DHANALAKSHMI SRINIVASAN ENGINEERING COLLEGE

DEPARTMENT OF EEE

EC6651 – COMMUNICATION ENGINEERING

TWO MARK QUESTIONS WITH ANSWERS

UNIT I
ANALOG COMMUNICATION

1. **Define Modulation and Amplitude Modulation.**

Modulation is the process of varying one or more properties of a periodic waveform, called the carrier signal, with a modulating signal which typically contains information to be transmitted. **Amplitude Modulation** is the process of changing the amplitude of a relatively high frequency carrier signal in proportion with the instantaneous value of the modulating signal.

2. **Define Modulation index.[Nov-Dec 2016]**

Modulation index is a term used to describe the amount of amplitude change present in an AM waveform .It is also called as coefficient of modulation. Mathematically modulation index is
m = Em / Ec
Where m = Modulation coefficient
Em = Peak change in the amplitude of the output waveform voltage.
Ec= Peak amplitude of the un-modulated carrier voltage.

3. **Define Percentage modulation for an AM wave.**

Percent modulation gives the percentage change in the amplitude of the output wave when the carrier is acted on by a modulating signal.

4. **What is the need for modulation? (AU April-May 09 & 11) (May/June 2016)**

Base band transmission has many limitations which can be overcome by using modulation, since modulation shifts low frequency to high and reduce the size of the antenna, avoid mixing of signals, increase the range and quality of communication

5. **Define Low level Modulation.**

In low level modulation, modulation takes place prior to the output element of the final stage of the transmitter. For low level AM class A amplifier is used.

6. **Define High level Modulation.**

In high level modulators, the modulation takes place in the final element of the final stage where the carrier signal is at its maximum amplitude. For high level modulator class C amplifier is used.

7. **What is the advantage of low level modulation?**

An advantage of low level modulation is that less modulating signal power is required to achieve a high percentage of modulation.

8. Distinguish between low level and high level modulation.

S.No	Low level modulation	High level modulation
1	Modulation takes place in prior to the output of the final stage of the Transmitter	Modulation takes place in the final stage where carrier signal is at maximum amplitude.
2	It requires less power to achieve a high entage of modulation.	It requires much higher amplitude of modulating signal to achieve a reasonable percent modulation

9. Define image frequency.

An image frequency is any frequency other than the selected radio frequency carrier that, if allowed to enter a receiver and mix with the local oscillator, will produce a cross product frequency that is equal to the intermediate frequency.

10. State the advantages of FM over AM. (AU Nov-Dec 09)

Frequency modulation is one type of angle modulation this has the advantages over amplitude modulation such as Noise reduction, improved system fidelity and more efficient use of power.

11. Define standing wave ratio. (AU Nov-Dec 09)

Standing wave the is ratio between the reflected wave and normal wave components voltage/current at any point is known as SWR, the plot of resultant voltage or current along the line length is termed as standing waves.

12. Define Local Oscillator tracking.

Tracking is the ability of the local oscillator in a receiver to oscillate either above or below the selected radio frequency carrier by an amount equal to the intermediate frequency throughout the entire radio frequency band.

13. Define High side injection tracking.

In high side injection tracking, the local oscillator should track above the incoming RF carrier by a fixed frequency equal to fRF +fIF.

14. Define Low side injection tracking.

In low side injection tracking, the local oscillator should track below the RF carrier by a fixed frequency equal to fRF -fIF.

15. Define tracking error. How it is reduced.

The difference between the actual local oscillator frequency and the desired frequency is called tracking error. It is reduced by a technique called three point tracking.

16. Define Heterodyning.

Heterodyne means to mix two frequencies together in a nonlinear device or to translate one frequency to another using nonlinear mixing.

17. What is super heterodyne receiver? (AU April-May 09 & 11)

Heterodyne means to mix two frequencies together in a nonlinear device or to translate one frequency to another using nonlinear mixing.

There are five sections to a super heterodyne receiver: that are RF section, Mixer/converter section, IF section, Audio detector section, and Amplifier section.

18. What are the advantages of the super heterodyne receiver? (AU April-May09)

Advantages in SH Receiver over TRF receivers are Improved the selectivity in terms of adjacent channels, more uniform selectivity over frequency range, improved in receiver stability, higher gain per stage and uniform bandwidth.

19. Explain the disadvantages of conventional/double side band full carrier system.

In conventional AM, carrier power constitutes two thirds or more of the total transmitted power. This is a major drawback is the carrier contains no information; the sidebands contain the information.

Second, conventional AM systems utilize twice as much bandwidth as needed with single sideband systems.

20. Define Single sideband suppressed carrier AM. [April/May 2017]

AM Single sideband suppressed carrier is a form of amplitude modulation in which the carrier is totally suppressed and one of the sidebands removed.

21. Define AM Vestigial sideband. [April/May 2017]

AM vestigial sideband is a form of amplitude modulation in which the carrier and one complete sideband are transmitted, but only part of the second sideband is transmitted.

22. What are the advantages and disadvantages of single side band transmission? [May/June 2016]

Advantages

1. The bandwidth requirement of the single sideband system is half than required by double sideband system.
2. Since SSB system utilizes half the bandwidth than DSB, the thermal noise power is reduced to half that of DSB system.
3. The full carrier DSB wave has poor efficiency since the major transmitted power is concentrated in the carrier which contains no information. Thus the total power in SSB is less than the total power in DSB. % power saving in SSB is 83.33%.
4. In the spectrum of AM wave, both the sidebands carry same amount of information which makes it meaningless to transmit same information in both the sidebands thus leading to power wastage. This is overcome in the SSB technique by suppressing undesired sideband.

Disadvantages

1. The generation of SSB is quite complex as the suppression of one of the sidebands is difficult.
2. The generation of SSB requires sharp cut off characteristics of the sideband suppression filter.
3. SSB receivers require more precise tuning than DSB
4. SSB receivers require carrier recovery and synchronization circuit which adds to their cost, complexity and size.

24. Define pulse code modulation.

In pulse code modulation, analog signal is sampled and converted to fix length, serial binary number for transmission. The binary number varies according to the amplitude of the analog signal.

25. Define direct frequency modulation.

In direct frequency modulation, frequency of a constant amplitude carrier signal is directly proportional to the amplitude of the modulating signal at a rate equal to the frequency of the modulating signal.

26. Define indirect frequency Modulation.

In indirect frequency modulation, phase of a constant amplitude carrier directly proportional to the amplitude of the modulating signal at a rate equal to the frequency of the modulating signal.

27. Define critical frequency. **(AU Nov-Dec 09)**

Critical frequency is the maximum frequency that the radio wave can be transmitted vertically and still some of the frequency will be refracted back to the transmitter.

28. Define instantaneous frequency deviation.

The instantaneous frequency deviation is the instantaneous change in the frequency of the carrier and is defined as the first derivative of the instantaneous phase deviation.

29. A carrier signal with power of 40Watts is amplitude modulated by a sinusoidal signal. Find the power of the modulated signal if the modulation index is 0.7.

Solution: **(AU Nov-Dec 09)**

Carrier power Pc= 40 Watts and m=0.7

Modulated power is P Total =Pc(1+(m)2/2) = 49.8Watts

30. Define frequency deviation.

Frequency deviation is the change in frequency that occurs in the carrier when it is acted on by a modulating signal frequency. Frequency deviation is typically given as a peak frequency shift in Hertz (Δf).The peak to peak frequency deviation (2Δf) is sometimes called carrier swing. The peak frequency deviation is simply the product of the deviation sensitivity and the peak modulating signal voltage and is expressed mathematically as Δf=K1 x Vm Hz.

31. Differentiate NBFM and WBFM [Nov-Dec 2016]

WIDEBAND FM:

Parameters :

1. modulation index : Greater than 1
2. maximum deviation: 75 kHz
3. range of modulating frequency: 30 Hz to 15 kHz
4. maximum modulation index: 5 to 2500
5. bandwidth : large,about 15 times higher than BW of narrowband FM
6. applications : entertainment broadcasting
7. pre-emphasis and de-emphasis : is needed.

NARROWBAND FM:

parameters :

1.modulation index: less than or slightly greater than 1
2. maximum deviation: 5kHz
3. range of modulating frequency : 30 Hz to 3 kHz
4. maximum modulation index : slightly greater than 1
5. bandwidth : small.approximately same as that of AM
6. applications: FM mobile communication like police wireless,ambulance etc
7. pre-emphasis and de-emphasis : is needed.

32. Define narrow band FM. [April/May 2017]

Narrowband FM is used for voice communications in commercial and amateur radio settings. In broadcast services, where audio fidelity is important, wideband **FM** is generally used. In two-way radio, **narrowband FM** (NBFM) is used to conserve bandwidth for land mobile, marine mobile and other radio services.

UNIT II
DIGITAL COMMUNICATION

1. State Shannon's fundamental theorem of information capacity.

The information capacity of a communication system represents the number of independent symbols that can be carried through that system in a given unit of time.

It is expressed in bits per sec

The information capacity of Gaussian channel is given

by $I=B \log_2 (1+S/N)$ bps

B→channel

Bandwidth S→signal power

N→noise within the channel.

2. Define bit rate and baud rate.

Bit rate refers to the rate of change of a digital information signal which is usually binary. Unit is bps Baud rate is also a rate of change, it refers to the rate of change of a signal on the transmission medium after encoding and modulation. Unit is baud

3. Write the advantages of BPSK.

i) BPSK has a Bandwidth which is lower than that of a BFSK signal.
ii) BPSK has the best performance of all the systems in presence of noise.
iii) It gives the minimum possibility of error.
iv) BPSK has very good noise immunity.

4. Compare Bandwidth efficiency of BPSK and QPSK modulated signals.

Bandwidth of BPSK $=f_b$

Bandwidth of QPSK $= f_b/2$

Where f_b is the input data rate

5. What is digital transmission?

Transmission of digital signals between two or more points in a communication system. The original information can be of analog or digital. If it is analog then it is converted to digital.

6. List the effects of 'M' in M-ary digital modulation technique.

M-ary encoding system able to transmit information at a rate that is $\log_2 M$ faster than the binary PAM system for a fixed channel bandwidth. M-ary system requires more transmitted power.

7. What is meant by non-coherent digital modulation technique?

Non-coherent digital modulation technique is the system in which a synchronous carrier is not used.

8. What is meant by carrier recovery?

Carrier is the process of extracting a phase coherent reference carrier from a received signal.

It is also called as phase referencing.

9. **What are the types of carrier recovery?**

Two types of carrier recovery circuits are

i) Squaring loop
ii) Costas loop

10. What is meant by offset QPSK?

Offset QPSK is the modified form of QPSK, where the bit waveforms on the I channel and Q channels are shifted in phase from each other by one-half of a bit time.

11. **Calculate the capacity of a standard 4 KHz telephone channel with a 30 dBsignal to noise ratio**?

Given:

B =4 KHz

S/N =30dB

Soln:

$I=3.32B \log_{10} (1+S/N)$

$=3.32(4x10\ ) \log_{10}$

$(1+1000) =39.84x10$

=39.84Kbps

12. Difference between BPSK and QPSK

Parameters	BPSK	QPSK
Variable Characteristics of the Carrier	Phase	Phase
Type of Modulation	Two Level	Four Level
Bit Rate / Baud Rate	Bit Rate = Baud Rate	Bit Rate = 2 Baud Rate
Complexity	Complex	Very Complex
Applications	Suitable for applications that needs high bit rate	Suitable for applications that needs very high bit rate

13. Compare QAM and QPSK.

Parameter	QPSK	QAM
Type Of Modulation	Quadrature Phase Modulation	Quadrature Amplitude Modulation
Noise Immunity	Better than ASK	Poorer than QPSK
System Complexity	Less Complex than ASK	More Complex than QPSK
Type of Modulation	Synchronous	Synchronous

14 .Comparison of Digital Modulation Systems [May/June 2016]

Parameter	Binary ASK	Binary FSK	Binary PSK
Variable Characteristics	Amplitude	Frequency	Phase
Noise Immunity	Low	Low	high
Performance in presence of noise	Poor	Better than ASK	Better than FSK
Complexity	Simple	Moderately Complex	Very Complex
Bit Rate	Suitable upto 100 Bps	Upto about 1200 bps	Suitable for high bit Rate

15. Why QPSK is better than PSK.

QPSK is better than PSK

- Due to multilevel modulation used in QPSK, it is possible to increase the bit rate to double the bit rate of PSK without increasing the Bandwidth
- The noise immunity of QPSK is same as that of PSK system
- Available channel bandwidth is utilized in a better way by the QPSK system than PSK system.

16. Define ASK.

In Amplitude Shift Keying the amplitude of the carrier is varied in proportional with the amplitude of the message signal. Here the message signal is digital and carrier is analog.

17. Define PAM.

The amplitude of a constant width, constant position is varied in proportion with the instantaneous magnitude of the modulating signal.

28. Define PWM.

The width of carrier pulse is made to vary in proportion with the instantaneous magnitude of the modulating signal.

19. Define PPM.

The amplitude and width of the pulse is kept constant but the position of each pulse is varied in accordance with the amplitudes of the sampled values of the modulating signal.

20. Define PTM.

Modulation of the time intervals between successive pulses of constant duration and amplitude in accordance with a signal; specify a system of multiplex high-frequency transmission using this method of modulation.

21. Define PCM.

Method used to digitally represent sampled analog signals. It is the standard form of digital audio in computers, Compact Discs, digital telephony and other digital audio applications. In a PCM stream, the amplitude of the analog signal is sampled regularly at uniform intervals, and each sample is quantized to the nearest value within a range of digital steps.

22. Define DM.

Delta modulation (DM or -modulation) is an analog-to-digital and digital-to-analog signal conversion technique used for transmission of voice information where quality is not of primary importance. DM is the simplest form of differential pulse-code modulation (DPCM) where the difference between successive samples is encoded into n-bit data streams.

23. Define sampling theorem and aliasing. [May/June 2016] [April/May2017]

Sampling theorem

It states that to convert a continuous time signal to discrete time signal, sampling frequency must be greater than or equal to twice of highest modulating frequency so that successful Reconstruction is possible.

Aliasing

In signal processing and related disciplines, **aliasing** is an effect that causes different signals to become indistinguishable (or aliases of one another) when sampled. It also refers to the distortion or artifact that results when the signal reconstructed from samples is different from the original continuous signal.

24. State any two advantages of MSK. [April/May 2017]

- MSK and BFSK produce constant envelope carrier signals with no amplitude variations.
- This is a desirable characteristic for improving the power efficiency of transmitters.

UNIT III
SOURCE CODES, LINE CODES AND ERROR CONTROL

1. Define Shannon Entropy.

Shannon entropy, which quantifies the expected value of the information contained in a message. Entropy is typically measured in bits, nats, or bans. Shannon entropy is the average unpredictability in a random variable, which is equivalent to its information content.

2. Define Shannon source coding theorem.

Shannon's source coding theorem (or **noiseless coding theorem**) establishes the limits to possible data compression, and the operational meaning of the Shannon entropy.

3. Define Shannon limit.

The **Shannon limit** or **Shannon capacity** of a communications channel is the theoretical maximum information transfer rate of the channel, for a particular noise level.

4. Define Huffman coding.

Huffman coding is an entropy encoding algorithm used for lossless data compression. The term refers to the use of a variable-length code table for encoding a source symbol (such as a character in a file) where the variable-length code table has been derived in a particular way based on the estimated probability of occurrence for each possible value of the source symbol.

5. What are the uses of Modified Huffman coding.

Modified Huffman coding is used in fax machines to encode black on white images (bitmaps). It combines the variable length codes of Huffman coding with the coding of repetitive data in run-length encoding.

6. Define SNR.

Ratio of signal power to the noise power, often expressed in decibels. A ratio higher than 1:1 (greater than 0 dB) indicates more signal than noise.

7. Define NRZ.

Non-return-to-zero (**NRZ**) line code is a binary code in which 1s are represented by one significant condition (usually a positive voltage) and 0s are represented by some other significant condition (usually a negative voltage), with no other neutral or rest condition.

8. Define RZ.

Return-to-zero (RZ) describes a line code used in telecommunication signals in which the signal drops (returns) to zero between each pulse. This takes place even if a number of consecutive 0's or 1's occur in the signal. The signal is self-clocking.

9. Define Error control coding. [April/May 2017]

Error control coding aims at developing methods for coding to check the correctness of the bit stream transmitted. The bit stream representation of a symbol is called the codeword of that symbol.

10. Mention the types of error control.

Linear Block Codes
Repetition Codes
Convolution Codes

11. Define linear block codes.

A code is linear if two codes are added using modulo-2 arithmetic produces a third codeword in the code. Consider a (n, k) linear block code. Here,

1. n represents the codeword length
2. k is the number of message bit
3. n − k bits are error control bits or parity check bits generated from message using an appropriate rule.

12. Define Repetition Codes.

This is the simplest of linear block codes. Here, a single message bit is encoded into a block of n identical bits, producing an (n, 1) block code. This code allows variable amount of redundancy. It has only two codewords - all-zero codeword and all-one codeword.

13. Define convolution Codes.

A **convolution code** is a type of error-correcting code in which

- Each m-bit information symbol (each m-bit string) to be encoded is transformed into an n-bit symbol, where m/n is the code rate ($n \geq m$) and
- The transformation is a function of the last k information symbols, where k is the constraint length of the code.

14. Define Block Codes.

Block codes comprise the large and important family of error-correcting codes that encode data in blocks. Block Codes are conceptually useful. They allow coding theorists, mathematicians, and computer scientists to study the limitations of all block codes in a unified way. Such limitations often take the form of bounds that relate different parameters of the block code to each other, such as its rate and its ability to detect and correct errors.

15. Define Modified AMI Codes.

Modified AMI codes are Alternate Mark Inversion (AMI) line codes in which bipolar violations may be deliberately inserted to maintain system synchronization. There are several types of modified AMI codes, used in various T-carrier and E-carrier systems.

16. Define Shannon–Fano coding.

In Shannon–Fano coding, the symbols are arranged in order from most probable to least probable, and then divided into two sets whose total probabilities are as close as possible to being equal. All symbols then have the first digits of their codes assigned; symbols in the first set receive "0" and symbols in the second set receive "1".

17. Define source coding. State the significance of source coding. [May/June 2016]

A line code (also called **digital** baseband modulation or **digital** baseband transmission method) is a code chosen for use within a **communications** system for baseband transmission purposes. Line **coding** is often used for **digital** data transport.

Significance

In information theory, Shannon's **source coding** theorem (or noiseless **coding** theorem) establishes the limits to possible data compression, and the operational meaning of the Shannon entropy. However it is possible to get the code rate arbitrarily close to the Shannon entropy, with negligible probability of loss.

UNIT IV
MULTIPLE ACCESS TECHNIQUES

1. Define spread spectrum.

Spread-spectrum techniques are methods by which a signal (e.g. an electrical, electromagnetic, or acoustic signal) generated with a particular bandwidth is deliberately spread in the frequency domain, resulting in a signal with a wider bandwidth.

2. Mention the uses of spread spectrum.

Used for a variety of reasons, including the establishment of secure communications, increasing resistance to natural interference, noise and jamming, to prevent detection, and to limit power flux density (e.g. in satellite downlinks).

3. Define multiple access.

Multiple access defined as a means of allowing multiple users to simultaneously share the finite bandwidth with least possible degradation in the performance of the system.

4. Mention the types of multiple access.

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

5. Define Frequency Division Multiple Access (FDMA).

In FDMA, each user is allocated a unique frequency band or channel. During the period of the call, no other user can share the same frequency band.

6. Define Time Division Multiple Access (TDMA).

TDMA systems divide the channel time into frames. Each frame is further partitioned into time slots. In each slot only one user is allowed to either transmit or receive.

