

DEPARTMENT OF ELECTRONICS AND COMMUNICATION**EC 8491-COMMUNICATION THEORY****UNIT-I AMPLITUDE MODULATION****1. Define modulation?**

Modulation is a process by which some characteristics of high frequency carrier signal is varied in accordance with the instantaneous value (amplitude) of the modulating signal.

2. What are the types of Analog modulation?

(i) Amplitude modulation.

- Conventional AM
- DSB-SC (Double Sideband Suppressed Carrier)
- SSB (Single Sideband)
- VSB (Vestigeal Side Band)

(ii) Angle Modulation

- Frequency modulation
 - Narrowband FM
 - Wideband FM
- Phase modulation.

3. What is the need for modulation?

- a. To reduce antenna height
- b. To avoid interference and noise
- c. For narrowbanding of signals
- d. For multiplexing

4. Define the term modulation index for AM.

Modulation index is the ratio of amplitude of modulating signal (V_m) to amplitude of carrier (V_c).
(i.e) $\mu = V_m/V_c$

5. What are the degrees of modulation?

- a) Under modulation ($\mu < 1$)
- b) Critical modulation ($\mu = 1$)
- c) Over modulation ($\mu > 1$)

6. Define Amplitude Modulation.

In amplitude modulation, the amplitude of a carrier signal is varied according to variations in amplitude of modulating signal.

The AM signal can be represented mathematically as, $AM = (A_c + A_m \sin \omega_m t) \sin \omega_c t$ and the modulation index is given as, $\mu = A_m/A_c$

7. State the Limitations of Amplitude modulation

- Wastage of Power
- Wastage of bandwidth

8. Define VSB and state any one of its application (NOV 2016)

Vestigial Sideband Modulation is defined as a modulation in which one of the sideband is partially suppressed and the vestige of the other sideband is transmitted to compensate for that suppression. VSB is used for video transmission in TV.

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9. A carrier is frequency modulated to a depth of 80%. Calculate the total power in the modulated wave, if the carrier is 10 watt (April 2015)

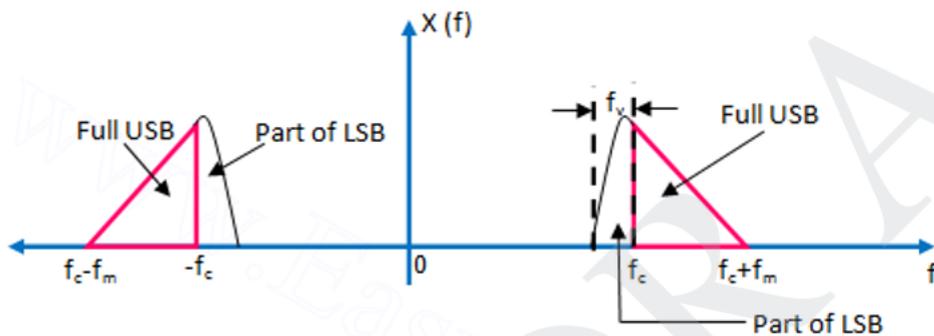
$$P_t = P_c \left(1 + \frac{\mu^2}{2} \right)$$

