Experiment No.: 5

Aim: To implement a basic function of Code Division Multiple Access (CDMA) to test the orthogonality and autocorrelation of a code to be used for CDMA operation. Write an application based on the above concept.

Theory:

Code-division multiple access (CDMA) is a channel access method used by various radio communication technologies. CDMA is an example of multiple access, where several transmitters can send information simultaneously over a single communication channel. This allows several users to share a band of frequencies (see bandwidth). To permit this without undue interference between the users, CDMA employs spread spectrum technology and a special coding scheme (where each transmitter is assigned a code).

CDMA is used as the access method in many mobile phone standards. IS-95, also called "cdmaOne", and its 3G evolution CDMA2000, are often simply referred to as "CDMA", but UMTS, the 3G standard used by GSM carriers, also uses "wideband CDMA", or W-CDMA, as well as TD-CDMA and TD-SCDMA, as its radio technologies.

The intended 4G successor to CDMA2000 was UMB (Ultra Mobile Broadband); however, in November 2008, Qualcomm announced it was ending development of the technology, favoring LTE instead

CDMA Orthogonality:

Techniques generally used are direct sequence spread spectrum modulation (DS-CDMA), frequency hopping or mixed CDMA detection (JDCDMA). Here, a signal is generated which extends over a wide bandwidth. A code called spreading code is used to perform this action. Using a group of codes, which are orthogonal to each other, it is possible to select a signal with a given code in the presence of many other signals with different orthogonal codes.

CDMA Autocorrelation:

Autocorrelation of the sequence, it determines the ability to synchronize and lock the spreading code for the received signal.

Code:

```
import numpy as np
c1=[1,1,1,1]
c2=[1,-1,1,-1]
c3=[1,1,-1,-1]
c4=[1,-1,-1,1]
rc=[]

print("Enter the data bits :")

d1=int(input("Enter D1 :"))
d2=int(input("Enter D2 :"))
d3=int(input("Enter D3 :"))
d4=int(input("Enter D4 :"))
r1=np.multiply(c1,d1)
r2=np.multiply(c2,d2)
r3=np.multiply(c3,d3)
r4=np.multiply(c4,d4)
resultant_channel=r1+r2+r3+r4;
print("Resultant Channel",resultant_channel)
Channel=int(input("Enter  the station to listen for C1=1 ,C2=2, C3=3 C4=4 :
"))

if Channel==1:
 rc=c1
elif Channel==2:
 rc=c2
elif Channel==3:
 rc=c3
elif Channel==4:
 rc=c4
inner_product = np.multiply(resultant_channel,rc)

print("Inner Product",inner_product)
res1=sum(inner_product)

data = res1/len(inner_product)
print("Data bit that was sent",data)
```

Output:

```
Enter the data bits :
Enter D1 :23
Enter D2 :5
Enter D3 :456
Enter D4 :56
Resultant Channel [ 540  418 -484 -382]
Enter  the station to listen for C1=1 ,C2=2, C3=3 C4=4 : 1
Inner Product [ 540  418 -484 -382]
Data bit that was sent 23.0
```

Conclusion:

Thus, we have studied the CDMA code to test autocorrelation and orthogonality of codes and executed the same using the java code as above and got proper output for it.

POST LAB

1. **What is CDMA and how does it differ from other multiple access techniques?**

CDMA, or Code Division Multiple Access, is a telecommunications technique enabling multiple users to share the same frequency band concurrently. Unlike FDMA and TDMA, which allocate exclusive frequency channels or time slots to users, CDMA assigns unique codes to each user for data transmission. These codes are designed to be orthogonal, minimizing interference between users. In contrast to OFDMA, which divides the frequency spectrum into subcarriers, CDMA does not require such division, allowing for efficient spectrum utilization. One advantage of CDMA is its increased capacity, as multiple users can transmit simultaneously on the same frequency band. Moreover, CDMA offers improved spectral efficiency compared to other techniques. However, CDMA necessitates complex signal processing methods and careful interference management to ensure efficient operation. Overall, CDMA provides enhanced capacity, spectral efficiency, and security in telecommunications systems.

2. **How does spread spectrum technology contribute to CDMA?**

Spread spectrum technology plays a crucial role in CDMA by enabling multiple users to share the same frequency band simultaneously while minimizing interference. In CDMA, each user's data is spread over a wider bandwidth using a unique spreading code. This spreading process "spreads" the signal, making it appear as noise to other users not using the same spreading code.

