

Zigbee Based Home Automation System for Physically Challenged And Elderly People

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Abstract

Zigbee is a wireless technology with more potential in the field of environmental control because of its benefits of low power consumption, cost efficiency, and excellent reliability, to make our home more energy efficient, we focused on home devices such as fans and lights, as well as the outside surroundings, such as the entrance. The module includes a Light Dependent Resistor (LDR) for sensing darkness and turning on the light. The Ultrasonic sensor detects the presence of a human and opens the door. The temperature sensor detects the room's temperature, and a fan is used to ventilate it, while the PIR sensor detects the person's movement, and the LED illuminates. Home Automation is undoubtedly a resource which can make a home environment automated. This method of saving energy also helps to protect our environment from major sorts of emission. It helps people to control their electrical devices through these devices and set up controlling actions. This is helpful for physically impaired and old age people..

Keywords: Home Automation, Zigbee, Arduino UNO, Ultrasonic Distance Sensor, PIR Sensor, Temperature Sensor, Elderly and Physically Challenged.

1. Introduction

In recent years, the proportion of people over the age of 65 has steadily increased. A home automation system for the elderly and disabled can make them feel safe and secure in their own homes. Home automation technology is constantly evolving, making it easier for the elderly and disabled to live more comfortably in their homes by meeting their specific needs. Many seniors and disabled people struggle to get to the front door on time. Motion sensor lights that turn on and off depending on who is entering or leaving a room are among the lighting features.

Several modern wireless communication standards were developed and implemented over the last decade. Most people in modern society are familiar with GSM, Wi-Fi, and Bluetooth. These standards have found widespread acceptance in their daily lives. Even though it appears that all people's wireless needs have been met, it turns out that there is a lack of something like Internet of Things (IOT), particularly in mainstream Home Automation.

Various modern wireless communication standards were developed and carried out during last decade. GSM, Wi-Fi and Bluetooth are documented by most of the people within the modern society. These standards have permeated into their daily routine with outstanding popularity. Even though it seems that all people's wireless requirements have fulfilled, it turns on, that they lack of something like Internet of Things (IOT) especially in mainstream Home Automation. Because of its low power consumption, low cost, and reliability, Zigbee Technology has greater potential in environmental monitoring and control. These features are extremely beneficial in terms of reducing energy consumption. It is used in the homes of the elderly and people with disabilities to ensure their independence, safety, and to save money.

2. Objectives

The goal of this project is to create a low-cost, dependable, and scalable home automation system aimed specifically at the elderly, handicapped, and disabled. With the deployment of smart sensors, we focused on home devices such as fans, lights, and doors to make them more energy efficient. The Zigbee transmits all sensed data from the sensors in an instant to the remote device, allowing a remote user to track the house from a remote location. This gives the user remote access for monitoring and controlling purposes.

A. Existing Home Automation System

There are numerous definitions of home automation available in the literature. One definition defines home automation as the introduction of technology within the home to improve the quality of life of its occupants through the provision of various services such as tele-health, multimedia entertainment, and energy conservation. The developed system for the aforementioned purpose has a number of services. The kit employs sensors to detect temperature, which is used to alert the user when a fire is detected; Infrared sensors are used to detect the number of people in the room, which is used to turn on the lights in the room. The module includes a Light Dependent Resistor that detects darkness and then turns on the light. A power sensor is installed to detect power consumption. The Zigbee communication device is used to transfer these values to the remote laptop. Two infrared sensors are used here to estimate the direction in which the person is crossing the room door.

B. Proposed Home Automation System

There are various wireless protocols available, but the ones most people are familiar with are Wi-Fi and Bluetooth, which are used in devices that many of us own, such as mobile phones and computers. A third option is Zigbee, which is intended for control and instrumentation.

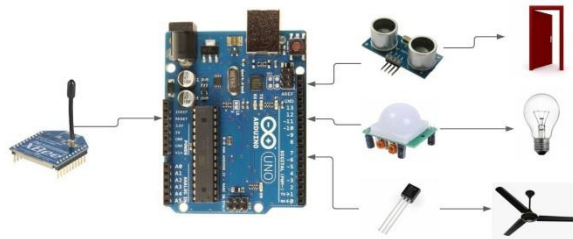


Figure 1 Proposed System

This project is made up of two circuits: a transmitter and a receiver. We use a proximity sensor to detect movement, a temperature sensor to determine the current temperature, and an ultrasonic sensor to determine distance. The receiver circuit consists of a receiving Zigbee module connected to Arduino; the Zigbee instantly transfers all sensed data from the sensors to the remote device, allowing a remote user to trace the house from a remote location. As illustrated in the figure. 1.