$$P_t = 10 \left(1 + \frac{(0.8)^2}{2} \right)$$

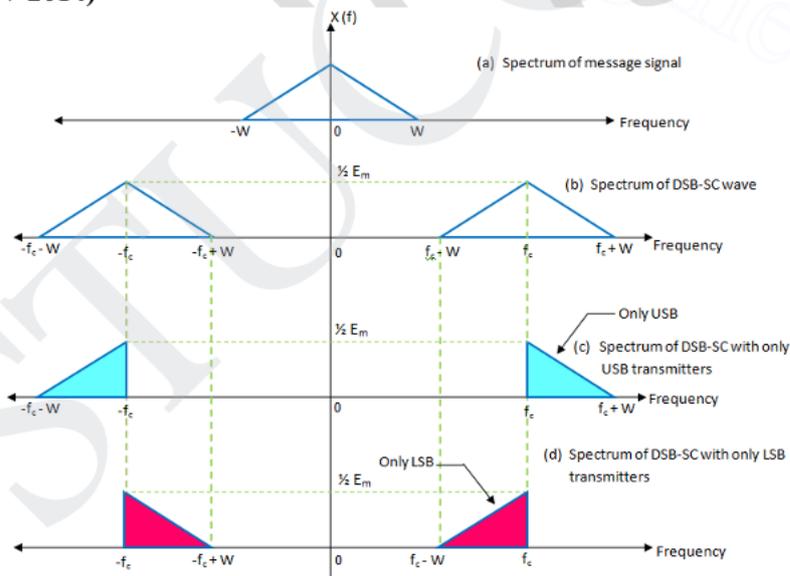
$$P_t = 13.2 \text{ watt}$$

10. Draw the Frequency spectrum of VSB. Where it is used? (April 2015)

VSB is used in video transmission. The spectrum of VSB is



14. Consider the signal whose spectrum is as shown in Figure. Modulates the sinusoidal carrier signal of 1MHz. Draw the spectrum of DSB-SC signal and SSB-SC (upper sideband) signal. (Nov-2014)



Here $f_c=1\text{MHz}$

15. Suggest a modulation scheme for the broadcast video transmission and justify. (Nov-2014, Nov 2016)

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In TV Transmission Vestigial Sideband modulation (VSB) is used for video transmission because video signal exhibits a large bandwidth and significant low-frequency content. Due to the vestige of the other sideband, there is no need for selective filtering in the lower end.

16. State the difference between single sideband and vestigial sideband transmission systems (May 2014)

SSB	VSB
One sideband is transmitted fully and other sideband is rejected fully.	One sideband is transmitted fully and a small part (i.e. vestige) of the other sideband is transmitted.
Bandwidth is $BW_{SSB} = W$, where W is message frequency band.	Bandwidth is $BW_{VSB} = W + v$, where v is vestigial frequency band.
Selective filtering is required	Selective filtering is not required

17. For an AM system, the instantaneous values of carrier and modulating signal are $60 \sin(\omega_c t)$ and $40 \sin(\omega_m t)$ respectively. Determine the modulation index. (MAY 2014)

Here $c(t) = 60 \sin(\omega_c t)$ and $m(t) = 40 \sin(\omega_m t)$

The modulation index $\mu = \frac{A_m}{A_c} = \frac{40}{60} = 0.667$

18. Derive an equation for the modulated signal of an AM system (MAY 2014)

The modulated signal

$$u_{AM}(t) = A_c [1 + m(t)] \cos(2\pi f_c t + \phi_c)$$

Where A_c is carrier amplitude, $m(t)$ is message signal, f_c is carrier frequency and ϕ_c is carrier phase.

19. What are the advantages of converting the low frequency signal into high frequency signal?

- To reduce antenna height
- To avoid interference and noise
- For narrowbanding of signals
- For multiplexing

20. Compare bandwidth and power requirement in terms of carrier power P_c for AM, DSB-SC and SSB (May 2016, Nov 2016)

Modulation Type	Bandwidth	Power saving
AM	$2f_m$	33.33%
DSB-SC	$2f_m$	66.66%
SSB	f_m	83.3%
VSB	$f_m + f_v$	<83.3% and >66.66%

21. What is Super Heterodyne Receiver?

The super heterodyne receiver converts all incoming RF frequencies to a fixed lower frequency, called intermediate frequency (IF). This IF is then amplified and detected to get the original signal.

22. What is single tone and multi tone modulation?

If modulation is performed for a message signal with more than one frequency component then the modulation is called multi tone modulation.

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If modulation is performed for a message signal with one frequency component then the modulation is called single tone modulation.