Spread spectrum technology contributes to CDMA in several ways:

1. Increased Capacity : By spreading each user's signal over a wider bandwidth, CDMA can accommodate more users within the same frequency band compared to other multiple access techniques. This leads to increased capacity in the system.
2. Enhanced Security : The spreading process in CDMA makes it resistant to interference and jamming. Since the signal appears as noise to unauthorized users, it is difficult for them to intercept or disrupt communication, enhancing the security of the system.
3. Improved Robustness : Spread spectrum technology helps CDMA systems to tolerate multipath interference and fading effects more effectively. The spread signal can be reconstructed even if parts of it are lost or corrupted during transmission.
4. Flexible Allocation : CDMA allows for flexible allocation of bandwidth among users since each user is assigned a unique spreading code. This enables dynamic resource allocation based on users' varying needs and traffic demands.

Overall, spread spectrum technology is fundamental to the operation of CDMA, enabling efficient and secure communication among multiple users within the same frequency band.

3. **What are the advantages of CDMA over other multiple access techniques like FDMA and TDMA?**

CDMA (Code Division Multiple Access) offers several advantages over other multiple access techniques such as FDMA (Frequency Division Multiple Access) and TDMA (Time Division Multiple Access). Firstly, CDMA provides increased capacity by allowing multiple users to share the same frequency band simultaneously without the need for frequency or time slot allocation. This leads to more efficient spectrum utilization. Secondly, CDMA offers enhanced security as each user's data is encoded with a unique code, making it difficult for unauthorized users to intercept or disrupt communication. Additionally, CDMA exhibits better resistance to interference and fading, resulting in improved call quality and reliability. Furthermore, CDMA allows for seamless handoffs between cells, leading to smoother mobility management. CDMA also supports variable data rates, catering to diverse user requirements. Moreover, CDMA systems require less complex infrastructure compared to FDMA and TDMA, leading to cost savings in deployment and maintenance. Additionally, CDMA is well-suited for multimedia applications due to its robustness and flexibility. Overall, CDMA stands out for its capacity, security, reliability, flexibility, and cost-effectiveness compared to other multiple access techniques.

4. **Can you explain the concept of "orthogonality" in CDMA?**

In CDMA (Code Division Multiple Access), "orthogonality" refers to the property where the spreading codes used by different users are mathematically orthogonal to each other. This means that when overlaid on top of each other, the codes do not interfere with one another. Orthogonality ensures that each user's signal can be accurately distinguished from others, even when transmitted simultaneously over the same frequency band. This property is essential for enabling multiple users to share the same spectrum without causing mutual interference. The orthogonal nature of spreading codes allows CDMA systems to achieve high spectral efficiency by accommodating multiple users within the same bandwidth. It also contributes to increased capacity and improved system performance. The design of orthogonal spreading codes involves carefully selecting sequences that exhibit minimal cross-correlation with each other. Maintaining orthogonality is crucial for the successful operation of CDMA networks, ensuring reliable communication and efficient spectrum utilization.

5. **What are the key challenges in implementing CDMA systems?**

Implementing CDMA systems comes with several key challenges. Firstly, managing interference is critical due to the shared spectrum nature of CDMA, requiring sophisticated interference mitigation techniques. Secondly, maintaining orthogonality among spreading codes is challenging as the number of users increases, necessitating careful code design and synchronization. Thirdly, achieving optimal power control is crucial to mitigate near-far effects and maintain system fairness. Additionally, handling multipath propagation and fading poses challenges in maintaining signal quality and reliability. Moreover, accommodating varying data rates and Quality of Service (QoS) requirements for different users adds complexity to system design and resource allocation. Ensuring secure communication in CDMA systems requires robust encryption and authentication mechanisms. Furthermore, supporting mobility management and seamless handoffs between cells demands efficient signaling and location tracking mechanisms. Optimizing CDMA performance in heterogeneous network environments with diverse user densities and coverage areas is another challenge. Balancing system capacity, coverage, and spectral efficiency while minimizing costs is critical for successful CDMA deployment. Lastly, evolving standards and technologies require continuous adaptation and interoperability considerations in CDMA system implementation.