MINI-PROJECT REPORT

ON

‘AUDIO SECURITY USING P-N SEQUENCE & RASPBERRY PI’

SUBMITTED BY

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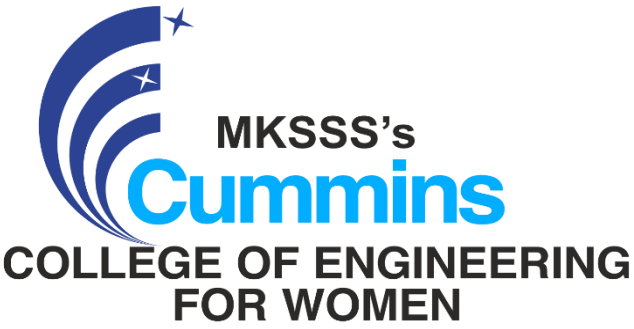
UNDER THE GUIDANCE OF

PROF. S. G. DUBE



DEPARTMENT OF

ELECTRONICS AND TELECOMMUNICATION ENGINEERING

MKSSS's

Cummins College of Engineering for Women, Pune

(An Autonomous Institute Affiliated to Savitribai Phule Pune University)

2023-2024

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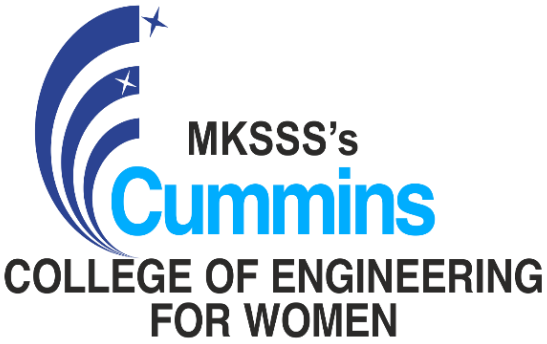

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MAHARSHI KARVE STREE SHIKSHAN SAMSTHA'S

CUMMINS COLLEGE OF ENGINEERING FOR WOMEN

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(An Autonomous Institute Affiliated to Savitribai Phule Pune University)

CERTIFICATE

This is to certify that the Mini Project work entitled

'AUDIO SECURITY USING P-N SEQUENCE & RASPBERRY PI '

is a bonafide record of the project work carried out in this institute

by

Dunung Sourabhi Ashwin (C. No. UEC2021211)
Kanawade Nandini Rajendra (C. No. UEC2021221)
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in partial completion of the term work for the Third Year B.Tech.

in
Electronics and Telecommunication Engineering
in the academic year 2023-2024.

This Mini-Project Report is a record of their own work carried out under our supervision and guidance.

Prof. S. G. Dube	**Dr. S. N. Ohatkar**	**Dr. M. B. Khambete**
Internal Guide	**Head of Department (E&Tc)**	**Principal, CCOEW, Pune-52.**

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Abstract:

In light of the contemporary imperative for secure handling of audio data, the present project was undertaken with a primary focus on enhancing audio data communication security. The chosen methodology involved the utilization of P-N sequences and MATLAB in conjunction with the application of Raspberry Pi. By leveraging this combination, our aim was to reinforce the security measures in audio data communication, addressing the pressing need for robust protection of sensitive information in today's digital landscape.

A. Brief Overview:

The initial phase of the project involved the use of MATLAB for the recording of an audio file in the .wav format, followed by the conversion of this file into a binary stream. The binary data was subsequently subjected to XOR operations with a P-N sequence. This modified data was then transformed into a .txt file for subsequent transmission between two Raspberry Pi microcontrollers. The Secure Communication (SC) protocols were employed for the inter-Raspberry Pi communication.

Upon reception by the second Raspberry Pi microcontroller, the text file was extracted and the XOR operation will be reversed only if the P-N sequence matches. The decrypted binary data was then processed to retrieve the original signal, which was subsequently converted back into an audio signal. This comprehensive process ensured the secure transmission and restoration of the audio data while employing P-N sequences and Raspberry Pi microcontrollers as the core components of the system.

B. Purpose and Objective:

The primary purpose of this project was to establish a robust security framework for file reception, considering the vulnerability of data transfer to potential interception by unauthorized third parties, leading to data breaches and information theft. This project aimed to implement advanced security measures to safeguard the integrity and confidentiality of the transmitted audio data, ensuring that sensitive information remains protected from potential eavesdropping and unauthorized access.

The main objective of this project was to develop an efficient and reliable audio file data communication security system using P-N sequences and Raspberry Pi, with a focus on preventing unauthorized access to sensitive information during the transfer process. By integrating secure communication protocols and encryption techniques, the project aimed to ensure the secure and uninterrupted transmission of audio data, thereby enhancing the overall security posture of the communication channel.

C. Methodology used:

1. Broad Spectrum Signal:

In this project, the utilization of a broad-spectrum signal was instrumental in ensuring the efficient transmission of audio data. By employing this technique, the project aimed to enhance the reliability and quality of the transmitted signal, thereby facilitating the secure transfer of data across the communication channel.

2. P-N Sequencing:

The integration of P-N (Pseudo-Noise) sequencing served as a pivotal element in the encryption and decryption process of the audio data. By applying P-N sequences, the project established a secure key mechanism that enabled the encoding and decoding of the transmitted data, bolstering the overall security of the communication system and preventing unauthorized access to sensitive information.

3. Secure Communication (SC) Protocols:

The incorporation of secure communication protocols played a crucial role in ensuring the confidentiality and integrity of the data during transmission between the two Raspberry Pi microcontrollers. By implementing robust SC protocols, the project aimed to establish a secure and encrypted communication channel, mitigating the risks of data interception and unauthorized access by malicious entities, thus fortifying the overall security framework of the audio data communication system.

D. Summary and Key Findings:

1. Decryption Based on P-N Sequence Matching:

The security of the audio data transmission was ensured through a stringent decryption process, which allowed the audio to be decrypted only when the P-N sequences matched between the transmitting and receiving ends. This key aspect of the project's methodology served as a critical security measure, preventing unauthorized access to the transmitted audio data and ensuring that the information remained confidential throughout the communication process.

2. Installation of MATLAB Libraries on Raspberry Pi:

An essential requirement for the successful implementation of the project was the installation of specific MATLAB libraries on the Raspberry Pi units. These libraries facilitated the smooth execution of the transmission and reception processes, ensuring seamless interoperability between the MATLAB environment and the Raspberry Pi platform. By incorporating these libraries, the project aimed to streamline the integration of MATLAB functionalities within the Raspberry Pi environment, enabling efficient data processing and communication between the two platforms.

3.Key Finding:

In the context of secure communication, the project emphasized the significance of utilizing both public and private keys for the secure transmission of audio data. The project's key finding highlighted the importance of securely transmitting the public key to the receiving end, enabling the recipient to decrypt the transmitted data using the corresponding private key. This approach effectively ensured that the audio data remained protected from unauthorized access during the transmission process, bolstering the overall security framework of the communication system.

Chapter I : Introduction

1.1 Understanding Audio Security:

Audio security involves implementing robust measures to safeguard audio data from unauthorized access, interception, and tampering. With the increasing prevalence of digital communication, ensuring the integrity and confidentiality of audio data has become paramount. This project delves into the intricate mechanisms of securing audio data transmission, emphasizing the significance of encryption techniques and secure communication protocols in fortifying the confidentiality and reliability of sensitive information during the transfer process.

1.2 Significance and Project Scope:

In an era where digital data breaches pose significant threats, the imperative to bolster audio data security has become more pronounced. This project addresses the pressing need for an effective security framework that not only encrypts the data but also ensures secure communication between devices. By implementing P-N sequences and Raspberry Pi, the project aims to enhance the security of audio data communication, enabling seamless and secure transfer of information between two endpoints. Furthermore, the project seeks to establish an efficient system that not only encrypts the data but also enables secure and reliable decryption at the receiver's end, thus mitigating the risks associated with unauthorized data access and interception.

1.3 Scope and Limitations:

The scope of this project encompasses the development of a robust and efficient audio data communication security system that employs P-N sequences and Raspberry Pi. By focusing on secure transmission protocols and encryption techniques, the project aims to ensure the confidentiality and integrity of the transmitted audio data. However, it is essential to acknowledge certain limitations, such as the potential constraints related to the processing power and memory capabilities of the Raspberry Pi, which may impact the overall efficiency of the encryption and decryption processes. Moreover, the project's scope is confined to the secure communication of audio data, and it does not address broader aspects of network security or data protection beyond the scope of audio transmission.

Chapter II : Literature Review

The necessity of data transmission security arises from the critical need to safeguard sensitive information during its transfer from one point to another. Several factors contribute to the importance of ensuring robust data transmission security:

1. Confidentiality: Protecting the confidentiality of data is crucial to prevent unauthorized access, interception, or eavesdropping by malicious entities. Secure data transmission protocols help ensure that sensitive information remains confidential and accessible only to authorized users.

2. Integrity: Data integrity ensures that information remains unchanged and unaltered during the transmission process. Implementing security measures helps detect and prevent any unauthorized modifications, ensuring the accuracy and reliability of the transmitted data.

3. Authentication: Data transmission security enables the verification of the identity of the parties involved in the communication process. By implementing authentication mechanisms, organizations can ensure that data is exchanged only between trusted and authorized entities, minimizing the risks associated with fraudulent activities and unauthorized access.

4. Non-repudiation: Non-repudiation ensures that the sender of the data cannot deny their transmission or involvement in the communication process. Robust data transmission security measures provide mechanisms for verifying the origin of data, thereby enabling accountability and preventing disputes related to the authenticity of transmitted information.