23. What are the advantages of VSB-AM?

1. It has bandwidth greater than SSB but less than DSB system.
2. Power transmission greater than DSB but less than SSB system.
3. No low frequency component lost. Hence it avoids phase distortion.

24. Define Coherent Detection.

During Demodulation carrier is exactly coherent or synchronized in both the frequency and phase, with the original carrier wave used to generate the DSB-SC wave. This method of detection is called as coherent detection or synchronous detection.

26. What are the advantages of signal sideband transmission?

- a) Power consumption
- b) Bandwidth conservation
- c) Noise reduction

27. What are the disadvantages of single side band transmission?

- a) Generation of SSB signal is difficult.
- b) Selective filtering is done to get back the original signal.
- c) Phase shifter should be of 90 degree exactly.

PART B

1. (a) Define Amplitude Modulation. How amplitude modulated signal can be generated using a non-linear modulator circuit.
(b) What is a DSB-SC signal? Write the working of a synchronous detector used to detect a DSB-SC signal with the output amplitude spectrum of each block
2. (a) Discuss in detail about frequency modulation and frequency division multiplexing technique with diagram
(b) Compare Amplitude Modulation and Frequency Modulation
3. Explain about Super Heterodyne Receiver with neat diagram (April 2015)
4. Derive the expression for DSB-SC AM and calculate its power & efficiency. Explain a method to generate and detect it.
5. (a) Discuss the methods of generation of DSBSC signal using Costas loop.
(b) Compare the characteristics of DSBFC, DSBSC, SSBFC, SSBSC schemes
6. (a) Explain the generation of SSB SC signal using phase shift method
(b) Suggest a scheme for recovering the message signal from the signal $s(t) = 2m(t) \cos 2\pi f_c t$. Explain the same.
7. (i) An AM signal is generated by modulating the carrier $f_c = 800\text{MHz}$ by the signal $m(t) = \sin 3000\pi t + 0.5 \cos 5000\pi t$. The AM signal $s(t) = 100[1 + m(t)] \cos 2\pi f_c t$ is fed to a 50ohm load
(a) Determine the average power in the carrier and in the sidebands
(b) Find the modulation index and peak power delivered to the load
(ii) Explain the function of switching modulator in the generation of AM signal
8. Explain the need for carrier suppression in an AM system. Draw and explain the functioning of one such system.
9. Explain the working of an AM transmitter and that of a receiver with a suitable block schematic

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10. (a) Discuss on the frequency components present in a periodic and non periodic signal.
(b) Derive the equation of an AM wave. Also draw the modulated AM wave for various modulation index
(c) The antenna current of an Am transmitter is 8 ampere when only the carrier is sent. The current increases to 8.93A when the carrier is modulated by a single wave. Find the percentage modulation
11. (a) Draw the VSB spectrum and explain the significance.
(b) How do you demodulate AM signal? Explain
(c) A 100 KHz carrier is simultaneously AM modulated with 300 Hz, 800Hz and 1.5 KHz audio sine wave. What will be the frequencies present in the output?

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UNIT-II ANGLE MODULATION

1. Define frequency modulation.

Frequency modulation is defined as the process by which the frequency of the carrier wave is varied in accordance with the instantaneous amplitude of the modulating or message signal.

2. Define phase modulation.

Phase modulation is defined as the process of changing the phase of the carrier signal in accordance with the instantaneous amplitude of the message signal.

3. What are the types of Frequency Modulation?

Narrowband FM (modulation index $\beta \ll 1$)

Wideband FM (modulation index $\beta \gg 1$)

4. What is the basic difference between an AM signal and a narrowband FM signal?

The spectrum of AM and NBFM are identical except that the spectral component at $f_c - f_m$ (lower side frequency) is 180 degrees out of phase.

