Nile Journal of Communication & Computer Science

Volume 8 , December 2024

Journal Webpage: https://njccs.journals.ekb.eg

# Data Acquisition and Robot Control via Zigbee-based Wireless Sensor Network for SSAFR Applications

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**Abstract**
Communication is key in multi-robot systems that handle real-time applications. WLAN has become an efficient method for wireless communication amongst several robots because of its outstanding performance. On the other hand, simultaneous data transmission amongst robots in larger systems is more They have limited communication skills, making things tough. In this case, ad hoc robot networking appears to be a better option. The primary purpose of this effort is to enable ad hoc wireless communication between robots using ZigBee technology. The AODV routing protocol was simulated on four nodes, which correspond to four moving objects. Robots on Network Simulator 2.29 can be used to describe the robot transfer simulation technique. SSAFR robot communication is a fascinating networking technology. In this study, the Zigbee wireless circumstances were discussed using the AODV and TCP protocols. The data indicate that AODV outperforms Zigbee networks in terms of throughput and energy usage.

**Keywords:** ZigBee, technology, WSN, & M2M.

## 1. Introduction -

Industrial component life cycles have gotten shorter as complexity has increased, yet in today's modern industries, producing precise parts at the first trial through the use of the most effective techniques is becoming increasingly important. As a result, the field of robot applications is seeing tremendous technical advancement, making it a fascinating topic to research. Other than ensuring that a robot can effectively carry out commands from a controller—which is directly connected to a computer for the purpose of controlling and monitoring—the primary concern is generally creating a properly functioning robot. Furthermore, one type of robot that is frequently employed in today's advanced production is the SSAFR Robot. Consequently, a result, the field of robot applications is seeing tremendous technical advancement, making it a fascinating topic to research. Other than ensuring that a robot can effectively carry out commands from a controller—which is directly connected to a computer for the purpose of controlling and monitoring—the primary concern is generally creating a properly functioning robot. Furthermore, one type of robot that is frequently utilized in today's advanced manufacturing is SSAFR Robot.

Therefore, industrial component life cycles have gotten shorter as complexity has increased, yet in today's modern industries, producing precise parts at the first trial through the use of the most effective techniques is becoming increasingly important. As a result, the field of robot applications is seeing tremendous technical advancement, making it a fascinating topic to research. Apart from the robot's capability to carry out commands from a controller—which is directly connected to a computer for control and monitoring—the primary focus is often on creating a properly functioning robot. Furthermore, one type of robot that is frequently employed in today's advanced production is the robot hand. Consequently, the topic of how to control a robotic hand is As a result, the field of robot applications is seeing tremendous technical advancement, making it a fascinating topic to research. Aside from the robot's capacity to carry out commands from a connected to a computer for control and monitoring—the primary focus is often on creating a properly functioning robot. Furthermore, one type of robot that is frequently utilized in today's advanced

manufacturing is the robot hand. Therefore, it would be interesting to look at the question of how to control a robotic hand.1. The SSAFR is one of the most basic models; it features a controller that allows manual autonomous movement control. Managing the robotic device's motion, aside from the robot's capacity to carry out commands from a controller—which is directly connected to a computer for control and monitoring—the primary focus is often on creating a properly functioning robot. Furthermore, one type of robot that is frequently utilized in today's advanced manufacturing is the robot hand. Therefore, it would be interesting to look at the question of how to control a robotic.

Without software, it is challenging to control the robotic arm's movement and carry out robot development tasks using a computer. Because of this, the arm's movement can be manually controlled with the SSAFR's controller. This makes utilizing a wireless control system to rebuild the SSAFR controller necessary. Wireless control and movement monitoring will be possible with the new technology. Because of this, a wireless control system must be used to rebuild SSAFR controller. The new system will have wireless control and movement monitoring capabilities.

**2. ZigBee wireless. Sensor Network.**

**2.1. ZigBee Arc**

Zigbee is now the best wireless networking choice on the market. This technology has a range of 10-20m, making it acceptable for home or office use, and it is being actively watched for its potential for ubiquitous computing.