5. Regulatory Compliance: Many industries and organizations are subject to regulatory requirements that mandate the implementation of secure data transmission practices. Adhering to these regulations not only ensures legal compliance but also helps in building trust and credibility among stakeholders and customers.

Overall, data transmission security is essential for protecting sensitive information, maintaining the integrity of communication channels, and fostering trust and confidence in digital transactions and communications. It plays a vital role in safeguarding against data breaches, cyberattacks, and unauthorized access, thereby preserving the confidentiality, integrity, and authenticity of transmitted data.

2.1 Literature Review on Wireless Communication:

The document discusses the wireless audio transmission system for real-time applications. It explains the functionality of different components like microphone, amplifier, ADC, and UART. The document presents the flowchart of the transmitter and receiver sections and showcases the results obtained using a serial terminal and MATLAB. Finally, it concludes that the proposed system is cost-effective, fast, and reliable.

The document is about a wireless audio transmission system for real-time applications. The document also provides information on the components and technologies used in

the proposed system, such as microphones, amplifiers, ADC, UART, Arduino, and MATLAB. It includes flowcharts, results, and references related to the implementation and evaluation of the system. The document concludes that the proposed system is cost-effective, fast, and reliable.

The key conclusions of the document are as follows:
Traditional systems that use wired transmissions for signals are costly and require greater power. The proposed wireless signal transmission system using a low-power microcontroller with high-speed ADCs and DACs, along with peripheral devices, offers a more cost-effective, faster, and reliable solution. The document presents flowcharts of the transmitter and receiver sections, showcasing the signal flow and data processing. Results obtained using a serial terminal and MATLAB demonstrate the successful transmission and reception of data wirelessly. Overall, the document highlights the potential of wireless audio transmission systems for real-time applications, emphasizing their cost-effectiveness, speed, and reliability. [1]

2.2 Literature Review of P-N Sequencing:

The spread spectrum signaling technique is used for security purposes in wireless networks. The algorithm to retrieve the PN sequence and pattern of spectrum in a spread spectrum system will increase wireless network security. There are two types of spread spectrum techniques: direct sequence spread spectrum and frequency hopped spread spectrum. The merit of a spread spectrum communication system is its potential to eliminate interference. The interference may be conscious or unconscious. The proposed spread spectrum pattern and PN sequence retrieval algorithm will provide the wireless ad hoc network with more security.
The purpose of using the spread spectrum signaling technique in a wireless network is to enhance security. Spread spectrum techniques make it difficult for unwanted users to access the wireless network. By spreading the data sequence over a wider bandwidth than necessary, the spread spectrum makes it challenging for unauthorized listeners to detect or recognize the transmitted data. This technique increases network security by ensuring that only the sender, who knows the specific spreading pattern and pseudo-noise (PN) sequence, can successfully retrieve and decode the data. Additionally, spread spectrum communication systems have the potential to eliminate interference, both intentional and unintentional, further enhancing the security and reliability of the wireless network. The two types of spread spectrum techniques mentioned in the document are direct sequence spread spectrum (DSSS) and frequency hopping spread spectrum (FHSS).
The algorithm for spread spectrum pattern and PN sequence retrieval will enhance the security of the wireless ad hoc network by providing a more secure means of communication. By utilizing spread spectrum techniques, the transmitted data becomes difficult to detect or recognize by unwanted listeners. The algorithm ensures that only the sender knows the PN sequence and pattern of the spread spectrum communication system, thereby enhancing network security. This prevents unauthorized access to the wireless network and protects against interception and jamming attempts. Additionally, spread spectrum communication systems have the potential to eliminate interference, both conscious and unconscious, further enhancing the security and reliability of the wireless ad hoc network.[2]

2.3 Literature Review of Raspberry Pi 3B+:

The Raspberry Pi 3B+ is a widely recognized single-board computer developed by the Raspberry Pi Foundation. Launched in 2018, it represents a significant advancement in the Raspberry Pi series, offering improved processing power, wireless connectivity, and a range of other features compared to its predecessors. Here is a detailed review of the Raspberry Pi 3B+:

1. Processing Power: The Raspberry Pi 3B+ is equipped with a 1.4 GHz quad-core ARM Cortex-A53 processor, which provides a noticeable performance boost compared to earlier models. This enhanced processing power allows for smoother multitasking and better performance in various computing tasks, making it suitable for a wide range of applications, including home automation, programming projects, and basic desktop computing.

2. Wireless Connectivity: One of the key improvements in the 3B+ model is its integrated wireless connectivity. It features both 2.4 GHz and 5 GHz IEEE 802.11 b/g/n/ac wireless LAN, enabling faster and more stable Wi-Fi connections. Additionally, it includes Bluetooth 4.2/BLE (Bluetooth Low Energy), allowing seamless connectivity with Bluetooth-enabled devices and peripherals.

3. Ethernet and USB Ports: The board maintains the standard 4 USB 2.0 ports for connecting various peripherals, such as keyboards, mice, and external storage devices. It also features a Gigabit Ethernet port, which facilitates high-speed wired network connectivity for applications that demand reliable and robust network connections.

4. GPIO Pins: Similar to earlier Raspberry Pi models, the 3B+ retains its 40-pin GPIO (General Purpose Input Output) header, allowing users to interface with various electronic components and create custom hardware projects. This feature makes the Raspberry Pi 3B+ a popular choice for electronics enthusiasts, hobbyists, and students learning about embedded systems and physical computing.
5. Form Factor and Compatibility: The Raspberry Pi 3B+ maintains the same form factor as its predecessors, ensuring backward compatibility with most existing Raspberry Pi cases and accessories. This compatibility makes it easier for users to upgrade to the newer model without needing to replace their existing peripherals and enclosures.[3]

2.4 Literature Review of Raspberry Pi 4B:

The Raspberry Pi 4B, released in 2019, is a significant upgrade over its predecessors in terms of performance, connectivity, and multimedia capabilities.

Improved Processing Power: The Raspberry Pi 4B features a more powerful 1.5GHz quad-core ARM Cortex-A72 processor, offering significant performance improvements over previous models. This enhanced processing power enables smoother multitasking, faster web browsing, and better overall performance for a wide range of computing tasks, including programming, multimedia, and light desktop use.

Increased RAM Options: Unlike its predecessors, the Raspberry Pi 4B is available in multiple RAM configurations, including 2GB, 4GB, and 8GB options. This increased

memory capacity allows for more complex and memory-intensive applications, making the Raspberry Pi 4B suitable for a broader range of tasks that require higher computing and multitasking capabilities.

Dual Micro HDMI Ports: The Raspberry Pi 4B is equipped with dual micro HDMI ports, supporting dual 4K displays at 60Hz or a single 4K display at 60Hz. This feature makes it a suitable choice for multimedia and display-intensive applications, including digital signage, media centers, and other projects requiring high-resolution displays.

USB 3.0 and Gigabit Ethernet: The board includes two USB 3.0 ports alongside two USB 2.0 ports, enabling faster data transfer rates for external storage devices and other USB peripherals. Additionally, the Raspberry Pi 4B features Gigabit Ethernet for high-speed wired network connectivity, providing faster and more reliable network performance compared to earlier models.

Dual-Band Wi-Fi and Bluetooth 5.0: The Raspberry Pi 4B offers dual-band 2.4GHz and 5GHz IEEE 802.11 b/g/n/ac wireless LAN, providing improved wireless connectivity and performance. It also includes Bluetooth 5.0/BLE, allowing seamless integration with a wide range of Bluetooth-enabled devices and accessories.

GPIO Pins and Form Factor: Similar to previous models, the Raspberry Pi 4B retains the 40-pin GPIO header, facilitating easy interfacing with various electronic components and peripherals. While the form factor is slightly larger than earlier models, it still maintains compatibility with most existing Raspberry Pi cases and accessories, ensuring ease of integration into existing projects and setups.

The Raspberry Pi 4B's enhanced processing power, increased RAM options, and improved connectivity make it a versatile and capable single-board computer suitable for a wide range of applications, from basic programming and educational projects to multimedia and home automation applications. Its compatibility with various operating systems and strong community support further contribute to its appeal among both enthusiasts and professionals in the maker and DIY communities. [4]

Chapter III : Methodology

The methodology section of the report encompasses various essential elements, including the explanation of the P-N sequence and its application in audio security. Additionally, it involves a detailed description of the Raspberry Pi implementation, outlining the process of downloading the operating system, configuring the SD card, connecting to a Wi-Fi mobile device, and establishing a connection to a monitor through all available interfaces. The hardware and software utilized in the project, such as the Raspi speaker, microphone, advanced IP scanner, VNC viewer, MATLAB, and the Bullseye operating system for Raspberry Pi, are thoroughly delineated. Moreover, the experimental design and setup entail the establishment of connections using VNC, SSH, and ping tests within the same hotspot network, as well as between the Raspberry Pi, laptop, and MATLAB files. This comprehensive methodology aims to provide a detailed and replicable framework for the implementation and execution of the audio security project using the Raspberry Pi platform.

3.1 P-N Sequences:

A Pseudo-Noise (PN) sequence generator is a mathematical algorithm that produces a deterministic sequence of binary values that appears random but is actually deterministic and reproducible. These sequences are commonly used in various applications such as telecommunications, spread spectrum systems, and cryptography, particularly for generating spreading codes and secure keys for encryption and decryption.

1. Pseudo randomness: The generated sequence appears random, exhibiting statistical properties similar to those of a truly random sequence. This property is essential in applications where randomness is required for tasks such as data encryption and signal modulation.

