ISSN 2277-2685
IJESR/June. 2025/ Vol-15/Issue-3s/654-661
M. Teja Sree *et. al.*, / International Journal of Engineering & Science Research

Remote-Controllable And Energy-Saving Room Architecture Based On Zigbee

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ABSTRACT

Automation is all around us. It is everywhere our eyes goes on. Things nowadays are getting automated, either we take an example of Self Driven Cars, or we see the entry doors in the shopping malls, the escalators, automation is even there in the application we use around us, they can be the chatbots, the automated background processing, it cannot be neglected, it is everywhere. With Home Automation, we can make many electrical and electronic devices communicate and operate each other. As well as we can create an interactive interface for people so that they can operate the devices. By home automation a lot of energy can be conserved as the loss of energy can be avoided. And using some low-cost, low-energy consumption devices like ZigBee, we can achieve Home Automation in a more efficient way. Initially Bluetooth devices were used in home automation and some home automation systems use Wi-Fi module, but here we have tried to implement the home automation using the ZigBee module so that it can connect to more devices and can work for longer ranges then the previously used modules. The primary goal of this project is to reduce energy consumption by dynamically adjusting the operation of room devices based on occupancy, environmental conditions (e.g., temperature, humidity, light levels), and user preferences. For example, lights and HVAC systems will be automatically turned off or adjusted when the room is unoccupied or when environmental conditions are within an optimal range. Moreover, users can remotely adjust settings, track energy usage, and receive real-time feedback, thus fostering energy-saving habits. The ZigBee-based communication network allows for low power consumption while ensuring reliable communication between devices, even over long distances. The system also includes features for fault detection, alerting users to unusual energy consumption patterns that might indicate malfunctioning devices, which can be addressed proactively to avoid energy wastage.

1-INTRODUCTION

It is an innovative initiative that aims to create an intelligent and energy-efficient room environment through the use of Zigbee, a low-power wireless communication protocol. This project integrates smart home technologies to enhance convenience, optimize energy consumption, and provide greater control over various devices in the room, including lighting, heating, ventilation, air conditioning (HVAC), and other electrical appliances. Zigbee's ability to support low-cost, reliable, and scalable mesh networking makes it an ideal choice for connecting a wide range of devices in a seamless and energy-efficient manner. The core of the system involves remote control capabilities, where users can monitor and adjust the room's environment via a smartphone, tablet, or computer from anywhere, offering comfort and flexibility. With integrated sensors, such as motion detectors, temperature sensors, and light sensors, the system automatically adjusts the operation of appliances based on real-time conditions. For instance, lighting can be switched off

when no one is in the room, or the HVAC system can be regulated based on temperature and occupancy data. The central control unit processes all data from the connected devices and sensors, providing a unified interface for users to set schedules, track energy usage, and receive insights on their consumption patterns. Furthermore, the system is designed with energy-saving features to reduce unnecessary energy usage, helping users cut down on electricity costs and contribute to sustainability efforts by minimizing their carbon footprint. Security and privacy features ensure that all communication across the Zigbee network remains encrypted and protected from unauthorized access. This project not only aims to improve the quality of life by making rooms smarter and more comfortable but also emphasizes the importance of energy conservation in today's world. It offers a scalable, cost-effective, and future-ready solution that can be expanded with new devices and seamlessly integrated with other smart home ecosystems, making it an essential step toward smarter, greener living spaces.

2-HARDWARE AND SOFTWARE REQUIREMENTS

In this chapter we will discuss software and hardware requirements for Remote-controllable and energy-saving room architecture based on Zigbee.

Hardware Requirements

Power supply:

The power supply section is the section which provide +5V for the components to work. IC LM7805 is used for providing a constant power of +5V.

The ac voltage, typically 220V, is connected to a transformer, which steps down that ac voltage down to the level of the desired dc output. A diode rectifier then provides a full- wave rectified voltage that is initially filtered by a simple capacitor filter to produce a dc voltage. This resulting dc voltage usually has some ripple or ac voltage variation.

