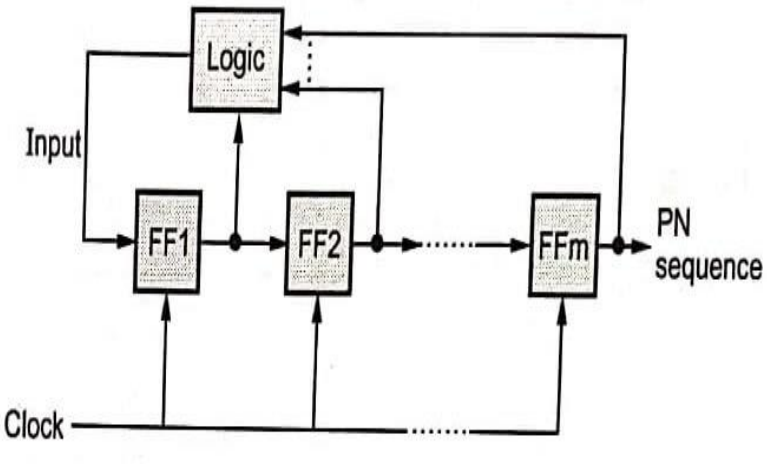
MODULE -4
SPREAD SPECTRUM COMMUNICATION MULTIPLE ACCESS TECHNIQUES

Spread Spectrum Modulation:-

- **It is a modulation technique in which transmitted sequence occupies much more band width than the minimum band width required**
- **This will cause much more band width usage of sequence while passing through the channel but it will provide better security**
- **It can also be defined as spectrum spreading at transmitter and dispreading at receiver**
- **Spreading is done by converting a single bit of input signal to multiple bits as a result frequency and bandwidth of input will increase**
- **The spreading of input data to multiple bits is done with the help of pseudo noise (PN) sequence generator**

Pseudo Noise (PN) Sequence Generator:-

Block diagram:-



PN sequence:-

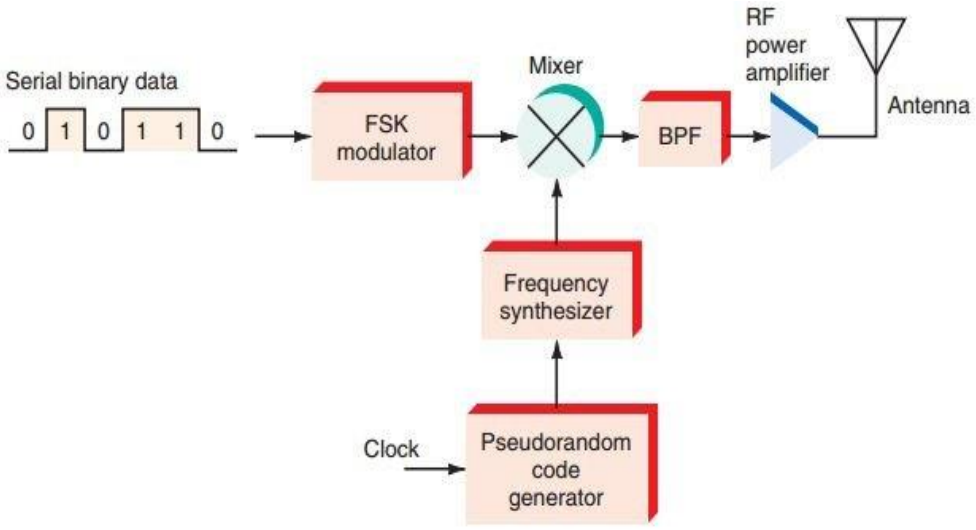
A Pseudo-Noise (PN) sequence, also known as a pseudo-random sequence or pseudo random binary sequence (PRBS), is a deterministic sequence of binary values that appears random but is generated using a deterministic algorithm

The output of a PN sequence generator is a binary sequence and it is generated using a deterministic algorithm, which means that if you know the algorithm and the initial conditions you can reproduce the same sequence of values.