2. Periodicity: PN sequences have a well-defined period, after which the sequence repeats itself. The period length depends on the specific algorithm used for generating the sequence and the initial seed values. The ability to produce a repetitive but seemingly random sequence is valuable for applications requiring the same pseudo-random sequence for synchronization or signal modulation purposes.

3. Cross-Correlation Properties: PN sequences often exhibit desirable cross-correlation properties, making them useful for tasks such as code division multiple access (CDMA) in telecommunications and radar signal processing. Low cross-correlation between different sequences ensures minimal interference between signals, enabling multiple users to share the same communication channel without significant signal degradation.

Some of the well-known PN sequence generators include the Linear Feedback Shift Register (LFSR), maximal length sequences (m-sequences), Gold codes, and Kasami sequences, among others. The choice of the PN sequence generator depends on the specific requirements of the application, including factors such as sequence length, autocorrelation properties, and cross-correlation properties. The versatility and reliability of PN sequence generators make them fundamental components in various

communication and security systems where the generation of deterministic yet seemingly random sequences is crucial.

3.1.1 Linear Feedback Shift Register (LFSR):

PN sequence generation using the Linear Feedback Shift Register (LFSR) technique involves the use of a shift register and feedback logic to produce a pseudo-random binary sequence. LFSR is a simple and efficient method commonly employed to generate sequences with good randomness properties, periodicity, and efficient hardware implementation. Here is an overview of the process and key features of PN sequence generation using the LFSR technique:

1. Structure: An LFSR consists of a shift register, which is a cascade of flip-flops, along with a feedback mechanism that determines the new bit to be shifted into the register. The feedback logic is based on the exclusive-OR (XOR) operation of selected bits within the shift register, which creates a feedback loop generating the next bit in the sequence.

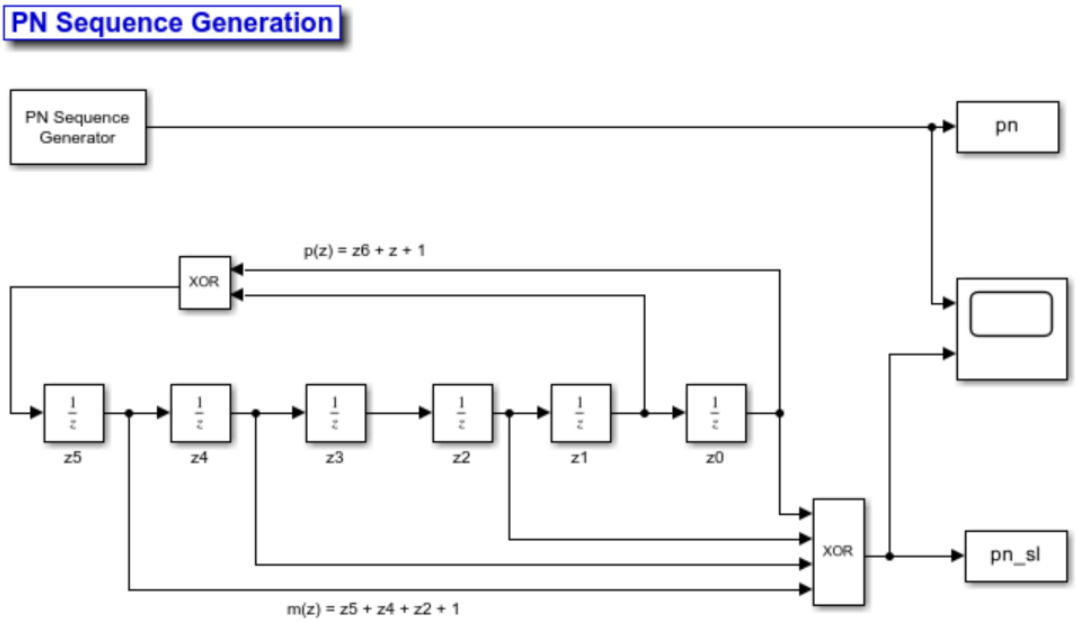


Fig. 3.1.1 PN Sequence Generator

2. Feedback Polynomial: The feedback logic in an LFSR is defined by a feedback polynomial, which specifies the positions of the bits within the shift register that are XORed to produce the next bit. The feedback polynomial determines the characteristic polynomial of the LFSR, which governs the period and properties of the generated PN sequence.

3. Periodicity: The length of the generated PN sequence is determined by the number of bits in the shift register and the feedback polynomial. For an n-bit LFSR, the maximum period of the generated sequence is 2^n - 1, meaning the sequence repeats after 2^n - 1 clock cycles. Careful selection of the feedback polynomial is essential to ensure maximal sequence length and good randomness properties.

4. Randomness Properties: While LFSR-generated sequences are not truly random, they exhibit pseudo-random properties that make them suitable for various applications, including digital communication, cryptography, and pseudorandom number generation. However, the statistical properties of LFSR sequences may not be sufficient for high-security applications, and additional cryptographic techniques may be required for enhanced security.

5. Applications: LFSR-based PN sequences find applications in various fields, including pseudorandom number generation, spreading codes in spread spectrum communication systems, error detection and correction codes, and test pattern generation for digital circuits.

Let us consider an example for better understanding:

For generating a PN sequence we need a number of Flip-Flops. The input sequence that we will be giving also the tapping positions of the FF.

Here,
No of FF= 3
Input sequence = [1,1,1]
Tapping position = [1,3]

Table No 3.1: PN Sequence Generation

Sr. No	Sequence			PN Sequence
	1	1	1	
1.	0	1	1	1
2.	1	0	1	1
3.	0	1	0	1
4.	0	0	1	0
5.	1	0	0	1
6.	1	1	0	0
7.	1	1	1	0

So, the obtained PN Sequence is: 1110100
To verify this PN Sequence:
The total No. of 1's = No, of FF's +1
4=3+1
Hence, the Sequence is verified.

3.1.2 Spread Spectrum Signal:

Converting a narrow spectrum signal into a spread spectrum signal using a Pseudo-Noise (PN) sequence involves the process of modulating the original signal with the PN sequence. This process helps spread the signal energy across a wider frequency band,

making it more resilient to interference and less susceptible to eavesdropping. Here's a detailed step-by-step guide on how to achieve this conversion:

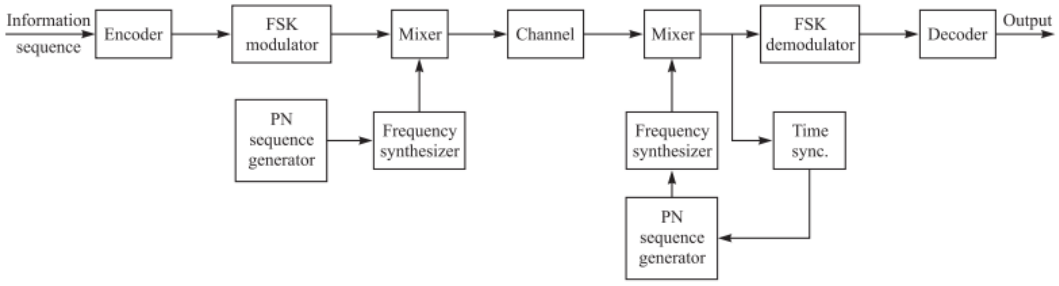


Fig 3.1.2 Spread Spectrum generator

1. Generate the PN Sequence:
Create a PN sequence using an appropriate algorithm, such as the Linear Feedback Shift Register (LFSR) or maximal length sequence (m-sequence) generator. Ensure that the sequence has good autocorrelation and cross-correlation properties to minimize interference with other signals and maximize the spread spectrum effect.

2. Data Encoding:
Map the original narrow spectrum signal, typically in the form of digital bits or symbols, to the PN sequence. Use a modulation technique such as binary phase shift keying (BPSK) or quadrature phase shift keying (QPSK) to modulate the data with the PN sequence. This process spreads the signal energy across a wider bandwidth, effectively converting it into a spread spectrum signal.

3. Signal Mixing:
Mix the modulated signal with a carrier wave using a process such as direct sequence spread spectrum (DSSS) or frequency hopping spread spectrum (FHSS). The carrier wave's frequency should be significantly higher than the original signal's bandwidth to ensure efficient spreading of the signal energy.

4. Transmitter Operation:
Transmit the spread spectrum signal over the desired communication channel. The spread spectrum signal's wider bandwidth and increased resistance to interference make it less susceptible to jamming and interception, enhancing the security and reliability of the communication link.

5. Receiver Operation:
Receive the spread spectrum signal using a compatible receiver capable of demodulating the signal and extracting the original narrow spectrum data. Apply the reverse process of mixing and decoding the signal using the same PN sequence to recover the original data from the spread spectrum signal.

3.2 Downloading Raspberry Pi:

Raspberry Pi is a series of small single-board computers (SBCs) developed in the United Kingdom by the Raspberry Pi Foundation in association with

Broadcom. It is capable of doing everything that you'd expect a computer to do.

The Raspberry Pi is a single computer board with a credit card size. The Raspberry Pi board comprises a program memory (RAM), processor and graphics chip, CPU, GPU, Ethernet port, GPIO pins, Xbee socket, UART, power source connector, and various interfaces for external devices. It even requires mass storage, for which we use an SD flash memory card. So Raspberry Pi will boot from this SD card. Essential hardware specifications of Raspberry Pi board mainly include an SD card containing Linux OS, a US keyboard, monitor, power supply, and video cable.