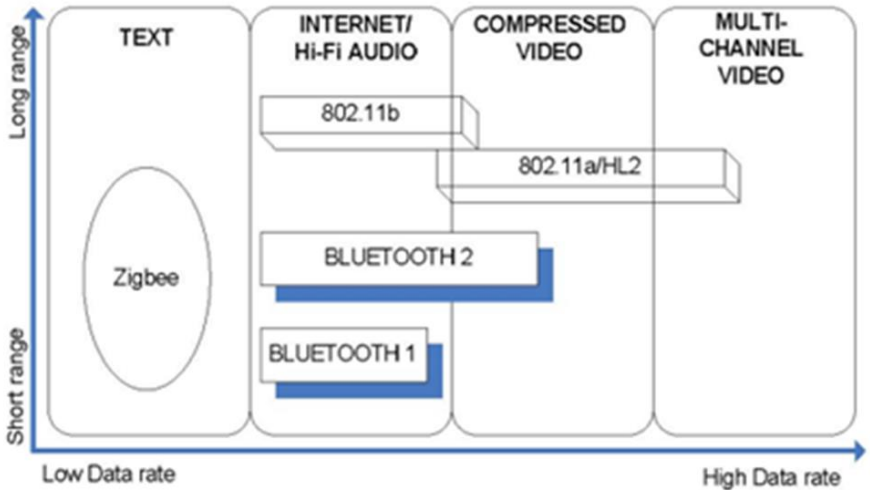



**Fig. 1** Wireless Network Technology

Zigbee is a wireless networking protocol with 255 nodes that provides modest data baud rates (20-250 kbps) over small distances (IOcm-i Om) while consuming minimal power. In comparison to IEEE 802.11 and other 802.15, Zigbee wireless communication prioritizes small size, low power consumption, and simple functionality. It consumes less electricity than Bluetooth. Because it lacks a composite feature structure, it has a significant time-to-market and application scalability advantage over Bluetooth.

**The features of Zigbee are as follows**:

- In Korea and around the world, the frequency bandwidth and baud rate are 2.4 GHz ISM Band (250 kbps), 915 MHz ISM Band (40 kbps), and 868 MHz (20 kbps) in Europe.
- The battery has a life cycle of 100-1000 days.
- For channel access, use the CSMA/CA technique.
- Supports up to 65,535 nodes and can be implemented in Star, Cluster tree, and Mesh topologies. - Coordinators can automatically deploy the network.

## 2.2. IEEE 802.15.4 (LR-WPAN) MAC

IEEE 802.15.4 is a subcommittee for the development of LR-WPAN (Low-Rate Wireless Personal Area Network). This organization seeks to standardize low-cost, long lasting battery technology enabling easier installation, greater mobility, and reliable data. Additionally, Task Group 4 defines PHY (physical) and MIAC (media access control).

## 3. SKXBEE Modules

This project requires two XBEE modules (Fig. 2) to communicate via Zigbee protocol between the PC controller

and mobile robot. The XBEE circuit differs from standard PCB circuits as it needs a 3.3 V DC supply. To produce a low dc voltage, pass the 5V output to the LM317 voltage regulator. Using XBee in autonomous robots allows for lower voltage input, resulting in longer battery life. The SKXBEE interfaces with the microcontroller circuit via 5 pins: Tx (RC7), Rx (RC6), 5V, GND, and reset.

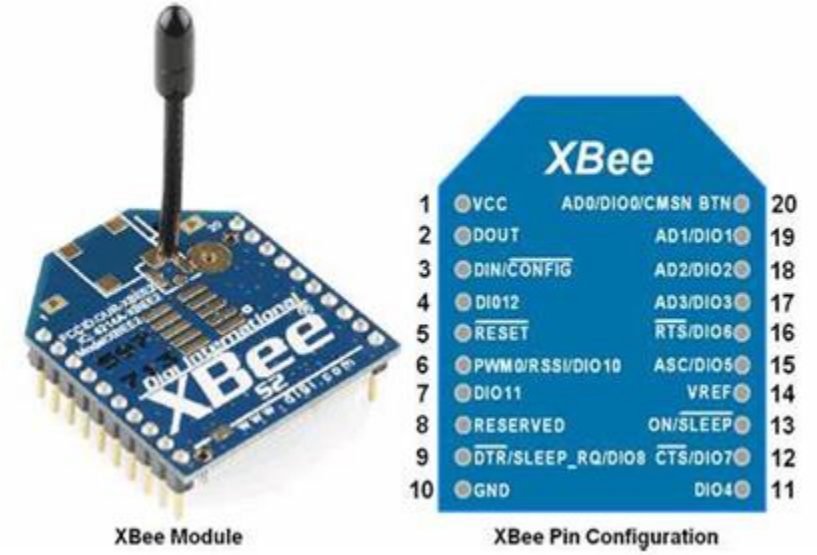



**Fig.2** Xbee datasheet

Digi's XBee and XBee-Pro RF modules are popular choices for wireless communication due to their versatility and ease of use. The XBee-Pro model offers significantly longer range than the standard XBee while maintaining the same operating system and programming interface.