PN sequences are usually designed to have a specific period or cycle length

Frequency-Hop Spread Spectrum(FHSS):-

Block Diagram:-



- **It is a analog spread spectrum**
- **Here the original input sequence is first FSK modulated and passed to mixter/spreader. The input to the spreader having bandwidth B and output will have a bandwidth Bss**
- **In the spreader FSK modulated signal and frequency from frequency synthesizer are mixed together and produce the required spread spectrum**

The PN generator will generate a particular code at an instant according to the code a carrier will be selected at that instant and used by frequency

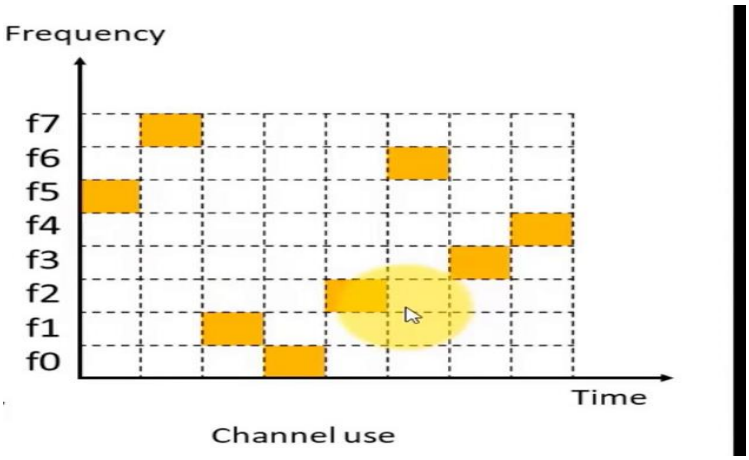
PN sequence	
Code	Carrier frequency
000	F1
001	F2
010	F3
011	F4
100	F5
101	F6
110	F7
111	F8

- Consider a

Consider a PN sequence having 3 bit

- Let as consider at an instant PN generator gives a code 100 then the frequency F5 will be given to the mixer for spreading the input sequence

Frequency hopping:-



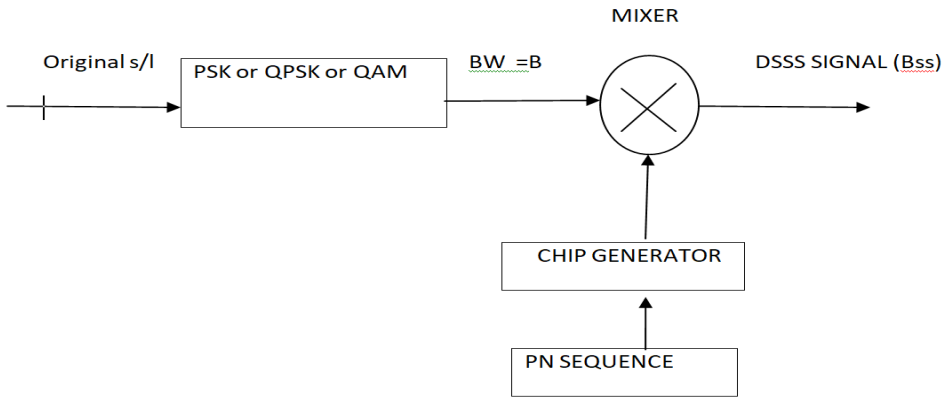
- Changing frequency with respect to time is called frequency hopping
- Here at the first instant it is selected F5 frequency ,At 2nd instant it is selected f7 frequency for mixing and so on ..
- Here after the 8th instant the next cycle will start

Application of FHSS:-

- **USED IN BLUETOOTH(1600 times frequency hopes per second)**
- **JTRS(Joint Tactical Radio System)**

Direct sequence spread spectrum(DSSS):-

- **It is a spreading technique which extends BW of input signal**
- **It is a digital spread spectrum technique**
- **Here input signal can be modulated by PSK/QPSK/QAM**
- **For increasing bit error rate (BER) and band width efficiency we use DSSS**
- **Chip generator uses barker codes for generation of codes,its output will be in terms of +1 or -1**

