Experiment No.: **Date:**

Title : Verify use of Orthogonal Walsh Code in CDMA environment

Learning Objectives : At the end of this experiment, students will be able to:

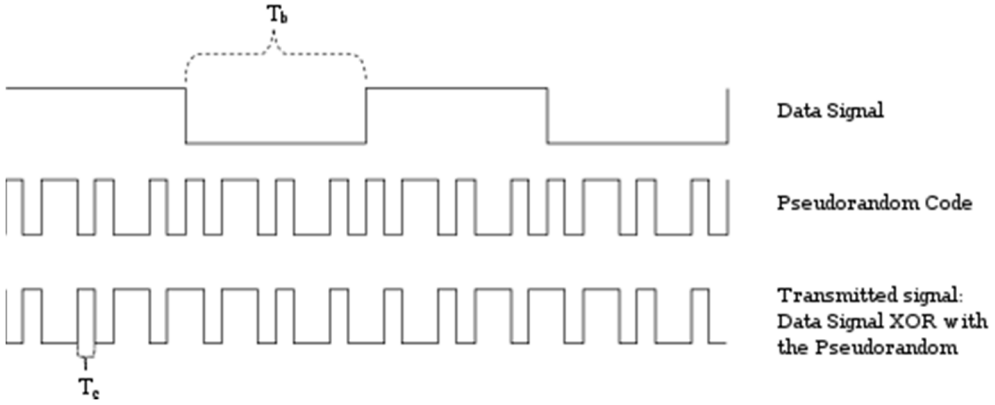
- Verify orthogonality property of Walsh Code.
- Use of Walsh Code In CDMA systems.
- Multiple user communication takes place simultaneously in CDMA environment.

Pre-requisite : Basic concept of multiplexing,Types of multiplexing techniques,CDMA.

Apparatus : Computing facility, MATLAB

Theory:

CDMA stands for Code Division Multiple Access, a digital cellular technology that uses spread-spectrum techniques. It permits a more uniform distribution of energy in the emitted bandwidth.
Unlike competing systems, such as GSM that use TDMA, CDMA does not assign a specific frequency to each user. Instead, every channel uses the full available spectrum. Individual conservations are encoded with a pseudo-random digital sequence. CDMA has greater voice quality and call clarity than any other technologies because it filters out the background noise, crosstalk and interference. It also has fewer dropped calls because it increases voice and data transmission reliability. Also, CDMA has greater spectral efficiency because it packs more transmissions into the same space, resulting in fewer cell sites, which lowers operators' cost. It also gives increased capacity, and improved coverage.
CDMA is a spread-spectrum multiple access technique. A spread spectrum technique spreads the bandwidth of the data uniformly for the same transmitted power. A spreading code is a pseudo-random code that has a narrow ambiguity function, unlike other narrow pulse codes. In CDMA a locally generated code runs at a much higher rate than the data to be transmitted. Data for transmission is combined via bitwise XOR (exclusive OR) with the faster code. The figure shows how a spread spectrum signal is generated. The data signal with pulse duration of T_b (symbol period) is XOR'ed with the code signal with pulse duration of T_c (chip period). (Note: bandwidth is proportional to $1/T$, where T = bit time.) Therefore, the bandwidth of the data signal is $1/T_b$ and the bandwidth of the spread spectrum signal is $1/T_c$. Since T_c is much smaller than T_b, the bandwidth of the spread spectrum signal is much larger than the bandwidth of the original signal. The ratio T_b/T_c is called the spreading factor or processing gain and determines to a certain extent the upper limit of the total number of users supported simultaneously by a base station.



Each user in a CDMA system uses a different code to modulate their signal. Choosing the codes used to modulate the signal is very important in the performance of CDMA systems. The best performance will occur when there is good separation between the signal of a desired user and the signals of other users. The separation of the signals is made by correlating the received signal with the locally generated code of the desired user. If the signal matches the desired user's code, then the correlation function will be high and the system can extract that signal. If the desired user's code has nothing in common with the signal the correlation should be as close to zero as possible (thus eliminating the signal); this is referred to as cross-correlation. If the code is correlated with the signal at any time offset other than zero, the correlation should be as close to zero as possible. This is referred to as auto-correlation and is used to reject multi-path interference.

An analogy to the problem of multiple access is a room (channel) in which people wish to talk to each other simultaneously. To avoid confusion, people could take turns speaking (time division), speak at different pitches (frequency division), or speak in different languages (code division). CDMA is analogous to the last example where people speaking the same language can understand each other, but other languages are perceived as noise and rejected.

Orthogonal codes are easily generated by starting with a seed of 0, repeating the 0 horizontally and vertically, and then complementing the 1 diagonally. This process is to be continued with the newly generated block until the desired codes with the proper length are generated. Sequences created in this way are referred as “Walsh” code. The Walsh code is used to separate the user in the forward CDMA link. In any given sector, each forward code channel is assigned a distinct Walsh code.

Walsh codes or Walsh-Hadamard codes are used to separate users on the downlink (DL) channel in CDMA systems (for example in CDMA2000, UMTS cellular standards etc.). Code orthogonality between two codes W_i and W_j is defined as

$$\int_0^T W_i(t)W_j(t)dt = \delta_{ij} \cdot T$$

An important requirement to keep in mind for the orthogonality condition to work is that the codes must be synchronized in time and this is easier to achieve on the DL where a single base station is orthogonalizing multiple users in its cell area. Walsh codes are also used for Mary orthogonal modulation on the uplink (UL) channel for each user.

Advantages:

1. No SIM card is required.
2. Improved call quality: CDMA provides better and more consistent sound quality than systems based on other technologies.
3. Enhanced privacy when compared to systems using other technologies.
4. Increased talk time and standby time for mobiles.
5. They are difficult to intercept for an unauthorized person.
6. They are easily hidden. For an unauthorized person, it is difficult to ever detect their presence in many cases.
7. They are resistant to jamming.
8. Capacity increases of 8 to 10 times that of an AMPS Analog system, and 4 to 5 times GSM, because of CDMA's unique spread spectrum technology.

Disadvantages:

1. In general, the collisions at the channel is a disadvantage of CDMA system and can be mitigated by careful selection of the sequence and power control that is close to perfect.
2. Since most countries have chosen the GSM standard, "roaming" on CDMA is limited.
3. A CDMA doesn't have a SIM card, which makes m-commerce difficult.

Question:

Consider a case where 8 chips/bit are used to generate the Walsh code. Mobile station A, B, C, D are assigned W1,W2, W3, W4 respectively. The station uses Walsh code to send a '1' binary bit and use negative Walsh code to send '0' binary bit. Assume all stations are synced in time. Therefore, the chip sequence begins at the same instant. When two or more stations transmit simultaneously, they are bipolar signals that add linearly. Consider the following 4 different cases, when one or more station transmits and show that receiver recovers the bit of station C.

In conclusion prove the orthogonality property of Walsh Codes.

Conclusion: