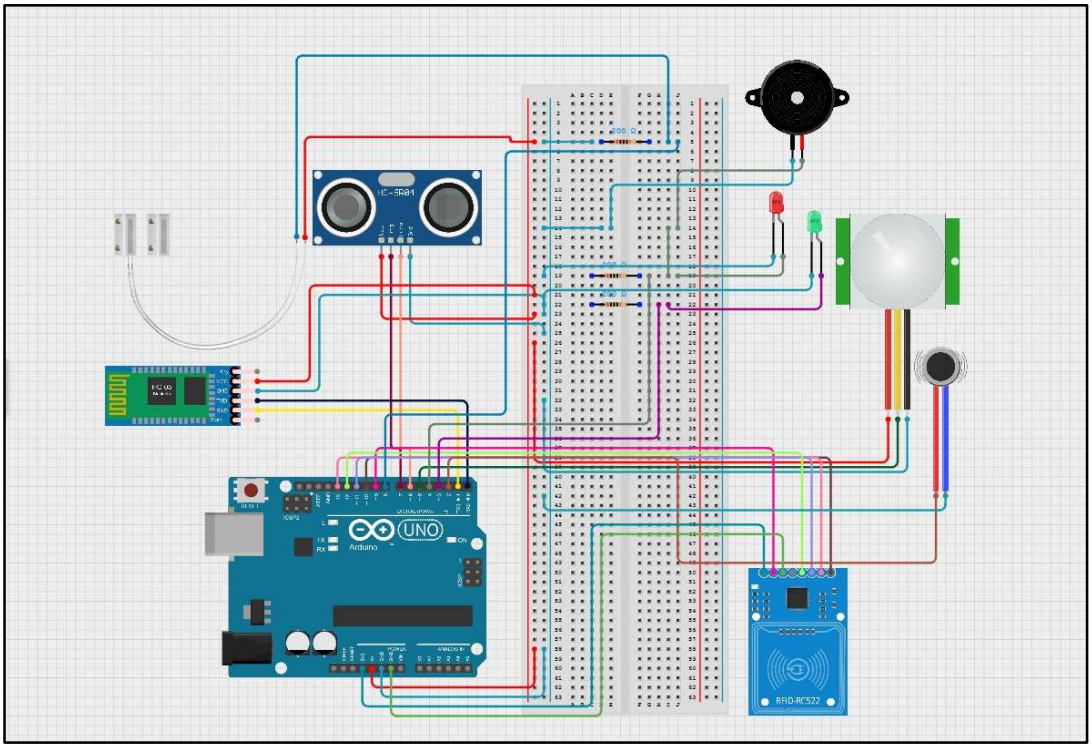


Figure 1.8: Block Diagram

Connections

All the components mentioned above are connected in accordance with the block diagram shown in Figure 1.8. This section provides further details of the pin connections.

Firstly, the ultrasonic sensor consists of VCC, ground, echo and trigger. The VCC and ground are connected to the breadboard, the trigger pin is connected to the seventh pin and the echo pin is connected to the sixth pin of the Arduino Uno R3 board respectively.

Secondly, the Passive infrared (PIR) Sensor consists of Vcc, ground, and output pins. The Vcc and ground are connected to the breadboard and the output pin is connected to the fifth pin of the Arduino Uno R3 board.

Thirdly, the Radio Frequency identification (RFID) consists of SDA, SCK, MOSI, MISO, ground, 3.3V, and reset pins. The SDA is connected to the tenth pin, SCK is connected to the thirteenth pin, MOSI is connected to the eleventh pin, MISO connected to the twelfth pin, reset pin is connected to the ninth pin, ground is connected to the ground pin and 3.3 V is connected to the 3.3 V pin in the Arduino Uno R3 pin respectively.

Then, the Bluetooth module consists of Vcc, ground, TX0 and RX0 pins. The Vcc and ground are connected to the breadboard. The TX0 pin of Bluetooth module is connected to RX0 pin of the Arduino Uno R3. The RX0 pin of Bluetooth module is connected to TX0 pin of the Arduino Uno R3.

Furthermore, the magnetic reed switch consists of two terminals: positive and negative. The positive terminal is connected to the 3.3 V pin of Arduino and the negative terminal is connected to pin 8 of the Arduino Uno R3 board and to 330-ohm resistor. The negative terminal of the resistor is connected to the ground of the breadboard.

Finally, the vibration sensor consists of three pins: Vcc, ground and output pin. The Vcc and ground are connected to the breadboard. The output pin is connected to the pin number 2 of the Arduino Uno R3 board.

