Question 4: What are the advantages of analog modulation schemes?

Answer: Analog modulation schemes offer several advantages:

Compatibility: Analog modulation schemes are compatible with legacy systems, allowing for the transmission of signals over existing infrastructure.

Simplicity: Analog modulation is often simpler to implement than digital modulation, requiring less complex hardware and signal processing.

Smooth Signal Transitions: Analog signals, like voice and music, are continuous and smooth, which can lead to pleasing transitions and less perceptible distortion.

Real-time Transmission: Analog modulation allows for real-time transmission of signals, making it suitable for applications like live broadcasting and voice communication.

Cultural Familiarity: Many people are accustomed to the characteristics of analog-modulated signals, like those in AM and FM radio, which can contribute to their continued use in specific contexts.

Question 2: What are the main types of wireless communication?

Answer: There are several types of wireless communication:

Radio Communication: Uses radio waves to transmit signals, commonly seen in FM/AM radio, television broadcasting, and walkie-talkies.

Cellular Communication: Enables mobile phones to communicate over a network of cell towers using technologies like 2G, 3G, 4G, and 5G.

Wi-Fi: Provides wireless internet connectivity within a limited area, such as homes, offices, or public spaces.

Bluetooth: Facilitates short-range communication between devices like smartphones, headphones, and IoT devices.

Infrared Communication: Uses infrared light to transmit signals, often used in remote controls and data transfer between devices.

Question 4: What are the advantages of FM over AM?

Answer: FM offers several advantages over AM:

Better Noise Immunity: FM signals are less affected by amplitude variations caused by noise and interference, resulting in better audio quality.

Constant Amplitude: FM signals maintain a constant amplitude regardless of the strength of the modulating signal, which reduces distortion.

Wider Frequency Bandwidth: FM signals have a wider bandwidth, allowing for higher-fidelity transmission of audio signals.

Less Susceptible to Atmospheric Noise: FM signals are less affected by atmospheric noise, making them suitable for higher-frequency applications.

such as electromagnetic interference, thermal effects, or environmental factors.

Question 3: What are the main types of noise in communication systems?

Answer: There are several types of noise that can affect communication systems:

Thermal Noise (Johnson-Nyquist Noise): Arises due to the random motion of electrons in a conductor and is present in all electronic components. It increases with temperature and affects analog systems.

Shot Noise (Schottky Noise): Results from the discrete nature of electron flow in current-carrying devices like diodes and transistors. It's most noticeable in low-current systems.

White Noise: Uniformly distributed noise across all frequencies, often used as a theoretical reference for noise analysis.

Gaussian Noise: Also known as normal noise, it has a probability distribution that follows the Gaussian curve. Many natural noise sources exhibit Gaussian characteristics.

Impulse Noise (Spike Noise): Sudden and short-duration increases in signal amplitude, often caused by external interference or equipment malfunctions.

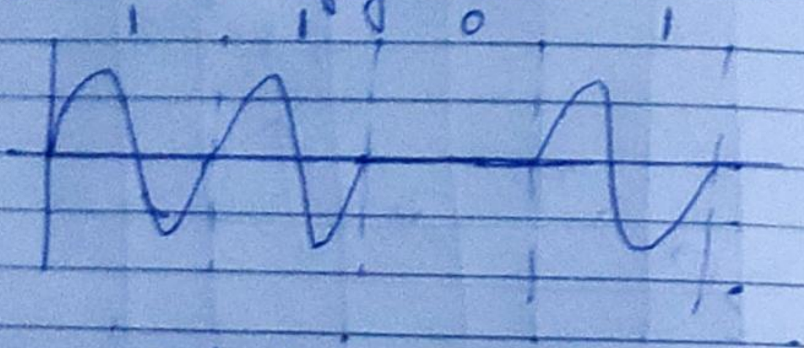
Intermodulation Noise: Arises when multiple signals interact and create additional frequencies in a nonlinear system.

External Interference: Noise introduced from external sources like other electronic devices, power lines, or cosmic radiation.

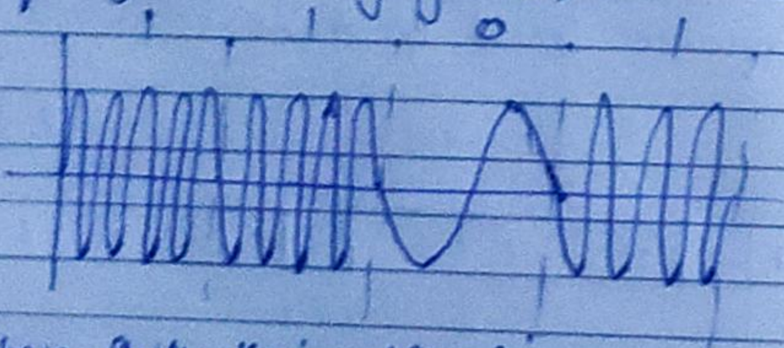
Atmospheric Noise: Noise caused by natural phenomena such as lightning discharges and solar radiation, often affecting radio communication.