7. Mention the features of

FDMA. Continuous
transmission Narrow
bandwidth Low ISI
Low overhead
Simple hardware at mobile unit
and BS Use of duplexer

8. Mention the features of TDMA. [April/May 2017]

- Multiple channels per carrier or RF channels.
- Burst transmission since channels are used on a timesharing basis. Transmitter can be turned off during idle periods.
- Narrow or wide bandwidth – depends on factors such as modulation scheme, number of voice channels per carrier channel.
- High ISI – Higher transmission symbol rate, hence resulting in high ISI. Adaptive equalizer required.

9. Define CDMA. [April/May 2017]

CDMA is also called DSSS (Direct Sequence Spread Spectrum).
In CDMA, the narrowband message signal is multiplied by a very large bandwidth signal called spreading signal (code) before modulation and transmission over the air. This is called spreading.

10. List the Spreading signal elements.

- Has Chip period and and hence, chip rate
- Spreading signal use a pseudo-noise (PN) sequence (a pseudo-random sequence)
- PN sequence is called a codeword
- Each user has its own cordword
- Codewords are orthogonal. (low autocorrelation)
- Chip rate is oder of magnitude larger than the symbol rate.

11. Mention the advantages of CDMA.

- Random access possible
  Users can start their transmission at any time
- Cell capacity is not concerete fixed like in TDMA or FDMA systems. Has soft capacity
- Higher capacity than TDMA and FDMA
- No frequency management
- No equalizers needed
- No guard time needed
- Enables soft handoff .

12. Define SDMA.

Space-division multiple access (**SDMA**) is a channel access method based on creating parallel spatial pipes next to higher capacity pipes through spatial multiplexing and/or diversity, by which it is able to offer superior performance in radio multiple access communication systems.

13. Define pseudo noise sequence. [May/June 2016]

In cryptography, **pseudorandom noise** (PRN) is a signal similar to **noise** which satisfies one or more of the standard tests for statistical randomness. Although it seems to lack any definite pattern, **pseudorandom noise** consists of a deterministic **sequence** of pulses that will repeat itself after its period.

14. Define near-far problem in CDMA. [May/June 2016]

The **near–far problem** or **hearability problem** is a situation that is common in wireless communication systems, in particular, CDMA. In some signal jamming techniques, the near–far problem is exploited to disrupt communications.

UNIT V
SATELLITE, OPTICAL FIBER – POWERLINE, SCADA

1. Define satellite.

Satellite is a celestial body that orbits around a planet. In aerospace terms, a satellite is a space vehicle launched by humans and orbits earth or another celestial body.

2. State Kepler's first law.

Kepler's first law states that a satellite will orbit a primary body following an elliptical path.

3. State Kepler's second law.

Kepler's second law states that for equal time intervals of time a satellite will sweep out equal areas in the orbital plane, focused at the bary center.

4. State Kepler's third law.

The third law states that the square of the periodic time of orbit is proportional to the cube of the mean distance between the primary and the satellite.

5. Define orbital satellite.

Orbital satellites are also called as Asynchronous satellite. Asynchronous satellites rotate around earth in an elliptical or circular pattern. In a circular orbit, the speed or rotation is constant however in elliptical orbits the speed depends on the height the satellite is above the earth.

6. Define protrude orbit. (AU April-May 09)

If the satellite is orbiting in the same direction as earth's rotation and at an angular velocity greater than that of earth, the orbit is called a prograde (or) posigrade orbit.

7. Define retrograde orbit? (AU April-May 09)

If the satellite is orbiting in the opposite direction as the earth's rotation or in the same direction with an angular velocity less than that of earth, the orbit is called a retrograde orbit.

8. Define Geo synchronous satellite? (AU Nov-Dec 09)

Geo synchronous or geo stationary satellites are those that orbit in a circular pattern with an angular velocity equal to that of Erath. Geosynchronous satellites have an orbital time of approximately 24 hours, the same as earth; thus geosynchronous satellites appear to be stationary as they remain in a fixed position in respect to a given point on earth.

9. Define apogee and perigee?

The point in an orbit which is located farthest from the earth is called apogee.
The point in an orbit which is located closest to earth is called perigee.

10. Define angle of inclination?

The angle of inclination is the angle between the earth's equatorial plane and the orbital plane of a satellite measured counterclockwise at the point in the orbit where it crosses the equatorial plane traveling from south to north.

11. Define Descending node?

The point where the polar or inclined orbit, crosses the equatorial plane, traveling from south
to north. This point is called descending node.

12. Define ascending node.

The point where a polar or inclined orbit crosses the equatorial plane traveling from north to south is called ascending node.

13. Define line of nodes.

The line joining the ascending and descending nodes through the center of earth is called line of nodes.

14. Define angle of elevation.

Angle of elevation is the vertical angle formed between the direction of travel of an electromagnetic wave radiated from an earth station antenna pointing directly toward a satellite and the horizontal plane.

15. Define Azimuth angle.

Azimuth is the horizontal angular distance from a reference direction, either the southern or northern most point of the horizon.

16. What are the advantages of optical fiber communication?

Greater information capacity

Immunity to crosstalk

Immunity to static interference

Environmental immunity Safety

Security

17. Define a fiber optic system.

An optical communications system is an electronic communication system that uses light as the carrier of information. Optical fiber communication systems use glass or plastic fibers to contain light waves and guide them in a manner similar to the way electromagnetic waves are guided through a waveguide.

18. Define refractive index.

The refractive index is defined as the as the ratio of the velocity of propagation of light ray in free space to the velocity of propagation of a light ray in a given material.

Mathematically, the refractive index is $n = c/\upsilon$

Where c = speed of light in free space, υ = speed of light in a given material

19. Define critical angle. (AU April-May09)

Critical angle is defined as the minimum angle of incidence at which a light ray may strike the interface of two media and result in an angle of refraction of 90°or greater.

20. Define single mode and multi mode propagation.

If there is only one path for light to take down the cable, it is called single mode.

21. Define acceptance angle.

It defines the maximum angle in which external light rays may strike the air/fiber interface and still propagate down the fiber with a response that is no greater than 10 dB below the maximum value.

22. Define numerical aperture. (AU April- May11)

Numerical aperture is mathematically defined as the sine of the maximum angle a light ray entering the fiber can have in respect to the axis of the fiber and still propagate down the cable by internal reflection.

23. Define modal dispersion.

Modal dispersion or pulse spreading is A Used by the difference in the propagation times of light rays that take different paths down a fiber. Modal dispersion can occur only in multimode fibers. It can be reduced by using single mode step index fibers and graded index fibers.

24. What are the advantages of hetero junction LEDs?

a. The increase in current density generates a more brilliant light spot.

b. The smaller emitting area makes it easier to couple its emitted light into fiber.

c. The small effective area has a smaller capacitance, which allows the planar hetero junction LED to be used at higher speeds.

25. What are the disadvantages of injection laser diode?

ILDs are typically on the order of 10 times more expensive than LEDs

Use ILDs operate at higher powers, they typically have a much shorter life time than LEDs.

ILDs are more temperature dependent than LEDs.

26. What are the different types of satellites? [May/June 2016]

- Low Earth Orbits.
- Sun-Synchronous orbits.
- Geosynchronous satellites.
- Geostationary satellites.

27. What are the different types of fiber? Which is more preferred? [April/may 2017]

There are three types of fiber optic cable commonly used: single mode, **multimode** and **plastic** optical fiber (POF). **Transparent glass** or **plastic** fibers which allow light to be guided from one end to the other with minimal loss. So it is mostly preferred.

DHANALAKSHMI SRINIVASAN ENGINNERING COLLEGE

DEPARTMENT OF EEE

EC6651-COMMUNICATION ENGINEERING

16 MARK QUESTIONS WITH ANSWERS

UNIT-I

1. **Explain in detail about AM transmitter.**

Transmitters that transmit AM signals are known as AM transmitters. These transmitters are used in medium wave (MW) and short wave (SW) frequency bands for AM broadcast. The MW band has frequencies between 550 KHz and 1650 KHz, and the SW band has frequencies ranging from 3 MHz to 30 MHz. The two types of AM transmitters that are used based on their transmitting powers are:

- High Level
- Low Level

High level transmitters use high level modulation, and low level transmitters use low level modulation. The choice between the two modulation schemes depends on the transmitting power of the AM transmitter. In broadcast transmitters, where the transmitting power may be of the order of kilowatts, high level modulation is employed. In low power transmitters, where only a few watts of transmitting power are required , low level modulation is used.

High-Level and Low-Level Transmitters Below figure's show the block diagram of high-level and low-level transmitters. The basic difference between the two transmitters is the power amplification of the carrier and modulating signals

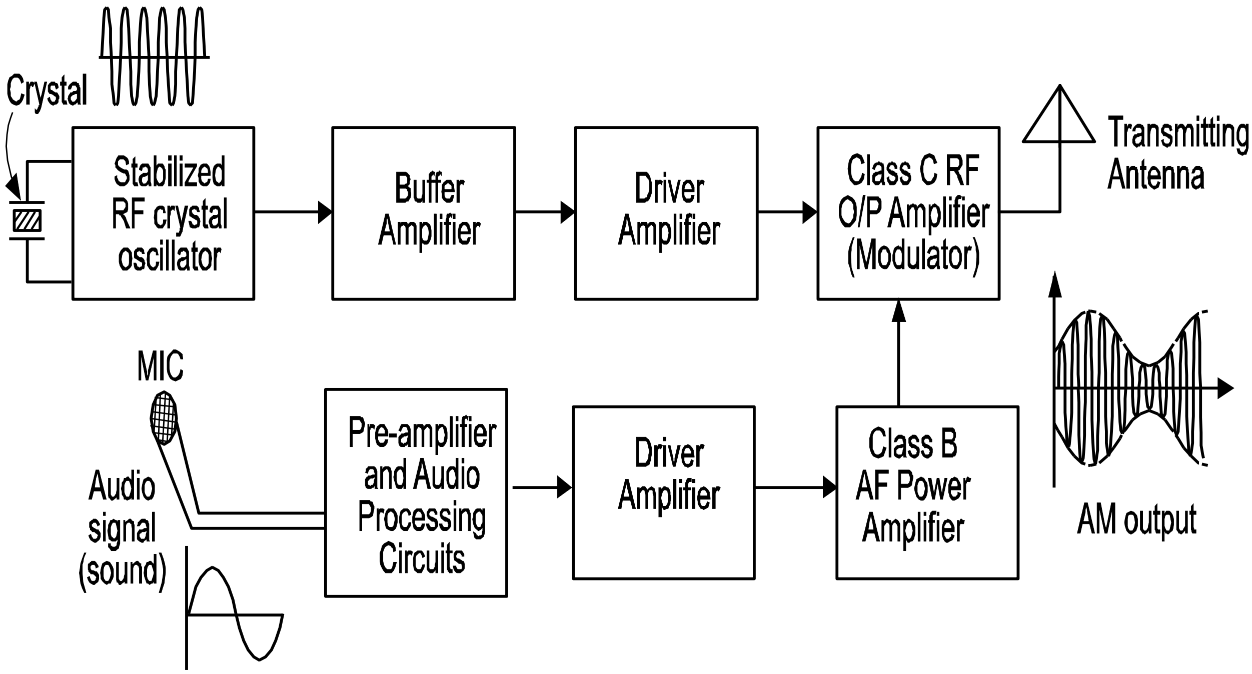


Figure is drawn for audio transmission. In high-level transmission, the powers of the carrier and modulating signals are amplified before applying them to the modulator stage, as shown in figure. In low-level modulation, the powers of the two input signals of the modulator stage are not amplified. The required transmitting power is obtained from the last stage of the transmitter, the class C power amplifier.

The various sections of the figure are:

- Carrier oscillator
- Buffer amplifier
- Frequency multiplier
- Power amplifier
- Audio chain
- Modulated class C power amplifier

ü **Carrier oscillator**

The carrier oscillator generates the carrier signal, which lies in the RF range. The frequency of the carrier is always very high. Because it is very difficult to generate high frequencies with good frequency stability, the carrier oscillator generates a sub multiple with the required carrier frequency. This sub multiple frequency is multiplied by the frequency multiplier stage to get the required carrier frequency. Further, a crystal oscillator can be used in this stage to generate a low frequency carrier with the best frequency stability. The frequency multiplier stage then increases the frequency of the carrier to its requirements.

ü **Buffer Amplifier**

The purpose of the buffer amplifier is twofold. It first matches the output impedance of the carrier oscillator with the input impedance of the frequency multiplier, the next stage of the carrier oscillator. It then isolates the carrier oscillator and frequency multiplier.

This is required so that the multiplier does not draw a large current from the carrier oscillator. If this occurs, the frequency of the carrier oscillator will not remain stable.

ü **Frequency Multiplier**

The sub-multiple frequency of the carrier signal, generated by the carrier oscillator , is now applied to the frequency multiplier through the buffer amplifier. This stage is also known as harmonic generator. The frequency multiplier generates higher harmonics of carrier oscillator frequency. The frequency multiplier is a tuned circuit that can be tuned to the requisite carrier frequency that is to be transmitted.

ü **Power Amplifier**

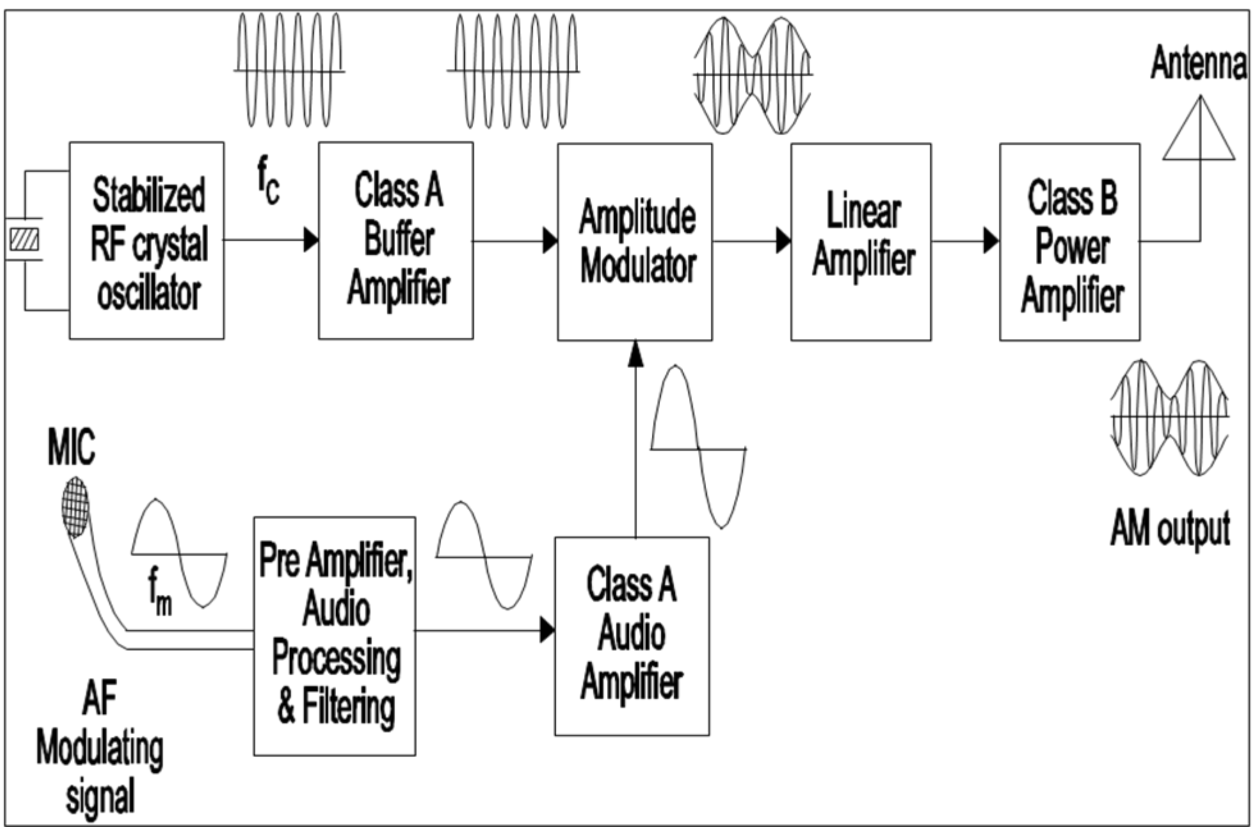
The power of the carrier signal is then amplified in the power amplifier stage. This is the basic requirement of a high-level transmitter. A class C power amplifier gives high power current pulses of the carrier signal at its output.

ü **Audio Chain**

The audio signal to be transmitted is obtained from the microphone, as shown in figure (a). The audio driver amplifier amplifies the voltage of this signal. This amplification is necessary to drive the audio power amplifier. Next, a class A or a class B power amplifier amplifies the power of the audio signal.

ü **Modulated Class C Amplifier**

This is the output stage of the transmitter. The modulating audio signal and the carrier signal, after power amplification, are applied to this modulating stage. The modulation takes place at this stage. The class C amplifier also amplifies the power of the AM signal to the reacquired transmitting power. This signal is finally passed to the antenna., which radiates the signal into space of transmission.



The low-level AM transmitter shown in the figure (b) is similar to a high-level transmitter, except that the powers of the carrier and audio signals are not amplified. These two signals are directly applied to the modulated class C power amplifier.

Modulation takes place at the stage, and the power of the modulated signal is amplified to the required transmitting power level. The transmitting antenna then transmits the signal.

ü **Coupling of Output Stage and Antenna**

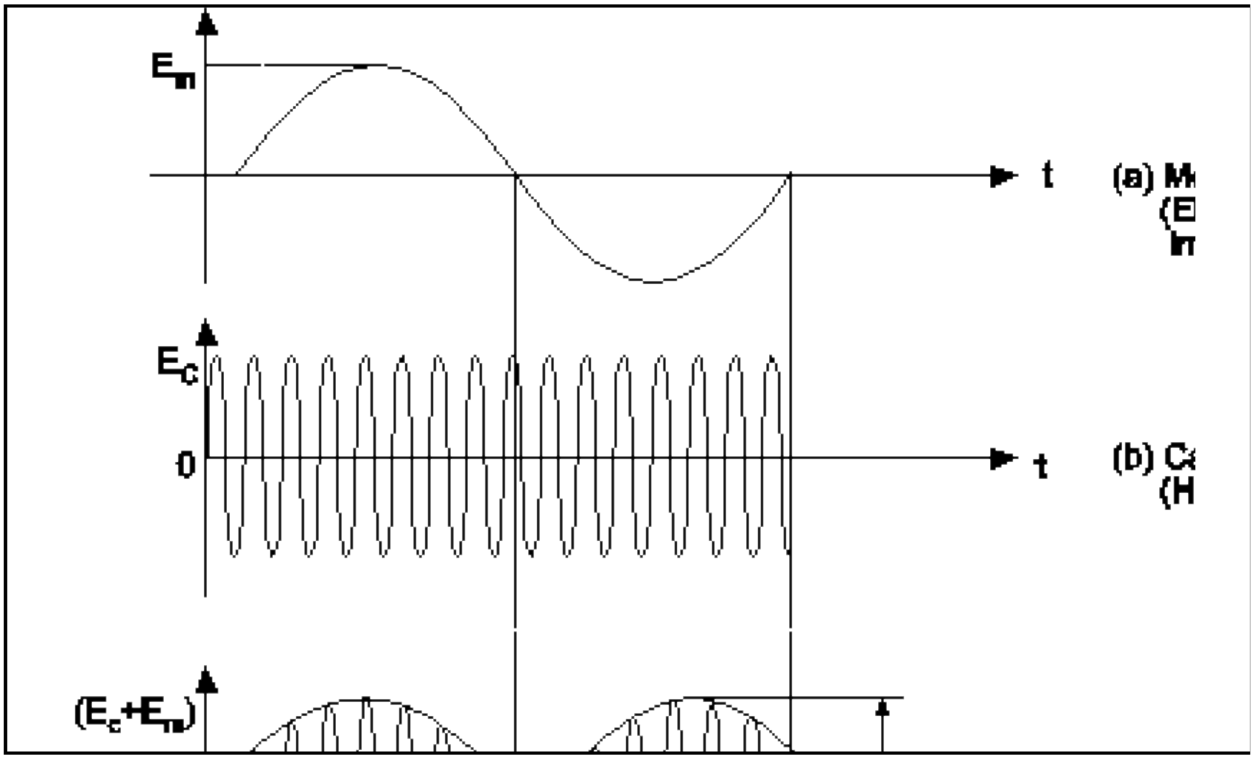
The output stage of the modulated class C power amplifier feeds the signal to the transmitting antenna. To transfer maximum power from the output stage to the antenna it is necessary that the impedance of the two sections match. For this, a matching network is required. The matching between the two should be perfect at all transmitting frequencies. As the matching is required at different frequencies, inductors and capacitors offering different impedance at different frequencies are used in the matching networks.