On the output end, there are two LEDs that are used in the project. Each LED represents the working condition of the system: the red LED indicates presence of an intruder whereas the green LED is the normal state of the system. The positive terminal of the red LED is connected to the negative terminal of the resistor. The positive terminal of the resistor is connected to the fourth pin of the Arduino Uno R3 board. The negative of the red LED is grounded. Similarly, the positive terminal of the green LED is connected to the negative terminal of the resistor. The positive terminal of the resistor is connected to the third pin of the Arduino Uno R3 board. The negative of the green LED is grounded.

There is also a buzzer connected in order to alert the user in case of intruder presence. The positive terminal of the buzzer is connected to the positive terminal of the resistor and the negative terminal is grounded. Overall, the components above connected in this particular manner provide the successful functioning of the system.

Hardware Connections

The image below shows all the components connected with the help of a breadboard and demonstrates the ideal situation where none of the sensors are activated.

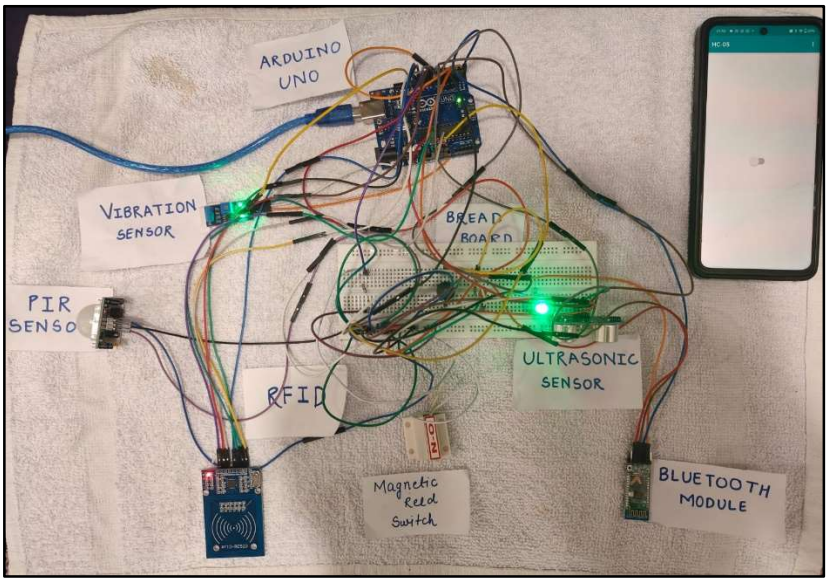


Figure 1.9: Hardware Connections

Result

The working of the ecosystem is tested for different test case scenarios in order to ensure every component is working and giving the necessary and expected outcome.

Firstly, the vibration sensor's working is checked by providing the sensor with a HIGH condition voluntarily, and the output is shown in the image below:

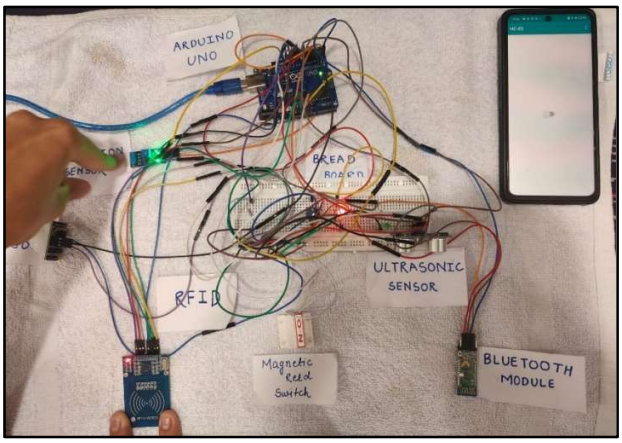


Figure 1.10: Vibration Sensor

Similarly, the working of the PIR sensor is demonstrated below:

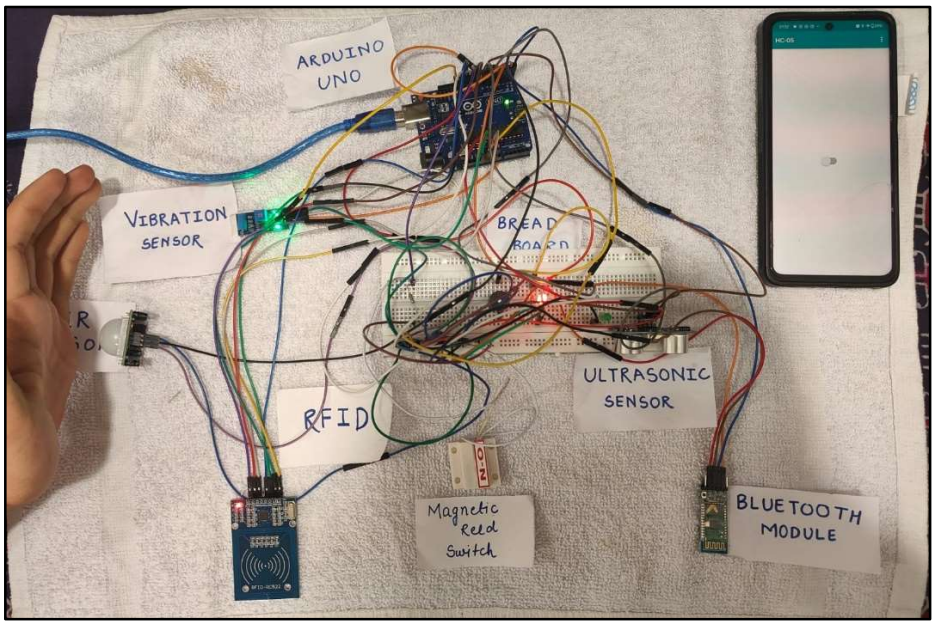


Figure 1.11: Passive Infrared (PIR) Sensor

Furthermore, the working of the ultrasonic sensor is shown in the figure below:

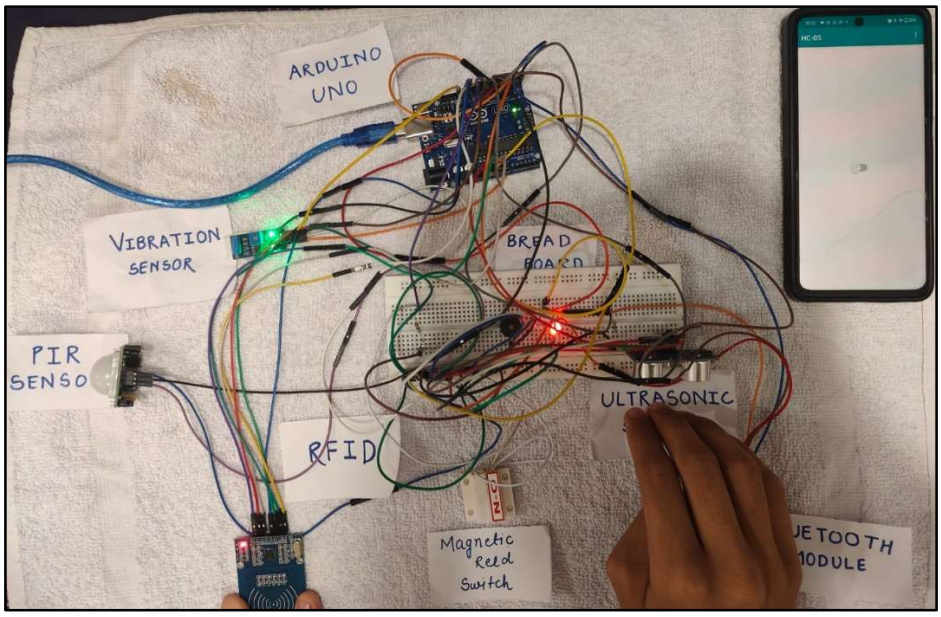


Figure 1.12: Ultrasonic Sensor

Finally, the working of the Magnetic Reed Switch is shown below:

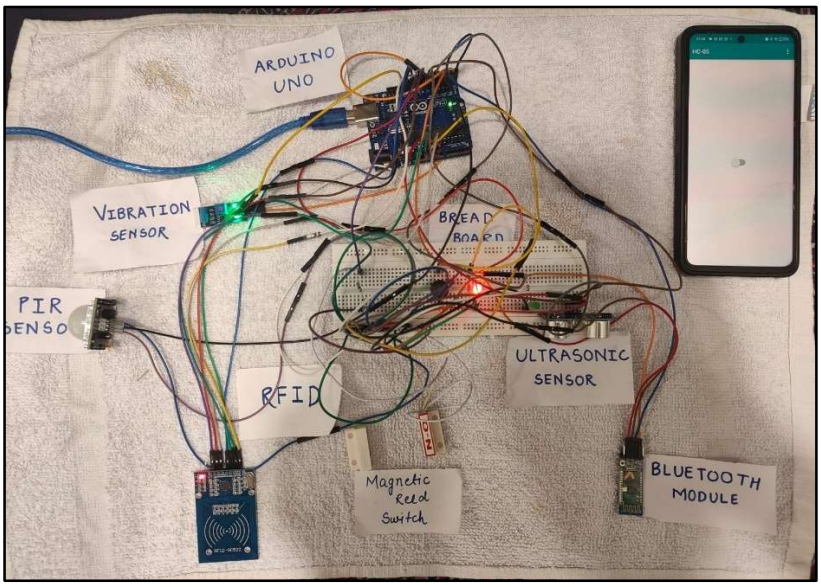


Figure 1.13: Magnetic Reed Switch

The RFID card works as shown below:

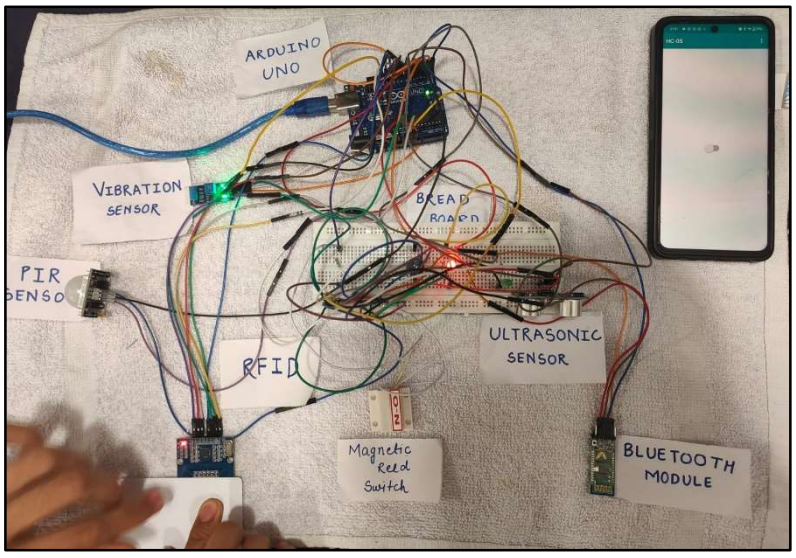


Figure 1.14: RFID Sensor

As shown in all of the demonstrations above, every time any one of the sensors is triggered, the LED turns red and a buzzer is also activated. As the working of the sensors is clear, the next step is to check the communication system that occurs via the Bluetooth module. The Bluetooth module helps to control the output of the entire ecosystem with the help of a phone. When the switch in the phone is ON, the output, that is, the LED and the buzzer are activated.

When the switch is OFF, the ecosystem operates in normal condition. The switch is what the owner can control with the help of the mobile. The operation of the Bluetooth module is demonstrated in the image below:

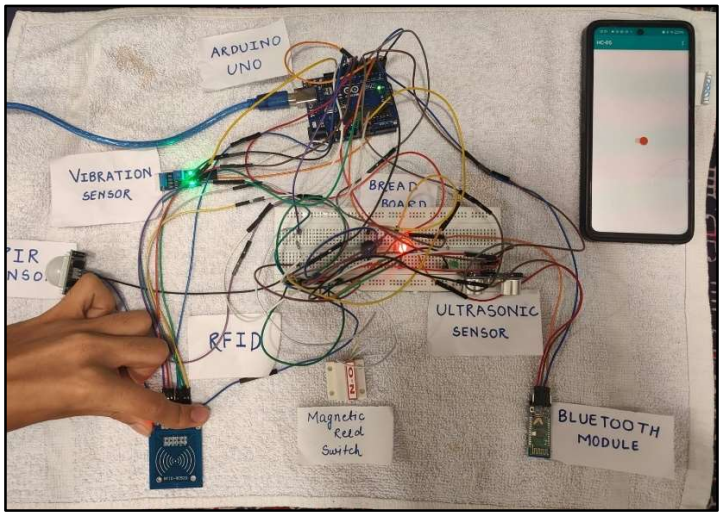


Figure 1.15: Bluetooth Module

As seen above, the switch in the mobile is ON, therefore, the LED shows a red light and a buzzer is heard.

Conclusion

Overall, this project is successful in making a working model of an IoT-based ecosystem that involves precise detection of movement and presence of intruders, an effective alarm system as well as a Bluetooth-based communication protocol that helps the user/owner to control the entire system with the help of an app on their own mobile device. With the presence of multiple sensors with different functions each, the security of the space will be very sophisticated, and the owner will be alerted immediately in case of breach. However, this project does hold some disadvantages that need to be modified as future scope. For example, the system can only be operated with the help of the mobile if the mobile is within 100 m of the Bluetooth module, which is very inconvenient provided the short range. That said, with the help of better equipment, the range of the system can be significantly increased. In conclusion, the project successfully demonstrates an Internet of Things (IoT)-based Home Security System.