One-Way Wireless Communication Using ASK Modulation Scheme

Divyansh Gupta
Roll No: 2101EE89
Junior Year, EE Dept.
Indian Institute of Technology Patna
Patna, India
divyansh_2101ee89@iitp.ac.in

Ayush Tripathi
Roll No: 2101EE90
Junior Year, EE Dept.
Indian Institute of Technology Patna
Patna, India
ayush_2101ee90@iitp.ac.in

Aditya Pandey
Roll No: 2101EE93
Junior Year, EE Dept.
Indian Institute of Technology Patna
Patna, India
aditya_2101ee93@iitp.ac.in

Aakash Sharma
Roll No: 2101EE01
Junior Year, EE Dept.
Indian Institute of Technology Patna
Patna, India
aakash_2101ee01@iitp.ac.in

Chitraksh Dhingra
Roll No: 2101EE25
Junior Year, EE Dept.
Indian Institute of Technology Patna
Patna, India
chitraksh_2101ee25@iitp.ac.in

Under Supervision of:
Dr. Amit Kumar Singh
Assistant Professor, EE Dept.
Indian Institute of Technology Patna
Patna, India
amitks@iitp.ac.in

Abstract—**This paper introduces a one-way wireless communication system employing Amplitude Shift Keying (ASK) modulation at 433 MHz frequency. The system consists of a transmitter and receiver, both controlled by Arduino Nano microcontrollers. Data is encoded into binary, modulated using ASK, and transmitted via a 17 cm antenna in form of hexadecimal packets. On the receiver side, the signal is captured, demodulated, and decoded for various actions. The integration of ASK modulation, 433 MHz transceivers, and Arduino Nano microcontrollers offers a cost-effective and reliable solution for wireless communication applications.**

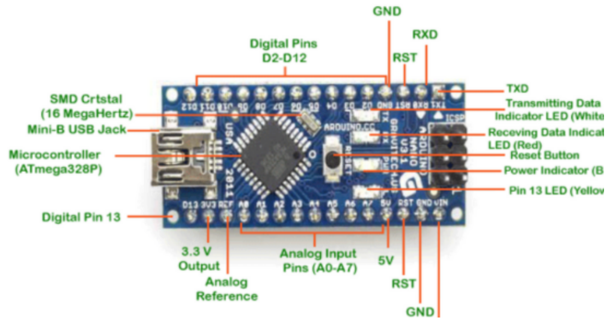
I. Introduction

Wireless communication systems play a pivotal role in modern technological landscapes, facilitating efficient data transfer over varying distances. In this context, the utilization of robust modulation techniques and suitable frequency bands becomes crucial for achieving reliable transmission. This paper presents a comprehensive exploration of a one-way wireless communication system, designed to transmit character messages between Arduino Nano microcontrollers via ASK modulation. Central to this setup is the use of 433 MHz transmitter and receiver modules equipped with 17 cm antennas, enabling effective signal transmission and reception. Through the integration of Arduino Nano microcontrollers, the system aims to provide a versatile and accessible platform for implementing wireless communication solutions. This introduction lays the groundwork for examining the intricacies of our proposed system, highlighting the importance of ASK modulation and the specific hardware components employed for achieving seamless data transfer..

II. Hardware Description

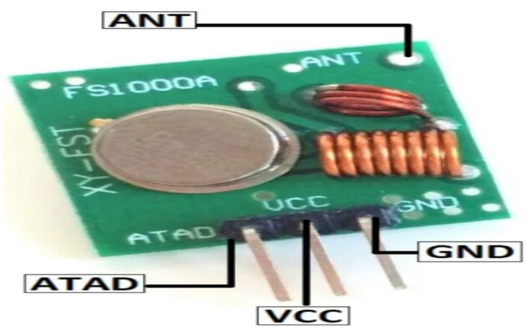
A. Arduino Nano(microcontroller)

The Nano, featuring the ATmega328P microcontroller, is a compact prototyping tool with 14 digital I/O pins (6 PWM) and 8 analog input pins. Operating at 5V (7-12V input range), it offers ample processing power with 32KB Flash memory (2KB for bootloader), 2KB SRAM, and 1KB EEPROM, all running at 16MHz. Besides controlling and interfacing tasks, the Nano encodes data for transmission and decodes received data in our one-way wireless communication system, showcasing its versatility in data handling.