Digital modulation:

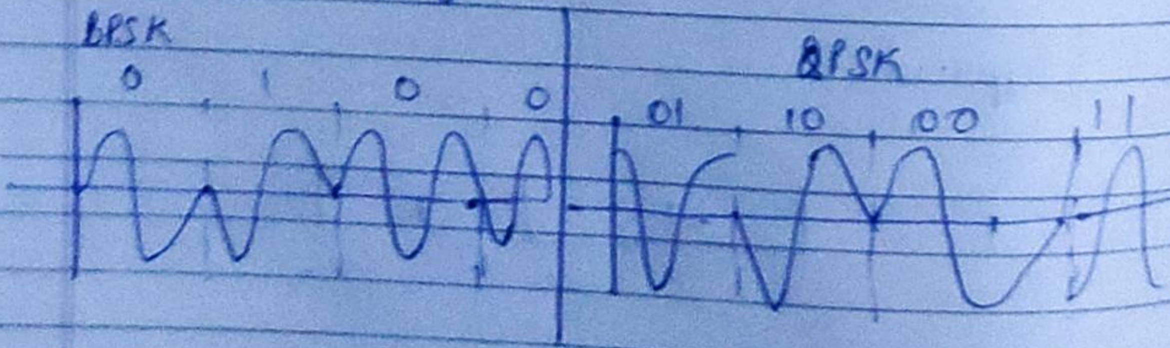
① Amplitude Shift Keying (ASK):



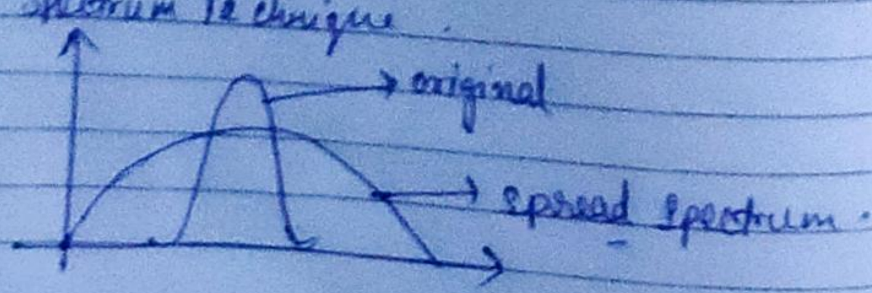
② Frequency Shift Keying (FSK):



③ Phase Shift Keying (PSK):

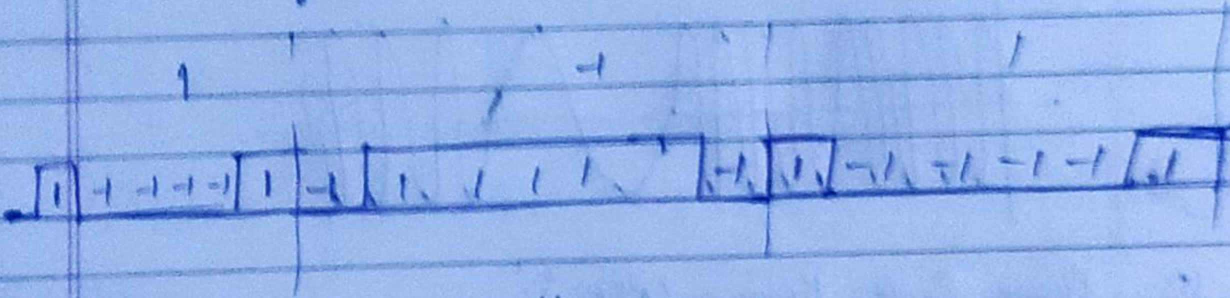


(*). Spread Spectrum Technique.



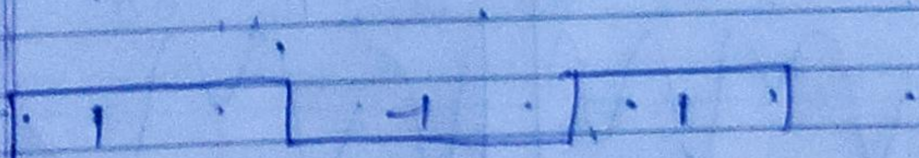
→ Frequency Hopping Spread Spectrum

→ Direct Sequence Spread Spectrum:



⇓

Despread :



Radio frequency Spectrum:

Very low frequency	3 - 30 KHz
low frequency	30 - 300 KHz
Medium frequency	300 - 3000 KHz
High frequency	3 - 30 MHz
Very High frequency	30 - 300 MHz
Ultra High frequency	300 - 3000 MHz
Super High frequency	3 - 30 GHz
Extremely High frequency	30 - 300 GHz

Wireless and Mobile Communication.

(*) Introduction:

→ Wireless communication involves the transmission of Information over a distance without the help of wires or cables.
→ It uses electromagnetic waves such as radio waves, microwaves or infrared waves to transfer information b/w two or more points.
→ It requires a sender, a medium and a receiver.
→ The sender modulates the information to a carrier signal, which is broadcasted by an antenna. The receiver then demodulates the signal and extracts the information.