5. What are the two methods of producing an FM wave?

Basically there are two methods of producing an FM wave. They are,

- i) Direct method: In this method the transmitter originates a wave whose frequency varies as a function of the modulating source. It is used for the generation of NBFM.
- ii) Indirect method: In this method the transmitter originates a wave whose phase is a function of the modulation. Normally it is used for the generation of WBFM where WBFM is generated from NBFM.

6. Define phase deviation.

The maximum phase deviation of the total angle from the carrier angle is called phase deviation.

7. Define frequency Deviation.

The maximum departure of the instantaneous frequency from the carrier frequency is called frequency deviation.

8. Define the deviation ratio D for non-sinusoidal modulation.

The deviation ratio D is defined as the ratio of the frequency deviation f , which corresponds to the maximum possible amplitude of the modulation signal $m(t)$, to the highest modulation frequency. $D = \Delta f / f_m$

9. Compare the power and bandwidth requirements of AM, FM, and PM

	AM	FM	PM
Power	$P_t = P_c(1 + \mu^2/2)$ $\mu =$ modulation index of AM	$P_t = P_c = A_c^2/2$ A_c is carrier amplitude	$P_t = P_c = A_c^2/2$, A_c is carrier amplitude
Bandwidth	AM : $2f_m$ DSB-SC: $2f_m$ SSB-SC : f_m VSB : $f_m + 2f_v$	NBFM : $2f_m$ WBFM : $2(\beta_{FM} + 1) f_m$ β_{FM} is the modulation index of FM	PM : $2(\beta_{PM} + 1) f_m$ β_{PM} is the modulation index of PM

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10. What are the disadvantages of FM system?

1. A much wider channel is required by FM.
2. FM transmitting and receiving equipments tend to be more complex and hence it is expensive.

11. How will you generate message from frequency-modulated signals?

First the frequency-modulated signals are converted into corresponding amplitude modulated signal using frequency dependent circuits. Then the original signal is recovered from this AM signal.

12. What are the applications of phase locked loop?

Phase locked loops are used for various purposes in AM and FM communication.

- (i) Automatic frequency correction in FM transmitter uses PLL to keep carrier frequency constant.
- (ii) PLL is used direct FM transmitter uses PLL to keep carrier frequency constant.
- (iii) PLL is also used in FM demodulators.

13. Define the modulation index of FM. (Nov 2016)

It is defined as the ratio of maximum frequency deviation to the modulating frequency.

$$\beta = \Delta f / f_m$$

14. How is the narrow band FM converted into wide band FM?

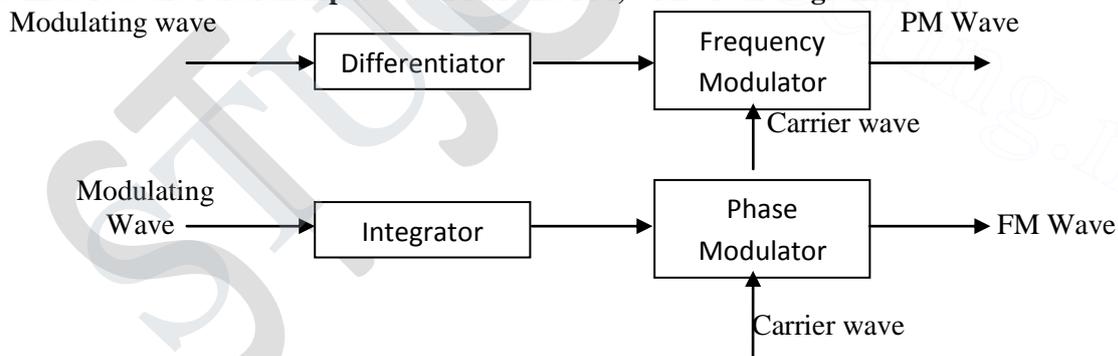
The narrowband FM signal can be converted to a wideband FM signal by simply passing it through a non-linear device with power P . Both the carrier frequency and the frequency deviation Δf of the narrowband signal are increased by a factor P .