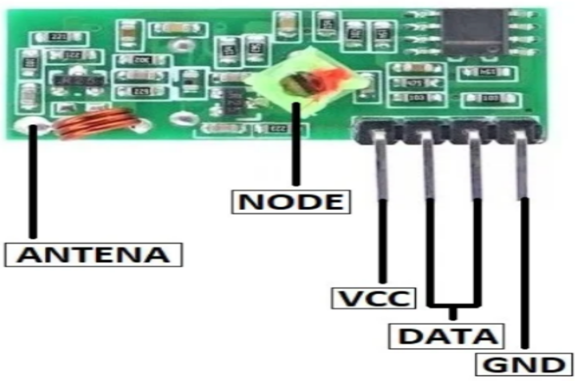
B. 433MHz Transmitter Module

This Module stands as a compact and cost-effective wireless communication solution, operating reliably within the 433MHz radio frequency spectrum. Its widespread adoption spans across remote control systems, home automation, and various other applications necessitating short-range wireless connectivity. The module's data pin, designated as ATAD, serves as the conduit for transmitting encoded data from input devices, establishing seamless communication with the Arduino Nano microcontroller via the D2 pin interface. While the inclusion of an antenna pin is optional, the module can effectively operate within a range of up to 3 meters without it. However, to extend its transmission range up to 100 meters, a small wire antenna can be employed. This feature enhances the module's adaptability and versatility, positioning it as an essential component within our proposed one-way wireless communication system.



C. 433MHz Reciever Module

This Module emerges as a compact and cost-effective component integral to short-range wireless communication applications. Featuring two data input pins, internally common with each other, this module ensures efficient reception of data streams, enabling seamless integration with the Arduino Nano microcontroller via the D2 pin. Notably, the presence of an antenna pin facilitates the extension of transmission range up to 100 meters by connecting an external wire antenna. The size of the antenna is tailored to the operating frequency, underscoring the module's adaptability to diverse communication scenarios. This module's description underscores its pivotal role in our proposed one-way wireless communication system, accentuating its versatility and efficacy in enabling reliable data reception over significant distances.



D. *17cm Single Strand Antenna*

The antenna employed in our setup consists of two 17 cm single-strand wires, meticulously chosen for their advantageous properties in wireless communication applications. Single-stranded wire, selected over multi-stranded alternatives, offers lower resistance, resulting in reduced losses and improved signal transmission efficiency, particularly at higher frequencies. Moreover, its lower capacitance enhances overall antenna performance, ensuring optimal signal reception and transmission. Additionally, single-strand wire exhibits superior resistance to corrosion, prolonging the antenna's operational lifespan, while its cost-effectiveness makes it a practical choice for antenna deployment. This antenna configuration embodies a balance of performance, durability, and affordability, making it an ideal fit for our one-way wireless communication system

III. Working Principle

The proposed one-way wireless communication system operates on the foundational principle of Amplitude Shift Keying (ASK) modulation, integrating Arduino Nano microcontrollers for control and data processing. The system comprises a transmitter and receiver, each equipped with specialized components tailored to facilitate seamless data transfer over a designated frequency band.