This wireless mobile robot application employs a standard XBee module with a transmit power of 1mW, operating at 2.5GHz with a data rate of 250kbps and a current consumption of 45-50mA. The XBee's compact size and low power consumption make it ideal for this application. For scenarios requiring extended range, the XBee-Pro with its 10mW output power would be a suitable alternative.

**4. System Designing**

Designing a zigbee application for communication The Node MCU controller controls two robots who send and receive data. Zigbee is preferred as a wireless controller due to its compact size, adaptability, cost-effectiveness, and simple software configuration [6]. The talk covers both hardware design (mechanical and electronic robot systems) and software design (system and program flowcharts for Node MCU).

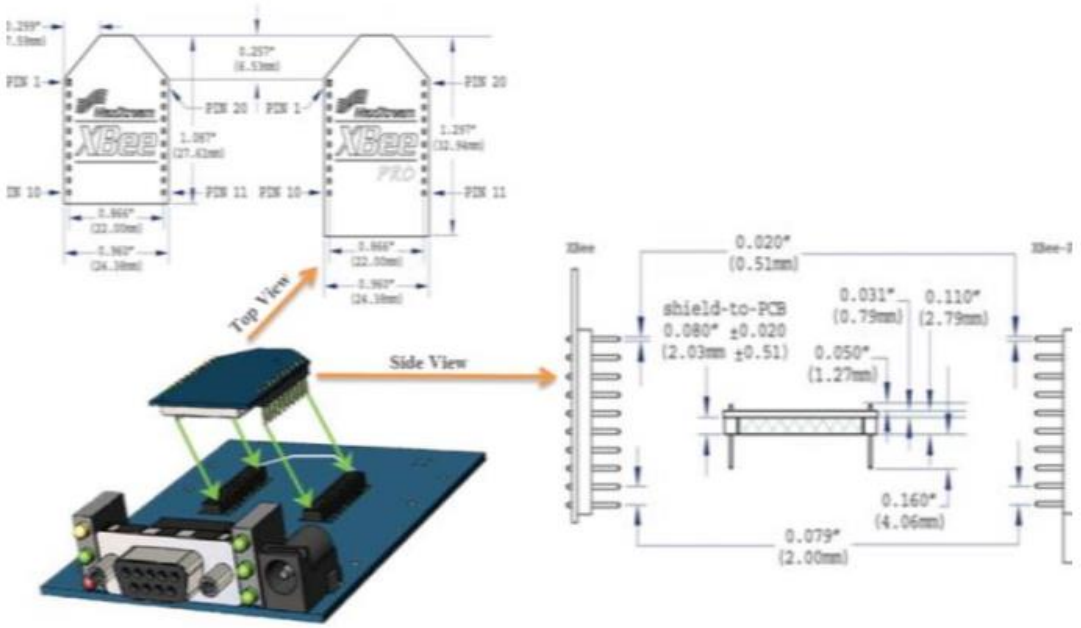



**Fig.3** System Designing

## 5. Function Description

Wireless communication between SSAFR robot with WSN sensor with receive values and save it at MySQL database.