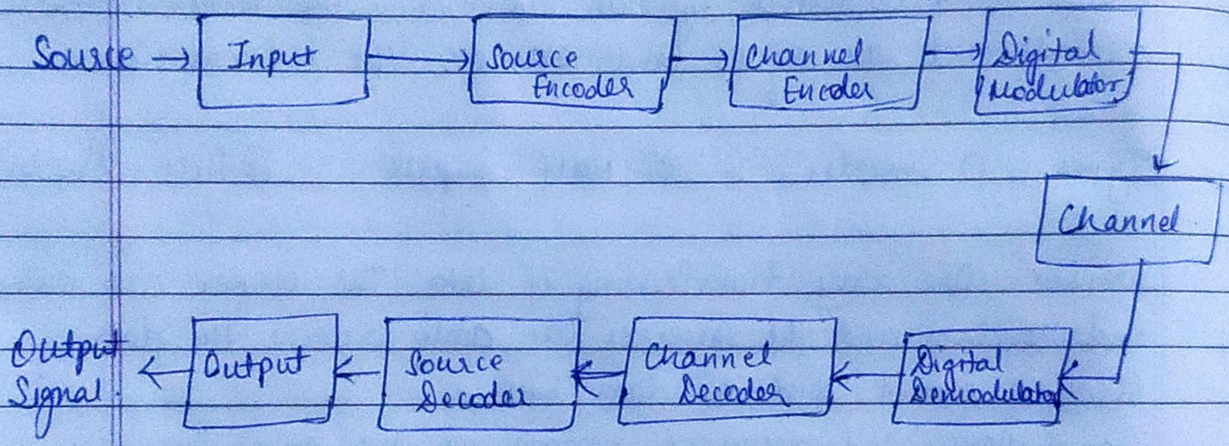
Types: ①. Simplex ②. Half - Duplex ③. Full - Duplex.

→ Simplex: One way transferring of data. The sender can only send the data and the receiver can only receive the data. Receiver cannot send the data back.
Transmitters and receivers operate at the same frequency.
Example → Television, Radio, etc.
→ Half - Duplex: The sender and the receiver can both send and receive data, but not at the same time.
Example → Walkie - Talkie.
→ Full - Duplex: Allows to send and receive a message at the same time. It is the most popular form of wireless communication. Example → phone call

* Elements of communication Systems:

Basic elements are

1. Sending and receiving devices: Eg: Computers or other communication devices.
2. Communication channel: The transmission medium.
3. Connecting devices: Acts as an interface between the sending and receiving devices and the communication channel
4. Data transmission specification: Rules and procedures that coordinate the sending and receiving devices.



Advantages:

1. Mobility: People can move it anytime they want
2. Increased Reliability.
3. Easy Installation: No cables to manage or connect.
4. Cost: Cost is cut because there is no installation process.
5. Rapid Disaster Recovery.

Disadvantages:

1. Security Issues: Security of data remains at high risk. The signals are transmitted through an open space. Easy to breach & hack.
2. Health issues for anyone who remains in contact for a longer

Elements of a Wireless Communication System: (cont)

1. Transmitter: Converts the information into electromagnetic signals.
2. Channel: The medium through which wireless signals travel. It could be air or any other medium.
3. Receiver: Decodes the transmitted signals back to usable information.
4. Antenna: Facilitates transmission and reception of electromagnetic signals b/w transmitter and receiver.
5. Modulation and demodulation circuits:
6. Multiplexing: Used to ~~ceaaf~~ combine multiple signals for simultaneous transmission.
7. Coding and Error Correction: Used to encode the transmitted data for error detection and correction.
8. Propagation Path: Physical path that the wireless signal follows.
9. Noise and Interference: Unwanted signals & disturbances that degrade the quality of transmitted signal.
10. Decoding & Processing circuits: Components that process and interpret the received signal to extract original information.

period of time, it may become a major health concern.

③ Signal Interference.

(*) **Signals:**

→ A signal is used to carry useful information.

→ They are electromagnetic waves that travel through the air.

→ Generated by a transmitter that encodes data into a sine function.

→ Signals are physical representation of data.

→ Users of communication system can only exchange data through transmission of signals.

$$e(t) = E_c \sin(\omega_c t + \theta)$$

where: $e(t)$ = instantaneous voltage.

E_c = peak Voltage

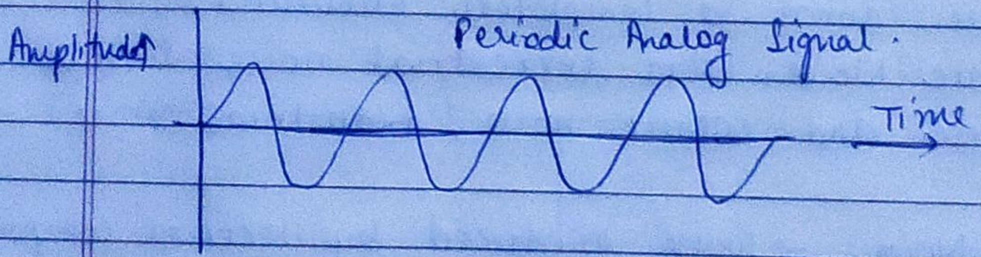
ω_c = carrier frequency

t = time in seconds.