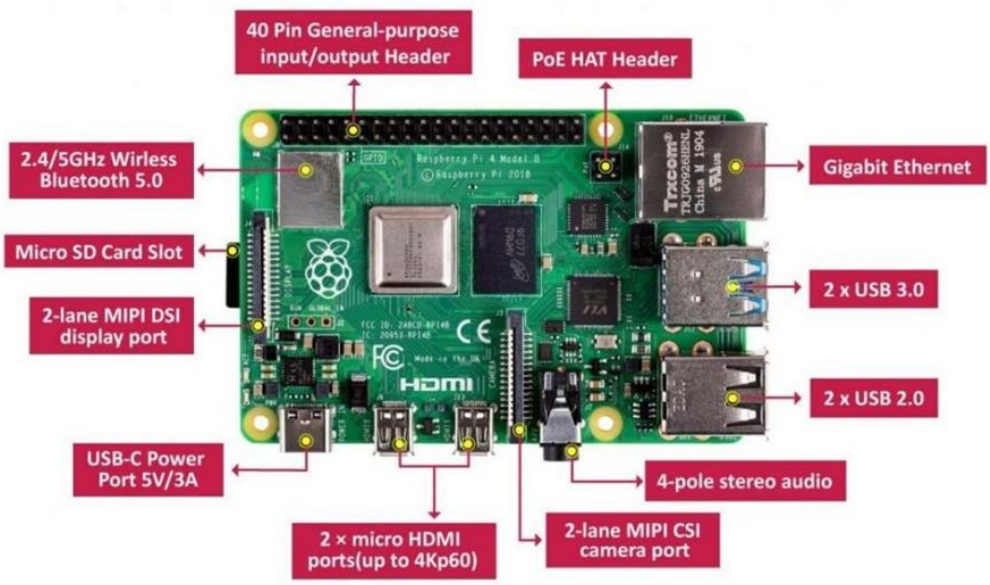


Fig 3.2.1: Raspberry Pi

[5]

This is the model that we are using for our project The model used for this project is Raspberry Pi 3 Model B+ On Pi Day 2018, the Raspberry Pi 3 Model B+ was launched with a faster 1.4 GHz processor, a three-times faster gigabit Ethernet (throughput limited to ca. 300 Mbit/s by the internal USB 2.0 connection), and 2.4 / 5 GHz dual-band 802.11ac Wi-Fi (100 Mbit/s).[26] Other features are Power over Ethernet (PoE) (with the add-on PoE HAT), USB boot, and network boot (an SD card is no longer required). It has an SD card of 16 GB. GPIO pins A GPIO pin is a generic pin whose value consists of one of two voltage settings (high or low) and whose behavior can be programmed through software. It is a way in which Raspberry Pi can control and monitor the outside world by being connected to electronic circuits.

3.2.1 Steps to install OS on Raspberry Pi:

Here are the detailed steps to install the Bullseye operating system on a Raspberry Pi:

1. Download the Bullseye Image:
Visit the official Raspberry Pi website or the Bullseye OS website to download the latest Bullseye image compatible with your Raspberry Pi model.

2. Prepare the MicroSD Card:
Insert the MicroSD card into your computer using an SD card adapter.
Use the SD Card Formatter tool to format the MicroSD card to ensure a clean and compatible file system.

3. Write the Bullseye Image to the MicroSD Card:
Download and install the Balena Etcher software, a popular tool for writing operating system images to SD cards.
Open Balena Etcher and select the downloaded Bullseye image file.
Choose the MicroSD card as the target device.
Click "Flash" to write the Bullseye image to the MicroSD card. Wait for the process to complete.

4. Configure Wi-Fi (Optional):
If you want to configure Wi-Fi before booting the Raspberry Pi, create a file named "wpa_supplicant.conf" in the boot partition of the MicroSD card.
Add the following lines to the "wpa_supplicant.conf" file:

```
country=US
ctrl_interface=DIR=/var/run/wpa_supplicant GROUP=netdev
update_config=1

    network={
ssid="YOUR_SSID"
psk="YOUR_WIFI_PASSWORD"
}
```

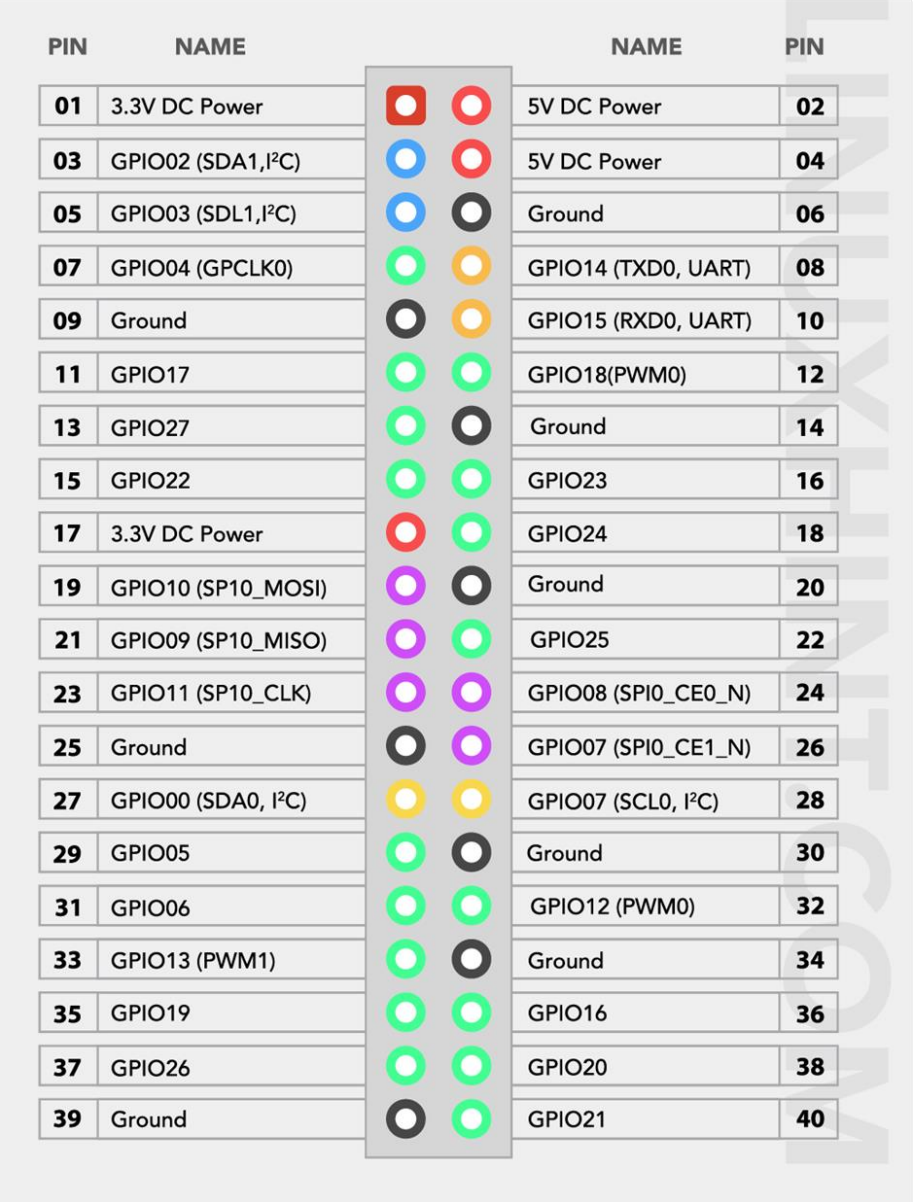
5. Enable SSH:
To enable SSH, create a file named "ssh" (without any extension) in the boot partition of the MicroSD card. This file will enable SSH on the Raspberry Pi.

6. Eject the MicroSD Card:
Safely eject the MicroSD card from your computer and insert it into the Raspberry Pi's MicroSD card slot.

7. Boot the Raspberry Pi:
Connect the Raspberry Pi to a monitor or TV using an HDMI cable.
Power on the Raspberry Pi by connecting it to a power source using a compatible USB-C power supply.

8. Complete the Setup:
Follow the on-screen instructions to complete the initial setup of the Bullseye operating system on the Raspberry Pi.
Configure any additional settings, such as language, time zone, and user account details, as prompted.

3.3 GPIO Pins configuration:



PIN	NAME		NAME	PIN
01	3.3V DC Power		5V DC Power	02
03	GPIO02 (SDA1,I²C)		5V DC Power	04
05	GPIO03 (SDL1,I²C)		Ground	06
07	GPIO04 (GPCLK0)		GPIO14 (TXD0, UART)	08
09	Ground		GPIO15 (RXD0, UART)	10
11	GPIO17		GPIO18(PWM0)	12
13	GPIO27		Ground	14
15	GPIO22		GPIO23	16
17	3.3V DC Power		GPIO24	18
19	GPIO10 (SP10_MOSI)		Ground	20
21	GPIO09 (SP10_MISO)		GPIO25	22
23	GPIO11 (SP10_CLK)		GPIO08 (SPI0_CE0_N)	24
25	Ground		GPIO07 (SPI0_CE1_N)	26
27	GPIO00 (SDA0, I²C)		GPIO07 (SCL0, I²C)	28
29	GPIO05		Ground	30
31	GPIO06		GPIO12 (PWM0)	32
33	GPIO13 (PWM1)		Ground	34
35	GPIO19		GPIO16	36
37	GPIO26		GPIO20	38
39	Ground		GPIO21	40

Fig 3.3.1 GPIO Pins

The GPIO (General Purpose Input/Output) pins on the Raspberry Pi provide a flexible interface for connecting various external devices and components, allowing users to interact with the physical world. Here is a detailed pin description of the GPIO pins on the Raspberry Pi:

Power Pins:

3.3V (Pin 1) and 5V (Pin 2): These pins provide 3.3 volts and 5 volts of power, respectively, for powering external components.