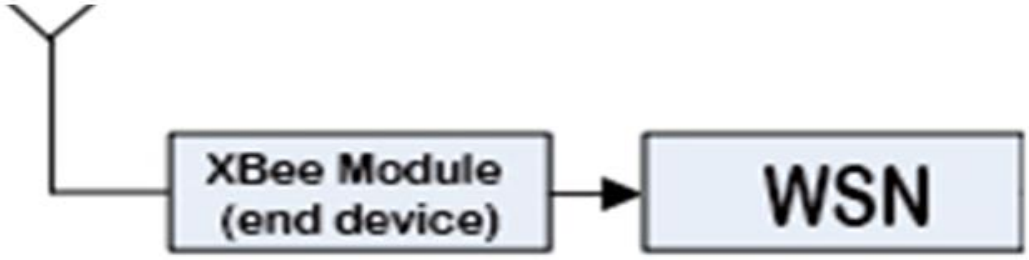



**Fig.4** Transmit chart

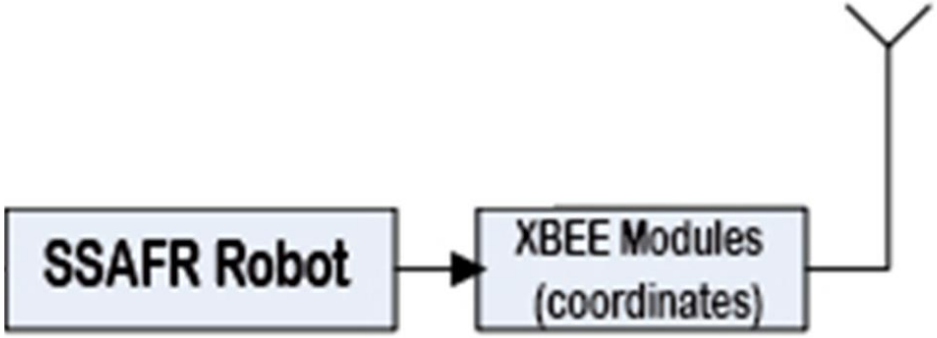



**Fig.5** Receiver chart

### 6. Overview

As shown in Fig. 6 depicts the creation of a Personal Area Network using two temperature sensor nodes, a robot, two routers, and a coordinator for this application.

Two sensor nodes in two labs are utilized for temperature measurement, while a LabVIEW FPGA Starter kit robot from National Instruments (NI) [6] with an encoder is dynamically controlled and monitored. In order to maintain network synchronization, the distant nodes equipped with ZigBee modules will likewise enter a state of sleep.

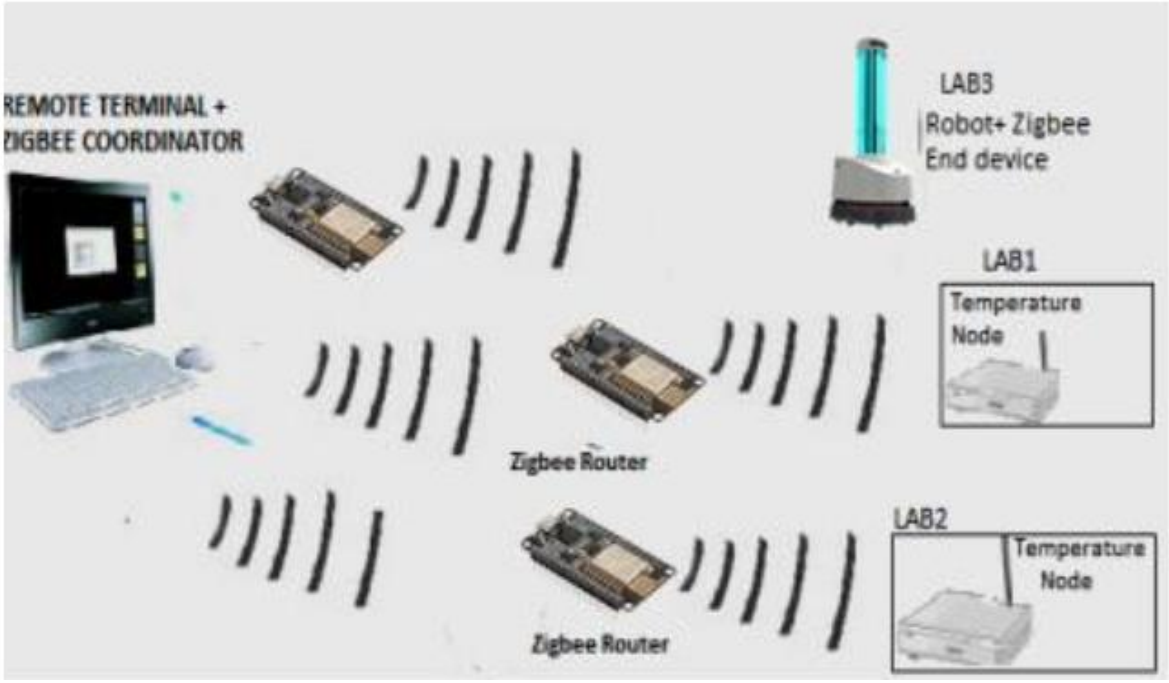



**Fig.6** Overview Chart

## 7. Script

Let's take that a step further to send WSN data from NodeMCU (Sender) to another Robot (Receiver) and toggle Led and set event when get value greater than 25 Celsius using Zigbee (Xbee)