2. **Explain in detail about AM generation.**
   Amplitude Modulation:

   Amplitude modulation (AM) is a technique used in electronic communication, most commonly for transmitting information via a radio carrier wave. AM works by varying the strength of the transmitted signal in relation to the information being sent. For example, changes in the signal strength can be used to specify the sounds to be reproduced by a loudspeaker, or the light intensity of television pixels. (Contrast this with frequency modulation, also commonly used for sound transmissions, in which the frequency is varied; and phase modulation, often used in remote controls, in which the phase is varied).

   In order that a radio signal can carry audio or other information for broadcasting or for two way radio communication, it must be modulated or changed in some way. Although there are a number of ways in which a radio signal may be modulated, one of the easiest, and one of the first methods to be used was to change its amplitude in line with variations of the sound.
   The basic concept surrounding what is amplitude modulation, AM, is quite straightforward. The amplitude of the signal is changed in line with the instantaneous intensity of the sound. In this way the radio frequency signal has a representation of the

sound wave superimposed in it. In view of the way the basic signal "carries" the sound or modulation, the radio frequency signal is often termed the "carrier".



When a carrier is modulated in any way, further signals are created that carry the actual modulation information. It is found that when a carrier is amplitude modulated, further signals are generated above and below the main carrier. To see how this happens, take the example of a carrier on a frequency of 1 MHz which is modulated by a steady tone of 1 kHz.

The process of modulating a carrier is exactly the same as mixing two signals together, and as a result both sum and difference frequencies are produced. Therefore when a tone of 1 kHz is mixed with a carrier of 1 MHz, a "sum" frequency is produced at 1 MHz + 1 kHz, and a difference frequency is produced at 1 MHz - 1 kHz, i.e. 1 kHz above and below the carrier.

If the steady state tones are replaced with audio like that encountered with speech of music, these comprise many different frequencies and an audio spectrum with frequencies over a band of frequencies is seen. When modulated onto the carrier, these spectra are seen above and below the carrier.

It can be seen that if the top frequency that is modulated onto the carrier is 6 kHz, then the top spectra will extend to 6 kHz above and below the signal. In other words the bandwidth occupied by the AM signal is twice the maximum frequency of the signal that is used to modulated the carrier, i.e. it is twice the bandwidth of the audio signal to be carried.

In Amplitude Modulation or AM, the carrier signal is given by

$$A\cos(\omega * t)$$

It has an amplitude of 'A'

modulated in proportion to the message bearing (lower frequency) signal

$$\mathrm{m(t)}$$

to give

$$A(1 + m(t))\cos(\omega_c t)$$

The magnitude of m(t) is chosen to be less than or equal to 1, from reasons having to do with demodulation, i.e. recovery of the signal from the received signal. The modulation index is then defined to be

$$\beta = \max_t m(t)$$

The frequency of the *modulating signal* is chosen to be much smaller than that of the carrier signal. Try to think of what would happen if the modulating index were bigger than 1.

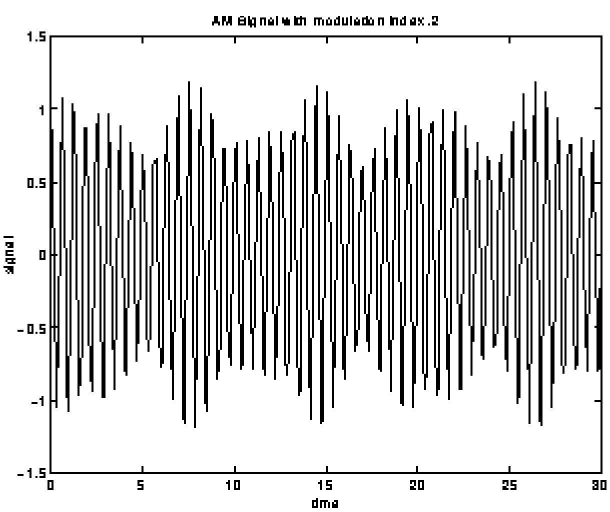


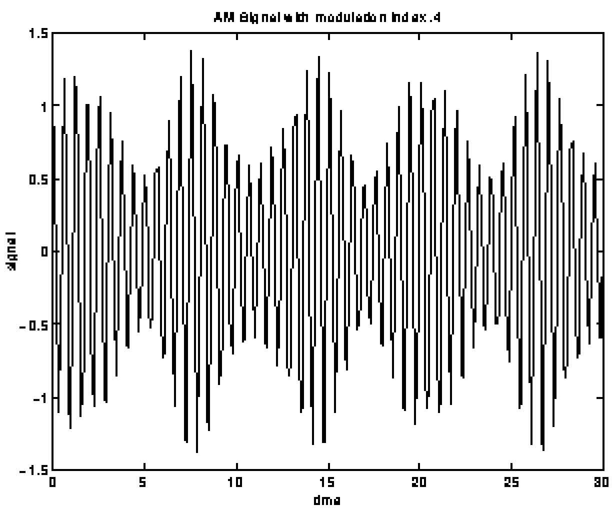
Fig.3. AM modulation with modulation index .2

Note that the AM signal is of the form

$$A(1 + \beta \sin \omega_m t) \cos(\omega_c t)$$
$$= A \cos \omega_c t + \frac{A\beta}{2}(\cos((\omega_c + \omega_m)t) + \cos((\omega_c - \omega_m)t))$$

This has frequency components at frequencies $\omega_c, \omega_c + \omega_m, \omega_c - \omega_m$

.



AM modulation with modulation index .4

Advantages of Amplitude Modulation, AM

There are several advantages of amplitude modulation, and some of these reasons have meant that it is still in widespread use today:

- It is simple to implement
- it can be demodulated using a circuit consisting of very few components
- AM receivers are very cheap as no specialised components are needed.

Disadvantages of amplitude modulation

Amplitude modulation is a very basic form of modulation, and although its simplicity is one of its major advantages, other more sophisticated systems provide a number of advantages. Accordingly it is worth looking at some of the disadvantages of amplitude modulation.

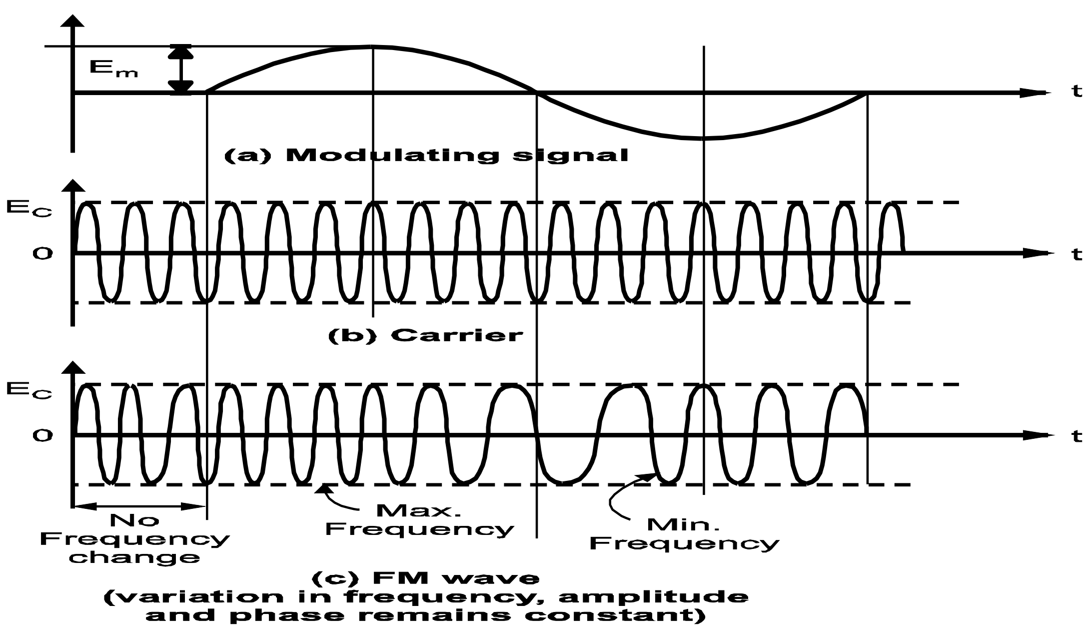
- It is not efficient in terms of its power usage
- It is not efficient in terms of its use of bandwidth, requiring a bandwidth equal to twice that of the highest audio frequency
- It is prone to high levels of noise because most noise is amplitude based and obviously AM detectors are sensitive to it.

3. Explain in detail about FM generation.

Definition of FM:

Frequency modulation is a technique of modulation in which the frequency of carrier is varied in accordance with the amplitude of modulating signal.

- In FM, amplitude and phase remains constant.
- Thus, the information is conveyed via. frequency changes



Frequency Modulation

Modulation Index

Definition:

Modulation Index is defined as the ratio of frequency deviation (δ) to the modulating frequency (f_m).

M.I. $= \frac{\text{Frequency Deviation}}{\text{Modulating Frequency}}$

$mf = \frac{\delta}{fm}$

In FM M.I.>1

Modulation Index of FM decides –

(i) Bandwidth of the FM wave.

(ii) Number of sidebands in FM wave.

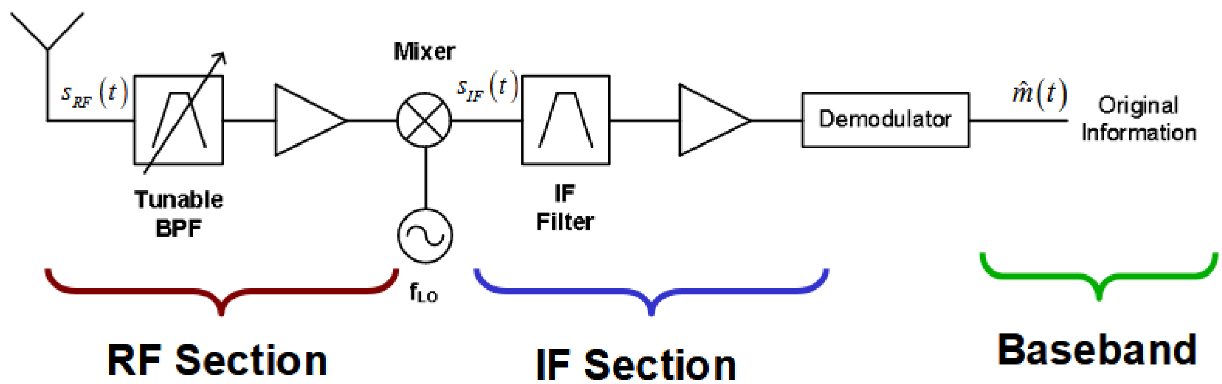
Percentage M.I. of FM

The percentage modulation is defined as the ratio of the actual frequency deviation produced by the modulating signal to the maximum allowable frequency deviation.

$\% \text{ M.I} = \frac{\text{Actual deviation}}{\text{Maximum allowable deviation}}$

4. Draw and explain super heterodyne receiver.

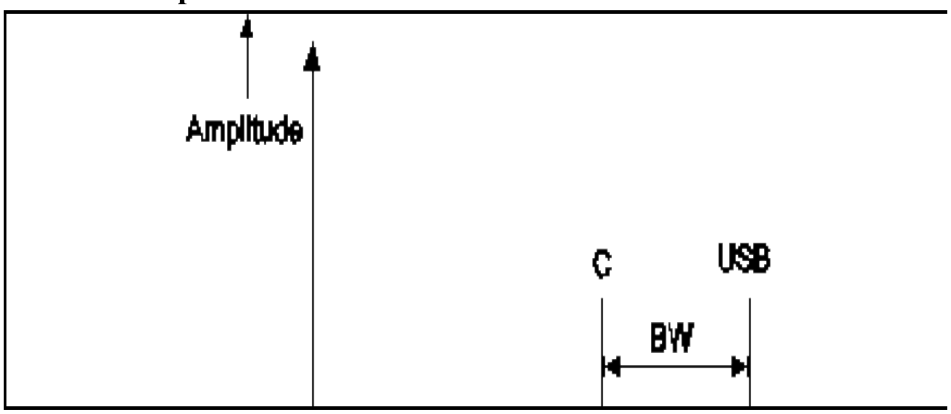
Structure of the Superheterodyne Receiver



- ***RF tuning & amplification:*** This RF stage within the overall block diagram for the receiver provides initial tuning to remove the image signal. It also provides some amplification. If noise performance for the receiver is important, then this stage will be designed for optimum noise performance. This RF amplifier circuit block will also increase the signal level so that the noise introduced by later stages is at a lower level in comparison to the wanted signal.
- ***Local oscillator:*** The local oscillator circuit block can take a variety of forms. Early receivers used free running local oscillators. Today most receivers use frequency synthesizers, normally based around phase locked loops. These provide much greater levels of stability and enable frequencies to be programmed in a variety of ways.
- ***Mixer:*** Both the local oscillator and incoming signal enter this block within the superheterodyne receiver. The wanted signal is converted to the intermediate frequency.

 IF amplifier & filter: This superheterodyne receiver block provides the majority of gain and selectivity. High performance filters like crystal filters may be used, although LC or ceramic filters may be used within domestic radios.
 Demodulator: The superheterodyne receiver block diagram only shows one demodulator, but in reality radios may have one or more demodulators dependent upon the type of signals being receiver.
 Audio amplifier: Once demodulated, the recovered audio is applied to an audio amplifier block to be amplified to the required level for loudspeakers or headphones. Alternatively the recovered modulation may be used for other applications whereupon it is processed in the required way by a specific circuit block.

5. Draw and explain SSB in detail.



- Single sideband modulation is widely used in the HF portion, or short wave portion of the radio spectrum for two way radio communication. There are many users of single sideband modulation.
- Many users requiring two way radio communication will use single sideband and they range from marine applications, generally HF point to point transmissions, military as well as radio amateurs or radio hams.
- Single sideband modulation or SSB is derived from amplitude modulation (AM) and SSB modulation overcomes a number of the disadvantages of AM.
- Single sideband modulation is normally used for voice transmission, but technically it can be used for many other applications where two way radio communication using analogue signals is required.
- As a result of its widespread use there are many items of radio communication equipment designed to use single sideband radio including: SSB receiver, SSB transmitter and SSB transceiver equipments.

- Single sideband, SSB modulation is basically a derivative of amplitude modulation, AM. By removing some of the components of the ordinary AM signal it is possible to significantly improve its efficiency.
- It is possible to see how an AM signal can be improved by looking at the spectrum of the signal. When a steady state carrier is modulated with an audio signal, for example a tone of 1 kHz, then two smaller signals are seen at frequencies 1 kHz above and below the main carrier.
- If the steady state tones are replaced with audio like that encountered with speech of music, these comprise many different frequencies and an audio spectrum with frequencies over a band of frequencies is seen.
- When modulated onto the carrier, these spectra are seen above and below the carrier. It can be seen that if the top frequency that is modulated onto the carrier is 6 kHz, then the top spectra will extend to 6 kHz above and below the signal.
- In other words the bandwidth occupied by the AM signal is twice the maximum frequency of the signal that is used to modulated the carrier, i.e. it is twice the bandwidth of the audio signal to be carried. Amplitude modulation is very inefficient from two points.
- The first is that it occupies twice the bandwidth of the maximum audio frequency, and the second is that it is inefficient in terms of the power used.
- The carrier is a steady state signal and in itself carries no information, only providing a reference for the demodulation process. Single sideband modulation improves the efficiency of the transmission by removing some unnecessary elements.
- In the first instance, the carrier is removed - it can be re-introduced in the receiver, and secondly one sideband is removed - both sidebands are mirror images of one another and the carry the same information. This leaves only one sideband - hence the name Single SideBand / SSB.

SSB receiver

- While signals that use single sideband modulation are more efficient for two way radio communication and more effective than ordinary AM, they do require an increased level of complexity in the receiver.

- As SSB modulation has the carrier removed, this needs to be re-introduced in the receiver to be able to reconstitute the original audio. This is achieved using an internal oscillator called a Beat Frequency Oscillator (BFO) or Carrier Insertion Oscillator (CIO).

- This generates a carrier signal that can be mixed with the incoming SSB signal, thereby enabling the required audio to be recovered in the detector.

- Typically the SSB detector itself uses a mixer circuit to combine the SSB modulation and the BFO signals. This circuit is often called a product detector because (like any RF mixer) the output is the product of the two inputs.

- It is necessary to introduce the carrier using the BFO / CIO on the same frequency relative to the SSB signal as the original carrier.

- Any deviation from this will cause the pitch of the recovered audio to change. Whilst errors of up to about 100 Hz are acceptable for communications applications including amateur radio, if music is to be transmitted the carrier must be reintroduced on exactly the correct frequency.

- This can be accomplished by transmitting a small amount of carrier, and using circuitry in the receiver to lock onto this.

- Tuning an SSB signal with the BFO set is quite easy.
- First set the receiver to the SSB position or the BFO to ON, and then if there is a separate switch set the LSB / USB switch to the format that is expected and then gradually tune the receiver.
- Adjust the main tuning control so that the pitch is correct, and the signal should be comprehensible. If it is not possible to distinguish the sounds, then set the LSB / USB switch to the other position and re-adjust the main tuning control if necessary to return the signal to the correct pitch, at which point the signal should be understandable.

SSB advantages

1. As the carrier is not transmitted, this enables a 50% reduction in transmitter power level for the same level of information carrying signal. [NB for an AM transmission using

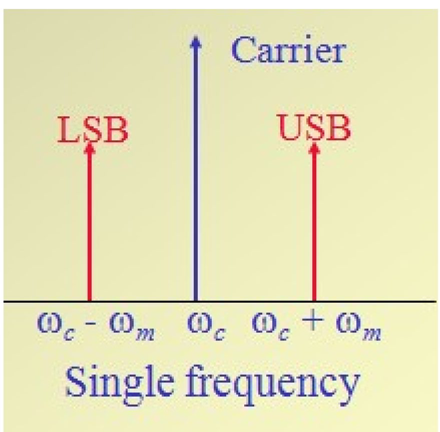
100% modulation, half of the power is used in the carrier and a total of half the power in the two sideband - each sideband has a quarter of the power.]

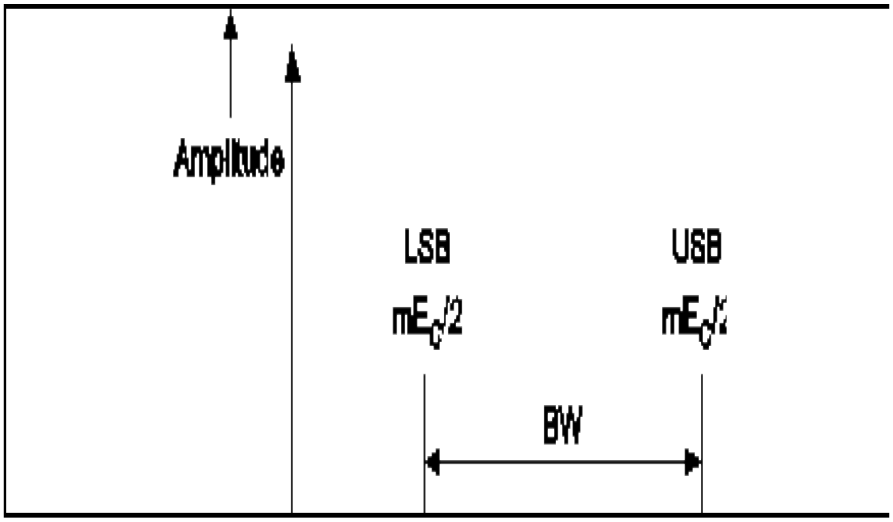
2. As only one sideband is transmitted there is a further reduction in transmitter power.

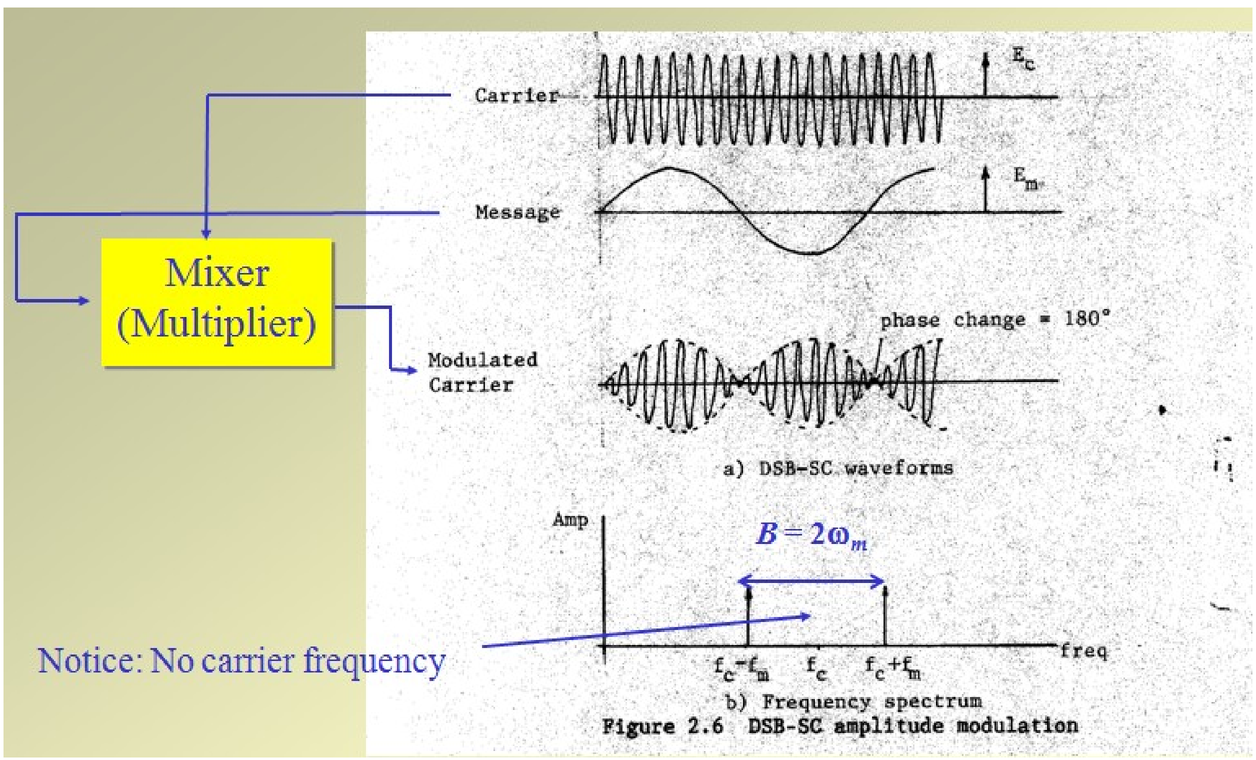
3. As only one sideband is transmitted the receiver bandwidth can be reduced by half. This improves the signal to noise ratio by a factor of two, i.e. 3 dB, because the narrower bandwidth used will allow through less noise and interference.

6. Explain in detail about DSB-SC.

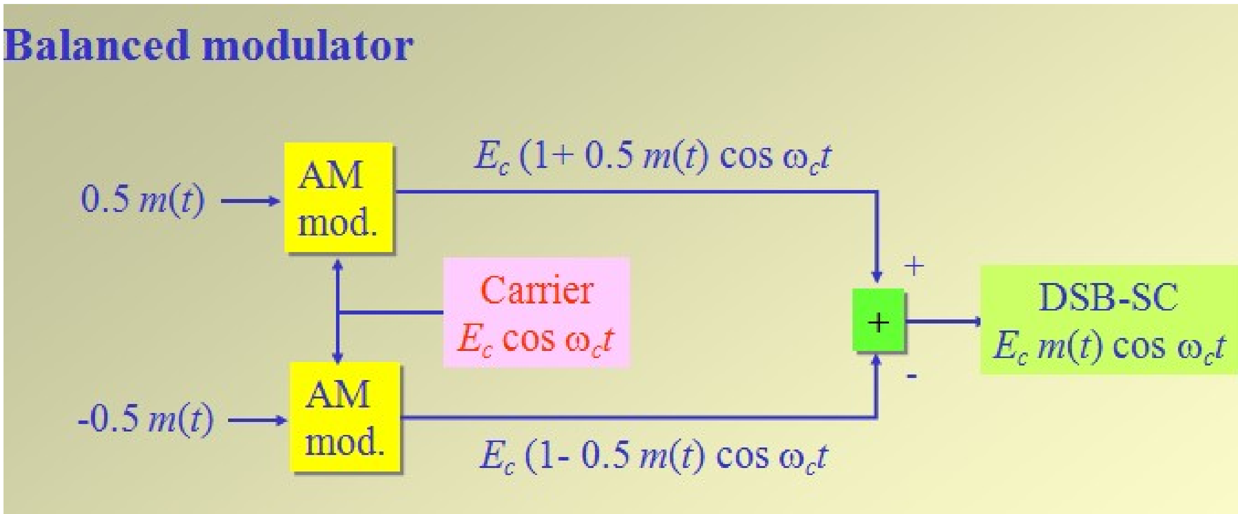
- Transmission in which frequencies produced by amplitude modulation are symmetrically spaced above and below the carrier frequency and the carrier level is reduced to the lowest practical level, ideally completely suppressed.
- The wave carrier is not transmitted but a great percentage of power that is dedicated to it is distributed between the sidebands, which implies an increase of the cover in DSB-SC, compared to AM, for the same power used.
- DSB-SC transmission is a special case of Double-sideband reduced carrier transmission.
- This is used for RDS (Radio Data System) because it is difficult to decouple.







DSB-SC implementation



- **Advantages:**
  - Lower power consumption
- **Disadvantage:**
  - Complex detection
- **Applications:**
  - Analogue TV systems: to transmit color information
  - For transmitting *stereo* information in FM sound broadcast at VHF

7. Compare NBFM and WBFM in detail.

Sr. No.	Parameter	NBFM	WBFM
1.	Modulation index	Less than or slightly greater than 1	Greater than 1
2.	Maximum deviation	5 kHz	75 kHz
3.	Range of modulating frequency	20 Hz to 3 kHz	20 Hz to 15 kHz
4.	Maximum modulation index	Slightly greater than 1	5 to 2500
5.	Bandwidth	Small approximately same as that of AM BW = $2f_m$	Large about 15 times greater than that of NBFM. BW = 2(δ+fmmax)
6.	Applications	FM mobile communication like police wireless, ambulance, short range ship to shore communication etc.	Entertainment broadcasting (can be used for high quality music transmission)

8. Draw and explain Armstrong method in detail.

FM Transmitter (Armstrong Method)

Advantages of FM

1. Transmitted power remains constant.
2. FM receivers are immune to noise.
3. Good capture effect.
4. No mixing of signals.

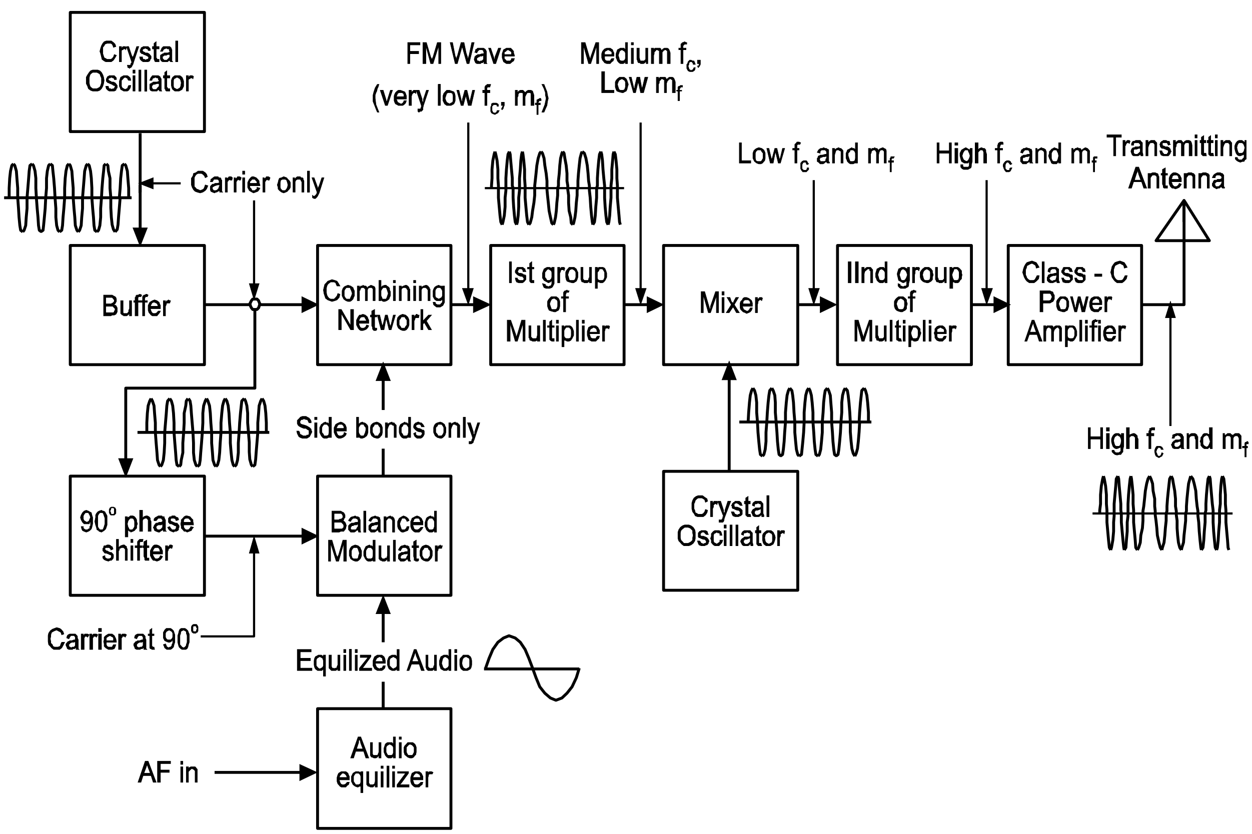
Disadvantages of FM

The greatest disadvantages of FM are:

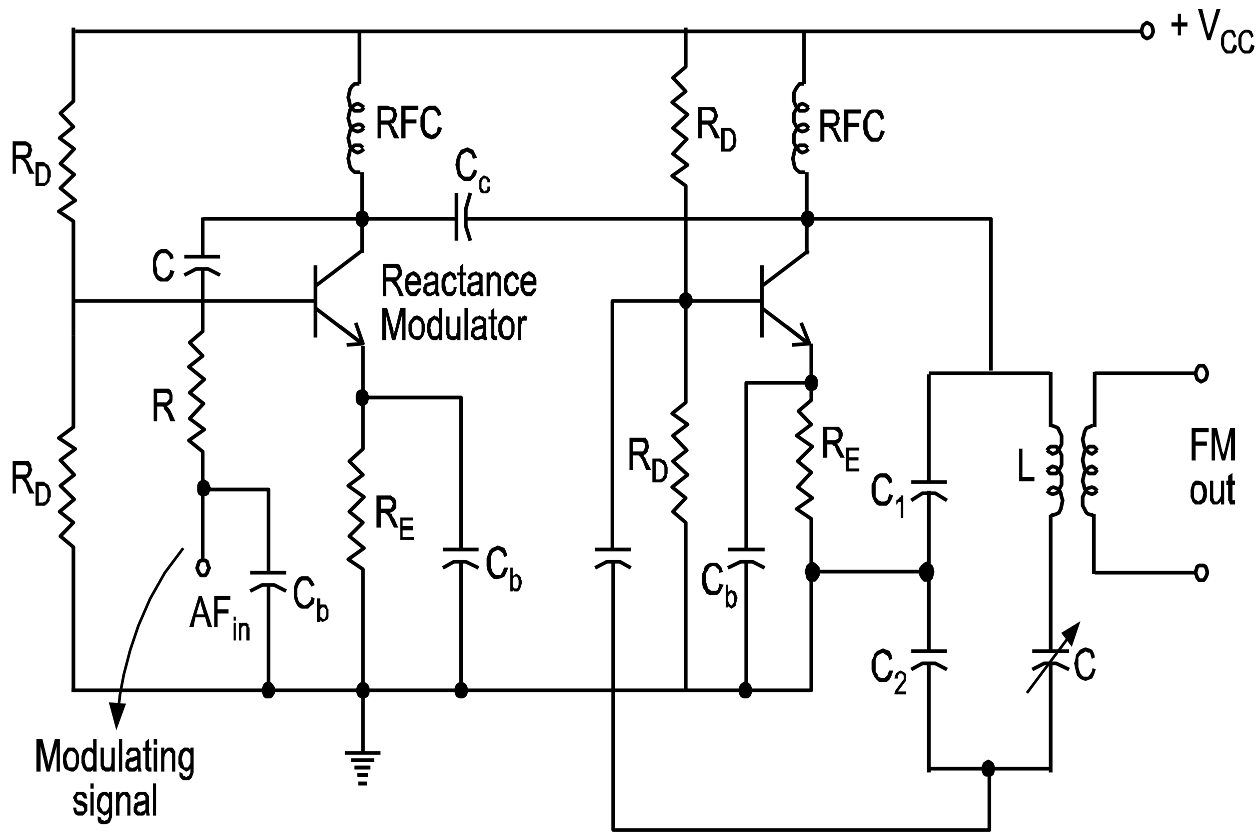
1. It uses too much spectrum space.
2. The bandwidth is wider.
3. The modulation index can be kept low to minimize the bandwidth used.
4. But reduction in M.I. reduces the noise immunity.
5. Used only at very high frequencies.

Applications of FM

1. FM radio broadcasting.
2. Sound transmission in TV.
3. Police wireless.



9. Explain in detail about Reactance modulations.

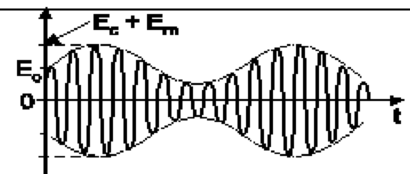
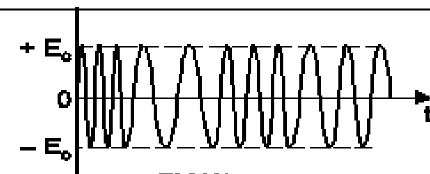


Limitations of Direct Method of FM Generation

1.In this method, it is very difficult to get high order stability in carrier frequency because in this method the basic oscillator is not a stable oscillator, as it is controlled by the modulating signal.

2. Generally in this method we get distorted FM, due to non-linearity of the varactor diode.

10. Compare AM and FM in detail.

Parameter	AM	FM
1. Definition	Amplitude of carrier is varied in accordance with amplitude of modulating signal keeping frequency and phase constant.	Frequency of carrier is varied in accordance with the amplitude of modulating signal keeping amplitude and phase constant.
2. Constant parameters	Frequency and phase.	Amplitude and phase.
3. Modulated signal	 AM Wave	 FM Wave
4. Modulation Index	m=Em/Ec	m = δ/ fm
5. Number of sidebands	Only two	Infinite and depends on m_f.
6. Bandwidth	BW = $2f_m$	BW = $2(\delta + f_{m(max)})$
7. Application	MW, SW band broadcasting, video transmission in TV.	Broadcasting FM, audio transmission in TV.

UNIT-II

1. Draw and explain various pulse modulation technique in detail.

- Pulse-amplitude modulation, acronym PAM, is a form of signal modulation where the message information is encoded in the amplitude of a series of signal pulses.
- Demodulation is performed by detecting the amplitude level of the carrier at every symbol period.

Types Of PAM

- 1.Single polarity PAM: In this a suitable fixed dc level is added to the signal to ensure that all the pulses are positive going.
- 2.Double polarity PAM: In this the pulses are both positive and negative going.

Pulse-amplitude modulation is widely used in baseband transmission of digital data, with non-baseband applications having been largely replaced by pulse-code modulation, and, more recently, by pulse-position modulation

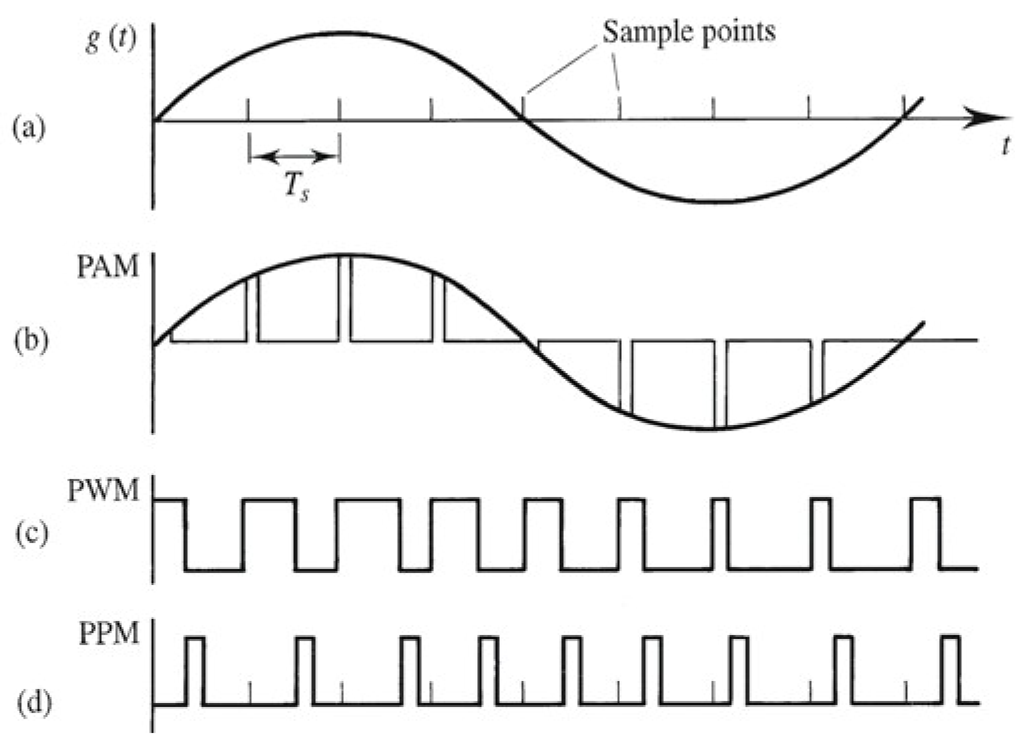
Pulse Width Modulation

- Pulse-width modulation (PWM), or pulse-duration modulation (PDM), is a commonly used technique for controlling power to inertial electrical devices, made practical by modern electronic power switches.
- The PWM switching frequency has to be much faster than what would affect the load, which is to say the device that uses the power.
- The main advantage of PWM is that power loss in the switching devices is very low.