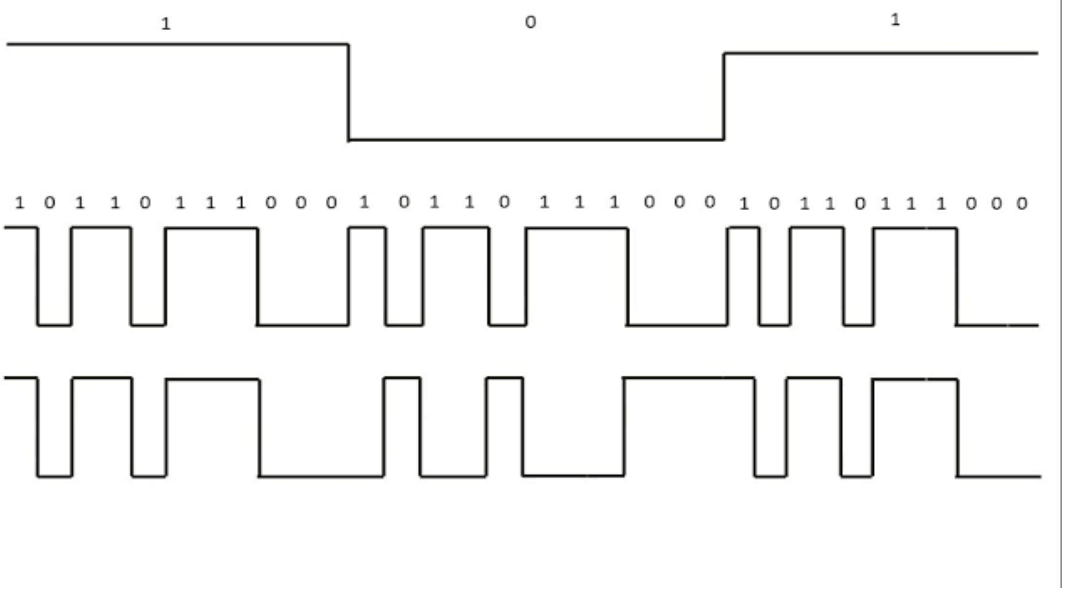


DSSS WAVEFORM:-

Input sequence

Spread code of length 11

Output code (Obtained by EX-NOR OF input and spread code)



Direct sequence spread spectrum(DSSS):-

Advantage of DSSS:-

- **Better security than FHSS**
- **Improved immunity against jamming compared to FHSS**

Application of DSSS:-

- **CDMA(2G AND 3G)**

Multiple Access Techniques:-

- **It is a method used in telecommunications to enable multiple users to share a common communication channel, such as a radio frequency band, a wired network, or a satellite link, without causing interference or collisions.**
- **There are several common multiple access techniques, each with its own advantages and limitations. Here are some of the most well-known ones:**

1) **Frequency Division Multiple Access (FDMA)**
2) **Time Division Multiple Access (TDMA)**
3) **Code Division Multiple Access (CDMA)**

Frequency Division Multiple Access (FDMA):-

- **It is a multiple access technique used in telecommunications and wireless communication systems to allow multiple users to share the available bandwidth in the frequency domain.**
- **The available frequency spectrum is divided into multiple non-overlapping subchannels or frequency slots**
- **On demand allocation of channel which will help for efficient use of channel to different users**

Features:-

- **FDMA channel carries only one phone circuit at a time**
- **when not in use FDMA channel will be idle**
- **FDMA provide relatively narrow channel (30KHZ)**
- **Tight RF filtering is required for avoiding near channel interference**
- **FDMA mobile unit used duplexer for separation of frequency which increase cost**
- **Total number of channels that can be simultaneously support in a FDMA system** $N = B_t - 2B_{guard} / B_c$

B_t - total spectrum, B_{guard} – guard band and B_c - channel band width

Advantages:-

- **FDMA minimizes interference between users since they operate on separate frequency bands.**
- **FDMA is relatively simple to implement and manage**
- **Frequency allocation remains constant during their communication session, ensuring predictable and continuous access to the spectrum**

Applications:-

- **Used in point-to-point microwave links**
- **Used in older analog cellular networks**