**Component**:

- 2x NodeMCU.
- 2x XBee Pro S2C modules.
- 1x XBee explorer board.
- DS18B20 "Digital Temperature Sensor".

**Downloading and Installing XCTU Software**

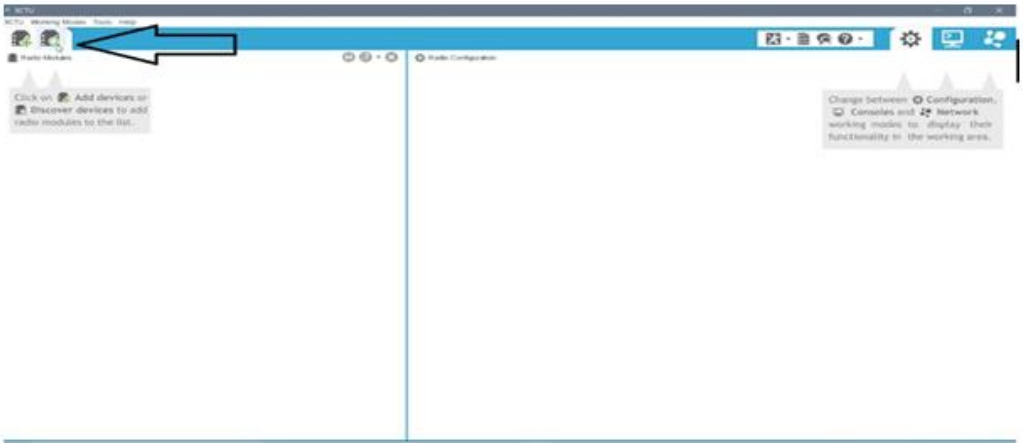
XCTU is a free multi-platform utility with an intuitive graphical user interface for developers working with Digi RF modules. It includes new tools for quickly and easily connecting, configuring, and testing XBee® RF modules.

Configuring, testing, and setting up your XBee devices requires the use of XCTU software. It is a free, cross-platform, user-friendly app for Use an explorer board or a USB to serial converter to communicate the XBee module to a PC or laptop. Connect XBee module to the explorer board with a USB and plug it in. Let's get our equipment ready before we start learning how to use this software and configure the module.

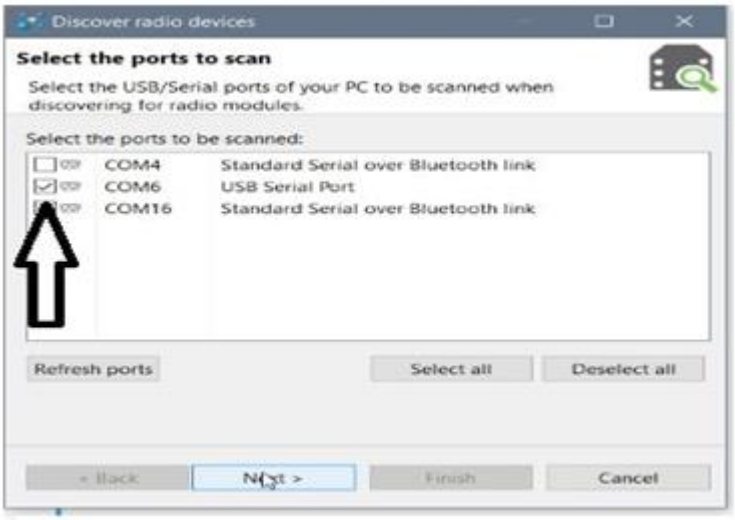

**Fig. 7** XCTU Software IDE

**Installing firmware on XBee modules.**

First, the firmware in both XBee modules needs to be installed; the XBee development board is used for this purpose.