3. Proposed System Hardware Design

The components used for hardware designing are

- Zigbee,
- Arduino UNO,
- Temperature Sensor
- Ultrasonic Distance Sensor,
- PIR sensor,
- Dc motor,
- Servo motor,
- Photo Resistor,
- LED,
- NPN Transistor,

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- Light bulb, resistors and
- H-bridge motor driver.

Component	Specification
Arduino Uno R3 -ATmega328	Operating voltage 5V, 14 digital I/O pins, Analog inputs-6.
Zigbee [Xbee S2C – RF Module]	<ul style="list-style-type: none"> • 200ft Indoor Range, 2.4GHz to 2.5GHz Transmission frequency, 2mW Power, 250,000 bps Data Rate, 100 - 1000 Battery Life
<i>Positional Micro Servo [Servo Motor SG-90]</i>	<ul style="list-style-type: none"> • Operating Voltage is +5V, Operating speed is 0.1s/60°, Rotation : 0°-180°, Torque: 2.5kg/cm
Ultrasonic Distance Sensor HC-SR04	<ul style="list-style-type: none"> • Operating voltage: +5V, Measuring Distance: 2cm to 450cm, 40Hz Frequency.
PIR Sensor HC-SR501	Input Voltage 4.V to 12V, 65mA power, 120° and 7 m distance covered.
Temperature Sensor [TMP36]	0°- 100°C Range, +12 Volt 3,5 mAmp and -5 Volt 1 mAmp
DC Motor	Operating Voltage 12V, 200 RPM, 1.5 Kg-Cm Torque.
Light bulb	Warm White, 10 W
H-bridge Motor Driver [L293D]	4.5 V to 36 V
Relay	5V 4-Channel
Photo resistor LDR	DC 3-5V, 5mm,1.8 gm.
Resistor	1 kΩ, 10 kΩ, 220Ω
LED	Red, 610 – 760 Wavelength, 1.6 - 2.0 VF

4. Zigbee RF Communication

Zigbee is a home area network that was created to exchange the proliferation of individual remote controls. Zigbee was created to meet the market demand for a low-cost, standards-based wireless network that emphasises low data rates, low power consumption, security, and reliability. To meet this demand, the Zigbee Alliance, an industry working group, is creating standardised application software on top of the IEEE 802.15.4 wireless standard. The Zigbee standard was created to be a low-cost, low-power-consuming, and low-data-rate-required system. The Zigbee standard is embedded in the Physical and Medium Access Layers (MAC).



Figure 2 Zigbee

Since Zigbee is a Zigbee Alliance standard, the higher layer specified in the Zigbee standard is for industry alliance. The use of Zigbee technology can be seen in home monitoring systems, climate sensor communication, data collection in a small area in the research field, and industrial control, among other things. The primary application of a Zigbee transceiver is in wireless sensor networking and automatic systems such as home control, biotelemetry, and personal care for senior citizens. The main application of Zigbee transmission is home, industry, and other organisation automation. Some of the most important applications of Zigbee

technology include light control, light machinery control, and SCADA networking. A comparative analysis of Zigbee, Bluetooth, and Wi-Fi technology is also included, which will help us understand how Zigbee differs from other wireless networking technologies.

Zigbee is a low-power wireless technology designed for device monitoring and control. Zigbee technology, which is based on the 802.15.4 standard, provides a robust and dependable solution in a noisy radio frequency RF environment. Zigbee features such as energy detection, clear channel assessment, and channel agility assist devices in selecting the best possible channel and avoiding other wireless networks such as Wi-Fi, while message confirmation ensures that the data was delivered to its terminal. Multiple levels of security ensure that the network and data are kept safe and secure. One of the most important characteristics of Zigbee is its ability to cover large areas with routers. This feature distinguishes Zigbee from other technologies. Mesh networking extends the network's range through routing, whereas self healing improves network reliability by rerouting messages in the event of a node failure.