Ground (GND) Pins: Several ground pins (Pin 6, 9, 14, 20, 25, 30, 34, 39) are available for completing the circuit and providing the ground connection.

GPIO Pins:
There are a total of 26 GPIO pins (Pin 4, 7, 8, 11, 12, 13, 15, 16, 18, 19, 21, 22, 23, 24, 26, 29, 31, 32, 33, 35, 36, 37, 38, 40) that can be used for both digital input and output operations.

Special Function Pins:
I2C Pins (SDA, SCL): These pins (Pin 3, 5) are used for connecting devices using the

I2C communication protocol.

SPI Pins (MOSI, MISO, SCLK, CE0, CE1): These pins (Pin 19, 21, 23, 24, 26) are used for connecting devices using the SPI (Serial Peripheral Interface) protocol.

UART Pins (TXD, RXD): These pins (Pin 8, 10) are used for serial communication with external devices.

PWM Pins: Several GPIO pins (Pin 12, 18) support Pulse-Width Modulation (PWM) output for controlling analog components such as motors and LEDs.

ID EEPROM: This pin (Pin 27) is used for identifying the type of HAT (Hardware Attached on Top) connected to the Raspberry Pi.

It's essential to consult the official Raspberry Pi documentation or pinout diagrams specific to your Raspberry Pi model to ensure accurate identification and usage of the GPIO pins.

Additionally, exercise caution when working with GPIO pins to prevent damage to the Raspberry Pi or connected components.

3.4 Hardware and Software components used:

3.4.1 Advanced IP Scanner:

Advanced IP Scanner is a free and fast network scanner that enables users to analyze and manage their local area networks (LANs). It is a powerful tool for scanning network devices, identifying their IP addresses, and collecting various information about the devices connected to a particular network. Here is detailed information about the Advanced IP Scanner:

1. Network Scanning:
Advanced IP Scanner allows users to scan their LANs and gather comprehensive information about the connected devices, including their IP addresses, MAC addresses, network device types, and names.

2. User-Friendly Interface:
The software features a user-friendly and intuitive interface, making it easy for both novice and experienced users to navigate and utilize its scanning and management capabilities effectively.

3. Remote Control:
In addition to scanning, Advanced IP Scanner enables users to remotely control computers that support the Remote Desktop Protocol (RDP) and access them directly from the interface.

4. Network Services Detection:
The software can detect and display information about shared folders and HTTP, HTTPS, and FTP services running on networked devices, providing users with a comprehensive overview of the network's services and resources.

5. Customizable Scanning Options:
Advanced IP Scanner allows users to customize the scanning process by adjusting scan speed, configuring timeout settings, and setting up custom device groups for easier management and organization of scanned results.

6. Export and Printing:
Users can export scan results to various formats, including CSV and XML, for further analysis and sharing. Additionally, the software enables users to print scan results directly from the interface for convenient documentation and reference.

7. Platform Compatibility:
Advanced IP Scanner is compatible with Windows operating systems, including Windows 10, Windows 8, Windows 7, and Windows Vista. It supports both 32-bit and 64-bit architectures, ensuring broad compatibility with a range of Windows-based systems.

3.4.2 VNC Viewer:

VNC Viewer is a cross-platform remote desktop software that allows users to access and control a remote computer or device from a local system. It provides a simple and effective way to remotely manage and interact with computers over a network or the internet. Here's a detailed overview of VNC Viewer:

1. Cross-Platform Support:
VNC Viewer is compatible with various operating systems, including Windows, macOS, Linux, and Unix, making it a versatile solution for remote desktop access across different platforms.

2. Remote Control Capabilities:
The software enables users to remotely control a computer or device as if they were sitting in front of it, allowing for seamless interaction with applications, files, and software installed on the remote system.

3. Secure Remote Access:
VNC Viewer provides secure remote access capabilities, allowing users to establish encrypted connections and transfer data securely between the local and

remote systems. This ensures that sensitive information remains protected during remote sessions.

4. Easy Configuration and Setup:
Setting up VNC Viewer typically involves installing the software on both the local and remote computers and configuring the necessary connection settings, including the remote computer's IP address or hostname and the appropriate authentication credentials.

5. Customizable Connection Settings:
VNC Viewer offers customizable connection settings, allowing users to adjust various parameters such as image quality, screen resolution, and input preferences to optimize the remote desktop experience based on specific requirements and network conditions.

6. File Transfer and Clipboard Sharing:
The software supports file transfer between the local and remote systems, enabling users to seamlessly transfer files and data during remote sessions. Additionally, VNC Viewer allows users to share the clipboard between the local and remote systems, simplifying the process of copying and pasting text and data across different environments.

3.4.3 MATLAB:

MATLAB is a high-level programming language and interactive environment widely used for numerical computing, data analysis, and visualization. It provides a comprehensive set of tools and functions for solving complex mathematical problems, conducting algorithm development, and performing data analysis tasks. Here is a detailed overview of MATLAB:

1. Programming Language:
- MATLAB is equipped with its programming language that allows users to create and execute scripts and functions for various computational tasks. Its syntax is designed for ease of use and supports a wide range of mathematical operations and data manipulation tasks.

2. Numerical Computing and Simulations:
- MATLAB offers a powerful set of built-in mathematical functions and libraries for conducting numerical computations, simulations, and mathematical modeling. It supports various mathematical operations, linear algebra, differential equations, and signal-processing tasks, making it a versatile tool for scientific and engineering applications.

3. Data Analysis and Visualization:
- MATLAB provides comprehensive tools for data analysis, visualization, and plotting. It allows users to analyze and visualize data using a variety of techniques, including 2D and 3D plotting, image processing, and animation, enabling users to gain insights and extract meaningful information from complex datasets.

4. Application Development:
- MATLAB facilitates the development of custom applications and user interfaces (UIs) using its App Designer and GUIDE (Graphical User Interface Development Environment) tools. These tools enable users to create interactive applications and UIs for data analysis, simulation, and engineering design tasks.

5. Simulink Integration:
- MATLAB integrates seamlessly with Simulink, a graphical simulation and model-based design environment, allowing users to model, simulate, and analyze dynamic systems and control algorithms. This integration is particularly useful for engineers and researchers working on complex systems and control design projects.

6. Toolboxes and Add-Ons:
- MATLAB offers a wide range of toolboxes and add-ons that extend its capabilities for various specialized applications, including image processing, control systems design, optimization, machine learning, and deep learning. These toolboxes provide additional functions and algorithms tailored to specific application domains, enhancing the versatility and utility of MATLAB for diverse tasks.

3.5 Experimental Design and Setup:

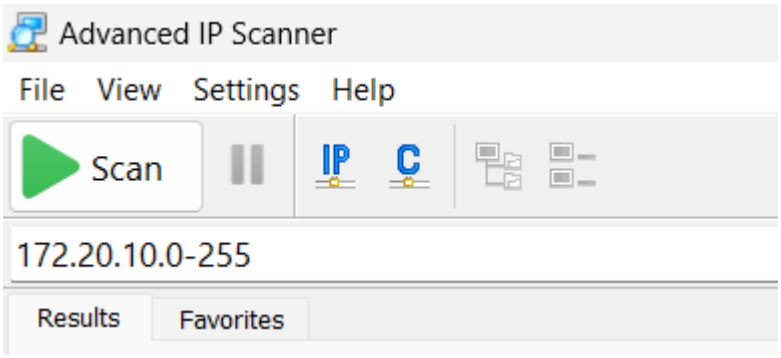
3.5.1 Setting Remote Desktop of Raspberry PI via SSH

Make sure that the Raspberry Pi and Laptop are connected to the same internet hotspot and on your Laptop terminal run the below command.

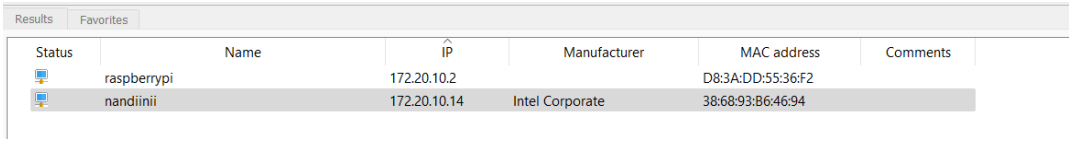
```
PS C:\Users\nandi> ipconfig

Windows IP Configuration


Wireless LAN adapter Local Area Connection* 1:

   Media State . . . . . . . . . . . : Media disconnected
   Connection-specific DNS Suffix  . :

Wireless LAN adapter Local Area Connection* 2:

   Media State . . . . . . . . . . . : Media disconnected
   Connection-specific DNS Suffix  . :

Wireless LAN adapter Wi-Fi:

   Connection-specific DNS Suffix  . :
   IPv6 Address. . . . . . . . . . . : 2401:4900:5319:4ae8:14dd:e6a6:fc3e:be02
   Temporary IPv6 Address. . . . . . : 2401:4900:5319:4ae8:91f6:cbe7:2f47:2d19
   Link-local IPv6 Address . . . . . : fe80::3d8c:36d1:1d0f:398%8
   IPv4 Address. . . . . . . . . . . : 172.20.10.14
   Subnet Mask . . . . . . . . . . . : 255.255.255.240
   Default Gateway . . . . . . . . . : fe80::a04e:cfff:fe73:4b64%8
                                       172.20.10.1
```

Under Wireless LAN adapter WIFI:

Copy the IPv4 Address and paste it in the Advanced IP Scanner Software to get the IP Address of the Raspberry Pi. Make sure to change the last 2-3 digits to 0-255.