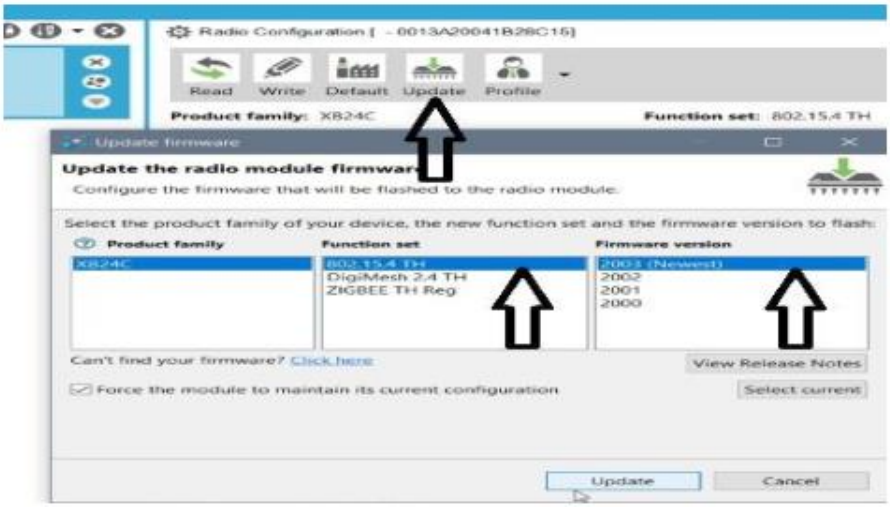


**Step 1:** Launch the XCTU software and select "Discover boards."

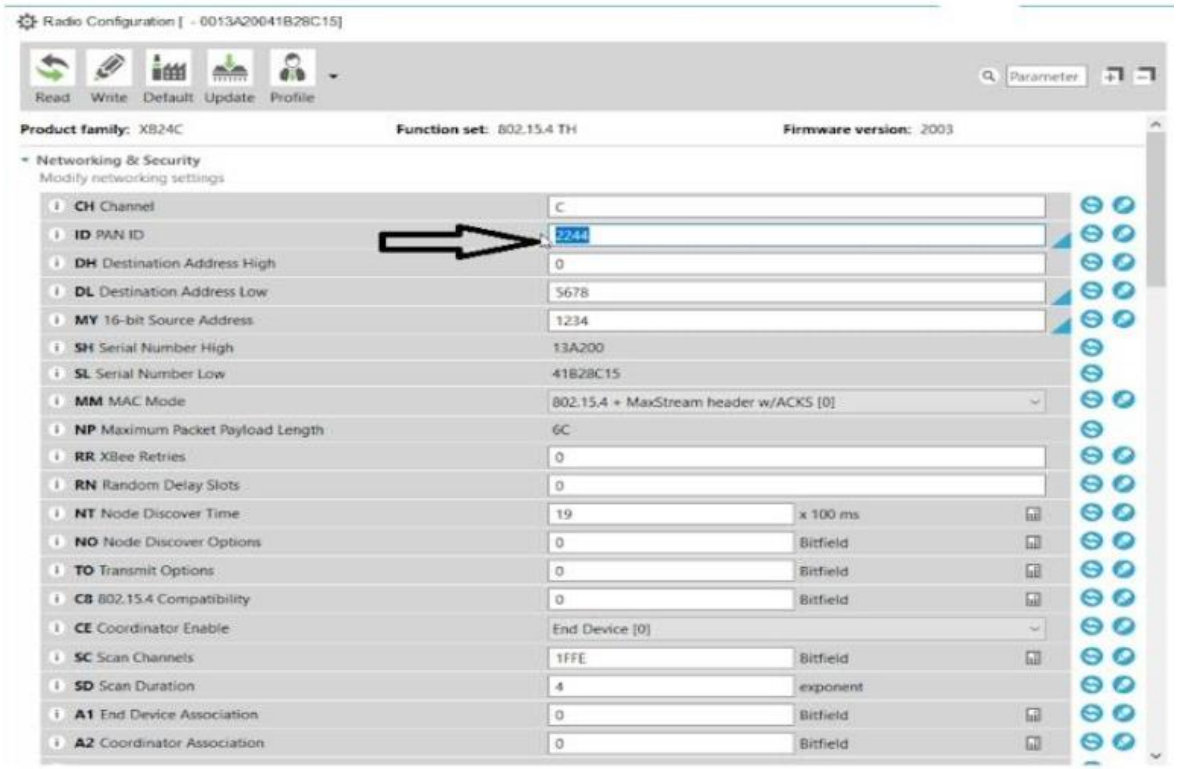



**Step 2**: Select the COM port for your XBee module, proceed and choose the XBee module's COM port, then click "Next".


**Step 3:** Save the default configurations and click "Finish."
**Step 4:** In the pop-up box that displays, select "Add Selected Devices".
**Step 5:** Your XBee module will be listed on the left. Selecting it refreshes the display.