System	Bluetooth	Wi-fi	Zigbee
Application	Cable replacement	Internet	Monitoring and Control
System Resource	250 KB	1 MB+	4 – 32 KB
Battery Life	1 – 7	Hours	100 - 1000
Nodes in Network	7	32	255/65K
Baseband(kb/s)	720	11 Mbps	20 - 250
Distance	1 – 10 m	100 m	1 – 100 m
Key Characteristics	Easy use, Price, High data rate	large network, Very high speed	Stability, low consumption, low cost.

Zigbee is commonly used in wireless remote controls, game controllers, a wireless mouse for a computer, and a variety of other applications. Zigbee mesh networking can help in areas such as energy management, light control, process control, and asset management at the industrial level. This app includes asset management, personnel tracking, and livestock tracking. Furthermore, Zigbee can be used in the healthcare industry. A Zigbee gateway provides an interface between a Zigbee network and other networks, such as an Internet Protocol (IP) network, allowing hospitals to improve patient care and relieve hospital overcrowding by allowing them to monitor patients at home.

5. Software Required

XCTU is a free multi-platform application that allows developers to collaborate with Digi RF modules through an easy-to-use graphical interface. It includes new tools for quickly setting up, configuring, and testing Zigbee RF modules. XCTU has all of the tools a developer needs to get up and running with Zigbee quickly. Unique features such as the graphical network view, which graphically represents the Zigbee network along with the signal strength of each connection, and the Zigbee API frame builder, which intuitively helps to build and interpret API frames for Zigbee when used in API mode, combine to make development on the Zigbee platform easier than ever.

XCTU's other highlights include the following:

- Managing and configuring multiple RF devices, including those connected remotely (over-the-air).
- The firmware update process logically restores your module settings, handling mode and baud rate changes automatically.
- There are two distinct API and AT consoles that have been designed from the ground up to communicate with your radio devices.
- To save the console session and load it on another PC running XCTU.
- XCTU includes a set of embedded tools that will be executed in the absence of an RF module.
- The frames generator can quickly generate any type of API frame in order to save its value.

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An update procedure allows you to automatically upgrade the appliance and therefore the radio firmware library without downloading any additional files. XCTU has extensive documentation that may be viewed at any time.

Arduino is an open source microcontroller that can be readily programmed, erased, and reprogrammed at any moment. It's an open source computing platform for building and programming electrical devices that's based on basic microcontroller boards. It may also function as a minicomputer, similar to other microcontrollers, by accepting inputs and manipulating the outputs of a variety of electrical devices.

It can also receive and send data over the internet with the aid of several Arduino shields, which are detailed in this article. Arduino employs hardware known as the Arduino development board and software known as the Arduino IDE for code development (Integrated Development Environment). Built using Atmel's 8-bit AVR microcontrollers or a 32-bit Atmel ARM, these microcontrollers are frequently programmed simply in the Arduino IDE using the C or C++ language.

Unlike the opposing microcontroller boards in India, Arduino boards were just introduced to the electronic industry a few years ago, and were first limited to small-scale applications. People who work in the electronics industry are progressively recognising and acknowledging the importance of Arduino in their own projects. This development board may also be used to upload fresh code to the board by simply connecting the board to a computer through USB. The Arduino IDE is a simplified integrated platform that runs on standard personal computers and allows users to develop Arduino applications in C or C++.

6. System Design

A. System Architecture

The following modules make up the proposed system:

1. Ultrasonic sensor-based automatic door opening and shutting module
2. PIR sensor-based automatic light control module
3. Temperature sensor-based automatic fan control
4. Using a Light Dependent Resistor as an automatic day light

As indicated in the block diagram Fig.3, the design contains three different sensors.



Figure 3 Block Diagram

B. Control Flow Diagram

When the ultrasonic sensor is turned on, it waits for an echo from an item that is within the detecting range. The door was initially shut since no item had been identified. The servo motor is triggered when an item is spotted, which causes the door to open. If the identified item is within the ultrasonic sensor's range, it will continue to be monitored. If the item is out of range, however, the servo motor is triggered once more, this time for the purpose of closing the door; otherwise, the door stays open. When an item is detected in the detecting region, the ultrasonic sensor transmits a command to the microcontroller.