Run the Scan button.



From here we can see that the Raspberry Pi is connected to the IP address 172.20.10.2

Now run the below command in the terminal of the laptop

```
PS C:\Users\nandi> ping 172.20.10.2

Pinging 172.20.10.2 with 32 bytes of data:
Reply from 172.20.10.2: bytes=32 time=34ms TTL=64
Reply from 172.20.10.2: bytes=32 time=18ms TTL=64
Reply from 172.20.10.2: bytes=32 time=5ms TTL=64
Reply from 172.20.10.2: bytes=32 time=6ms TTL=64

Ping statistics for 172.20.10.2:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 5ms, Maximum = 34ms, Average = 15ms
PS C:\Users\nandi>
```

Ping is a network utility tool used to test the reachability of a host (computer or server) on an Internet Protocol (IP) network, such as the Internet. It also measures the round-trip time it takes for a packet of data to travel from one computer to another and back to the sender. Ping is a basic and commonly used tool for troubleshooting network connectivity and diagnosing network-related issues.

If you get response like (see below figure), check the IP address.

```
PS C:\Users\nandi> ping 172.20.10.4

Pinging 172.20.10.4 with 32 bytes of data:
Reply from 172.20.10.14: Destination host unreachable.
Reply from 172.20.10.14: Destination host unreachable.
Reply from 172.20.10.14: Destination host unreachable.
Reply from 172.20.10.14: Destination host unreachable.

Ping statistics for 172.20.10.4:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
PS C:\Users\nandi>
```

Now when you run this command,

```
PS C:\Users\nandi> ssh nandinipi@172.20.10.2
The authenticity of host '172.20.10.2 (172.20.10.2)' can't be established.
ED25519 key fingerprint is SHA256:Oc9Z7c++odBaK9f7owL40O8VIXabgQUTE0or4z679Lk.
This host key is known by the following other names/addresses:
    C:\Users\nandi/.ssh/known_hosts:13: 172.20.10.6
Are you sure you want to continue connecting (yes/no/[fingerprint])? yes
```

The SSH client on your local machine will attempt to establish a secure connection to the remote computer with the specified IP address using the username "nandinipi." You'll be prompted to enter the password for the "nandinipi" user on the remote computer, assuming password-based authentication is in use.

```
nandinipi@172.20.10.2's password:
Linux raspberrypi 6.1.21-v8+ #1642 SMP PREEMPT Mon Apr  3 17:24:16 BST 2023 aarch64

The programs included with the Debian GNU/Linux system are free software;
the exact distribution terms for each program are described in the
individual files in /usr/share/doc/*/copyright.

Debian GNU/Linux comes with ABSOLUTELY NO WARRANTY, to the extent
permitted by applicable law.
Last login: Fri Nov  3 14:17:12 2023
nandinipi@raspberrypi:~ $
```

If the connection is successful, you'll have a remote terminal session on the target computer and can execute commands, manage files, or perform other tasks on that system, all while ensuring the communication is encrypted and secure.

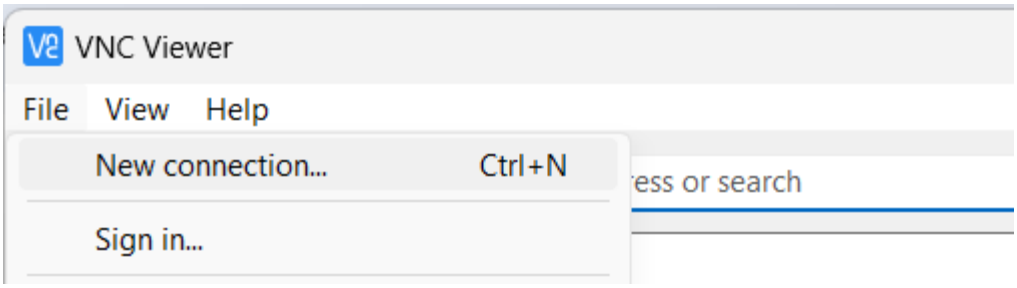
Now, to open a remote desktop we shall use VNC service.
VNC stands for Virtual Network Computing, and it is a technology and software application that allows you to access and control the desktop of a remote computer over a network, typically the internet. VNC provides a graphical desktop-sharing system, which means that you can view and interact with the graphical user interface (GUI) of a remote computer as if you were sitting in front of it, regardless of the physical distance between you and the remote system.

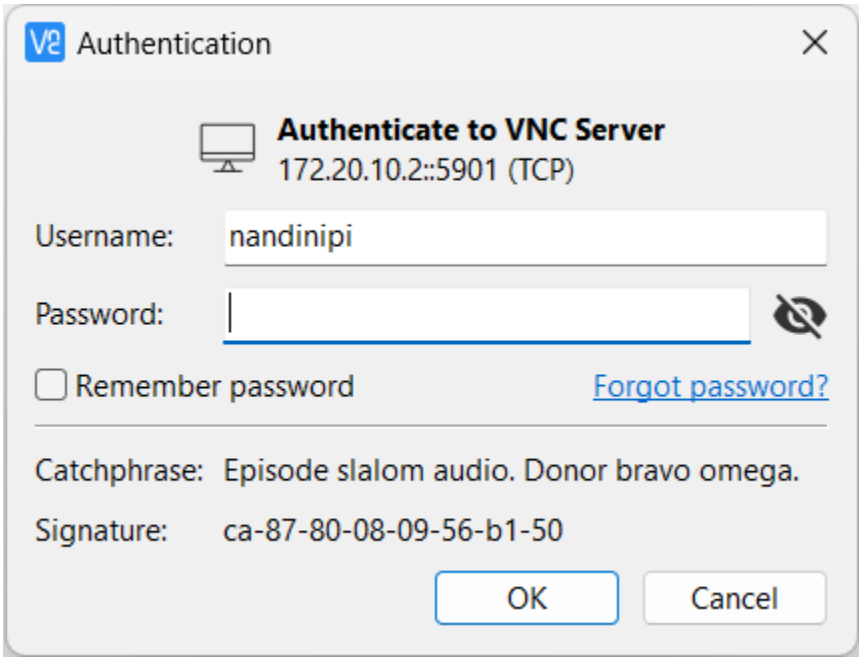
```
nandinipi@raspberrypi:~ $ vncserver-virtual
RealVNC(R) Server 7.5.1 (r50075) ARMv6 (May 30 2023 13:25:19)
Copyright (C) RealVNC Ltd.
RealVNC and VNC are trademarks of RealVNC Ltd and are protected by trademark
registrations and/or pending trademark applications in the European Union,
United States of America and other jurisdictions.
Protected by UK patent 2481870; US patent 8760366; EU patent 2652951.
See https://www.realvnc.com for information on VNC.
For third party acknowledgements see:
https://www.realvnc.com/docs/7/foss.html
OS: Raspbian GNU/Linux 11, Linux 6.1.21, aarch64

On some distributions (in particular Red Hat), you may get a better experience
by running vncserver-virtual in conjunction with the system Xorg server, rather
than the old version built-in to Xvnc. More desktop environments and
applications will likely be compatible. For more information on this alternative
implementation, please see: https://www.realvnc.com/doclink/kb-546

Running applications in /etc/vnc/xstartup

VNC Server catchphrase: "Episode slalom audio. Donor bravo omega."
            signature: ca-87-80-08-09-56-b1-50

Log file is /home/nandinipi/.vnc/raspberrypi:1.log
New desktop is raspberrypi:1 (172.20.10.2:1)
```

```
Log file is /home/nandinipi/.vnc/raspberrypi:1.log
New desktop is raspberrypi:1 (172.20.10.2:1)
nandinipi@raspberrypi:~ $
```

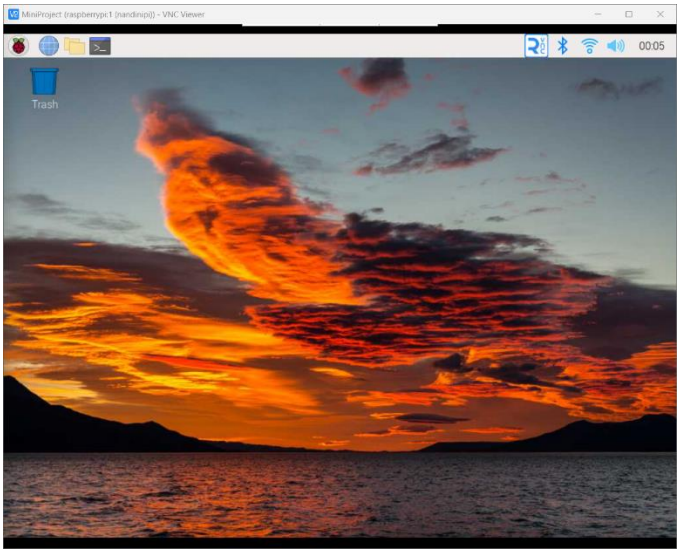
In IPv4 (Internet Protocol version 4) addresses, the ":1" is used to denote a specific network interface or port on a device. For example, if you have the IP address 192.168.1.1:1, it means you are referring to a specific endpoint or interface on the device with the IPv4 address 192.168.1.1.

Now, Open the VNC Viewer and create a new connection,





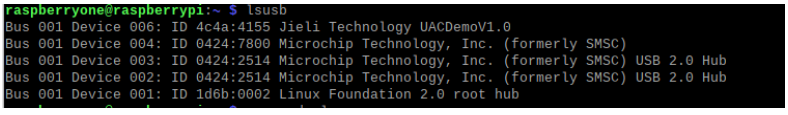
Enter the password and Username of the Raspberry Pi you want to connect to.