θ = phase angle (in radians)

$\omega = 2\pi f$

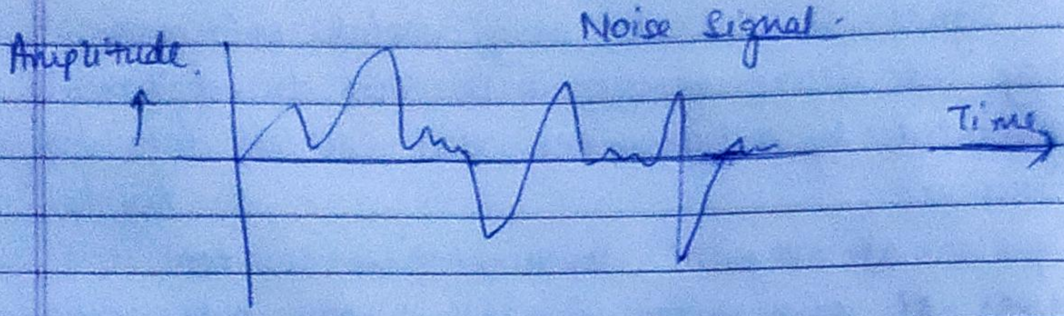
$\boxed{f = \text{frequency in Hz}}$



(*) **NOISE:**

→ In any communication system, during the transmission of signal, some unwanted signals get introduced into the communication, making it unpleasant for the receiver & questioning the quality of communication. Such a disturbance is called Noise.

→ It is an unwanted signal.
→ It interferes with the original message signal and corrupts the parameters of message signal.



Examples: ①. Hiss sound in radio receivers, Buzz sound amidst telephone convos, flicker in television, etc.

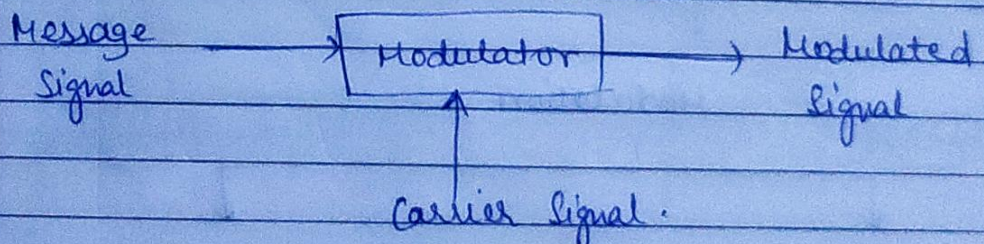
(3). Types of Noises: There are two main ways by which noise can be created:

①. External Source: Noise produced by external sources which may occur in the medium or channel of communication.
→ This noise cannot be completely eliminated.
→ Atmospheric Noise, Extra terrestrial noise such as solar noise and cosmic noise, Industrial noise.

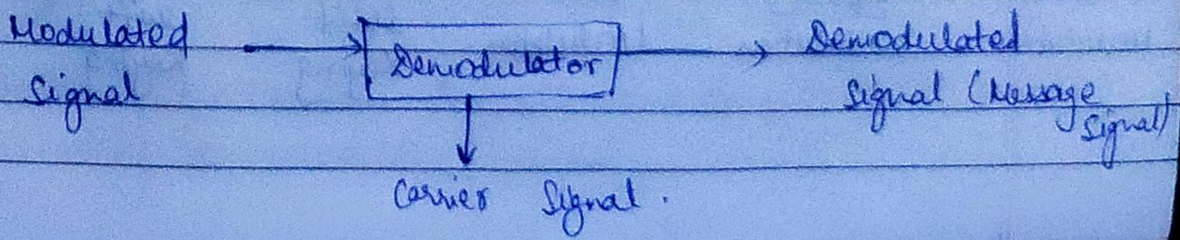
②. Internal Noise: → Noise produced by receiver components while functioning.
→ This noise is ~~quantifiable~~ quantifiable.
→ A proper receiver design may lower the effect of this internal noise.
→ Electrical noise, shot noise (due to the random movement of electrons and holes), Transit time noise, Miscellaneous noise, etc.

(*). Signal to Noise Ratio: It is the ratio of signal power to noise power.
There are two ways to improve S/N ①. Increase the signal power ②. Reduce the noise power.
→ Increasing signal power beyond a certain point can cause problems.
→ Reducing noise power requires limiting bandwidth and if possible, reducing the noise temperature of a system.

(*). Modulation and Demodulation:
→ For a signal to be transmitted to a distance, without the effect of any external interferences or noise addition or without getting faded away, it has to undergo a process called Modulation.
→ Modulation improves the signal strength without disturbing the parameters of original signal.
→ A high frequency signal can travel upto a longer distance, without getting affected by external disturbances.



→ The process of obtaining the original message from the modulated signal is called demodulation.



→ Advantages of Modulation:

1. Reduction of Antenna size.
2. No signal mixing
3. Increased communication range.
4. Multiplexing of signals.
5. Improved Reception quality.