The servo motor is used to control the microcontroller's actions, such as opening and shutting the door. The door remains closed if no person or object is detected by the ultrasonic sensor's radar.

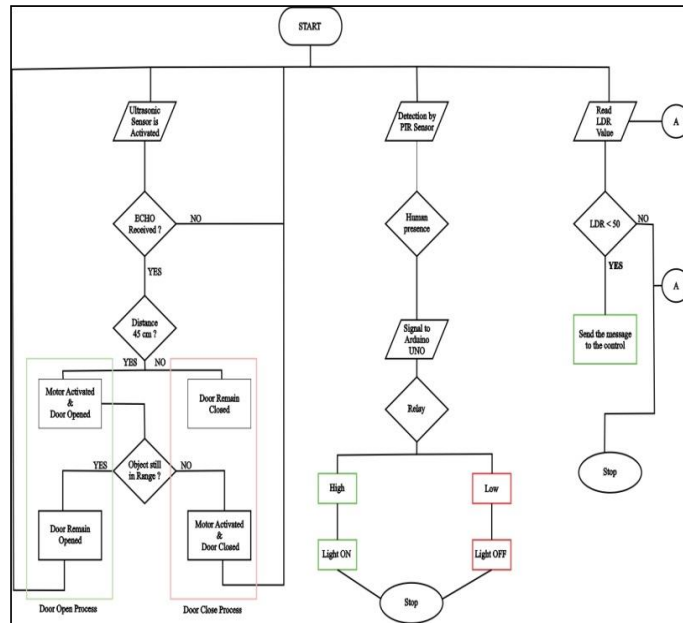


Figure 4 Flow Diagram

When there is no human movement, the PIR Sensor fails to detect anyone and the OUT pin remains low. The PIR Sensor detects the change in infrared radiation in the room when the individual enters it. As a result, the PIR Sensor's output becomes HIGH. Because the PIR sensor's Data OUT is linked to Arduino's Digital Pin 8, if it develops HIGH, Arduino will activate the relay by setting the relay pin to LOW, as the relay module is an active LOW module. This will activate the light. As long as there is movement in front of the sensor, the light will remain on. When a human leaves the room, the infrared radiation remains constant, there is no change, and the PIR Sensor's data output becomes LOW. As a result, the Arduino will switch off the relay and set the relay pin to HIGH, turning off the room light.

The temperature sensor is connected to an Arduino board, which retrieves data about the room's temperature. If the temperature is high, the data is processed more quickly; if the temperature is low, the data is processed more slowly. Furthermore, if the temperature falls below the stated threshold, the fan will turn off. Using the Arduino's PWM pins, the fan speed is regulated in a similar way as the temperature.

The LDR, which detects daylight and light, is the circuit's main component. A light-dependent resistor (LDR) is a resistor that changes resistance in response to light. When light shines on the LDR area, the resistance decreases, and when the LDR is dark, the resistance increases. When enough light falls on LDR throughout the day, it lowers its resistance, resulting in a potential difference at the respective pin of the comparator. Now both comparators compare the input voltage to the reference voltage; if the input voltage is higher than the reference voltage, the LED will light up; otherwise, the LED will remain dark.

7. Methodology & Implementation

A. Zigbee Interfacing with Arduino UNO

The IEEE 802.15.4 technical standard, which characterises the operation of low-rate wireless personal area networks (LR-WPANs), is supported by Zigbee (XBee) radios and is designed for point-to-point, star, and other types of wireless communication over the air. Zigbee is a high-level communication protocol based on IEEE 802.15.4 that is used to construct personal area networks with low-power digital radios.

The following are the main characteristics of Zigbee wireless devices: • They use the 2.4 GHz (Unlicensed Radio Band) radio frequency.

- Low data rate (about 250Kbps).
- Power consumption is low (1mW, 6mW, 250mW etc.).
- Short-range wireless communication (90m, 750m, 1 mile, etc.)