15. A carrier is frequency modulated by a sinusoidal modulating frequency 2 KHz, resulting in frequency deviation of 5 kHz. What is the bandwidth occupied by the modulated waveform?

Given: $f_m = 2$ kHz, $\Delta f = 5$ kHz.

To find: Bandwidth of the modulated signal $BW = 2(\Delta f + f_m) = 2(5 \times 10^3 + 2 \times 10^3)$
 $BW = 14$ kHz.

16. Illustrate the relationship between FM and PM, with block diagrams.



17. What is the transmission bandwidth of FM? (Nov 2015)

Bandwidth of Narrowband FM = $2f_m$
 Bandwidth of WBFM or FM = $2(1+\beta)f_m$
 Where β is modulation index of FM

18. What is the indirect method of FM generation (Nov 2015)

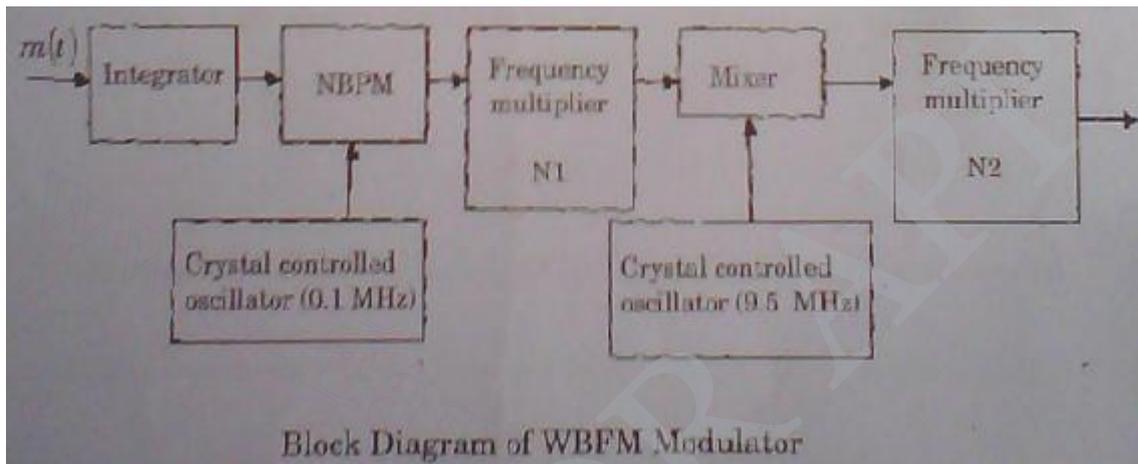
or

Compare narrow band FM and wide band FM.

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Sl.No	Parameter/ Characteristics	Wideband FM	Narrowband FM
1.	Modulation Index	Greater than 1	Less than (or) slightly greater than 1
2.	Maximum deviation	75 KHz	5KHz
3.	Range of modulating frequency	30 Hz to 15 KHz	30 Hz to 3 KHz
4.	Bandwidth	$2(\Delta f + f_m)$	$2f_m$



19. State the Carson’s rule. April 2015

Carson has proved that the number of sidebands having significant amplitudes containing 99% of the total power is $1+\beta$. (ie). The bandwidth of FM is $2(1+\beta)f_m$, Where β is modulation index of FM

20. List the advantages and disadvantages of FM over AM (Nov 2014)

Advantages of FM over AM

- All the transmitted power in FM is useful, while in AM most of the transmitted power is in carrier which contains no information.
- The amplitude of FM is constant which makes it independent of the modulation depth, while in AM modulation depth directs the transmitted power.
- Noise in FM is reduced to a large extent by employing amplitude limiters to remove the amplitude variations caused by noise. However these amplitude limiters cannot be used in AM as information is contained in the amplitude variations of the signal. Thus FM reception is immune to noise than AM reception.
- The noise in FM can be further reduced by increasing the deviation, which is not in AM.
- In FM if there are two or more signals received at the same frequency, the FM receiver will capture the stronger signal and eliminate the weaker signal. However in AM if there are two more signals received at the same frequency, then both will be demodulated which can lead to interference.
- FM broadcast operates in the upper VHF and UHF range, where noise effects are minimal. While on the other hand AM broadcast operates in the medium frequency (MF) and high frequency (HF) which are easily affected due to noise.