(*). Signals in Modulation Process: 3 signals

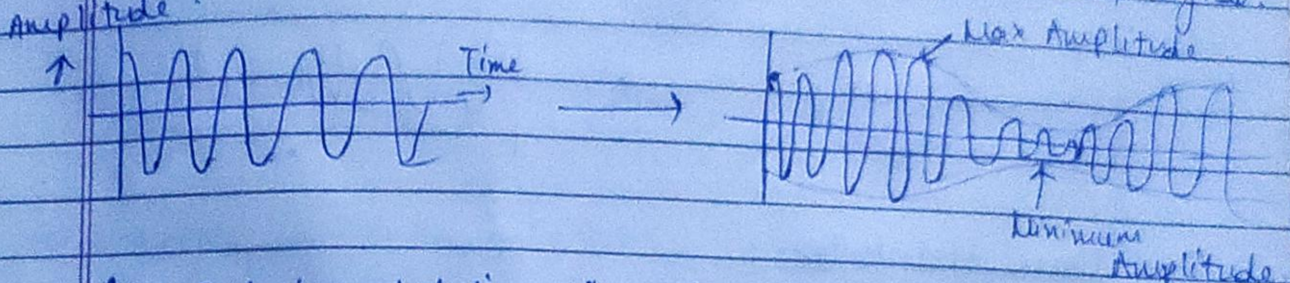
1. Message or Modulating Signal: The signal which contains a message to be transmitted. It is the baseband signal which has to undergo the process of modulation to get transmitted. Hence, it is also called as Modulating Signal.
2. Carrier Signal: The high frequency signal which has a certain amplitude, frequency and phase but contains no information. It is an empty signal and it is used to carry the signal to the receiver after modulation.
3. Modulated Signal: The resultant signal after the process of modulation. Combination of Modulating signal and carrier signal.

Modulation

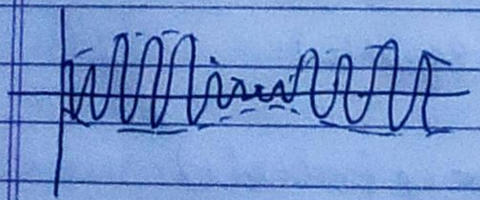
- Analog Modulation
  - Amplitude Modulation
  - Frequency Modulation
  - Phase Modulation.
- Digital Modulation
  - Amplitude Shift Keying
  - Frequency Shift Keying
  - Phase Shift Keying.

(*) Analog Modulation Schemes: → Amplitude Modulation (AM)
→ Frequency Modulation (FM)
→ Phase Modulation (PM)

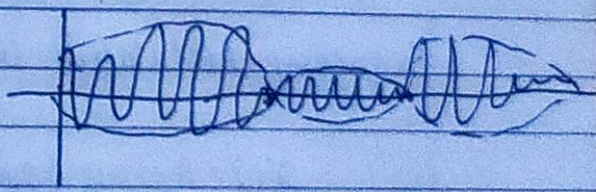
→ Amplitude Modulation: Technique used for transmitting messages with a radio wave.
The information sent is based on amplitude of signal.



For perfect modulation, the value of modulation index should be 1 which implied percentage of modulation should be 100%.
If the modulation index is less than 1, then it is called under Modulation.
If modulation index is more than 1, then it is called over-modulated wave.



Under Modulated Wave.



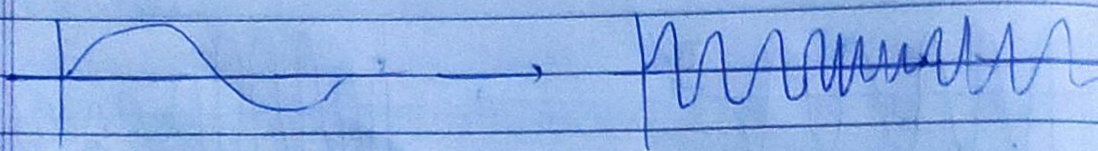
Over Modulated Wave.

→ Angle Modulation: 2 types → Frequency Modulation
→ Phase Modulation.

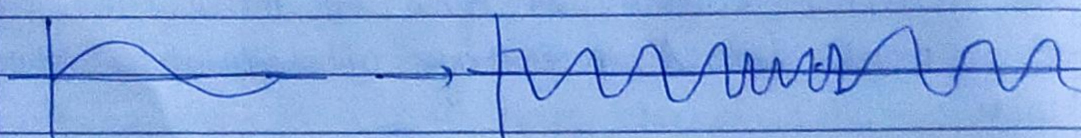
(*) Frequency Modulation: Instantaneous frequency is varied according to modulating signal.

(iv). Phase modulation: Instantaneous phase of the carrier is varied according to modulated signal.

→ Frequency Modulation: The frequency of the modulated waves increases/decreases based on the amplitude of modulating signal.



→ Phase Modulation:



When the amplitude is positive, the phase shifts in one direction and if the amplitude is negative, the phase changes in the opposite direction.

Frequency Modulated wave: (Equation):

$$s(t) = A_c \cos(2\pi f_c t + 2\pi k_f \int m(t) dt)$$

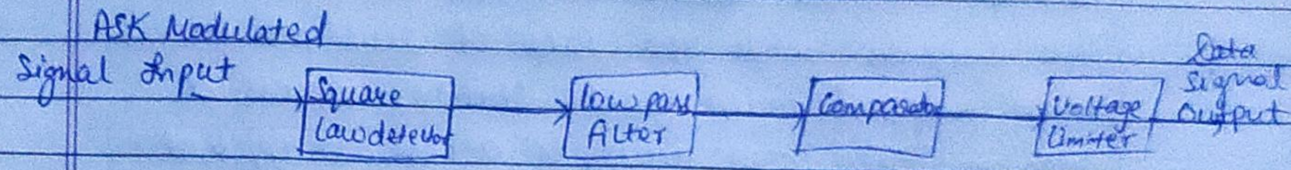
Phase Modulated wave: (Equation):

$$s(t) = A_c \cos(2\pi f_c t + k_p m(t))$$

(*). Amplitude Shift Keying (ASK):

→ A type of Amplitude Modulation which represents binary data in the form of variations in the amplitude of a signal.