A regulator circuit removes the ripples and also retains the same dc value even if the input dc voltage varies, or the load connected to the output dc voltage changes. This voltage regulation is usually obtained using one of the popular voltage regulator IC units.

TRANSFORMER:

Transformers convert AC electricity from one voltage to another with little loss of power. Transformers work only with AC and this is one of the reasons why mains electricity is AC.

Step-up transformers increase voltage, step-down transformers reduce voltage. Most power supplies use a step-down transformer to reduce the dangerously high mains voltage (230V in India) to a safer low voltage.

The input coil is called the primary and the output coil is called the secondary. There is no electrical connection between the two coils; instead they are linked by an alternating magnetic field created in the soft-iron core of the transformer. Transformers waste very little power so the power out is (almost) equal to the power in. Note that as voltage is stepped down current is stepped up.

The transformer will step down the power supply voltage (0-230V) to (0- 6V) level. Then the secondary of the potential transformer will be connected to the bridge rectifier, which is constructed with the help of PN junction diodes. The advantages of using bridge rectifier are it will give peak voltage output as DC.

RECTIFIER

There are several ways of connecting diodes to make a rectifier to convert AC to DC. The bridge rectifier is the most important and it produces full-wave varying DC. A full-wave rectifier can also be made from just two diodes if a centre-tap transformer is used, but this method is rarely used now that diodes

are cheaper. A single diode can be used as a rectifier but it only uses the positive (+) parts of the AC wave to produce half-wave varying DC

BRIDGE RECTIFIER:

When four diodes are connected as shown in figure, the circuit is called as bridge rectifier. The input to the circuit is applied to the diagonally opposite corners of the network, and the output is taken from the remaining two corners. Let us assume that the transformer is working properly and there is a positive potential, at point A and a negative potential at point B. the positive potential at point A will forward bias D3 and reverse bias D4.The negative potential at point B will forward bias D1 and reverse D2. At this time D3 and D1 are forward biased and will allow current flow to pass through them; D4 and D2 are reverse biased and will block current flow.

One advantage of a bridge rectifier over a conventional full-wave rectifier is that with a given transformer the bridge rectifier produces a voltage output that is nearly twice that of the conventional full-wave circuit.

i. The main advantage of this bridge circuit is that it does not require a special centre tapped transformer, thereby reducing its size and cost.

ii. The single secondary winding is connected to one side of the diode bridge network and the load to the other side as shown below.

The result is still a pulsating direct current but with double the frequency.

VOLTAGE REGULATORS:

Voltage regulators comprise a class of widely used ICs. Regulator IC units contain the circuitry for reference source, comparator amplifier, control device, and overload protection all in a single IC. IC units provide regulation of either a fixed positive voltage, a fixed negative voltage, or an adjustably set voltage. The regulators can be selected for operation with load currents from hundreds of milli amperes to tens of amperes, corresponding to power ratings from milli watts to tens of watts.

A fixed three-terminal voltage regulator has an unregulated dc input voltage, Vi, applied to one input terminal, a regulated dc output voltage, Vo, from a second terminal, with the third terminal connected to ground. The series 78 regulators provide fixed positive regulated voltages from 5 to 24 volts. Similarly, the series 79 regulators provide fixed negative regulated voltages from 5 to 24 volts. Voltage regulator ICs are available with fixed (typically 5, 12 and 15V) or variable output voltages. They are also rated by the maximum current they can pass. Negative voltage regulators are available, mainly for use in dual

supplies. Most regulators include some automatic protection from excessive current ('overload protection') and overheating ('thermal protection'). Many of the fixed voltage regulator ICs has 3 leads and look like power transistors, such as the 7805 +5V 1Amp regulator. They include a hole for attaching a heat sink if necessary.

MICROCONTROLLER:

A Microcontroller (or MCU) is a computer-on-a-chip used to control electronic devices. It is a type of microprocessor emphasizing self-sufficiency and cost-effectiveness, in contrast to a general-purpose microprocessor (the kind used in a PC). A typical microcontroller contains all the memory and interfaces needed for a simple application, whereas a general purpose microprocessor requires additional chips to provide these functions.