PWM has also been used in certain communication systems where its duty cycle has been used to convey information over a communications channel

Types of PWM

- Three types of pulse-width modulation (PWM) are possible:
- The pulse center may be fixed in the center of the time window and both edges of the pulse moved to compress or expand the width.
- The lead edge can be held at the lead edge of the window and the tail edge modulated.
- The tail edge can be fixed and the lead edge modulated.



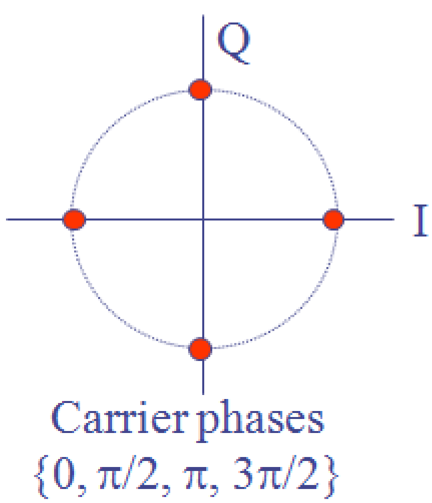
- **Pulse-position modulation (PPM)** is a form of signal modulation in which M message bits are encoded by transmitting a single pulse in one of possible time-shifts

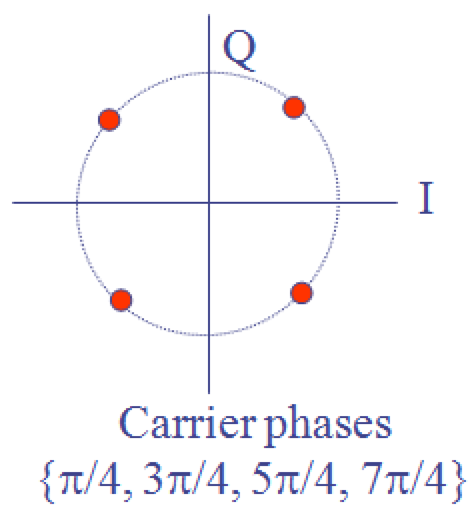
- One of the key difficulties of implementing this technique is that the receiver must be properly synchronized to align the local clock with the beginning of each symbol. Therefore, it is often implemented differentially as differential pulse-position modulation, whereby each pulse position is encoded relative to the previous, such that the receiver must only measure the difference in the arrival time of successive pulses.

- It is possible to limit the propagation of errors to adjacent symbols, so that an error in measuring the differential delay of one pulse will affect only two symbols, instead of affecting all successive measurements.

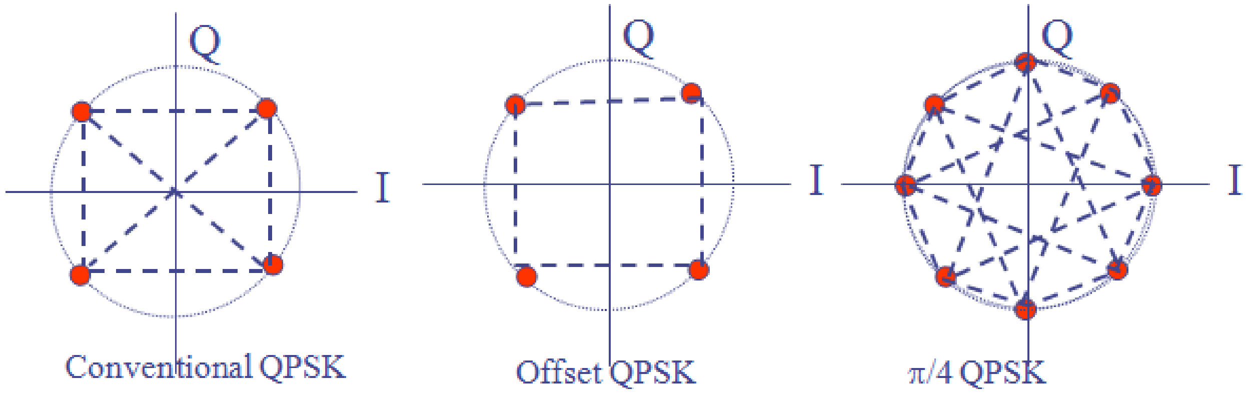
2. Explain in detail about QPSK with suitable diagrams.

◈ Quadrature Phase Shift Keying (QPSK) can be interpreted as two independent BPSK systems (one on the I-channel and one on Q-channel), and thus the same performance but twice the bandwidth (spectrum) efficiency.





◆ Quadrature Phase Shift Keying has twice the bandwidth efficiency of BPSK since 2 bits are transmitted in a single modulation symbol



◆ Conventional QPSK has transitions through zero (i.e. 180^0 phase transition). Highly linear amplifiers required.

◆ In Offset QPSK, the phase transitions are limited to 90^0, the transitions on the I and Q channels are staggered.

◆ In π/4 QPSK the set of constellation points are toggled each symbol, so transitions through zero cannot occur. This scheme produces the lowest envelope variations.

◆ All QPSK schemes require linear power amplifiers

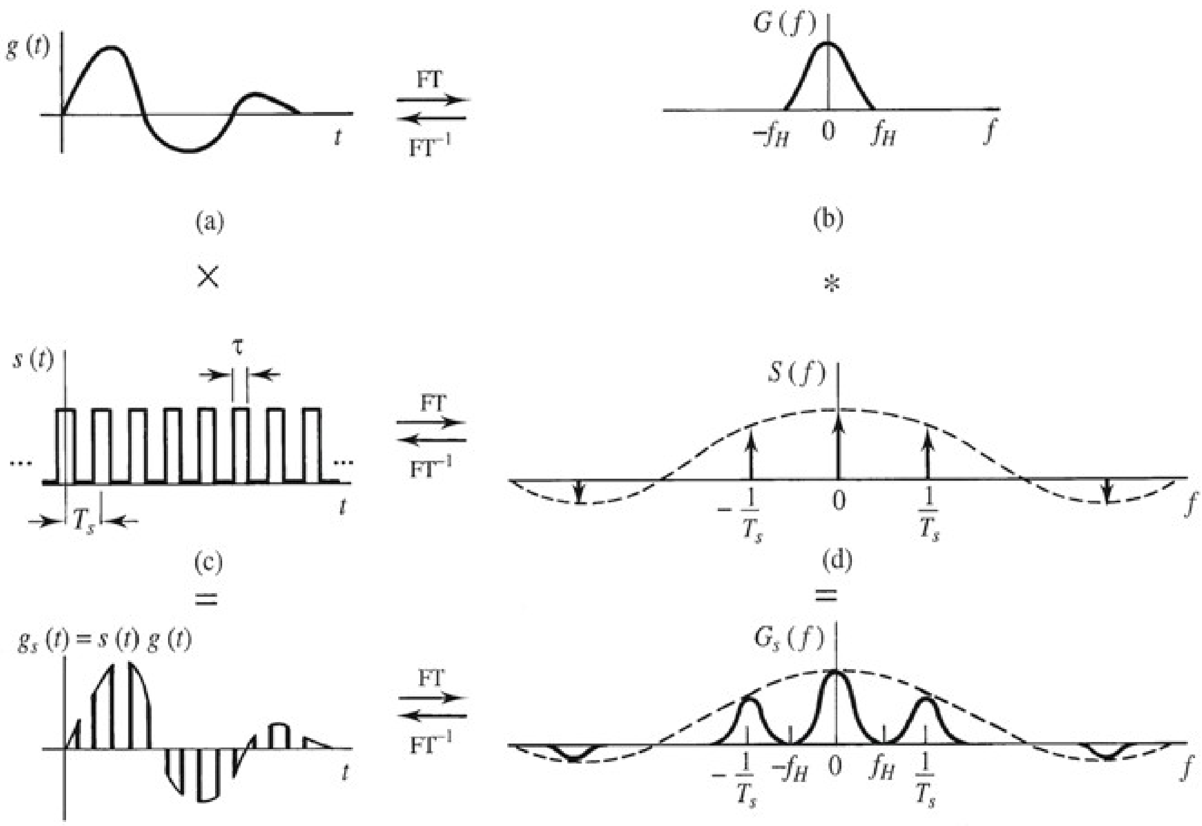
◆ Also a type of linear modulation scheme

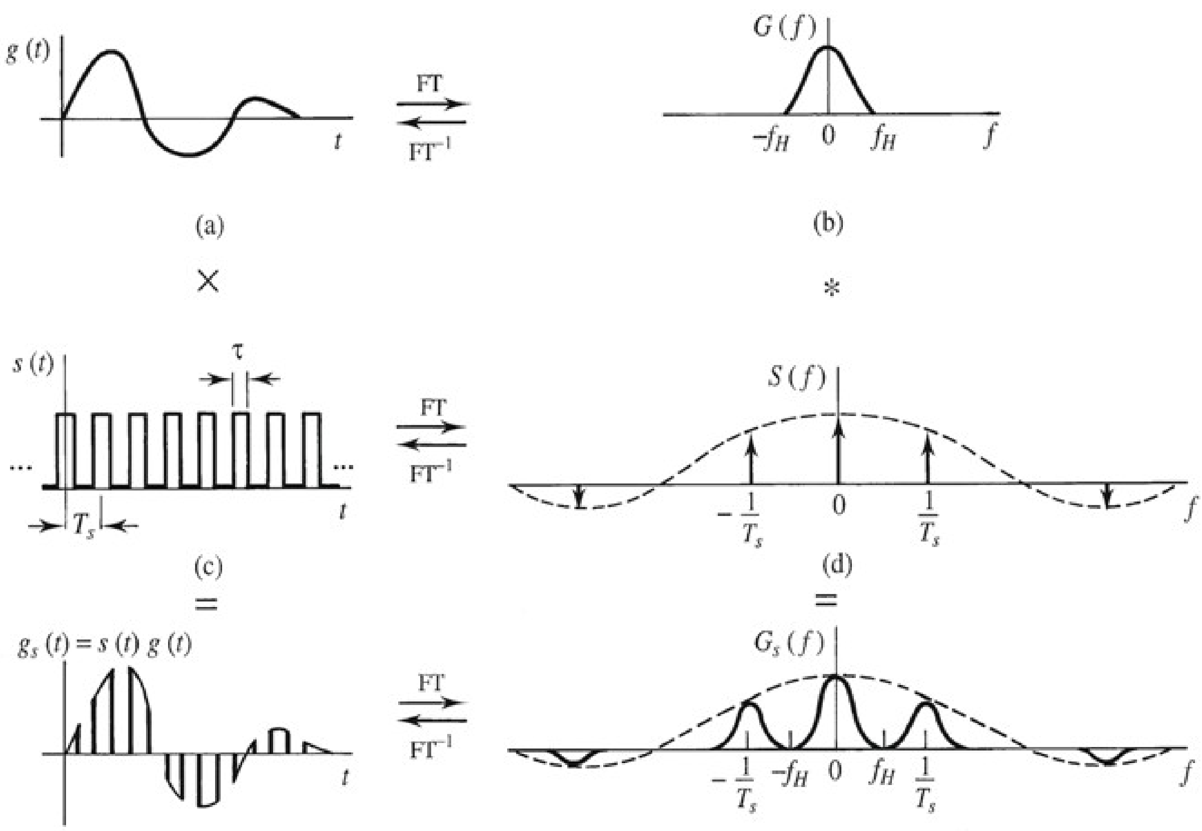
◆ Quadrature Phase Shift Keying (QPSK) has twice the bandwidth efficiency of BPSK, since 2 bits are transmitted in a single modulation symbol.

4. Explain in detail about sampling techniques.

Many signals originate as continuous-time signals, e.g. conventional music or voice
By sampling a continuous-time signal at isolated, equally-spaced points in time, we obtain a sequence of numbers

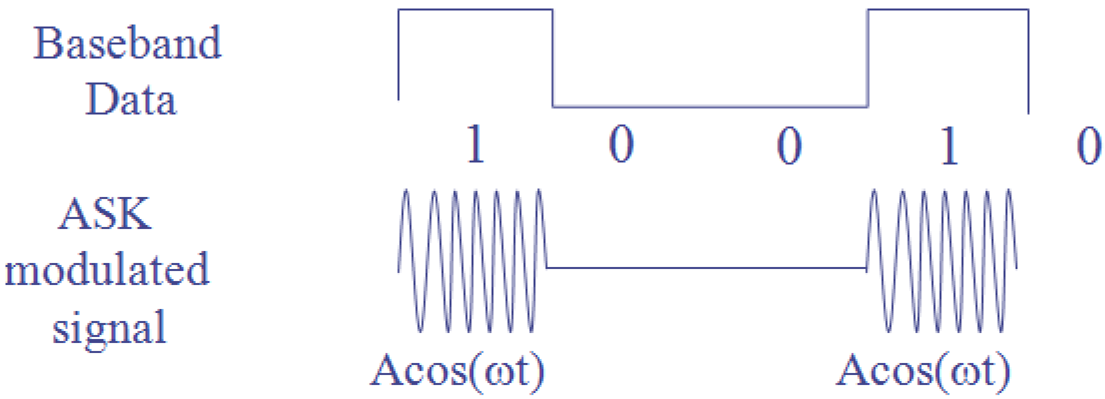
- Replicates spectrum of continuous-time signal
  At offsets that are integer multiples of sampling frequency
- Fourier series of impulse train where $w_s = 2\pi f_s$


g (t)
t
FT
FT⁻¹
G (f)
−f_H 0 f_H f
(a)
(b)
s (t)
τ
T_s
t
S (f)
−1/T_s 0 1/T_s f
(c)
(d)
g_s (t) = s (t) g (t)
t
G_s (f)
−1/T_s −f_H 0 f_H 1/T_s f


g (t)
t
FT
FT⁻¹
G (f)
−f_H 0 f_H f
(a)
(b)
s (t)
τ
T_s
t
S (f)
−1/T_s 0 1/T_s f
(c)
(d)
g_s (t) = s (t) g (t)
t
G_s (f)
−1/T_s −f_H 0 f_H 1/T_s f

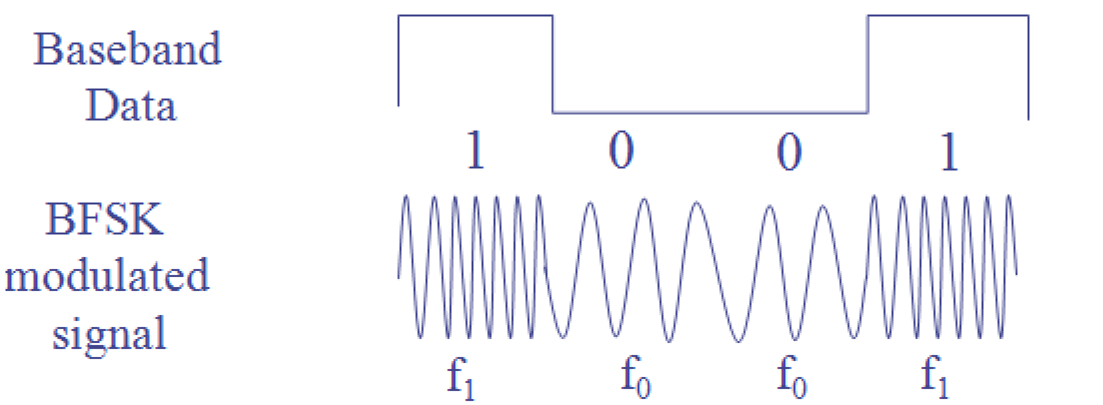
5. **Draw and explain ASK and FSK in detail.**

ASK



- Pulse shaping can be employed to remove spectral spreading
- ASK demonstrates poor performance, as it is heavily affected by noise, fading, and interference

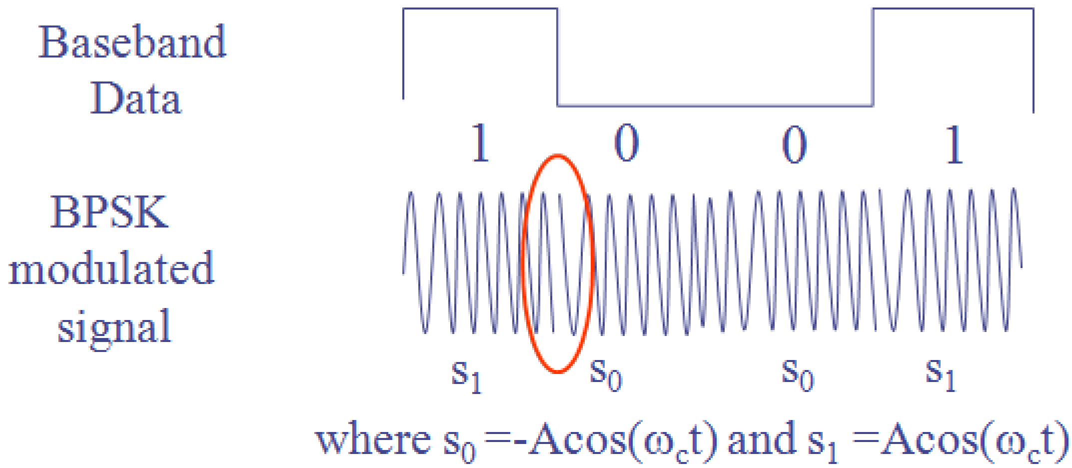
FSK



where $f_0 = A\cos(\omega_c - \Delta\omega)t$ and $f_1 = A\cos(\omega_c + \Delta\omega)t$

FSK can be expanded to a M-ary scheme, employing multiple frequencies as different states

6. **Explain in detail about PSK and BPSK.**
PSK



- Major drawback – rapid amplitude change between symbols due to phase discontinuity, which requires infinite bandwidth. Binary Phase Shift Keying (BPSK) demonstrates better performance than ASK and BFSK
- BPSK can be expanded to a M-ary scheme, employing multiple phases and amplitudes as different states

Binary Phase Shift Keying (BPSK)

If the sinusoidal carrier has an amplitude A_c and energy per bit E_b

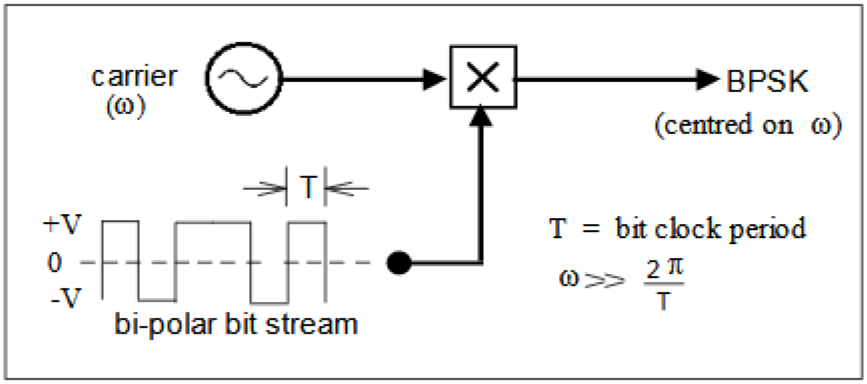
Then the transmitted BPSK signal is either:

$$S_{BPSK}(t) = \sqrt{\frac{2E_b}{T_b}} \cos(2\pi f_c t + \theta_c) \quad 0 \le t \le T_b \text{ (binary 1)}$$