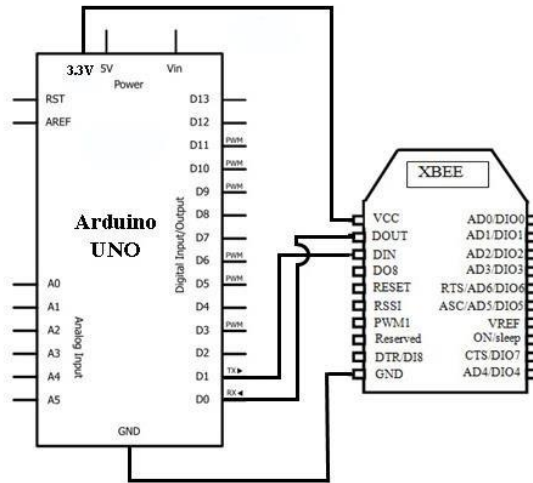


Figure 5 Interfacing Zigbee with Arduino UNO

We've linked a Zigbee S2 to an Arduino UNO in this example. API enable is set to 1 on this Zigbee, which is setup as a Coordinator in API mode. The Arduino software serial is used to communicate with Zigbee. The received data is shown on the serial monitor using Arduino's Serial. Another Zigbee device is set up as a Router with API enable set to 1. Both Zigbee devices have the same API enable setting. Pin DIO1 (pin 19 on the module) of the Router (or End Device) Zigbee module is connected to a switch and configured as a Digital Input. The fixed terminals of a potentiometer are connected to 1.2V and ground, while the variable terminal is attached to pin AD2 (pin 18 on the module) of the Router (or End Device) Zigbee module, resulting in the pin being set as an Analog Input. The IO Sampling (IR) rate is frequently configured to meet the application's requirements, such as 100 msec. Digi International's X-CTU software is used to configure and adjust all of the parameters.

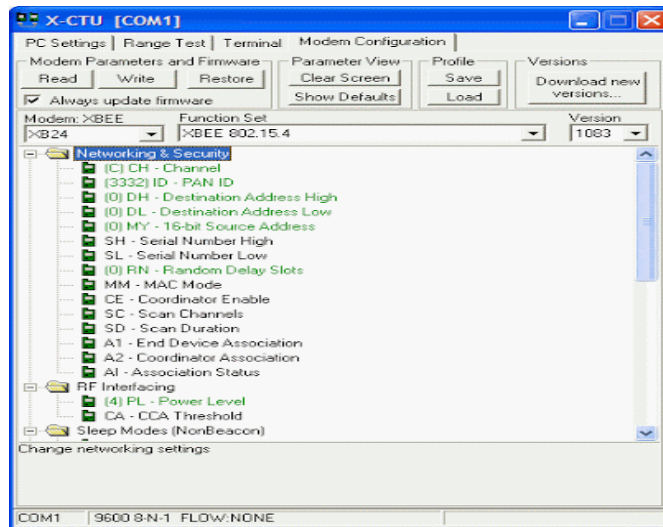


Figure 6 Using Classic XCTU Software

The Router (or End Device) XBee module delivers the potentiometer's IO samples, and therefore the switch's IR setting, on a regular basis. The coordinator receives the data, and the programme is uploaded to the Arduino, which analyses the data and extracts the IO samples report. This is shown on the serial monitor so that the workings may be checked often. To avoid needing to utilise an extra device for debugging, the modifications essentially swap out the Serial ports used for communication and debugging.

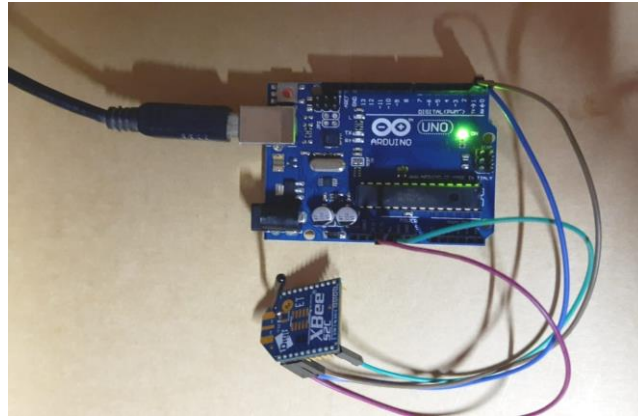


Figure 7 Zigbee Receiver

B. Hardware Implementation

The Arduino UNO is connected to the Zigbee. The ultrasonic sensor HCSR04 and the servo motor are both linked to the Arduino UNO. When the HC-SR04 ultrasonic distance sensor detects an item within the specified detection range, a signal is transmitted to the microcontroller, which uses the servo motor to open the door. When there is no item inside the measured range, however, the door is simulated to close. The door will remain open as long as things are detected within the measured detection range.