Zigbee:

A Zigbee system consists of several key components that work together to enable wireless communication and control. At the heart of the system is the Coordinator, which serves as the central hub and

and terminating devices, as well as providing network security. Routers extend the network coverage by relaying data between devices and the Coordinator, ensuring that messages reach their intended destination. End Devices, such as sensors, actuators, or smart home devices, communicate with the Coordinator or Routers to transmit and receive data. Zigbee Modules and Sticks are also available, providing pre-built solutions for integrating Zigbee functionality into devices. These components can be combined in various topologies, including star, tree, and mesh configurations, to create a robust and reliable network. Overall, the Zigbee components work together to provide a secure, scalable, and interoperable solution for wireless control and automation.

3-REMOTE-CONTROLLABLE AND ENERGY-SAVING ROOM ARCHITECTURE BASED ON ZIGBEE

Existing system

In The existing system of remote-controllable and energy-saving room architecture is infrared (IR)

Block diagram

The project comprises of important features of Home Automation. In this system user can control the devices wirelessly by just pressing the switch from anywhere. Figure 1 Shows the how the receiver is sending data to the microcontroller and then the microcontroller sending instructions to the relay module so that relay module will know which device

Communication it is commonly used for controlling household appliances and traditional appliances like air conditioners, televisions, and audio systems that rely on infrared signals. IR signals require a direct line of sight and can be blocked by obstacles, making this system best suited for small or single-room applications. Infrared (IR) Communication is a short distance operation typically up to 5-10 meters (16-33 feet) and it is Suitable for controlling appliances like TVs, audio systems, or air conditioners within the same room.

Proposed system

In the Proposed System the ZigBee communication is a low-power, wireless communication protocol designed for applications requiring reliable, low-data-rate, and short-range connectivity. It is widely used in smart home automation, industrial monitoring, and Internet of Things (IoT) devices due to its efficiency, scalability, and flexibility. It is a long distant operation which is typically up to 10-100 meters (33-328 feet) and suitable for Ideal for smart home or building automation, connecting sensors, actuators, and devices over larger areas without requiring direct line-of-sight.

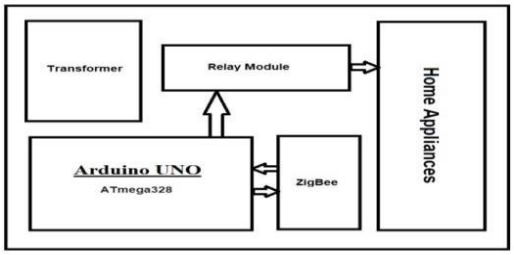


Fig 1: Receiver Circuit

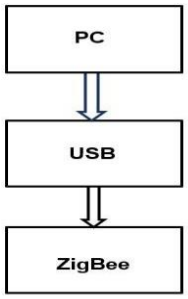


Fig 2: Transmitter Circuit

to turn ON/OFF. Figure 2 Shows that how the transmitter is connected to the microcontroller so that whenever the input is changed the microcontroller sends that data to the ZigBee and it transmits data to the receiver circuit

.Fig 1: Block diagram

Methodology

This project has two sections Hardware and Software Implementation. The hardware consists of the development and designing of main controller, ZigBee module, and relay module into a single circuit. While the software consists of microcontroller programming using embedded C.

Hardware Implementation: In this section we have two circuits. First one is the receiver circuit and the other one is the transmitter circuit. The Arduino UNO on both the circuits is

the main component of the hardware and this will act as an interface between the home appliances and Zigbee on the receiver circuit and as an interface between the switches and Zigbee on the transmitter circuit. Our main controller i.e., Arduino UNO is based on ATmega328 8-bit Microcontroller having 14 digital Input/Output pins, 6 analog pins and a 16 MHz quartz crystal.

Software Implementation: It is the programming part which means it consists of a set of instructions which we have written on our microcontroller. The programming part is done in both the circuits in two different ways. However, we are using two ZigBee modules and we know that it is a transceiver module. So, at the receiver circuit we have programmed the microcontroller to make the ZigBee work as a receiver and on the transmitter circuit we have programmed the microcontroller to make the ZigBee work as a transmitter.