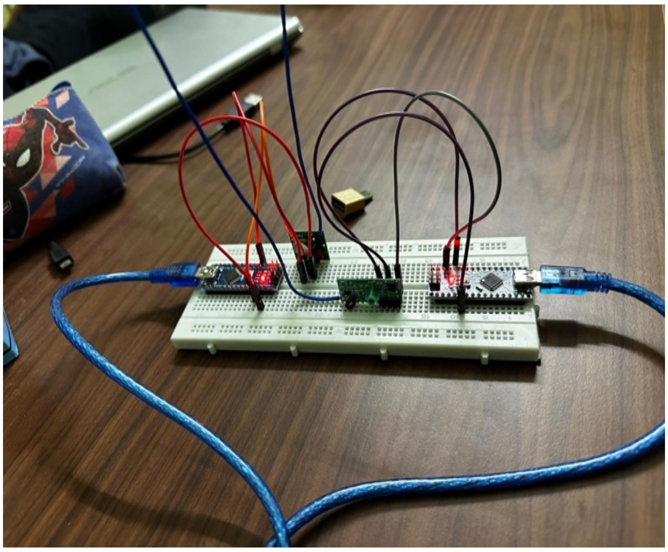
Character-type messages undergo encoding into a hexadecimal bit string format before modulation at the transmitter end. ASK modulation dynamically adjusts the amplitude of the carrier signal to represent the encoded data, ensuring efficient embedding within the transmitted signal. Operating at a frequency of 433 MHz, the transmitter transmits the modulated signal wirelessly through optimized 17 cm single-stranded wire antennas, meticulously designed for enhanced signal propagation.

Upon reception, the identical antennas on the receiver end capture the transmitted signal, which undergoes demodulation to extract the original data. This process involves meticulous analysis of amplitude variations within the received signal, allowing for precise data retrieval. The decoded data is subsequently processed by the receiver Arduino Nano microcontroller to execute predefined actions, facilitating seamless integration with various applications.

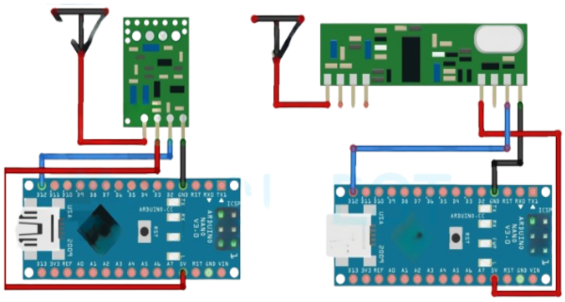
The utilization of specialized antennas optimized for the 433 MHz frequency band is pivotal in ensuring robust signal transmission and reception. These antennas, crafted from 17 cm single-stranded wire, exhibit low resistance, reduced losses, and enhanced performance, bolstering the system's reliability and efficacy over extended distances.

In summary, the integration of ASK modulation, Arduino Nano microcontrollers, and optimized antennas forms the cornerstone of the proposed one-way wireless communication system. This meticulously designed system offers a robust platform for reliable data transfer, suitable for a diverse array of wireless communication applications..

IV. Implemented Hardware Diagram



V. Circuit Diagram



VI. Software Program Description

A. *Transmission Program Overview*

Our code leverages the RadioHead library to enable wireless data transmission through ASK modulation, specifically tailored for a microcontroller like the Arduino Nano. During initialization in the setup function, the code configures the transmitter object with specific pin configurations, ensuring seamless communication with associated hardware components. Furthermore, optional serial communication initialization allows for effective debugging, facilitating diagnostic messages in case of transmitter initialization failure. Within the main loop, a predefined message, "Hello, Sir," is defined and transmitted using the RadioHead driver as the data payload. The program subsequently awaits successful packet transmission before introducing a short delay, ensuring the transmission process repeats at regular intervals.

This iterative transmission cycle exemplifies the program's capability to continuously relay data wirelessly. By leveraging ASK modulation and the RadioHead library, the microcontroller (Nano) efficiently transmits data, fostering persistent communication. This approach ensures seamless integration into various applications, exemplifying the versatility and reliability of the transmitter program in enabling wireless data transmission.

B. Reciever Program Overview

Our code implements a communication system using the RadioHead ASK library, tailored for receiving wireless data transmissions. During initialization, serial communication is established for debugging, and the radio driver is initialized to facilitate communication with the transmitter.

Within the loop() function, the receiver continuously monitors for incoming messages from the transmitter. It employs a buffer to store received data and utilizes the recv() function to check for available data packets. Upon receiving data, the message is printed via serial communication, allowing real-time monitoring of received data.

Crucially, the code operates non-blockingly, enabling concurrent execution of other tasks while awaiting incoming messages. This approach enhances receiver efficiency and flexibility, making it adaptable to diverse applications.