→ The binary signal when ASK Modulated, gives zero value for low input and carrier output for High Input



(*). Frequency Shift Keying (FSK):

→ A digital modulation technique in which frequency of carrier signal varies according to the digital signal changes.

→ The output is high in frequency for binary High input and low in frequency for binary low input.

→ The binary 1s and 0s are called Mark and Space frequencies.

(*). Phase Shift Keying (PSK):

→ The phase of the carrier signal is changed by varying the sine and cosine inputs at a particular time.

→ It is widely used for wireless LANs, bio-metric, contactless operations, Bluetooth communications, etc.

→ PSK is of 2 types: Binary Phase Shift Keying (BPSK)
Quadra Phase Shift Keying (QPSK)

(*) BPSK: Also called 2-phase PSK or Phase Reversal Keying. The sine wave carrier takes 2 reversals such as 0° and 180°.

(*) QPSK: The sine wave carrier takes four phase reversals such as 0°, 90°, 180° and 270°.

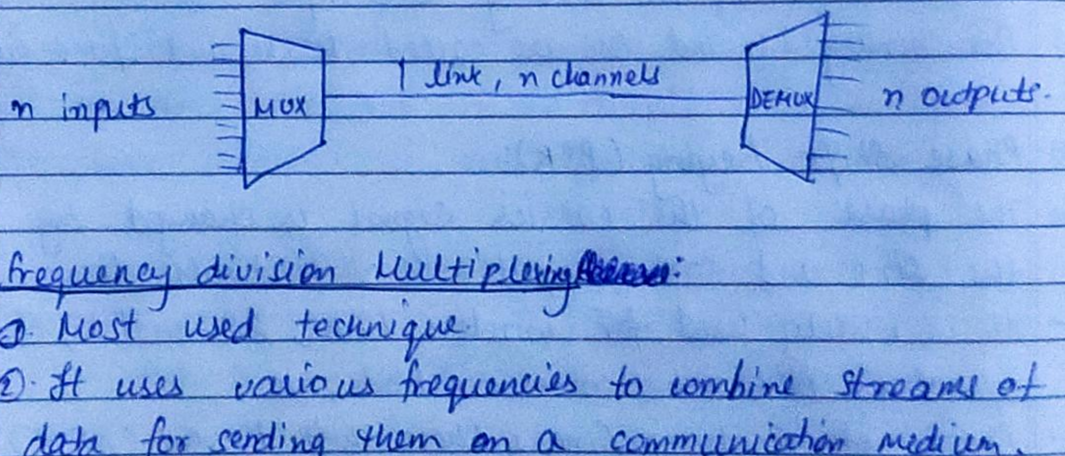
(A). Multiplexing and Multiple Access Techniques:

→ Multiplexing: When the aggregation of channels is done before the modulation process, it is known as multiplexing.

→ Multiple Access: There is a need for several users to share a common channel resource at the same time. This happens with the help of Multiple Access. When several independent stations access a medium, the term "multiple access" is applied.

Types of Multiple Access Techniques:

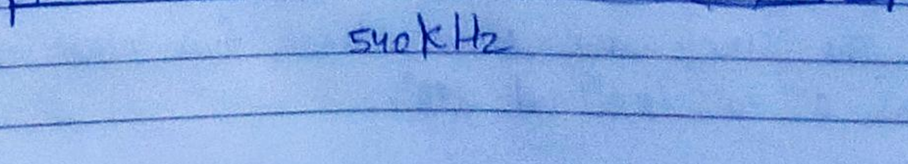
1. FDMA (Frequency Division Multiple Access)
2. TDMA (Time Division Multiple Access)
3. CDMA (Code Division Multiple Access).



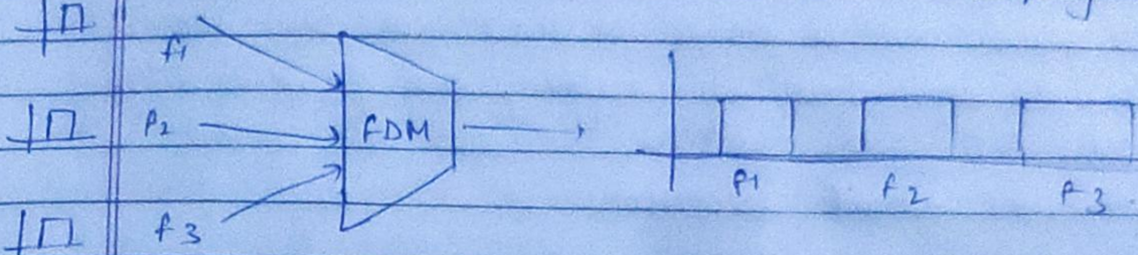
→ Frequency division Multiplexing:

1. Most used technique
2. It uses various frequencies to combine streams of data for sending them on a communication medium.