4-RESULTS AND DISCUSSION

Output:

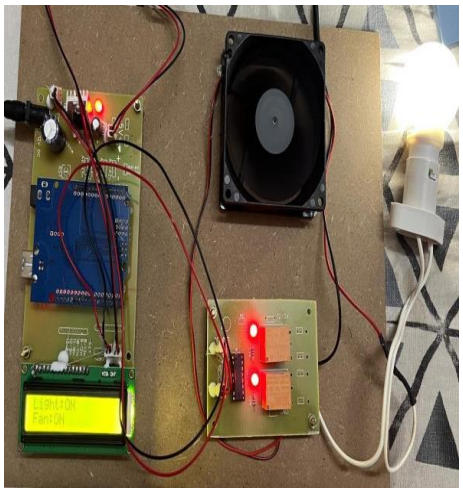
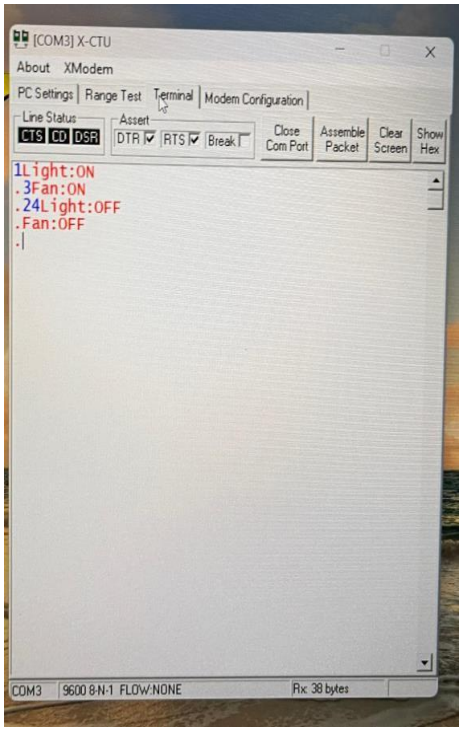