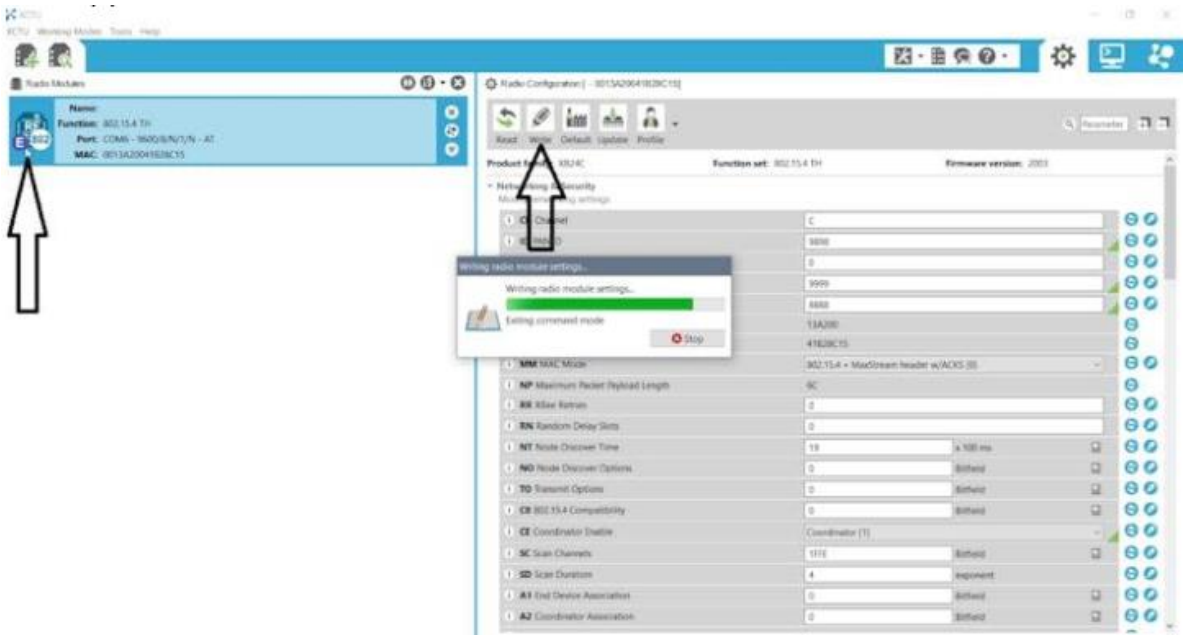



**Step 6:** Click "Update," choose "802.15.4 TH" from the Function set, select the most recent firmware from the Firmware version, and then click "Update" to upgrade the firmware. Then, a pop-up window appears. Select the YES button.




**Step 7:** Assign a unique 4-digit PAN ID to identify your network. Ensure both XBee modules use the same ID to connect them.


**Step 8:** Enter the destination address as four digits.
**Step 9:** Enter the Source Address as any four-digit number.



**Step 10:** Assign the "Coordinate [1]**" device to one. with the extra gadget as the "end device"**

**Circuit schematics:**

- **Transmit**

Connect pin 1 (VCC) of the XBee module to the Node MCU's 3.3V and GND to the Node MCU's GND. These two connectors provide power to the transmitting XBee module. Attach Pin 2 (Dout) to Node MCU's GPIO5 and Pin 3 (Din) to Node MCU's GPIO1.