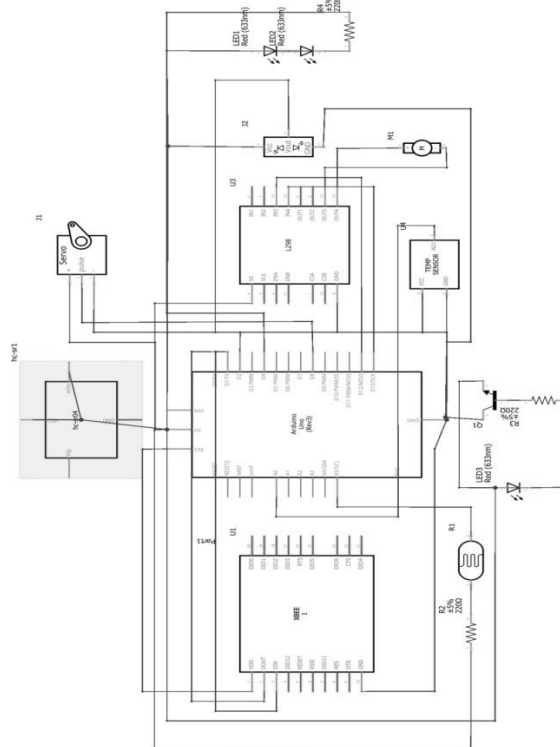


Figure 8 Circuit Diagram

The PIR sensor is attached to digital pin number two on the Arduino. When the PIR sensor detects motion, the OUTPUT pin goes HIGH, applying the triggering voltage to the transistor's base, causing the transistor to turn on and current to flow through the circuit. This activates the BULB. By activating the PIR sensor, we may change the duration of the Bulb ON. TMP36 sensor has been linked to Arduino analogue pin number A0 for temperature sensing. It has been used to regulate the speed of a fan based on the ambient temperature. When the temperature sensor detects a change in temperature, the associated input will turn on and the fan will turn on. If the temperature is below freezing,.

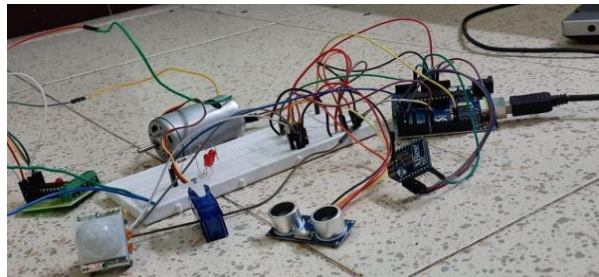


Figure 9 Zigbee Transmitter

The Arduino analogue pin number A5 is connected to one leg of the LDR sensor, which is connected to the VCC pin, and the other leg is connected to the Arduino ground port through a resistor. For determining whether it is Day or Night, the threshold value is modified to 10 from a discrete number (0-1023); if the input voltage is larger than the reference voltage, the LED will glow; otherwise, the LED will be turned off. The Zigbee wireless technology instantly sends all of the data collected by the sensors to the remote device, allowing a user to track the property from afar. As a result, the circuit is connected as indicated in Figure 14..

C. Software Used

XCTU is a free multi-platform utility that runs on Windows, Mac OS X, and Linux. The Zigbee radios are programmed using this software. Using this programme and a simple graphical interface, developers may communicate with Digi RF modules.

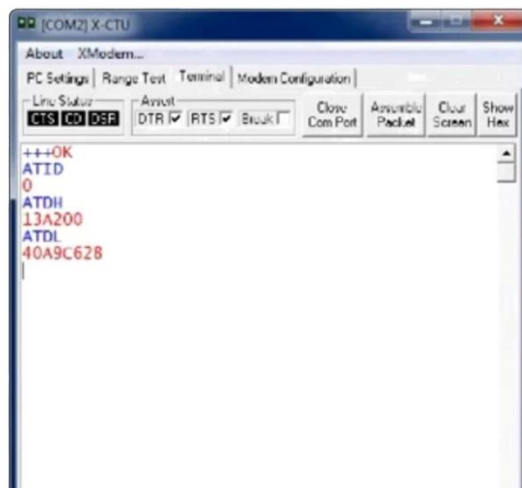


Figure 2 Interfacing using X-CTU Software

It contains new tools for setting up, configuring, and testing Zigbee RF modules. The primary prerequisite for configuring the two Zigbee pro modems (one at the coordinator end and the other at the receiver end) is that I their PAN IDs match. (ii) AT/API command mode should be enabled for both. Figure 15 depicts the setup of Zigbee parameters in XCTU software, as well as the basic change in the configuration of Zigbee parameters.