Overall, the receiver program provides a straightforward yet robust solution for wirelessly receiving and processing data. Leveraging inexpensive RF modules, it ensures reliable communication between transmitter and receiver, catering to various practical needs.

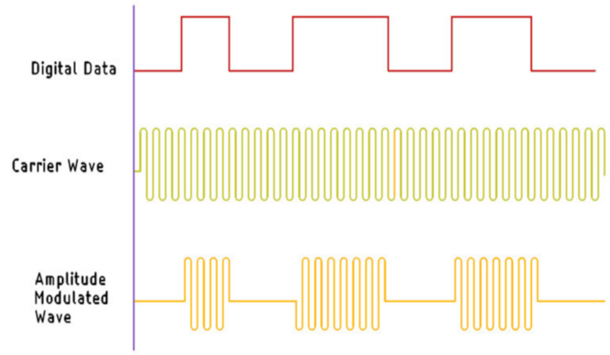
VII. ASK Modulation Scheme

Amplitude Shift Keying (ASK) stands as a fundamental method in digital communication, employed to convey digital information by altering the amplitude of a carrier signal. In ASK modulation, distinct amplitude levels represent different binary states, with high amplitude denoting a '1' and low amplitude representing a '0'. This modulation technique serves as a cornerstone in wireless data transfer, enabling efficient encoding and decoding of information. The advantage of Amplitude Shift keying is that it is very simple to implement. The decoder circuitry is quite simple to design. Furthermore, ASK requires less bandwidth than other modulation techniques such as FSK (Frequency Shift Keying). This is one of the reasons why it is cost effective.

The disadvantage of ASK is that it is susceptible to interference from other radio equipment and ambient noise. However, as long as you transmit data at a relatively slow rate, it can work reliably in most environments.

In our project, we utilized ASK modulation scheme along with inbuilt Arduino Nano libraries to facilitate wireless data transmission between the transmitter and receiver. Consider a scenario where a character message such as "HELLO" is transmitted using ASK modulation. Initially, each character undergoes conversion into its binary representation, which is then grouped into hexadecimal digits for simplicity. These hexadecimal digits serve as the basis for modulating the amplitude of the carrier signal. At the receiver end, the modulated signal is demodulated to extract the hexadecimal digits, which are subsequently converted back to binary and then to ASCII characters. This meticulous process reconstructs the original message, showcasing the efficacy of ASK modulation in facilitating wireless data transfer.

The utilization of ASK modulation scheme, coupled with inbuilt Arduino Nano libraries, underscores its pivotal role in wireless communication systems. Offering a reliable and efficient method for encoding and decoding digital information, ASK modulation enables seamless transmission and reception of data, making it a cornerstone technology in modern digital communication protocols.