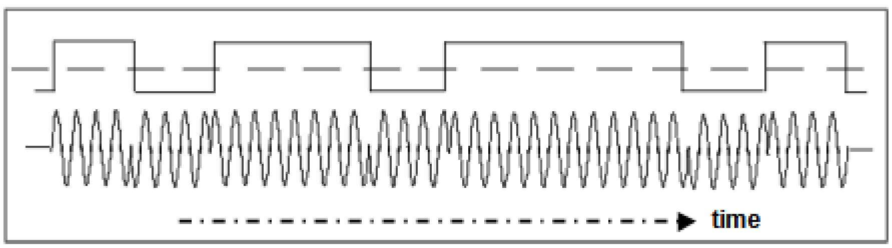
$$S_{BPSK}(t) = \sqrt{\frac{2E_b}{T_b}} \cos(2\pi f_c t + \pi + \theta_c)$$

$$= -\sqrt{\frac{2E_b}{T_b}} \cos(2\pi f_c t + \theta_c) \quad 0 \le t \le T_b \text{ (binary 0)}$$

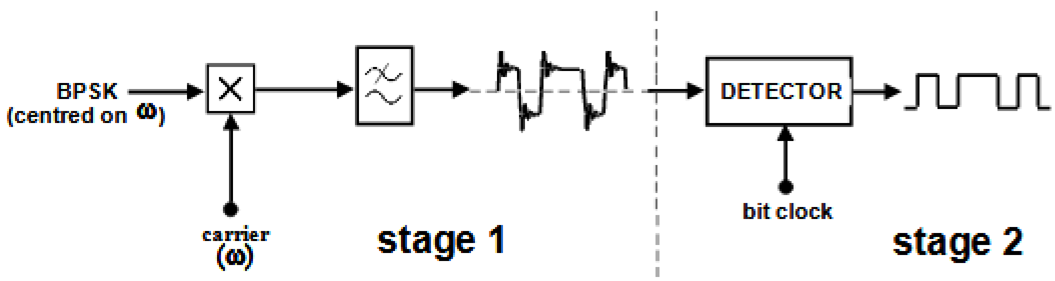
<u>Generation of BPSK</u>



BPSK signal in time domain



BPSK demodulation



Linear Modulation Techniques:

Digital modulation can be broadly classified as:

1. Linear (change Amplitude or phase)

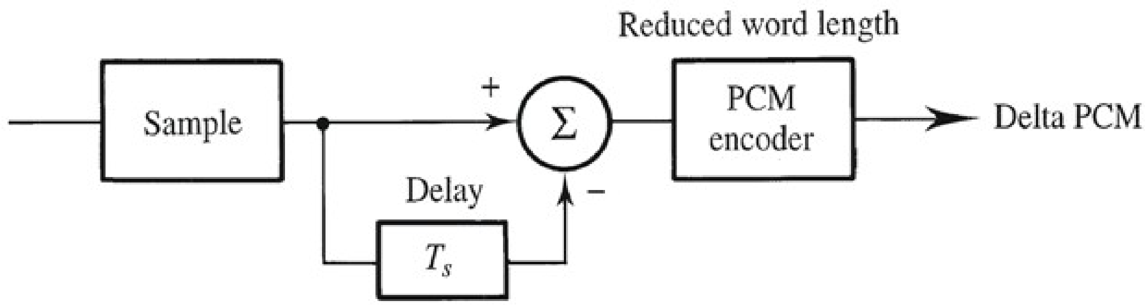
2. Non linear modulation techniques (change frequency).

Linear Modulation Techniques:

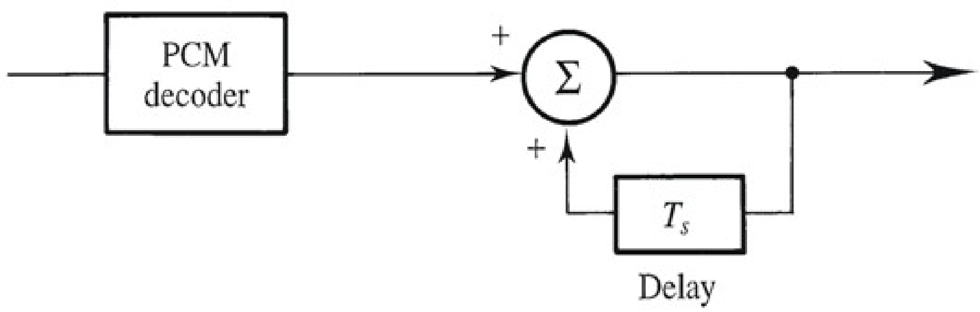
- The amplitude /phase of the transmitted signal s(t), varies linearly with the modulating digital signal, m(t).

- These are bandwidth efficient (because it doesn't change frequency) and hence are very attractive for use in wireless communication systems where there is an increasing demand to accommodate more and more users within a limited spectrum.
- Linear Modulation schemes have very good spectral efficiency,
- However, they must be transmitted using linear RF amplifiers which have poor power efficiency.
- Phase modulation" can be regarded as "amplitude" modulation because it can really change "envelope

7. Draw and explain Pulse Code Modulation in detail.



(a) Delta PCM encoder



Pulse-code modulation (**PCM**) is a method used to digitally represent sampled analog signals. It is the standard form of digital audio in computers, compact discs, digital telephony and other digital audio applications. In a PCM stream, the amplitude of the analog signal is sampled regularly at uniform intervals, and each sample is quantized to the nearest value within a range of digital steps.

Merits

- The PCM (pulse code modulation) convenient for long distance communication.
- It has a higher transmitter efficiency.
- It has a higher noise immunity.

Demerits

- The PCM (pulse code modulation) requires large bandwidth as compared to analog system.
- Encoding, decoding and quantizing circuit of PCM is very complex.

Applications

- The PCM is used in the satellite transmission system.
- It is used in space communication.
- It is used in telephony.
- The compact disc (CD) is a recent application of PCM.

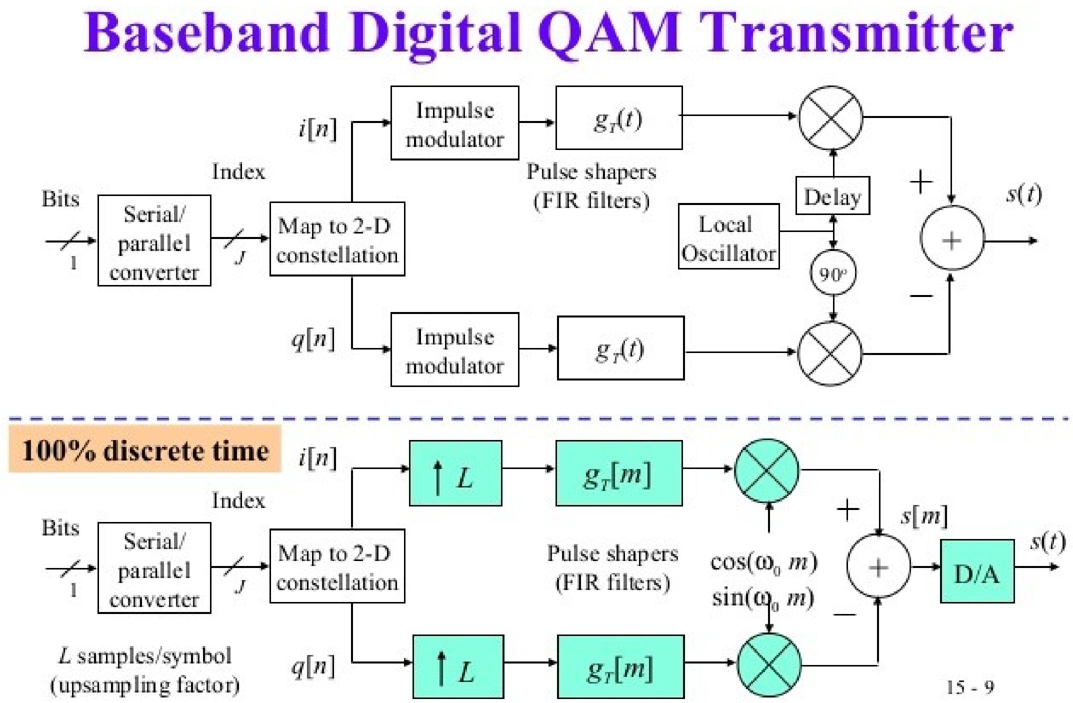
8. Explain in detail about QAM.

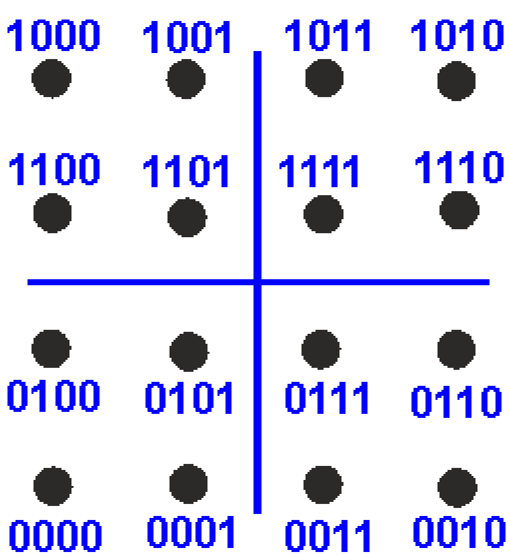
- Quadrature Amplitude Modulation or QAM is a form of modulation which is widely used for modulating data signals onto a carrier used for radio communications. It is widely used because it offers advantages over other forms of data modulation such as PSK, although many forms of data modulation operate alongside each other.

- Quadrature Amplitude Modulation, QAM is a signal in which two carriers shifted in phase by 90 degrees are modulated and the resultant output consists of both amplitude and phase variations. In view of the fact that both amplitude and phase variations are present it may also be considered as a mixture of amplitude and phase modulation.

- A motivation for the use of quadrature amplitude modulation comes from the fact that a straight amplitude modulated signal, i.e. double sideband even with a suppressed carrier occupies twice the bandwidth of the modulating signal.

- This is very wasteful of the available frequency spectrum. QAM restores the balance by placing two independent double sideband suppressed carrier signals in the same spectrum as one ordinary double sideband suppressed carrier signal.





QAM advantages and disadvantages

- Although QAM appears to increase the efficiency of transmission for radio communications systems by utilizing both amplitude and phase variations, it has a number of drawbacks.
- The first is that it is more susceptible to noise because the states are closer together so that a lower level of noise is needed to move the signal to a different decision point.

Receivers for use with phase or frequency modulation are both able to use limiting amplifiers that are able to remove any amplitude noise and thereby improve the noise reliance. This is not the case with QAM.

- The second limitation is also associated with the amplitude component of the signal. When a phase or frequency modulated signal is amplified in a radio transmitter, there is no need to use linear amplifiers, whereas when using QAM that contains an amplitude component, linearity must be maintained.

- Unfortunately linear amplifiers are less efficient and consume more power, and this makes them less attractive for mobile applications.

9. Explain in detail about MSK and GMSK.

MSK and GMSK stands for Minimum Shift Keying and Gaussian Minimum Shift Keying respectively. GMSK is derivative of base MSK modulation scheme. As we know, sidebands of standard PSK modulated spectrum extend from carrier frequency. This is overcome by MSK and GMSK.

Representation of MSK

$$s(t) = s_1\phi_1(t) + s_2\phi_2(t) \qquad 0 \leq t \leq T_b$$

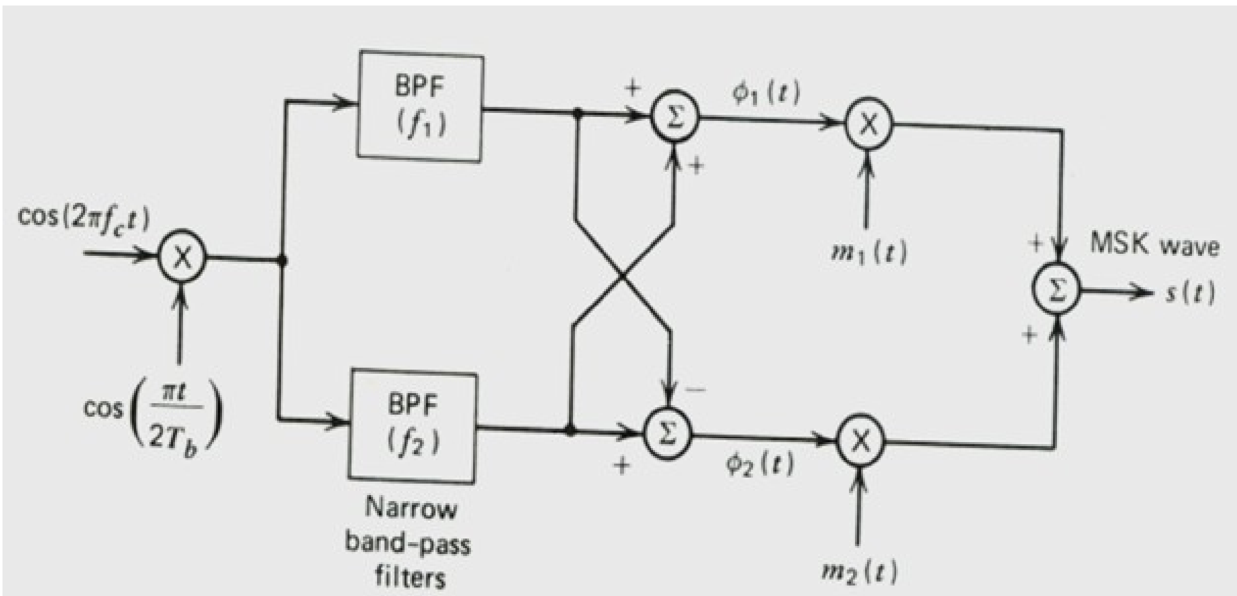
the appropriate form for the orthonormal basis functions $\phi_1(t)$ and $\phi_2(t)$ is as follows:

$$\phi_1(t) = \sqrt{\frac{2}{T_b}}\cos\left(\frac{\pi}{2T_b}t\right)\cos(2\pi f_c t) \qquad -T_b \leq t \leq T_b \qquad (7.59)$$

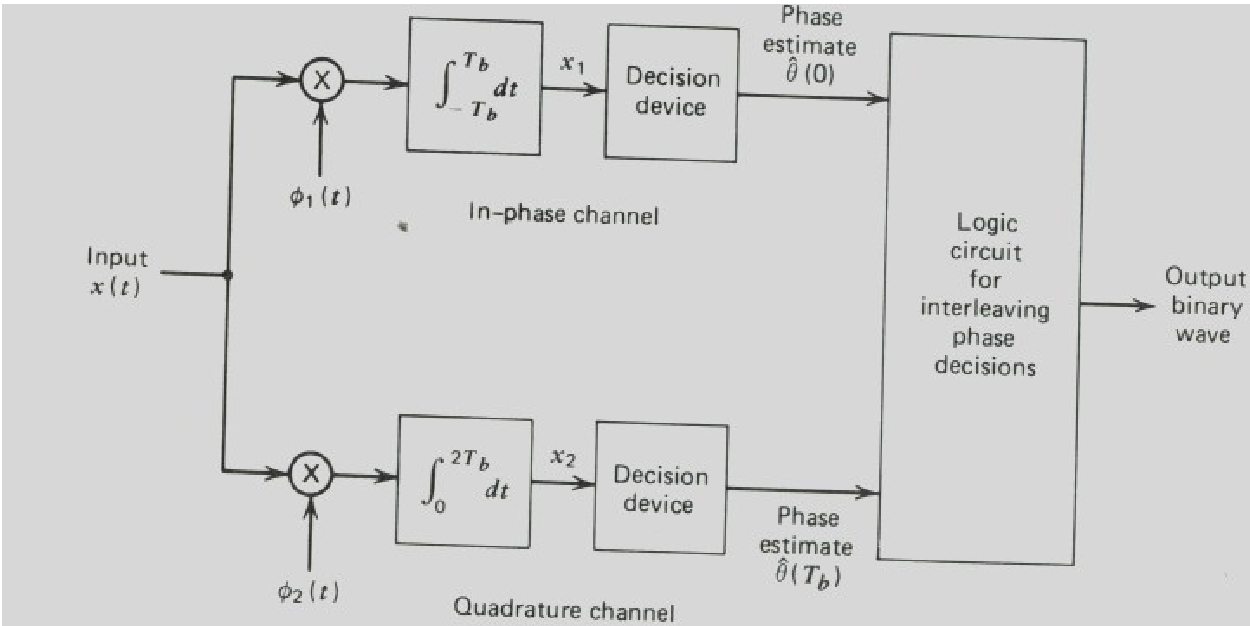
and

$$\phi_2(t) = \sqrt{\frac{2}{T_b}}\sin\left(\frac{\pi}{2T_b}t\right)\sin(2\pi f_c t) \qquad 0 \leq t \leq 2T_b \qquad (7.60)$$

MSK transmitter



MSK Receiver



Following are the benefits or **advantages of MSK or GMSK**:

The sidebands of PSK modulated spectrum is minimized by this modulation technique. Hence sideband power is reduced.
The MSK or GMSK spectrum is less affected by noise and hence leads to good SNR. This helps in achieving very stable and long distance communication. Due to this fact, the GMSK modulation technique is being employed in GSM technology.
Above fact, helps in achieving good receiver sensitivity.
PAPR is maintained low due to no phase continuities and occurrence of frequency changes at zero cross over of RF carrier. Due to this, highly linear PA (Power Amplifier) is not required.
Spectral efficiency is better and higher while demodulator is less complex.
GMSK provides constant envelope over the entire bandwidth. Hence it offers excellent power efficiency.
It provides good BER performance.
GMSK offers self synchronizing capabilities.
GMSK is good choice for voice modulation.

Following are the **disadvantages of MSK or GMSK**:
PSD of MSK does not fall fast and hence Interference between adjacent channels is observed. GMSK uses BT of 0.3 and hence good rejection can be achieved between adjacent channels. Here B is 3dB bandwidth of shaping filter and T is bit duration.

Both MSK and GMSK requires more power to transmit data compare to other modulation types such as QPSK.
It requires complex channel equalization algorithms e.g. adaptive equalizer at receiver.
Inter symbol interference may occur.

10. Write notes on coherent and non-coherent detection.

Coherent Detection

- An estimate of the channel phase and attenuation is recovered. It is then possible to reproduce the transmitted signal and demodulate.
- Requires a replica carrier wave of the same frequency and phase at the receiver.
- Also known as synchronous detection (I.e. carrier recovery)
- Carrier recovery methods include
  - Pilot Tone (such as Transparent Tone in Band)
    - Less power in the information bearing signal, High peak-to-mean power ratio
  - Carrier recovery from the information signal
    - E.g. Costas loop
- Applicable to
  - Phase Shift Keying (PSK)
  - Frequency Shift Keying (FSK)
  - Amplitude Shift Keying (ASK)

Non-Coherent Detection

- Requires no reference wave; does not exploit phase reference information (envelope detection)
  - Differential Phase Shift Keying (DPSK)
  - Frequency Shift Keying (FSK)
  - Amplitude Shift Keying (ASK)
  - Non coherent detection is less complex than coherent detection (easier to implement), but has worse performance.