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Disadvantages of FM over AM

- FM has infinite number of sidebands, while there are only two sidebands in AM.
- The channel bandwidth in FM is much higher, up to 10 times as that of AM, whereas AM has narrow channel bandwidth which is $2f_m$.
- The design of FM transmitter and receiver is relatively complex for the modulation and demodulation purpose as compared to AM transmitter and receiver
- FM transmission and reception equipment is expensive as the circuitry is complex as compared to AM equipments which are inexpensive and relatively simple.
- In FM since the reception is limited to line of sight, the area of reception for FM is much smaller than for AM.

21. Why is frequency modulation is preferable for voice transmission? (May 2014)

The main advantage of FM is its immunity to noise, the static surrounding the transmission path. In situations where the AM signal will be totally swamped by the noise, FM will come across as a clear winner, totally unaffected. The noise is additive to the amplitude, but to affect the frequency, you really need some complex circuits and that surely is a boon for FM. Noise adds to the FM amplitude no doubt, but the signal is contained in its frequency changes.

PART B

1. The message signal $m(t) = a \cos 2\pi f_m t$ is used to either frequency modulated or phase modulate the carrier $A_c \cos 2\pi f_c t$ Find the modulated signal in each case.
 - (a) Bring out the relationship between PM and FM
 - (b) Describe a method each for generation and demodulation of FM signal
2. (i) Explain how FM is achieved using varactor diodes.
(ii) Make atleast five comparisons of AM and FM systems.
3. (i) Derive the expression for the single tone frequency modulated signal and hence prove that is the constant envelope modulation requiring infinite bandwidth.
(ii) Explain the operation of PLL as a FM demodulator
4. A carrier frequency of 80MHZ is frequency modulated by a sine wave amplitude of 20volts and frequency of 80MHZ.the frequency sensitivity of the modulator is 20KHZ/vdf.
5. (i) Determine the appropriate bandwidth of the FM wave by using carsons rule.
(ii) Determine the bandwidth by transmitting only those frequencies whose amplitude exceed 1% of the unmodulated carrier amplitude.
6. (i) Derive the expression for the single tone frequency modulated signal and hence prove that is the constant envelope modulation requiring infinite bandwidth.
(ii) Draw the typical spectrum of the FM
7. (i) Explain the FM discriminator with a suitable diagram.
(ii)How FM can be derived from PM and vice versa. Explain in detail.
8. (i) Derive the mathematical representation of FM waves.
(ii)When the modulating frequency in an FM system is 400Hz and the modulating voltage is 2.4V, the modulation index is 60. Calculate the maximum deviation. What is the modulating index when the modulating frequency is reduced to 250 Hz and the modulating voltage is simultaneously raised to 3.2V?

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9. (i) Derive the expression for wide band FM in terms of Bessel functions.
(ii) How phase and frequency modulation are related? Explain.
(iii) Differentiate Narrowband and Wideband FM.
- 10.(i) Explain the Armstrong method to generate FM signal .
(ii) Explain how the phase modulation is related to frequency modulation?
- 11.(i) When the modulating frequency in an FM system is 400Hz and the modulating voltage is 2.4V the modulation index is 60. Calculate the maximum deviation. What is the modulation index when the modulating frequency is reduced to 250Hz and the modulating voltage is simultaneously raised to 3.2V.
(ii) With necessary diagrams explain the operation of slope detector for demodulating FM signal.