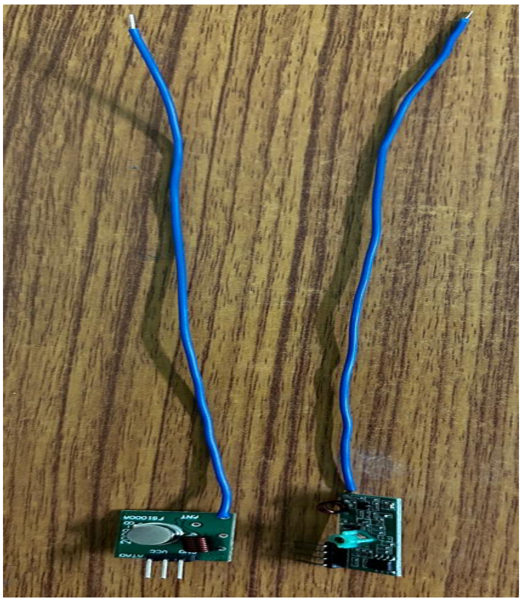


VIII. Antenna Modelling

The selection of antenna length plays a critical role in optimizing the performance of wireless communication systems, particularly in relation to the operating frequency. Without an antenna, communication range is severely restricted, often limited to only a few meters. For optimal efficiency, the antenna length should ideally correspond to a quarter or a half wavelength of the signal frequency. In our case, with a frequency (f) of 433 MHz and an antenna length (L) of 17.25 cm, the calculated wavelength (λ) using λ = C (speed of light) / f yields approximately 0.691 meters. Remarkably, the antenna length of 17.25 cm aligns closely with a quarter wavelength for the specified frequency, thus positioning it near the ideal length for facilitating efficient transmission and reception. Even with the simplest design, such as a single-core wire, effective communication over distances of up to 50 meters is feasible. But we can easily communicate over 300-500m distance through RF module.

Beyond length considerations, antennas exhibit distinct radiation patterns that delineate their coverage areas and polarization characteristics, significantly impacting signal integrity. Ensuring impedance matching between the antenna and the transmission line is paramount to achieving maximum power transfer, while antenna gain serves to amplify signals in specific directions, thereby extending communication ranges. Additionally, bandwidth considerations and the utilization of multi-antenna techniques such as diversity and Multiple-Input Multiple-Output (MIMO) further enhance system flexibility and reliability.

Moreover, it is imperative to account for environmental factors such as terrain, obstacles, and atmospheric conditions, which exert notable influence on antenna performance. Careful design and strategic placement of antennas are essential to mitigate potential signal degradation caused by these environmental variables, ultimately optimizing system performance and ensuring reliable wireless communication in diverse operational scenarios.



(17cm Transmitter and Reciever Antenna Used)

IX. Results

We conducted wireless communication experiments between two laptops positioned less than 50 meters apart. The transmission of the message "Hello, Sir" occurred rapidly, with data appearing in the receiving laptop's serial log within seconds. The use of a 17cm antenna optimized for the 433MHz frequency proved crucial for efficient and low-power communication. However, beyond a distance of 50 meters, we experienced signal loss, highlighting the importance of proximity in wireless communication reliability.

X. Conclusion

We successfully demonstrated one-way wireless communication employing 433MHz transmitter (Tx) and receiver (Rx) modules. We found that the 433MHz frequency band is suitable for applications requiring moderate range and power efficiency. However, limitations in signal range and susceptibility to interference, especially in environments with significant electromagnetic noise, were observed. Future research could focus on mitigating these limitations through signal processing techniques and antenna optimizations, while exploring alternative frequency bands may offer enhanced performance. Overall, our study provides valuable insights for the practical implementation of 433MHz-based wireless communication systems.

XI. Future Scope of Extension

Looking ahead, our project offers promising opportunities for extension and refinement in the domain of wireless communication. Firstly, optimizing transmission protocols and exploring advanced modulation techniques can enhance data transfer rates and efficiency, fostering faster and more reliable communication. Additionally, expanding our system to support bidirectional communication enables dynamic interaction and opens doors to applications like remote control systems and interactive data exchange. Moreover, integrating our wireless communication solution with emerging technologies such as artificial intelligence (AI) and machine learning (ML) presents exciting prospects for enhancing system adaptability and performance. Lastly, ensuring scalability and interoperability will be crucial for widespread adoption, necessitating standardization of communication protocols and compatibility with existing networks. Through these avenues of extension, we can further elevate the capabilities and applicability of our wireless communication system, driving innovation and addressing evolving communication requirements.

References

[1] P. Das, and A. K. Singh, " Gain Enhancement of Millimeter Wave Antenna by Ultra-thin Radial Phase Gradient Metasurface for 5G Applications" in IETE Journal of Research, pp. 1-10, March, 2023.

[2] Roy, Kawshik. (2020). 433 MHz (Wireless RF) Communication between Two Arduino UNO. American Journal of Engineering Research. 5. 358-362..

[3] http://www.electronicshub.org/wireless-transmitter-and-receiver-using-rf-modules/

[4] https://randomnerdtutorials.com/rf-433mhz-transmitter-receiver-module-with-arduino/

[5] Taha, Zahraa. (2017). Wireless Communication for Gas Detection using 433RF Modules and Arduino Processor. 975-8887.