Now you have successfully opened the Raspi terminal.

Now,
Recording the Audio File

Open the Raspberry Pi terminal and enter the below command to check for the USB microphone connection



Bus 001 Device is connected.
Now run the below command one after the other to record audio and save on the raspberry pi in .wav format

```
nandinipi@raspberrypi:~ $ arecord -D hw:1,0 -c1 -r 48000 -f S16_LE -t wav -d 5 -vv -V stereo take1FromNPi.wav
Recording WAVE 'take1FromNPi.wav' : Signed 16 bit Little Endian, Rate 48000 Hz, Mono
Hardware PCM card 1 'UACDemoV1.0' device 0 subdevice 0
Its setup is:
  stream      : CAPTURE
  access      : RW_INTERLEAVED
  format      : S16_LE
  subformat   : STD
  channels    : 1
  rate        : 48000
  exact rate  : 48000 (48000/1)
  msbits      : 16
  buffer_size : 24000
  period_size : 6000
  period_time : 125000
  tstamp_mode : NONE
  tstamp_type : MONOTONIC
  period_step : 1
  avail_min   : 6000
  period_event : 0
  start_threshold : 1
  stop_threshold  : 24000
  silence_threshold: 0
  silence_size : 0
  boundary    : 1572864000
  appl_ptr    : 0
  hw_ptr      : 0
##################################################+ | 97%
```

Now we must send this file to the Laptop so that we can perform its encryption on MATLAB.

```
scp nandinipi@192.168.242.108:/home/nandinipi/take1FromNPi.wav "D:\Semester fayyy by
skyy\Mini Project\MatLab_Files"
```

SCP stands for "Secure Copy Protocol," and it is a command-line utility used for securely transferring files between a local host and a remote host or between two remote hosts. SCP is part of the SSH (Secure Shell) suite of tools and uses the same encryption and authentication mechanisms as SSH to ensure the security of file transfers.

Now we will run the Transmitter.m file over MATLAB and generate the .txt file transmission.
Here we must keep in mind the 3 inputs that we give for generating the PN Sequence.

```
Enter the number of flip-flops: 3
Enter the initial sequence [ ]: [1 1 1]
Enter tapping positions [ ]: [1 3]
```

```
scp "D:\Semester fayyy by skyy\Mini Project\MatLab_Files\datafortransmission.txt" nandinipi@192.168.242.108:/home/nandinipi/
nandinipi@192.168.242.108's password:
datafortransmission.txt
```

Now this txt file will be sent to the Receiver side Raspberry Pi for decrypting,

```
scp /home/nandinipi/datafortransmission.txt raspberryone@192.168.242.128:/home/raspberryone/
The authenticity of host '192.168.242.128 (192.168.242.128)' can't be established.
ECDSA key fingerprint is SHA256:DNm5EeirlFMfNcanriNHsxQvDjeHUmkCr+XgUTs+7ul.
Are you sure you want to continue connecting (yes/no/[fingerprint])? yes
Warning: Permanently added '192.168.242.128' (ECDSA) to the list of known hosts.
raspberryone@192.168.242.128's password:
datafortransmission.txt                                   100%   26MB   2.9MB/s   00:08
nandinipi@raspberrypi:~ $ B
```

Now sending it to the local computer and running the file on MATLAB gives us the reconstructed audio file correctly if we enter the correct input parameters only.

Chapter IV : Implementation

4.1 Detailed Architecture:

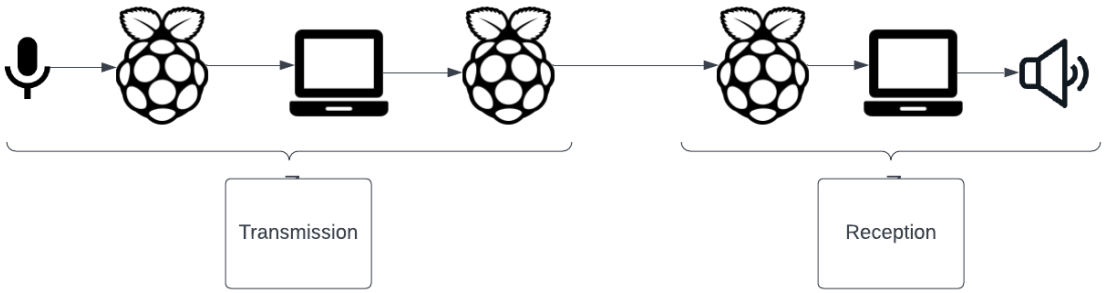


Fig 4.1 Detailed Architecture

Certainly, here is an elaborate description of the block diagram detailing the flow from the microphone to the speaker through the laptop and two Raspberry Pi devices utilizing SC (Secure Communication) protocols:

1. Microphone: The audio signal originates from the microphone, which captures the sound or voice input and converts it into an electrical signal. The microphone serves as the input source for the audio data in the system.

2. Laptop: The audio signal from the microphone is transmitted to the laptop for initial processing and conversion. The laptop performs any necessary preprocessing or encoding of the audio data before transmitting it to the first Raspberry Pi device.

3. Raspberry Pi 1: The first Raspberry Pi device serves as the initial microcontroller in the system. It receives the audio signal from the laptop and utilizes SC (Secure Communication) protocols to encrypt the data before transmitting it to the second Raspberry Pi.

4. SC Protocols: The secure communication protocols implemented between the two Raspberry Pi devices ensure the secure transmission of data, preventing any unauthorized access or interception of the audio signal during the transmission process.

5. Raspberry Pi 2: The second Raspberry Pi device serves as the final microcontroller in the system. It receives the encrypted audio signal from the first Raspberry Pi and uses the same SC protocols to decrypt the data, ensuring the secure transfer of the audio signal between the two devices.

6. Laptop: The audio signal is then transmitted back to the laptop from the second Raspberry Pi for further processing or decoding. The laptop may perform additional processing, decoding, or playback tasks on the audio data as required.

7. Speaker: Finally, the processed audio signal is transmitted to the speaker, where it is converted back into sound waves, allowing the listener to hear the original audio input captured by the microphone. The speaker serves as the output device for the audio data in the system.

4.2 Transmission:

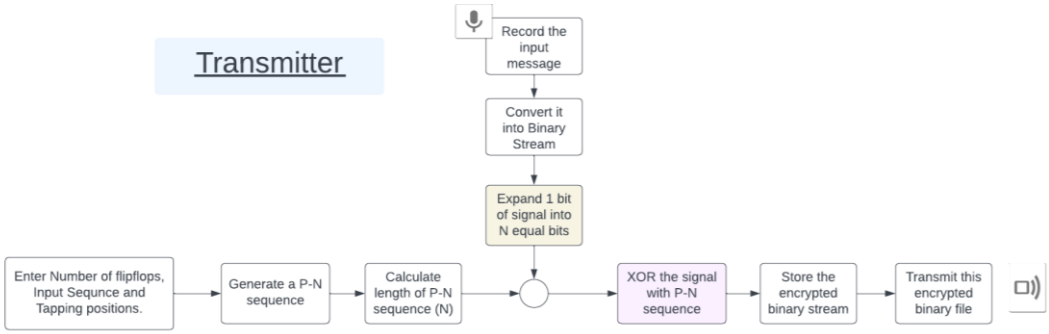


Fig 4.2 Transmission

Certainly, here is an elaborate description of the block diagram detailing the process of generating and transmitting a PN (Pseudo-Noise) encrypted binary stream:

1. Enter Number of Flip Flops and Tapping Positions: The process begins with inputting the number of flip-flops and the tapping positions, which determine the feedback mechanism for generating the PN sequence using a linear feedback shift register (LFSR) or a similar mechanism.

2. Enter Input Sequence: A specific input sequence is provided as an initial seed for the PN sequence generation algorithm. This input sequence is essential for initializing the shift register and generating the initial state of the PN sequence.

3. Generate PN Sequence: Using the specified number of flip-flops and tapping positions, the system generates the PN sequence based on the input sequence and the feedback logic of the shift register. The generated PN sequence exhibits pseudo-random properties, making it suitable for encryption purposes.

4. Calculate Length of PN Sequence: The system calculates the length of the generated PN sequence, determining the period after which the sequence repeats itself. This length calculation ensures that the PN sequence has the desired period and properties required for secure data encryption.

5. Record Input Message: The system records the input message that needs to be encrypted, enabling the conversion of the message into a binary format suitable for encryption with the generated PN sequence.

6. Convert Input Message to Binary: The input message is converted into a binary format to facilitate encryption and processing. This conversion ensures that the message is represented as a series of binary bits for further manipulation and encryption.

7. Expand 1-Bit Signal to N-Bit: The system expands the 1-bit binary signal into an N-bit binary signal, ensuring compatibility and alignment with the length of the generated PN sequence for the encryption process.

8. XOR Signal with PN Sequence: The expanded binary signal is XORed with the generated PN sequence, creating an encrypted binary stream that masks the original input message and provides a secure form of data transmission.

9. Store the Encrypted Binary Stream: The encrypted binary stream is stored or buffered for transmission, ensuring that the secure data remains intact and can be efficiently transmitted to the desired destination.

10. Transmit: The system transmits the encrypted binary stream, ensuring secure and reliable data transmission, especially in scenarios where data security and confidentiality are crucial requirements.