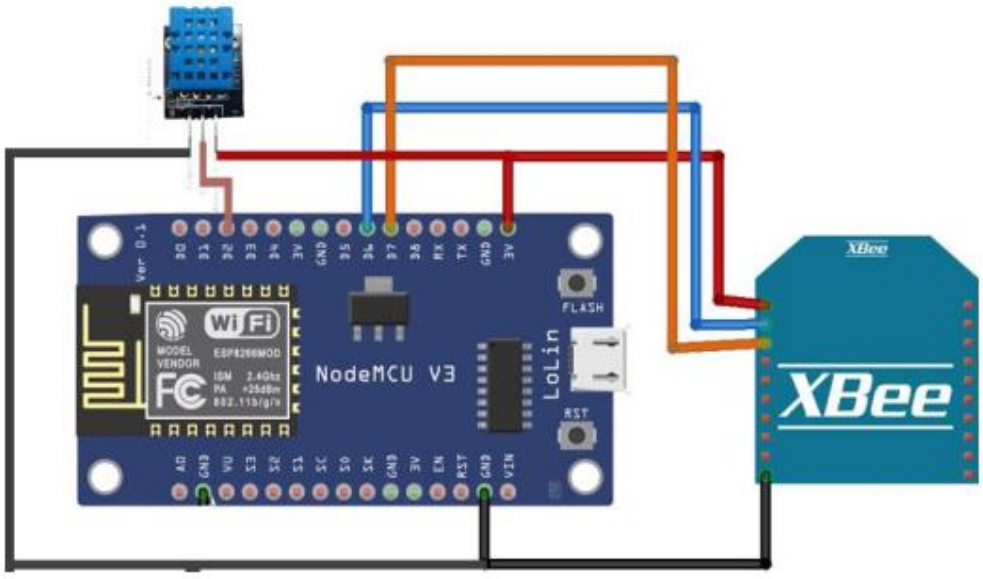



**Fig. 8** Transmit schematics

- **(Receiver)**

Connect the XBee's GND to the NodeMCU's GND and Vcc to the NodeMCU's 3.3V. Then, connect the XBee's Dout to the NodeMCU's D6 and Din to D7 for data reception.

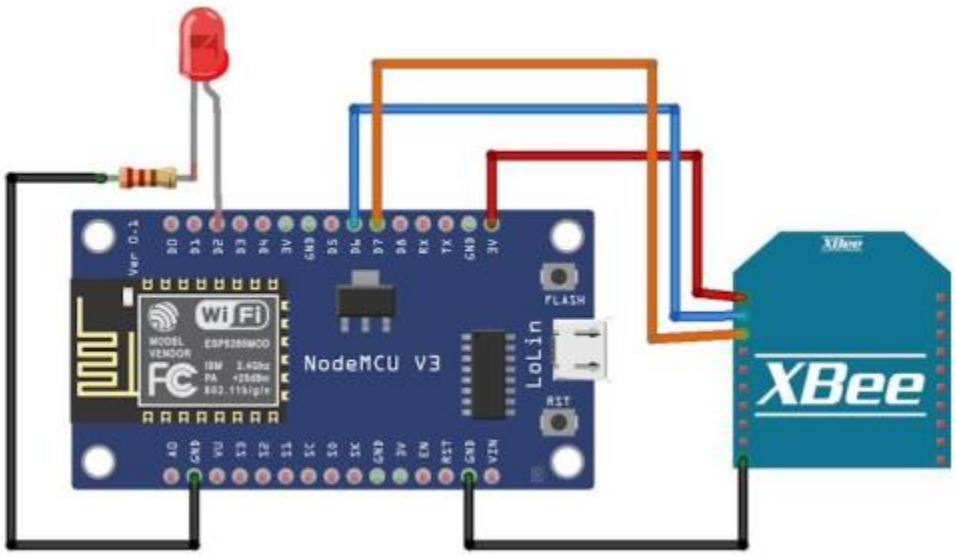



**Fig. 9** Receiver schematics

We used LEDs to indicate whether or not data was received. Connect the LED anode to NodeMCU D2 and the LED cathode to GND using a 220ohm resistor.

## 8. Summary and Conclusion

A WSN prototype was deployed in our institution's Electrical and Cryogenic laboratories to monitor temperature conditions. Additionally, a robotic platform was wirelessly controlled, with its position tracked in real-time via a remote console. To extend network coverage and efficiently route data between labs, two XBee routers were implemented. The provided table summarizes the distance and communication delay between various network components and the central coordinator.

This study compared the performance of AODV and TCP protocols in Zigbee wireless environments. Results indicate that AODV outperforms TCP in terms of throughput and energy efficiency within the Zigbee network architecture.

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