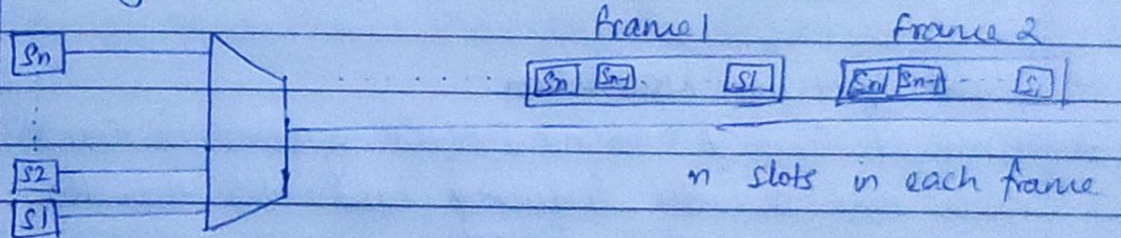
Example: A traditional television transmitter.



→ Channels can be seperated by strips of unused bandwidth - Guard bands.
→ Guard bands are used to prevent from overlapping

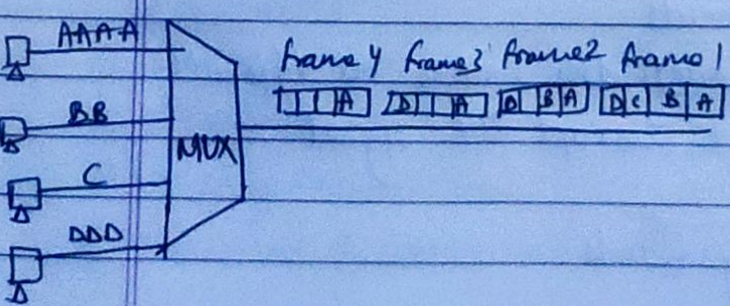


Time Division Multiplexing:
→ The time frame is divided into slots.
→ In frequency division multiplexing, all the signals operate at the same time with different frequencies but in time division multiplexing, all the signals operate ~~at~~ with same frequency at different times.

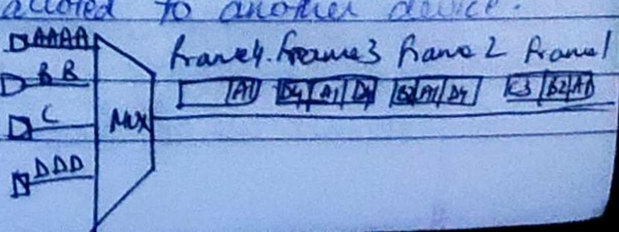


→ 2 types → (a) Synchronous TDM | (b) Asynchronous TDM.

(a) Synchronous TDM: If there are n number of connections then the frame is divided into n slots. One slot is allocated for each I/P line.



(b) Asynchronous TDM: Sampling rate is different for each of the signals. Common clock is not required. If the allocated device for a time slot transmits nothing and sits idle, then that slot is alloted to another device.

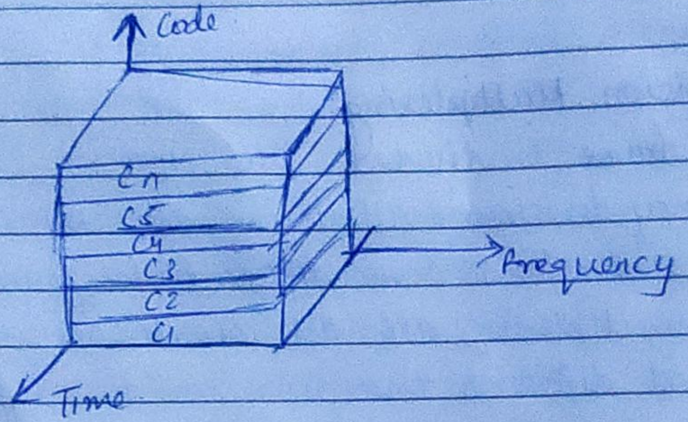


(*). <u>Code Division Multiplexing</u>:

→ It uses special kind of coding scheme to allow the transmitter to share the media at the same time.

→ It allows multiple groups to share the same channel at the same time by assigning each group to different code.

→ It uses spread spectrum



(*). Spread Spectrum Modulation:

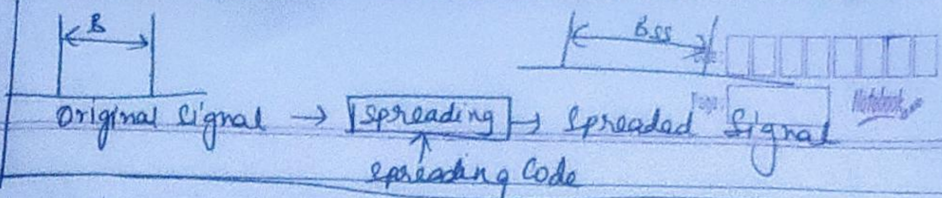
→ Technique used in communication systems to transmit signals over a wider frequency bandwidth than the minimum required bandwidth.

→ It involves spreading the signal's energy across a broad spectrum, making the signal more resistant to noise and jamming.

Advantages:

1. Resistance to Interference: Improves communication quality in noisy environments.
2. Jamming Protection: Wide bandwidth makes it difficult for intentional jammers to disrupt the signal.
3. Improved Security
4. Efficient use of frequency bands

B = Bandwidth of Source Signal.
Bss = Bandwidth of spreaded signal.