UNIT-III

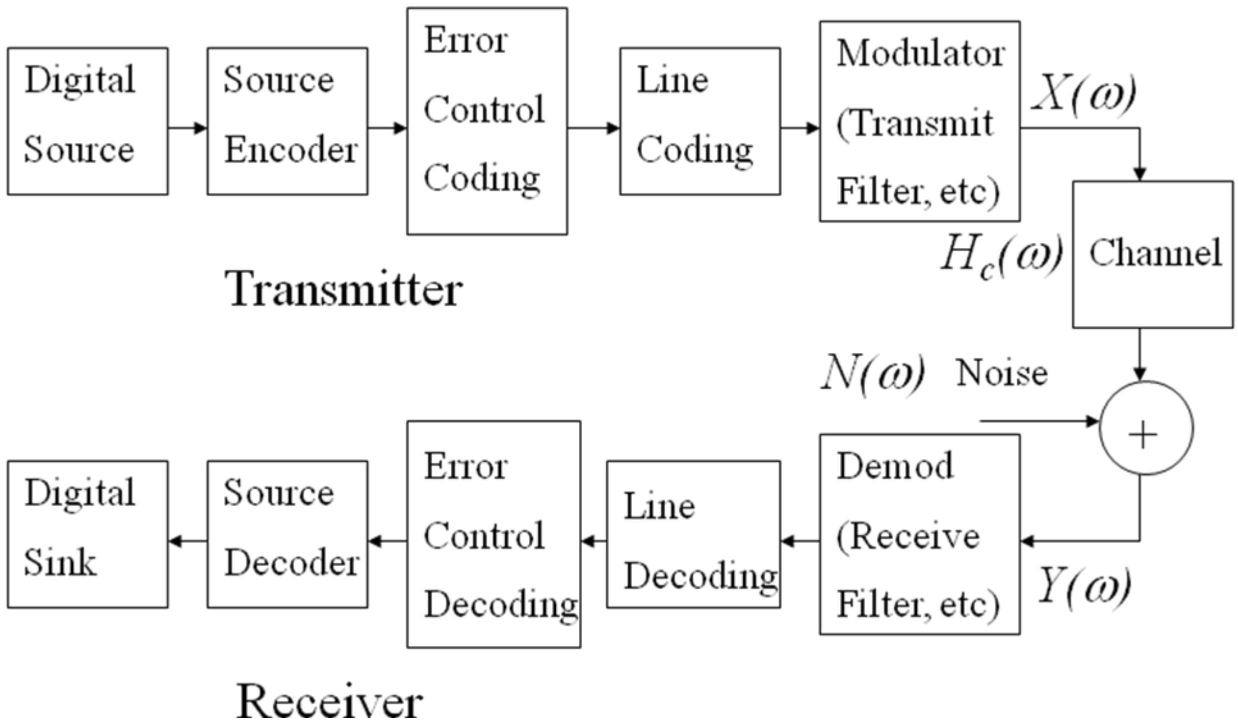
1. Explain in detail about error control codes and its applications.

- Channel is noisy
- Channel output prone to error

•We need measure to ensure correctness of the bit stream transmitted

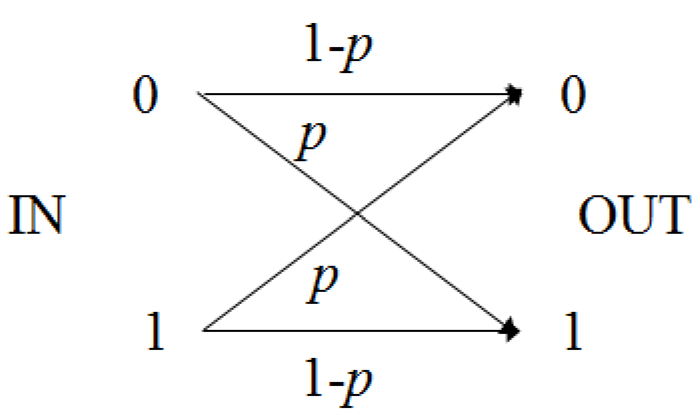
- Error control coding aims at developing methods for coding to check the correctness of the bit stream transmitted. The bit stream representation of a symbol is called the codeword of that symbol.
  - Extra bits are added to the data at the transmitter (redundancy) to permit error detection or correction at the receiver
  - Done to prevent the output of erroneous bits despite noise and other imperfections in the channel

- The positions of the error control coding and decoding are shown in the transmission model



Error Models

- Binary Symmetric Memoryless Channel
  - Assumes transmitted symbols are binary
  - Errors affect '0's and '1's with equal probability (i.e., symmetric)
  - Errors occur randomly and are independent from bit to bit (memoryless)



p is the probability of bit error or the Bit Error Rate (BER) of the channel

- Many other types
- Burst errors, i.e., contiguous bursts of bit errors
  - output from DFE (error propagation)
  - common in radio channels
  - Insertion, deletion and transposition errors
- We will consider mainly random errors

Error Control Techniques

- Error detection in a block of data
  - Can then request a retransmission, known as automatic repeat request (ARQ) for sensitive data
  - Appropriate for
    - Low delay channels
    - Channels with a return path
  - Not appropriate for delay sensitive data, e.g., real time speech and data
- Forward Error Correction (FEC)
  - Coding designed so that errors can be corrected at the receiver
  - Appropriate for delay sensitive and one-way transmission (e.g., broadcast TV) of data
  - Two main types, namely block codes and convolutional codes. We will only look at block codes

Applications

- Useful in satellite communication
- Useful in TV communication

2. Write short notes on BSE and BEC.

BEC- Binary Erasure Channel

- BEC

  $C = 1 - \varepsilon$,

where ε is the erasure probability.

- BSC

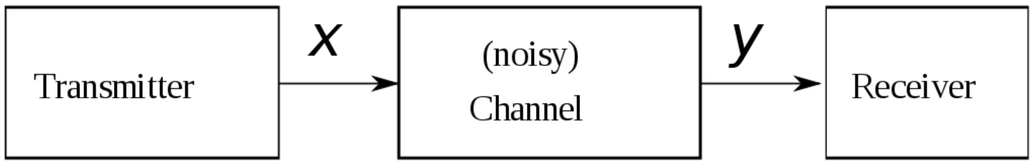
  $C = 1 - H(\rho)$,

where ρ is the error probability of the channel and $H(\rho)$ is the entropy with the parameter ρ.

- Benefits
  - In principle:
    - If you transmit information at a rate $R < C$, then the error-free transmission is possible.
  - In practice:
    - Reduce the error rates
    - Reduce the transmitted power requirements

3. Explain in detail about noise coding theorem.

In information theory, the noisy-channel coding theorem (sometimes Shannon's theorem), establishes that for any given degree of noise contamination of a communication channel, it is possible to communicate discrete data (digital information) nearly error-free up to a computable maximum rate through the channel.



The **Shannon limit** or **Shannon capacity** of a communications channel is the theoretical maximum information transfer rate of the channel, for a particular noise level.

Theorem

1. For every discrete memoryless channel, the channel capacity

$$C = \sup_{p_X} I(X;Y)$$

2. If a probability of bit error p_b is acceptable, rates up to $R(p_b)$ are achievable

$$R(p_b) = \frac{C}{1 - H_2(p_b)}$$

and $H_2(p_b)$ is the *binary entropy function*

$$H_2(p_b) = -\left[p_b \log_2 p_b + (1 - p_b) \log_2 (1 - p_b)\right]$$

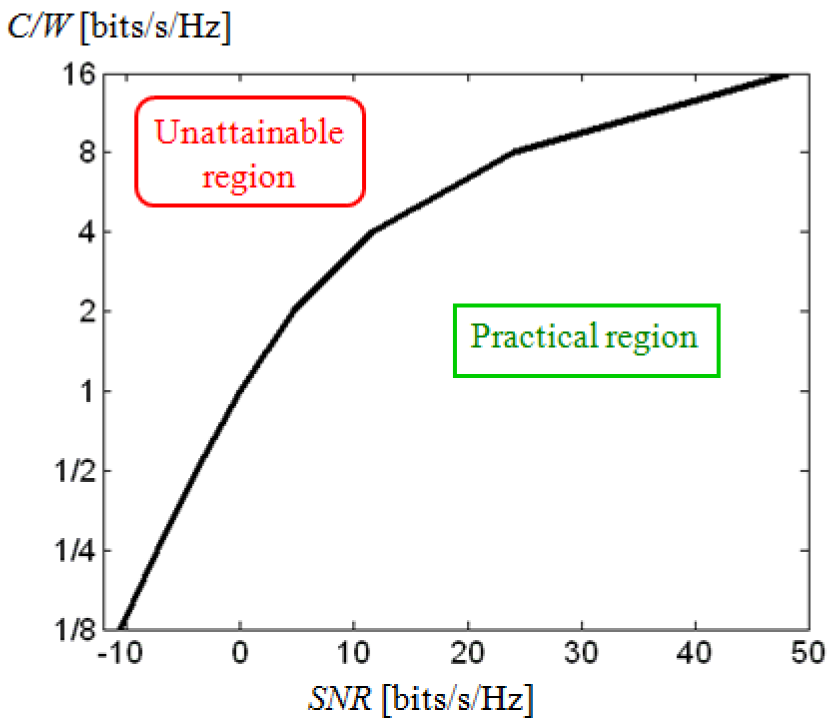
3. For any p_b, rates greater than $R(p_b)$ are not achievable.

4. Draw and explain any two SNR trade off codes.

By increasing the bandwidth alone, the capacity cannot be increased to any desired value.

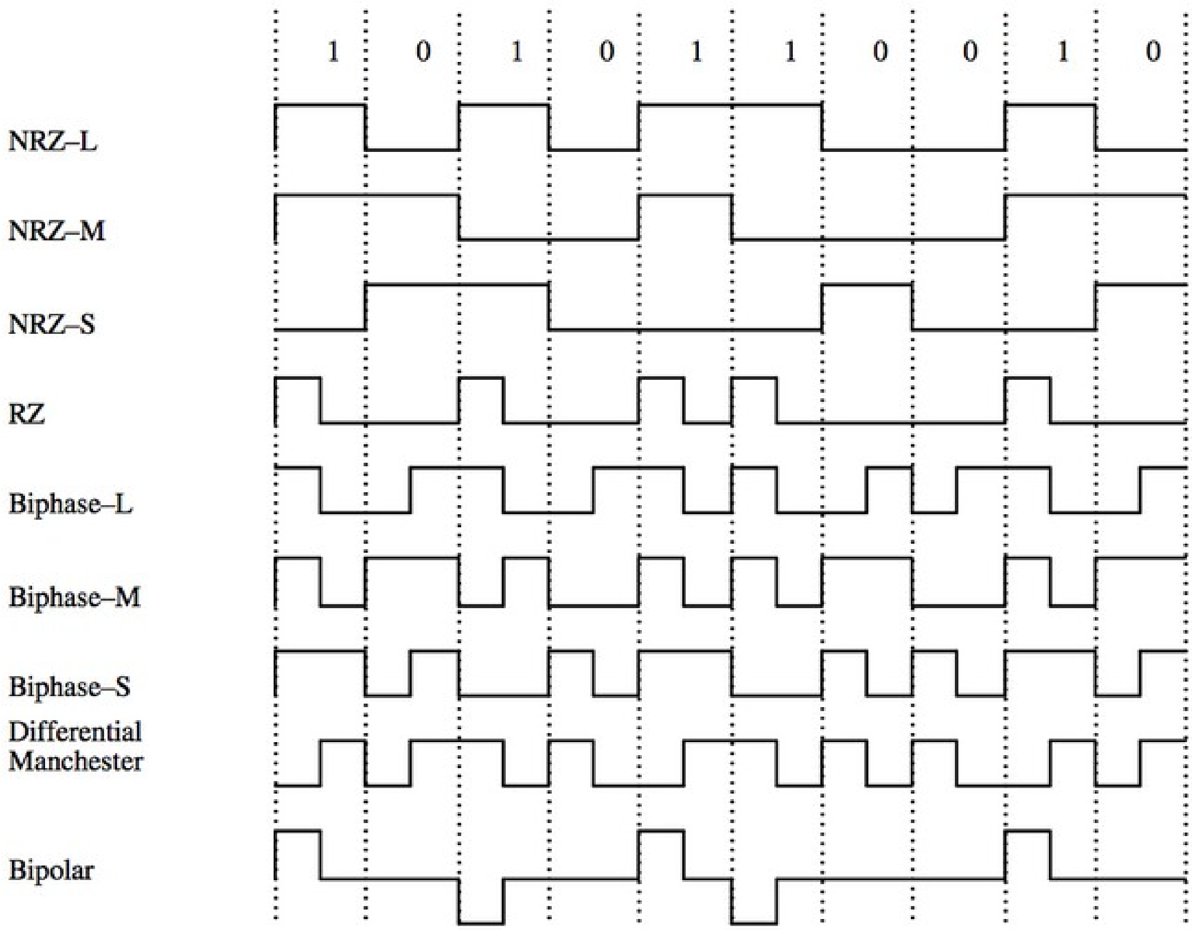
← NRZ - In telecommunication, a non-return-to-zero line code is a binary code in which ones are represented by one significant condition, usually a positive voltage, while zeros are represented by some other form.

RZ- **RZ (return-to-zero**) refers to a form of **digital** data transmission in which the binary low and high states, represented by numerals 0 and 1, are transmitted by voltage pulses having certain characteristics



There exists a limiting value of below which there can be no error-free communication at any information rate.

← . The signal state is determined by the voltage during the first half of each data binary digit .



5. Write notes on Error-correcting codes.

Error-correcting codes at fixed SNR influence the error performance in two ways:

1. Improving effect:
   - The larger the redundancy, the greater the error-correction capability
2. Degrading effect:
   - Energy reduction per channel symbol or coded bits for real-time applications due to faster signaling.
3. The degrading effect vanishes for non-real time applications when delay is tolerable, since the channel symbol energy is not reduced.

- Hamming codes constitute a class of single-error correcting codes defined as:

$n = 2^r - 1$, $k = n - r$, $r > 2$

- The minimum distance of the code $d_{min} = 3$
- Hamming codes are perfect codes.

6. Explain in detail about block codes .

A block code is a rule for converting a sequence of source bits , of length K, say, into a transmitted sequence of length N bits, where, in order to add redundancy, N will of course be greater than K. A neat example of a block code is the (7,4) Hamming code, which transmits N=7 bits for every K=4 source bits

An (n, k) linear systematic code is completely specified by a k × n generator matrix of the following form.

$$G = \begin{bmatrix} \bar{g}_0 \\ \bar{g}_1 \\ \vdots \\ \bar{g}_{k-1} \end{bmatrix} = [I_k P]$$

where *Ik is the k × k identity matrix.*

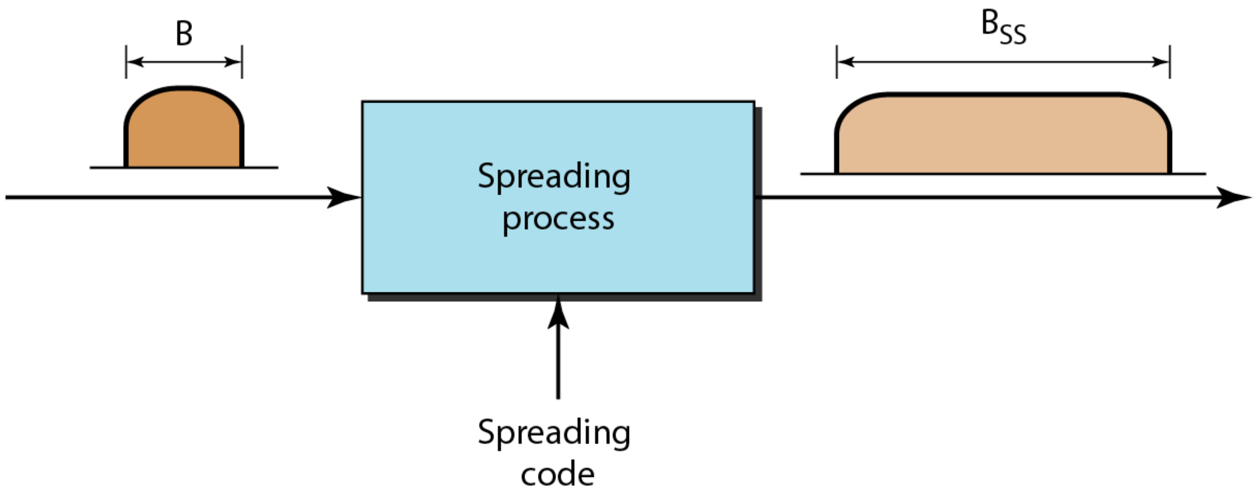
- The number of code word is 2^k since there are 2^k distinct messages.
- The set of vectors $\{g_i\}$ are linearly independent since we must have a set of unique code words.
- linearly independent vectors mean that no vector g_i can be expressed as a linear combination of the other vectors.
- These vectors are called biases vectors of the vector space C.
- The dimension of this vector space is the number of the basis vector which are *k*.
- $G_i \in C \rightarrow$ the rows of G are all legal code words.

UNIT-IV

1. Draw and explain Direct Sequence Spread Spectrum technique.

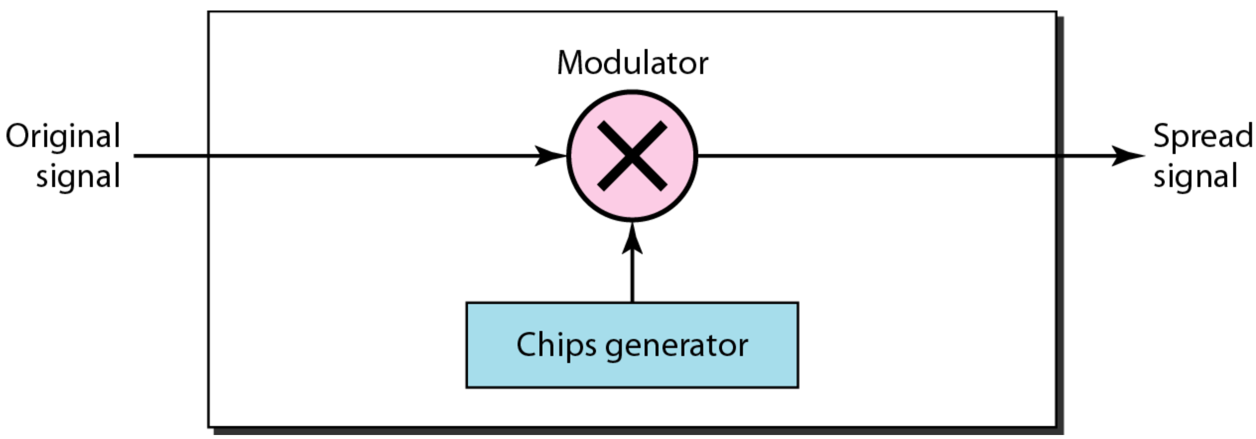
Spread Spectrum

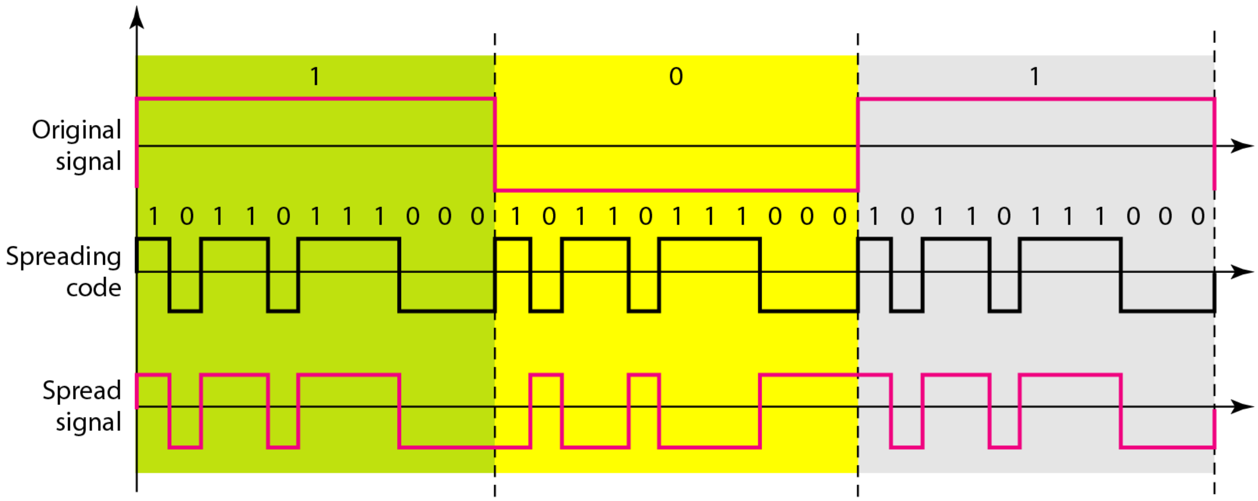
In spread spectrum (SS), we combine signals from different sources to fit into a larger bandwidth, but our goals are to prevent eavesdropping and jamming. To achieve these goals, spread spectrum techniques add redundancy.