Fig 5.1.1: output

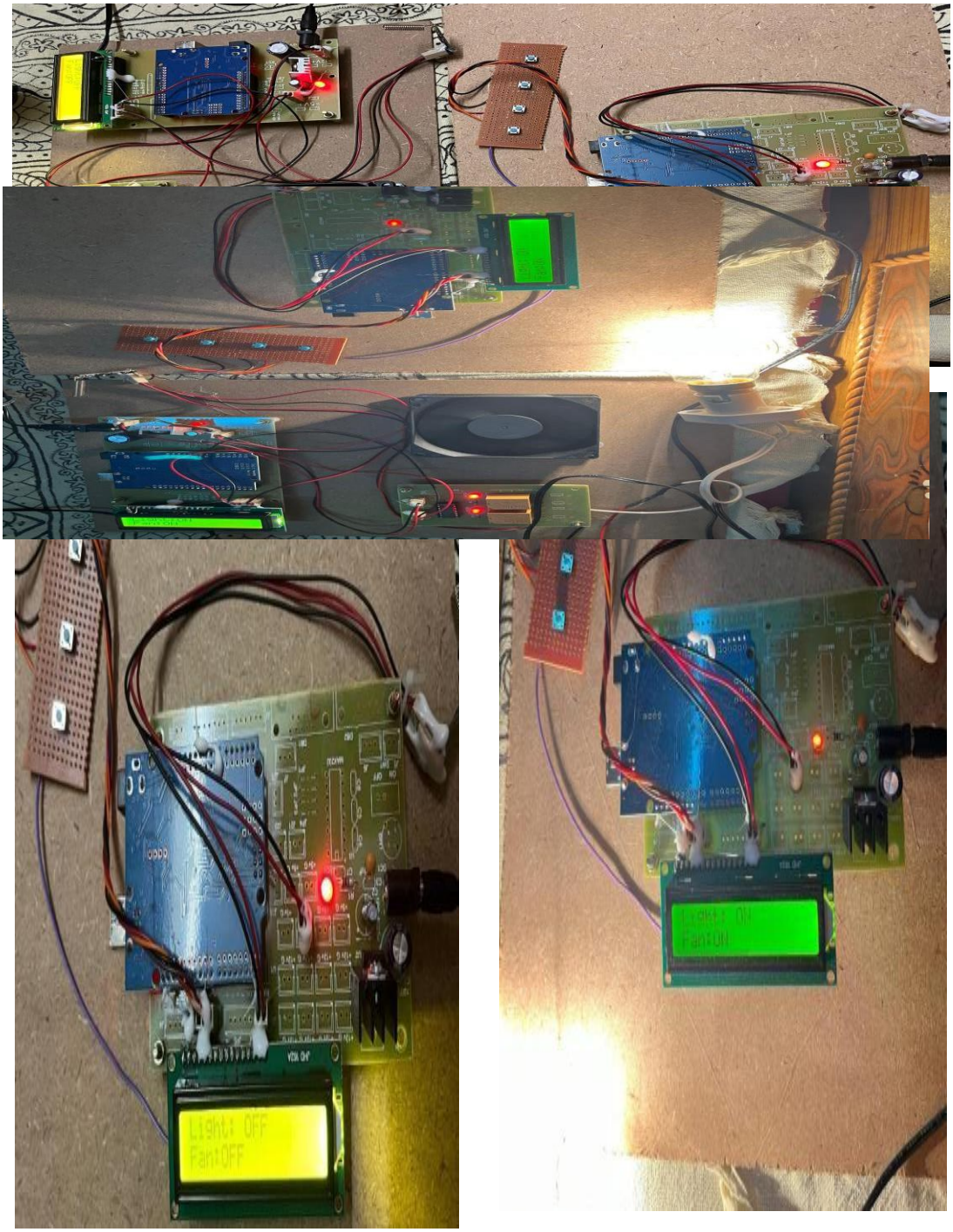
As a result, A prototype of a home automation system consisting of a ZigBee module, a microcontroller, and relays has been implemented. Which works fine up to a range of 15 meters approx. When comparing to other modules in the market like Wi-Fi or Bluetooth,

this range is much better than that on small range modules. Ranges of these modules vary as we go to the higher price variants of them. After surveying we also found that comparing ZigBee to other devices at



similar prices gives us the best range at ZigBee

modules only.



However, if better ZigBee modules are used then ZigBee can range up to 15 miles whereas Wi-Gi stops at 300 ft. As ZigBee is also a low-ost device by implementing the ZigBee module, we have found that ZigBee is a betterce be used in Home Automation

5-CONCLUSION

In conclusion, the Remote-Controllable and Energy-Saving Room Architecture based on Zigbee has demonstrated significant potential in optimizing energy efficiency, enhancing convenience, and contributing to sustainability in both residential and commercial environments. The integration of Zigbee technology provides a robust solution for managing lighting, HVAC systems, appliances, and other smart devices, effectively reducing unnecessary energy consumption. Through the ability to remotely control and monitor these systems, users can not only improve comfort but also lower their energy costs by ensuring devices are only used when needed. Zigbee's low-power, mesh networking capabilities also ensure that devices are energy-efficient, extending their operational lifespan and reducing the frequency of maintenance. While challenges such as limited range, interference from other wireless devices, and compatibility concerns with certain devices exist, these are often outweighed by the numerous benefits, including scalability, ease of integration with a wide range of devices, and real-time energy monitoring. As the demand for smart homes and energy-efficient buildings continues to rise, Zigbee-based solutions are well-positioned to play a key role in the future of energy management, offering a sustainable approach to creating more intelligent, eco-friendly living and working spaces. This project highlights the value of leveraging Zigbee for room automation, illustrating how remote-controllable, energy-saving technologies can contribute to reducing energy consumption, cutting costs, and advancing environmental sustainability, making it a promising choice for modern smart home and building automation systems.

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