The Arduino IDE is an open source programme that is used to write and compile code for the Arduino module. It's Arduino software, which makes code compilation so simple that even a layperson with no prior technical expertise may get started with the training. It operates on the Java platform and is compatible with operating systems such as MAC, Windows, and Linux. It has built-in functions and commands that are useful for editing, debugging, and compiling code in the Arduino environment.

```
home_automation | Arduino 1.8.13
File Edit Sketch Tools Help

home_automation
#include<Servo.h>
const int pingPin = 7;
int servoPin = 8;
int ldr_pin = A5;
int ldr_value;
int light = 3;

Servo servo;

void setup() {
  // initialize serial communication:
  Serial.begin(9600);
  servo.attach(servoPin);
  pinMode(2, INPUT);
  pinMode(4, OUTPUT);
  pinMode(11, OUTPUT);
  pinMode(12, OUTPUT);
  pinMode(13, OUTPUT);
  pinMode(A0, INPUT);
  digitalWrite(2, LOW);
  digitalWrite(11, HIGH);
  pinMode(light, OUTPUT); pinMode(ldr_pin, INPUT);
}

void loop() {
  long duration, inches, cm;
  pinMode(pingPin, OUTPUT);
}

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Figure 3 Code used for Arduino UNO

The range of Arduino modules is applicable including Arduino Uno, Arduino Mega, Arduino Leonardo, Arduino micro and so on. Each of them contains a microcontroller on the board that's absolutely programmed and accepts knowledge within the sort of code. The main code built up on the IDE platform will set up a hex file which is later transferred and uploaded within the controller on the board. The IDE environment generally consists of 2 basic parts: Editor and Compiler where former is employed for writing the specified code and later is used for compiling and uploading the code into the given Arduino Module. This environment supports both C and C++ languages.

8. Conclusion

Home automation systems have grown in importance as a control system field. Zigbee plays a significant part in home automation in today's world of communication. Zigbee devices can run for several years on a little battery because of their low power output. As a general rule, a smart house is one that has an integrated home automation system to improve quality of life by providing a secure environment.

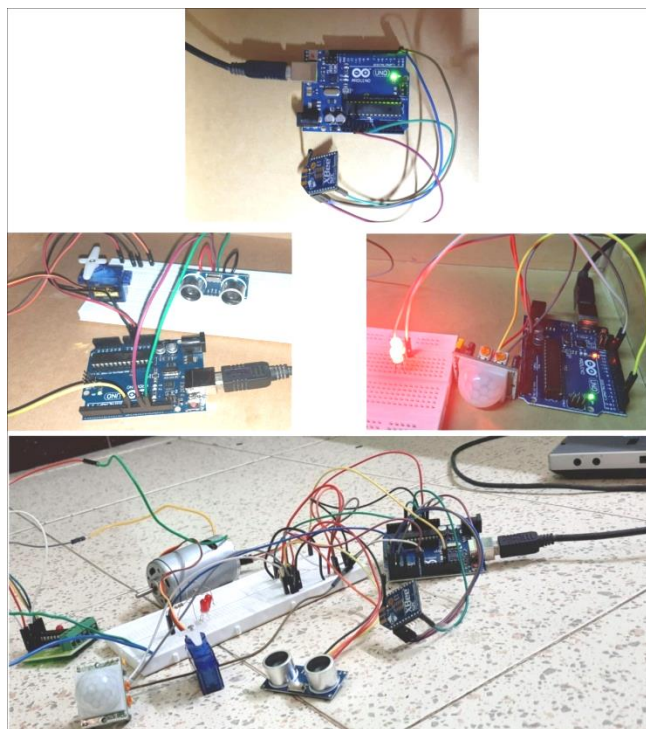


Figure 12 Overall System

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