DSSS

In DS-SS, the message signal is multiplied by a Pseudo Random Noise Code (PN code), which has noise-like properties. Each user has his own codeword which is orthogonal to the codes of other users. In order to detect the user, the receiver is required to know the codeword used by the transmitter. Unlike TDMA, CDMA does not require time synchronization between the users.





2. Explain in detail about FDMA.

FDMA is one of the earliest multiple-access techniques for cellular systems when continuous transmission is required for analog services. In this technique the bandwidth is divided into a number of channels and distributed among users with a finite portion of bandwidth for permanent use. The vertical axis that represents the code is shown here just to make a clear comparison with CDMA (discussed later in this chapter). The channels are assigned only when demanded by the users. Therefore when a channel is not in use it becomes a wasted resource. FDMA channels have narrow bandwidth (30Khz). For this reason, although x[n] is strictly the nth number in the sequence, we often refer to it as the nth sample. We also often refer to \the sequence x[n]" when we mean the entire sequence. Discrete-time signals are often depicted graphically as follows:

They are usually implemented in narrowband systems. Since the user has his portion of the bandwidth all the time, FDMA does not require synchronization or timing control, which makes it algorithmically simple. Even though no two users use the same frequency band at the same time, guard bands are introduced between frequency bands to minimize adjacent channel interference. Guard bands are unused frequency slots that separate neighboring channels. This leads to a waste of bandwidth. When continuous transmission is not required, bandwidth goes wasted since it is not being utilized for a portion of the time. In wireless communications, FDMA achieves simultaneous transmission and reception by using Frequency division duplexing (FDD). In order for both the transmitter and the receiver to operate at the same time, FDD requires duplexers.

4. Explain in detail about TDMA.

In digital systems, continuous transmission is not required because users do not use the allotted bandwidth all the time. In such systems, TDMA is a complimentary access technique to FDMA. Global Systems for Mobile communications (GSM) uses the TDMA technique. In TDMA, the entire bandwidth is available to the user but only for a finite period of time. In most cases the available bandwidth is divided into fewer channels compared to FDMA and the users are allotted time slots during which they have the entire channel bandwidth at their disposal. TDMA requires careful time synchronization since users share the bandwidth in the frequency domain. Since the number of channels are less, inter channel interference is almost negligible, hence the guard time between the channels is considerably smaller. Guard time is a spacing in time between the TDMA bursts. In cellular communications, when a user moves from one cell to another there is a chance that user could experience a call loss if there are no free time slots available. TDMA uses different time slots for transmission and reception. This type of duplexing is referred to as Time division duplexing (TDD). TDD does not require duplexers.

5. Explain in detail about CDMA.

Code Division Multiple Access

- In CDMA, all the users occupy the same bandwidth, however they are all assigned separate codes, which differentiates them from each other.
- CDMA systems utilize a spread spectrum technique in which a spreading signal, which is uncorrelated to the signal and has a large bandwidth, is used to spread the narrow band message signal.
- Direct Sequence Spread Spectrum (DS-SS) is most commonly used for CDMA.
- In DS-SS, the message signal is multiplied by a Pseudo Random Noise Code (PN code), which has noise-like properties.
- Each user has his own codeword which is orthogonal to the codes of other users. In order to detect the user, the receiver is required to know the codeword used by the transmitter.
- Unlike TDMA, CDMA does not require time synchronization between the users.

- A CDMA system experiences a problem called self-jamming which arises when the spreading codes used for different users are not exactly orthogonal. While dispreading, this leads to a significant contribution from other users to the receiver decision statistic. If the power of the multiple users in a CDMA system is unequal, then the user with the strongest signal power will be demodulated at the receiver.
- The strength of the received signal raises the noise floor for the weaker signals at the demodulators.
- This reduces the probability that weaker signals will be received. This problem, known as the near-far problem can be taken care of by using power control.
- This ensures that all the signals within the coverage of the base station arrive with same power at the receiver.

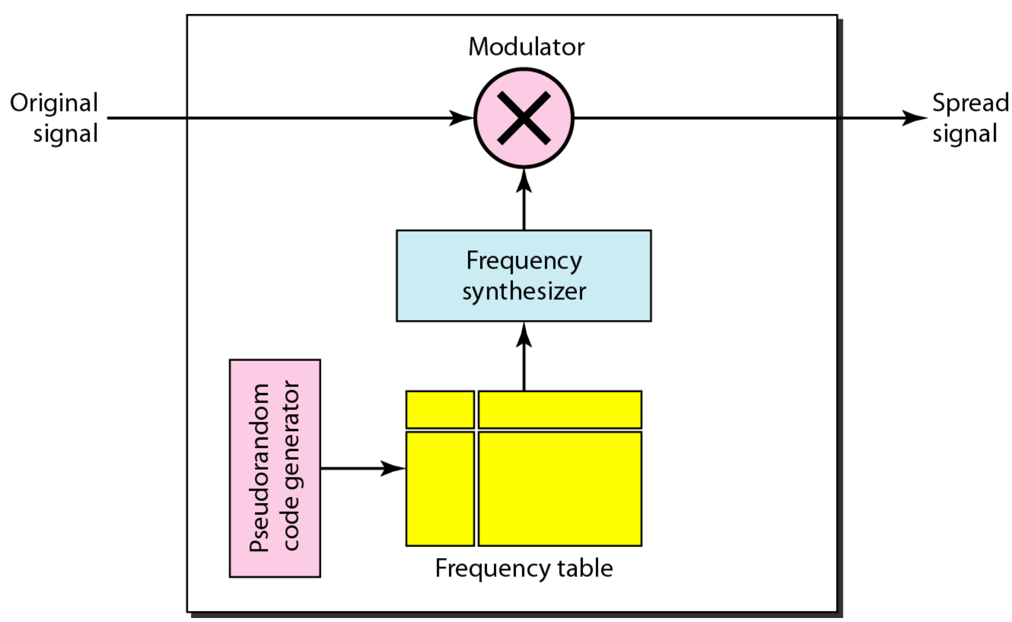
6. Write notes on SDMA.

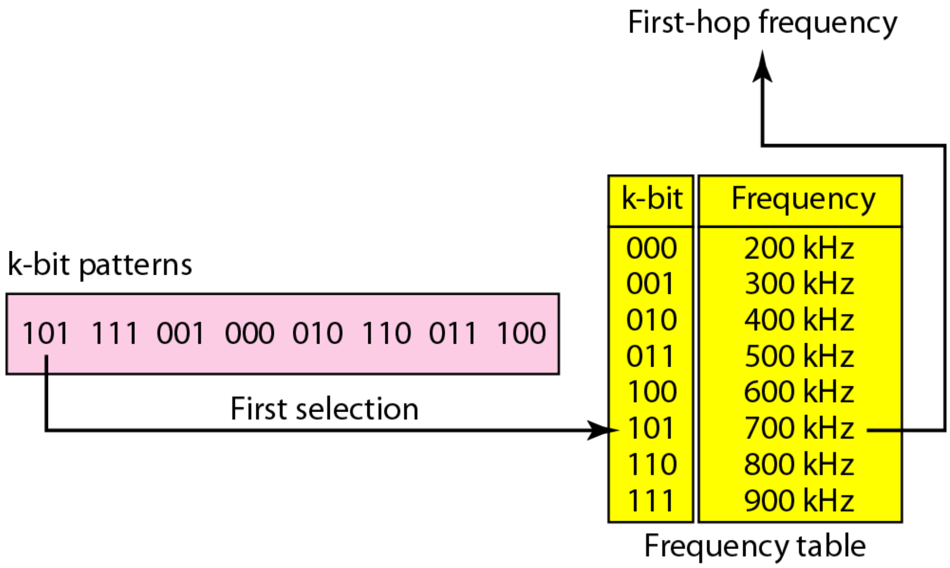
Space Division Multiple Access (SDMA)

- SDMA utilizes the spatial separation of the users in order to optimize the use of the frequency spectrum.
- A primitive form of SDMA is when the same frequency is re-used in different cells in a cellular wireless network.
- However for limited co-channel interference it is required that the cells be sufficiently separated.
- This limits the number of cells a region can be divided into and hence limits the frequency re-use factor.
- A more advanced approach can further increase the capacity of the network. This technique would enable frequency re-use within the cell.
- It uses a Smart Antenna technique that employs antenna arrays backed by some intelligent signal processing to steer the antenna pattern in the direction of the desired user and places nulls in the direction of the interfering signals.
- Since these arrays can produce narrow spot beams, the frequency can be re-used within the cell as long as the spatial separation between the users is sufficient.

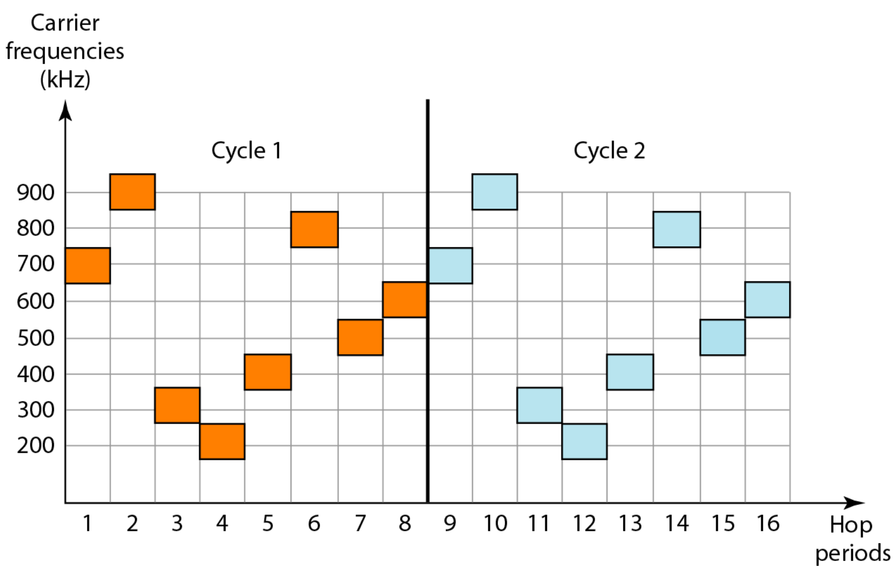
- In a practical cellular environment it is improbable to have just one transmitter fall within the receiver beam width.
- Therefore it becomes imperative to use other multiple access techniques in conjunction with SDMA.
- When different areas are covered by the antenna beam, frequency can be re-used, in which case TDMA or CDMA is employed, for different frequencies FDMA can be used.

7. Draw and explain Frequency Hop Spread Spectrum technique.

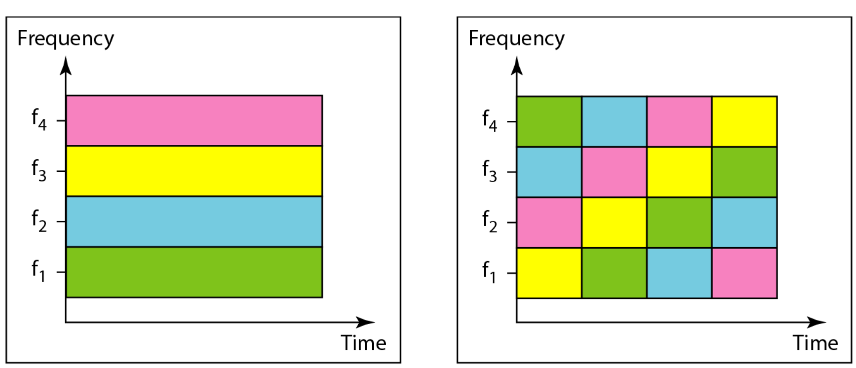




FHSS cycles



Bandwidth sharing



a. FDM b. FHSS

- A signal that occupies a bandwidth of B, is spread out to occupy a bandwidth of B_{ss}
- All signals are spread to occupy the same bandwidth B_{ss}
- Signals are spread with different codes so that they can be separated at the receivers.
- Signals can be spread in the frequency domain or in the time domain.

8. Write notes on merits and applications wireless communication.

Wireless communications

Applications

- Communication radio
- Wireless networks
- Cellular phones
- Short range communication
- **advantages:**
  - mobility
  - a wireless communication network is a solution in areas where cables are impossible to install (e.g. hazardous areas, long distances etc.)
  - easier to maintain
- **disadvantages:**
  - has security vulnerabilities
  - high costs for setting the infrastructure
  - unlike wired comm., wireless comm. is influenced by physical obstructions, climatic conditions, interference from other wireless devices

UNIT-V

1. Explain in detail about satellite and types of orbits.

- A satellite communication system will have a number of users operating via a common satellite transponder, and this calls for sharing of the resources of power, bandwidth and time.
- Here we describe these techniques and examine their implications, with emphasis on principles rather than detailed structure or parameters of particular networks, which tend to be very system specific.
- The term used for such sharing and management of a number of different channels is multiple access.

Types of Satellite Orbits

There are three basic kinds of orbits, depending on the satellite's position relative to Earth's surface:

- **Geostationary** orbits (also called **geosynchronous** or **synchronous**) are orbits in which the satellite is always positioned over the same spot on Earth. Many geostationary satellites are above a band along the equator, with an altitude of about 22,223 miles, or about a tenth of the distance to the Moon. The "satellite parking strip" area over the equator is becoming congested with several hundred television, weather and communication satellites! This congestion means each satellite must be precisely positioned to prevent its signals from interfering with an adjacent satellite's signals. Television, communications and weather satellites all use geostationary orbits. Geostationary orbits are why a DSS satellite TV dish is typically bolted in a fixed position.
- The scheduled Space Shuttles use a much lower, **asynchronous** orbit, which means they pass overhead at different times of the day. Other satellites in asynchronous orbits average about 400 miles (644 km) in altitude.
- In a **polar** orbit, the satellite generally flies at a low altitude and passes over the planet's poles on each revolution. The polar orbit remains fixed in space as Earth rotates inside the orbit. As a result, much of Earth passes under a satellite in a polar orbit. Because polar orbits achieve excellent coverage of the planet, they are often used for satellites that do mapping and photography.

2. Explain in detail about optical fibre and its types.

OPTICAL FIBRE:

- An **optical fiber** is a flexible, transparent fiber made of very pure glass (silica) not much bigger than a human hair that acts as a waveguide, or "light pipe", to transmit light between the two ends of the fiber.
- The field of applied science and engineering concerned with the design and application of optical fibers is known as **fiber optics**.
- Optical fibers are widely used in fiber-optic communications, which permits transmission over longer distances and at higher bandwidths (data rates) than other forms of communication.
- Fibers are used instead of metal wires because signals travel along them with less loss and are also immune to electromagnetic interference.
- Fibers are also used for illumination, and are wrapped in bundles so they can be used to carry images, thus allowing viewing in tight spaces. Specially designed fibers are used for a variety of other applications, including sensors and fiber lasers.
- An optical fiber junction box. The yellow cables are single mode fibers; the orange and blue cables are multi-mode fibers: 50/125 µm OM2 and 50/125 µm OM3 fibers respectively.
- Optical fiber typically consists of a transparent core surrounded by a transparent cladding material with a lower index of refraction. Light is kept in the core by total internal reflection. This causes the fiber to act as a waveguide.
- Fibers that support many propagation paths or transverse modes are called multi-mode fibers (MMF), while those that only support a single mode are called single-mode fibers (SMF).
- Multi-mode fibers generally have a larger core diameter, and are used for short-distance communication links and for applications where high power must be transmitted. Single-mode fibers are used for most communication links longer than 1,050 meters (3,440 ft).

3. Explain in detail about various types of optical detectors used in communication.

- The detection of optical radiation is usually accomplished by converting the optical energy into an electrical signal.
- Optical detectors include photon detectors, in which one photon of light energy releases one electron that is detected in the electronic circuitry, and thermal detectors, in which the optical energy is converted into heat, which then generates an electrical signal.
- Often the detection of optical energy must be performed in the presence of noise sources, which interfere with the detection process.
- The detector circuitry usually employs a bias voltage and a load resistor in series with the detector.
- The incident light changes the characteristics of the detector and causes the current flowing in the circuit to change.
- The output signal is the change in voltage drop across the load resistor. Many detector circuits are designed for specific applications.

Avalanche photodetectors (APDs) are used in long-haul fiber optic systems, since they have superior sensitivity, as much as 10 dB better than PIN diodes. Basically, an APD is a P-N junction photodiode operated with high reverse bias.

The materials is typically InP/InGaAs. With the high applied potential, impact ionization from the light wave generates electron-hole pairs that subsequently cause an avalanche across the potential barrier. This current gain gives the APD its greater sensitivity. APDs are commonly used up to 2.5 Gbps and sometimes to 10 Gbps if the extra cost can be justified.

Silicon photodiodes (APDs) are used in lower frequency systems (up to 1.5 or 2 GHz) where they can meet low cost and modest frequency response requirements.

Si devices are used in pairs in wavelength sensors. The ratio of longer and shorter wavelength sensors is proportional to the input wavelength. Hopefully, this short tutorial provides a useful introduction to an important part of optical communication systems.

4. Write notes on INSAT and INTELSAT.

INSAT

- The Indian National Satellite (INSAT) system was commissioned with the launch of INSAT-1B in August 1983 (INSAT-1A, the first satellite was launched in April 1982 but could not fulfil the mission).
- INSAT system ushered in a revolution in India's television and radio broadcasting, telecommunications and meteorological sectors.
- It enabled the rapid expansion of TV and modern telecommunication facilities to even the remote areas and off-shore islands. Together, the system provides transponders in C, Extended C and K_u bands for a variety of communication services.
- Some of the INSATs also carry instruments for meteorological observation and data relay for providing meteorological services. KALPANA-1 is an exclusive meteorological satellite. The satellites are monitored and controlled by Master Control Facilities that exist in Hassan and Bhopal.

INTELSAT

Intelsat, S.A. is a communications satellite services provider. Originally formed as International Telecommunications Satellite Organization (ITSO, or **INTELSAT**), it was—from 1964 to 2001—an intergovernmental consortium owning and managing a constellation of communications satellites providing international broadcast services.

5. Explain various optical sources in detail.

The basic concept behind the **optical** transmitter is that it converts electrical input signals into modulated light for transmission over an **optical** fiber used **optical sources** for generating the light pulses. These are light emitting diode (LED) and Laser Diode (LD).

- LEDs
- SLEDs – Surface Emitting LEDs
- ELEDs – Edge Emitting LEDs
- LDs – Laser Diodes
- Tunable Lasers

<u>LED</u>

- Emits incoherent light through spontaneous emission.
- Used for Multimode systems w/ 100-200 Mb/s rates.

- Broad spectral width and wide output pattern.
- 850nm region: GaAs and AlGaAs
- 1300–1550nm region: InGaAsP and InP
- Two commonly used types: ELEDs and SLEDs