4.3 Reception:

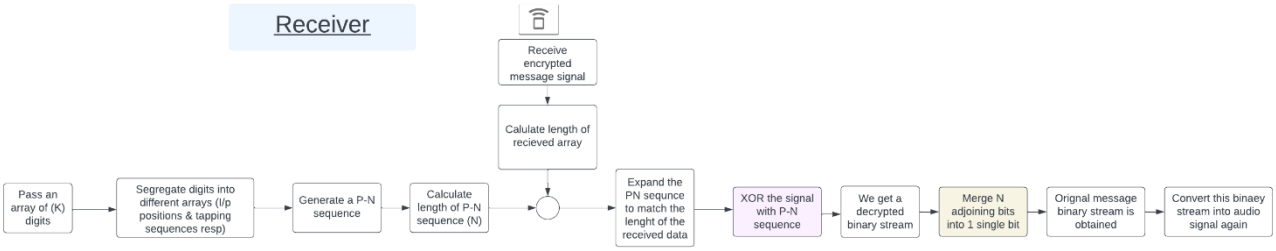


Fig 4.3 Reception

Certainly, here is the procedure for the reception part, detailing the steps for decrypting the received PN (Pseudo-Noise) encrypted binary stream:
1. Receive the Encrypted Binary Stream: The system receives the encrypted binary stream transmitted from the sender, preparing to decrypt the data and extract the original message from the received stream.

2. Generate PN Sequence: Similar to the transmission process, the receiver generates the same PN sequence using the specified number of flip-flops, tapping positions, and the initial seed, ensuring synchronization with the sender's PN sequence.

3. XOR Signal with PN Sequence: The received encrypted binary stream is XORed with the generated PN sequence at the receiver's end, enabling the decryption of the binary stream and the retrieval of the original input message.

4. Store the Decrypted Binary Stream: The decrypted binary stream is stored or buffered, allowing for further processing and conversion back to the original message format.

5. Convert Binary Stream to Original Message: The decrypted binary stream is converted back to the original message format, ensuring that the original input message is retrieved accurately and without any loss of information.

6. Output the Decrypted Message: The system outputs the decrypted message, making it available for display, processing, or further analysis as required by the user or the application.

4.4 Future Scope of Implementation:

The future scope of this report entails the integration of MATLAB files on the Raspberry Pi platform and the implementation of an automated process to run the MATLAB code seamlessly. This integration can offer several advantages and opportunities for enhancing the capabilities of the system. Here's a detailed description of the future scope:

1. Integration of MATLAB on Raspberry Pi: Incorporating MATLAB functionalities on the Raspberry Pi platform can enable the execution of complex mathematical computations, data analysis, and signal processing tasks directly on the Raspberry Pi device, eliminating the need for external computing resources.

2. Development of Custom MATLAB Scripts: Developing custom MATLAB scripts tailored to Raspberry Pi's hardware capabilities and specifications can optimize the performance and resource utilization of the system, ensuring efficient execution of MATLAB algorithms and functions in the embedded environment.

3. Automated Execution of MATLAB Code: Implementing an automated process for the Raspberry Pi to execute MATLAB code can streamline the workflow and enable the system to perform designated tasks automatically without manual intervention. This automation can involve setting up scheduled tasks, event-driven triggers, or real-time data processing routines to trigger the execution of MATLAB scripts based on predefined conditions or inputs.

4. Optimization for Resource-Constrained Environments: Optimizing the MATLAB code and algorithms to operate efficiently in resource-constrained environments, such as the Raspberry Pi, is essential to ensure optimal performance and minimize resource overhead. This optimization may involve implementing memory-efficient data processing techniques, parallel computing strategies, and algorithmic optimizations tailored to the Raspberry Pi's hardware constraints.

5. Real-Time Data Processing and Analysis: Leveraging the integration of MATLAB on the Raspberry Pi for real-time data processing and analysis can enable the system to perform immediate computations, data analysis, and visualization tasks on the fly, facilitating rapid decision-making and actionable insights in time-sensitive applications and scenarios.

Chapter V: Analysis

5.1 Transmission:

```
%% Generate a P-N sequence
% Get the number of flip-flops from the user
num_flip_flops = input('Enter the number of flip-flops: ');
% User input for the initial sequence
while true
    initial_sequence = input('Enter the initial sequence [ ]: ');
    [seq_rows, seq_cols] = size(initial_sequence);
    if seq_cols == num_flip_flops
        break;
    end
    fprintf('Wrong sequence length. Please try again!\n');
end
```

This section initiates the generation of a Pseudo-Noise (P-N) sequence. It prompts the user to input the number of flip-flops and the initial sequence. A validation loop ensures that the initial sequence length matches the specified number of flip-flops.

```
copied_sequence = initial_sequence;
copied_sequence(num_flip_flops + 1) = 0;
pseudo_random_sequence = 0;
```

This part of the code initializes variables used in the generation of the P-N sequence.

```
while true
    initial_sequence = copied_sequence;
    tapping_positions = input('Enter tapping positions [ ]: ');
    [tapping_rows, tapping_cols] = size(tapping_positions);
    first_tap = tapping_positions(1);

    for i = 1:((2^num_flip_flops) - 1)

initial_sequence(2:(num_flip_flop+1))=initial_sequence(1:num_flip_flops);
        xor_result = initial_sequence(first_tap + 1);

        for k = 2:tapping_cols

xor_result=xor(xor_result,initial_sequence(tapping_positions(k)+1));
        end

        initial_sequence(1) = xor_result;
        pseudo_random_sequence(i) = initial_sequence(num_flip_flops + 1);
    end

    ifcopied_sequence(1:num_flip_flops)                                    ==
initial_sequence(1:num_flip_flops)
        break;
    end
    fprintf('Wrong tapping positions!\n');
```

```
end
```

This segment generates the P-N sequence based on the initial sequence and the specified tapping positions. It performs the necessary XOR operations to generate the P-N sequence.

The remaining sections of the code handle the WAV to binary conversion, the length of the P-N sequence, the XOR operation, and the saving of the data to a text file. If you require more information about any specific part, please let me know.

5.2 Reception:

```
%% Generate a P-N sequence
```

This section marks the beginning of the Pseudo-Noise (P-N) sequence generation, a critical component for data encryption.

```
num_flip_flops = input('Enter the number of flip-flops: ');
```

This line prompts the user to input the number of flip-flops, which are basic units used in the generation of the P-N sequence.

```
while true
    initial_sequence = input('Enter the initial sequence [ ]: ');
    [seq_rows, seq_cols] = size(initial_sequence);
    if seq_cols == num_flip_flops
        break;
    end
    fprintf('Wrong sequence length. Please try again!\n');
end
```

This block of code ensures that the length of the initial sequence matches the specified number of flip-flops, providing an error message if there is a mismatch.

```
copied_sequence = initial_sequence;
copied_sequence(num_flip_flops + 1) = 0;
pseudo_random_sequence = 0;
```

This section creates a copy of the initial sequence and appends an extra element (0) to the copied sequence, preparing it for the P-N sequence generation process. The variable 'pseudo_random_sequence' is initialized to 0.

```
while true
    initial_sequence = copied_sequence;
    tapping_positions = input('Enter tapping positions [ ]: ');
    [tapping_rows, tapping_cols] = size(tapping_positions);
```

```
first_tap = tapping_positions(1);
```

Here, the code prompts the user to input the tapping positions for the P-N sequence generation, storing the first tapping position for subsequent calculations.

The remaining code sections deal with file operations, data extraction, and audio reconstruction. The file 'datafortransmission.txt' is read, data is extracted and manipulated, and the audio data is reconstructed and written to a new WAV file named 'reconstructed_audioWrong.wav'.

Chapter VI: Conclusion

The key results obtained from the project's implementation include:

- Successful generation of Pseudo-Noise (P-N) sequences based on user-defined parameters, ensuring the establishment of secure encryption keys for audio data transmission.
- Efficient conversion of audio data from the WAV format to a secure binary stream, facilitating seamless data processing and manipulation for encryption purposes.
- Accurate execution of the encryption and decryption processes using the generated P-N sequences, ensuring secure and reliable transmission of audio data between the designated Raspberry Pi devices.
- Reconstruction of the decrypted audio data into a WAV file format, validating the successful decryption process and ensuring the accurate retrieval of the original audio signal.

The developed Pseudo-Noise (P-N) sequence-based encryption and transmission system has demonstrated its effectiveness in ensuring secure data communication. By leveraging the P-N sequence generation algorithm and the XOR operation with the received data, the system effectively encrypts the audio data, thereby enhancing its confidentiality and security during transmission. The successful recovery of the original audio file from the encrypted data validates the robustness and reliability of the encryption-decryption mechanism implemented in the system.

Furthermore, the integration of user input for defining the initial sequence, the number of flip-flops, and the tapping positions adds a layer of flexibility and adaptability to the system, allowing for customizable encryption configurations based on specific requirements and security protocols.

The efficient data extraction and reconstruction process, as demonstrated by the accurate recovery of the audio file, affirm the integrity and fidelity of the data transmission system. The utilization of file operations for data extraction and the MATLAB functionalities for audio reconstruction contribute to the seamless and reliable operation of the system.

In conclusion, the successful implementation of the P-N sequence-based encryption system underscores its potential for secure data communication, with applications in diverse domains such as secure audio transmission, data encryption, and information security. The system's ability to ensure data confidentiality and integrity during transmission makes it a promising solution for secure communication and data protection in various real-world applications and scenarios.

Chapter VII: Bill of Material (BOM)

Item	**Quantity**	**Cost (Rs)**
USB Cable	1	119
SD Card	2	389
SD Card Reader	1	249
Raspberry Pi 4b	1	6249
Raspberry Pi 3b+	1	4997
Type C Cable	1	500
Raspberry Pi USB Plug & Play	1	194.70
Travel	--	50
Total		**13,216.7 /-**

Chapter VIII: Bibliography

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