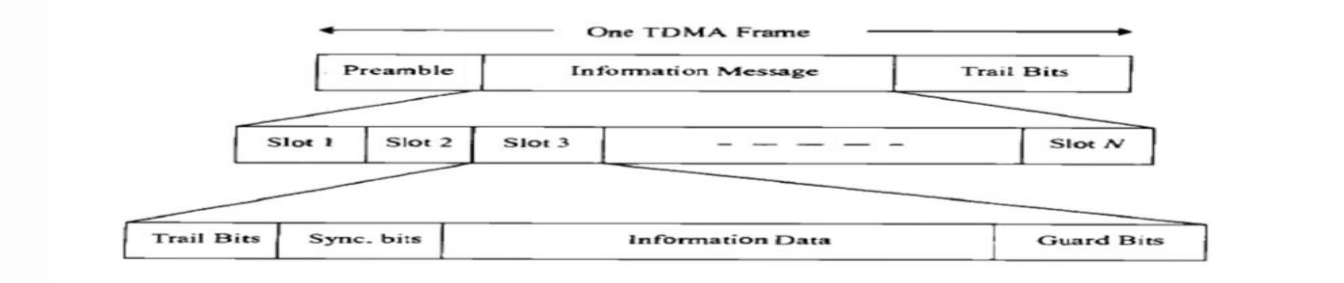
Time Division Multiple Access (TDMA):-

- It is a multiple access technique used in telecommunications to allow multiple users or devices to share the same communication channel by allocating them specific time slots or time intervals.
- TDMA is commonly used in various digital communication systems
- Each time slot represents a specific portion of time during which a user can transmit or receive data by using the entire bandwidth
- TDMA transmit data in a buffer and burst method, which is a discontinuous data transmitting method ,hence data should be in digital format and digital modulation is required.
- Easy hand off-(during free or idle time slot the mobile unit will check the power level from neighbouring base stations and will connect to the powerful station)
- Since we use buffer and burst method we have to identify each data so high synchronization overhead is required
- Guard slots are necessary to separate users
- On demand supply make system more efficient
- Total number of channels that can be simultaneously support in a FDMA system N= $B_t - 2B_{guard} / B_c$

  m- max number of users on each channel

TDMA frame:-

- In tdma frame preamble and trail bits are used for synchronize data from transmitter to the receiver and viceversa
- Information msg are divided in to multiple slots depends up on how much users are using
- Every slots again has trail , synchronization, guard bits
- Trail and synchronization bits are used for synchronization
- Guard bits are used for preventing overlapping of data when any delay in packet transmission occurs



Advantages:-

- TDMA efficiently utilizes the available channel bandwidth
- Users are allocated specific time slots, ensuring predictable access to the communication channel.
- users transmit at different times, there is minimal interference

Application:-

- older cellular networks like 2G
- some satellite communication

Code Division Multiple Access (CDMA) :-

- CDMA is a digital wireless communication technology that allows multiple users to share the same frequency band simultaneously.
- Unlike TDMA and FDMA which divide the channel into time slots or frequency bands, CDMA uses entire time and entire frequency and a unique coding scheme(pseudo random code or spreading sequence) that assigns a specific code to each user
- The codes are orthogonal to each other ie. They are independent to each other and cannot interfere with each other
- It is a spread spectrum communication
- Soft capacity limit(ie,capacity can be increased by increasing number of orthogonal codes)
- Soft handoff , here when moving from one station to near station frequency is not changing
- Near far effect avoided by power control ,i.e., far away user has to transmit with high power and near to station user will transmit with less power