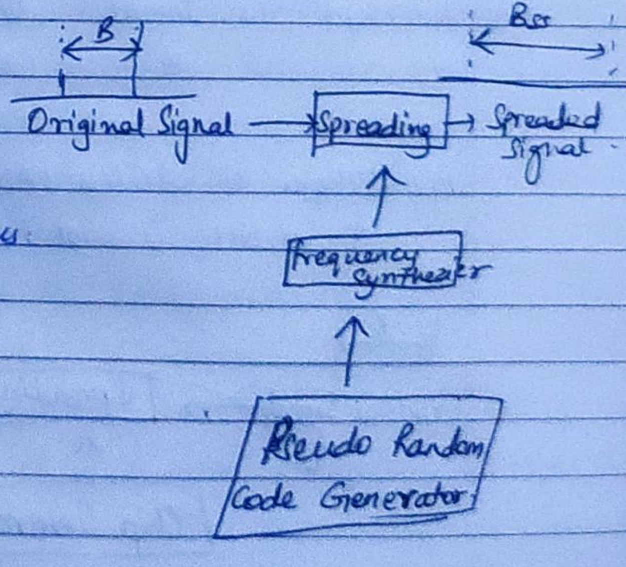


2 types of Spread Spectrum

① Frequency Hopping Spread Spectrum Modulation.
② Direct Sequence Spread Spectrum Modulation.

(*) Frequency Hopping Spread Spectrum Modulation:
→ used in wireless communication systems.
→ In FHSS, the carrier frequency of the transmitted signal changes rapidly and periodically.
→ This technique spreads the signal's energy across a wide frequency band, making it more resistant to noise and jamming.
→ It works by changing the carrier frequency at a high rate typically hopping from one frequency to another in a synchronized manner. b/w transmitter and receiver.
→ The hopping system is prearranged and known to both the ends.
→ The receiver tunes its frequency according to the sequence.

<u>Advantages:</u>
①. Resistance to Interference.
②. Jamming Resistance.
③. Security
④. Co-existence with other systems.



<u>Application:</u>
① Wireless LANs
② Bluetooth
③ Military Communication
④. Industrial & Commercial Systems.

(*) Direct Sequence Spread Spectrum (DSSS)

→ Technique used in wireless communications systems.

→ Data signal is combined with a higher rate spreading code, also known as chipping code

→ This code spreads the signal's energy across a wider frequency bandwidth, making the signal more robust and providing enhanced security.

→ It works by multiplying the original data signal with the chipping code at the transmitter.

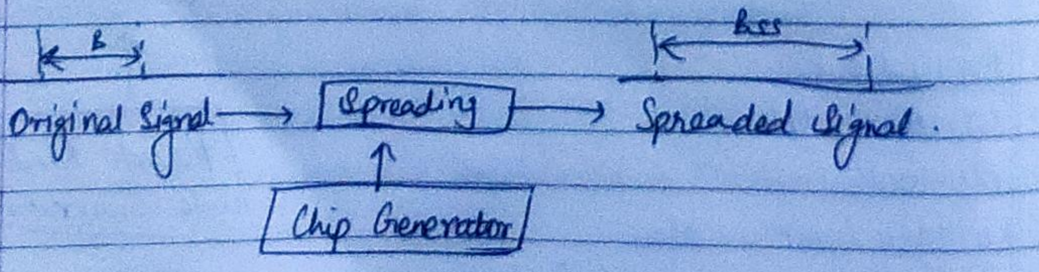
→ This process expands the signal's bandwidth, making it appear as a noise like interference to unintended receivers.

→ At the receiver, the same chipping code is used to despread the signal, extracting the original data.

→ The chipping code is designed to have certain mathematical properties that aid in the recovery process.

Advantages ①. Interference Resistance. ②. Privacy & Security ③ Makes it difficult for unintended listeners to intercept the signal. ④. Accurate data recovery, It can recover original data accurately.

Applications: ①. Wireless LANs ②. CDMA Cellular Networks. ③. Satellite Communication ④ Wireless Sensor Networks.



Date:
Page:

(i). Radio Frequency Spectrum:

→ Refers to the range of frequencies used for wireless communication and other application

→ Comprises of a wide range of electromagnetic waves from extremely low frequencies to extremely High Frequencies.

→ The portion of frequency spectrum that is useful for radio communication extends from 100 kHz to 50 GHz

→ Radio communication employs several frequency bands, including

(a). Very Low Frequency (VLF): Used for submarine communication due to their ability to penetrate water and soil.

(b). Low Frequency: Used for long range navigation and radio broadcasting.

(c). Medium Frequency: Traditional ~~[illegible]~~ AM Radio broadcasts.

(d). High Frequency (HF): Used for international long distance communication.

(e). Very High Frequency (VHF): Commonly used for FM Radio, TV broadcasting, landline mobile communications.

(f). Ultra High Frequency (UHF): Used for television broadcasting, satellite communication, etc.

(g). Super High Frequency (SHF) & Extremely High frequency (EHF): Used for microwave communication, satellite communication, High speed data transmission.

→ The frequency of a radio signal plays a significant role in determining its communication range.

→ Lower frequency signals tend to propagate over longer distances.

→ Higher frequency signals are more susceptible to attenuation and absorption by atmosphere and obstacles, limiting their range.