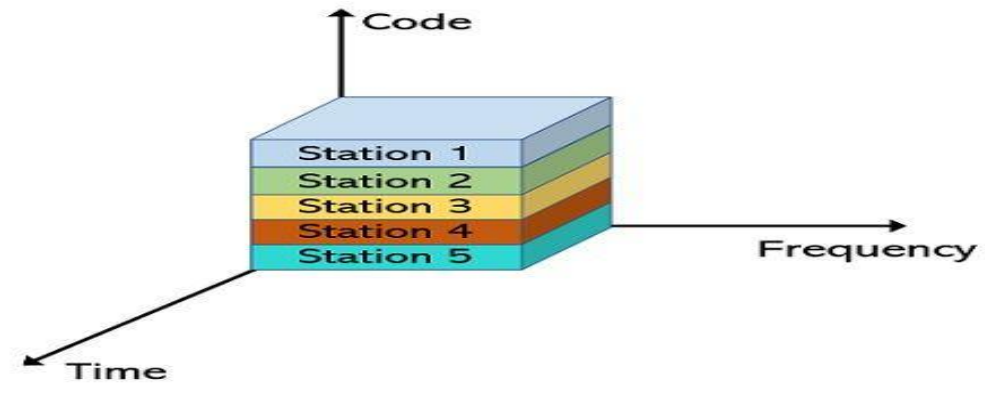


Illustration of CDMA

Advantages:-

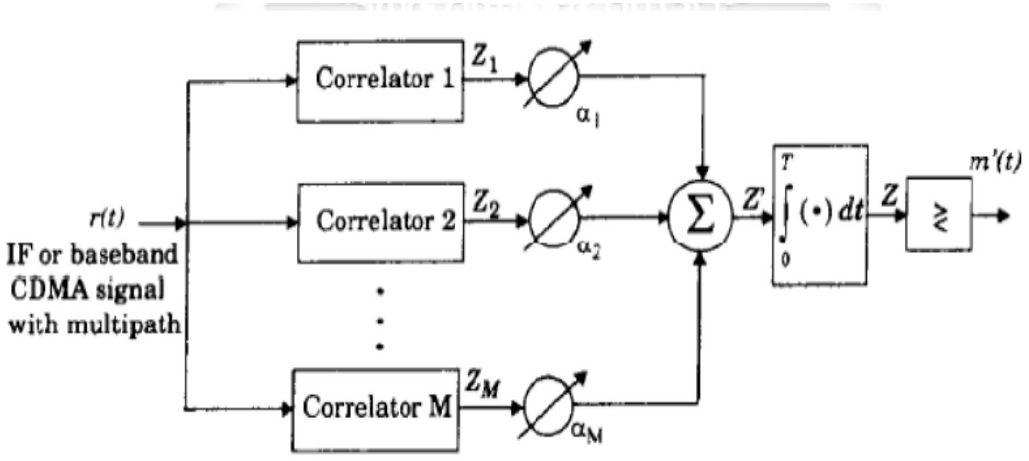
- **Efficient Spectrum Usage**
- **CDMA systems are robust against interference(since noise can be suppressed using the appropriate code).**
- **suitable for both small and large networks**

Application:-

- **Used 2G and 3G cellular networks**

CDMA -Rake receiver:-

- **A CDMA Rake receiver is a specialized type of receiver used in wireless communication systems to recover transmitted signals from multiplepath**
- **The term "Rake" in the Rake receiver refers to the process of "raking" or collecting multiple signal components from different paths and combining them to improve the reception quality.**
- **The signal reaches the receiver using multiple channels/path at different time, which create multiple copies of the signal at the receiver , these signals has different time delay**
- **Similarly different path produces different attenuation also**
- **Rake receiver should be able to separately identify the information by neglecting the path loss and time delay of the channel**



- **The signal receiver in rake receiver is first demodulated and given to the correlators**
- **Correlator circuits have different time delay which are used to extract the information which also have different time delay**

- **Output of correlators is given to attenuators, this attenuators are weighted attenuators which will depend on channel attenuation characteristic,**
- **Attenuators will compensate the attenuation produced in the respective path and combining the outputs we will get the original information**

Multicarrier communication:-

- **Multicarrier communication is a technique used in telecommunications and wireless communication systems where data is transmitted and received over multiple subcarriers within a broader frequency band. The primary idea behind multicarrier communication is to divide the available bandwidth into several narrower subchannels, each of which carries a part of the data. Each subcarrier typically operates independently, and they are often orthogonal to each other to avoid interference**

orthogonal space sub carrier:-

Definition:-

- **The subcarriers are spaced from one another by an amount that makes them orthogonal(perpendicular) to one another. This means that despite their close adjacent spacing from one another they will not interfere with one another.**

Importance of orthogonal space sub carrier:-

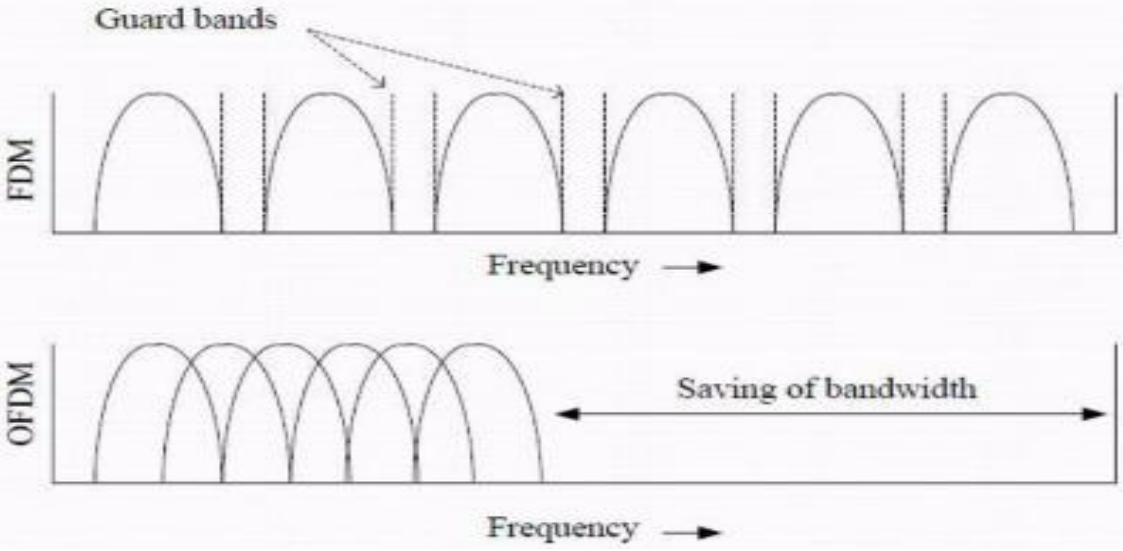
- **Orthogonal subcarriers ensure that these signals do not interfere with each other**
- **orthogonal subcarriers maximize spectral efficiency**
- **Orthogonal subcarriers can reduce the effects of fading and multipath interference because they provide spatial diversity**
- **Orthogonal subcarriers provide higher SNR**
- **Orthogonality simplifies the signal processing at the receiver**

Orthogonal Frequency Division Multiplexing(OFDM):-

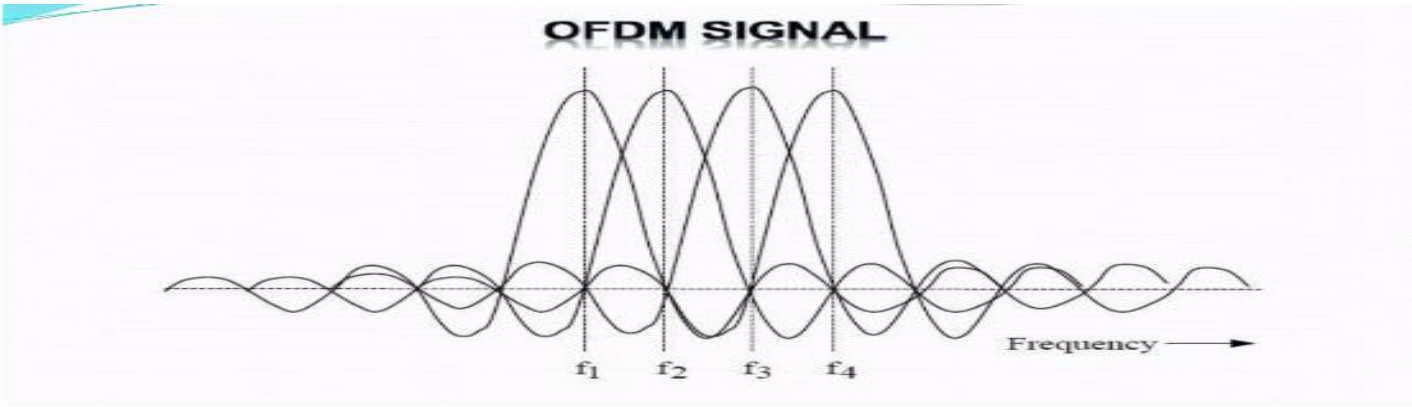
- **In OFDM the available frequency spectrum is divided in to multiple subcarriers ,the subcarriers are orthogonal to each other, meaning they are carefully designed to be independent and non-interfering.**
- **Each sub carrier is modulated with a conventional modulation scheme (QAM OR PSK)at a low symbol rate**
- **OFDM is a modulation technique widely used in modern wireless communication systems, including Wi-Fi, 4G LTE, 5G, and digital television broadcasting.**

- System bandwidth is divided into a set of parallel overlapping, yet orthogonal sub-bands independent to each other
- Data is first split into independent streams, which modulate different sub-carriers
- Then are multiplexed to create OFDM signal
- OFDM is a special case of FDM
- Significantly improves spectral efficiency
- Avoid the need for steep band pass filters
- Avoids the need of a bank of oscillators, since can be implanted digitally

FDM vs OFDM:-



OFDM SPECTRUM:-



ADVANTAGE OF OFDM:-

- Permits densely packed & overlapping sub-carriers
- Offers spectrally efficient transmission scheme
- Can be digitally implemented using, fast & efficient signal processing
- Permits flexible use of spectrum
- Supports different modulation schemes based on channel conditions
- Almost completely avoids the need for an equalizer