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UNIT-III RANDOM PROCESS

1. Define white noise. State its power spectral density

The noise sources are Gaussian and have flat spectral density over a wide frequency range. If the noise spectrum has all frequency components in equal portion, then it is called as white noise. The power spectral density of white noise is independent of the operating frequency, which is given as

$$S_w(\omega) = N_0/2$$

2. Define a random variable. Specify the sample space and the random variable for a coin tossing experiment.

Random variable is defined as a rule or mapping from the original sample space to a numerical sample space subjected to certain constraints. Random variable is also defined as a function where domain is the set of outcomes and whose range is R , is the real line. All our random variables will be defined on finite sample spaces. The possible outcomes for one coin toss can be described by the sample space $\Omega = \{\text{heads, tails}\}$.

3. When is a random process called deterministic?

A random process represents an ensemble of time functions, the value of which at any given time can be pre-determined or specified – thus a deterministic process.

Ex: $X(t) = A \cos(\omega t + \Theta)$ where A and ω are constant and Θ is a random variable. Once the parameter Θ is determined, $X(t)$ as a function of time is entirely specified and is thus a deterministic process.

4. Define random process.

A random process is a collection of sample functions (random variable), each of which varies randomly with time, where random variable is observing a random process at a fixed instant of time.

5. Define noise.

Noise is defined as any unwanted form of energy, which tends to interfere with proper reception and reproduction of wanted signal.

6. Give the classification of noise.

Noise is broadly classified into two types. They are

- (i) External noise
- (ii) Internal noise.

7. Define signal to noise ratio.

Signal to noise ratio is the ratio of signal power to the noise power at the same point in a system.

8. Define thermal noise. Give the expression for the thermal noise voltage across a resistor.

The electrons in a conductor possess varying amounts of energy. A small fluctuation in this energy produces small noise voltages in the conductor. These random fluctuations produced by thermal agitation of the electrons is called thermal noise.

9. Give the characteristics of shot noise.

- (i) Shot noise is generated due to fluctuations in the number of electrons or holes.
- (ii) Shot noise has uniform spectral density.
- (iii) Mean square noise current depends upon direct component of current.

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(iv) Shot noise depends upon operating conditions of the device.

10. State Central Limit theorem.

Under certain conditions, the sum of the large number of independent random variables follows a Gaussian function irrespective of individual distributions. The central limit theorem states that the probability distribution of V_N approaches a normalized Gaussian distribution $N(0,1)$ in the limit as the number of random variables N approaches unity.

11. State the properties of a Gaussian Process

1. If a Gaussian Process $X(t)$ is applied to a stable linear filter, then the random process $Y(t)$ developed at the output of the filter is also Gaussian.
2. If a Gaussian Process is stationary, then the output process is also strictly stationary

12. State the conditions of wide sense stationary

1. Mean of the process $E[x(t)]$ is a constant
2. Autocorrelation $R_x(t, t+\tau)=R_x(\tau)$
3. Variance $C_x(0)< \infty$

13. Define Auto correlation

Auto correlation refers to the matching of the signal with a delayed version of itself

$$R_x(t) = \int x(t)x(t + \tau)f_{x(t)x(t+\tau)}dt$$

It provides the measure of how closely the signal matches a copy of itself as the copy is shifted to τ units in time.

14. Define power spectral density

Power spectral density is the characterization of random process in frequency domain. It is the Fourier Transform of autocorrelation of the random process.

$$S_x(t) = \int R_x(\tau)exp(-j2\pi f\tau)d\tau$$

15. Define Gaussian process.

A random process Y has Gaussian distribution if its has the following probability density function,

$$f_y(y) = \frac{1}{\sqrt{2\pi\sigma_y^2}}exp[-\frac{(y - \mu_r)^2}{2\sigma_y^2}]$$

Where μ_r is mean and σ_y^2 is variance of the process

16. Define Ergodicity .

A process where any member of the ensemble exhibits the same statistical behaviour as that of the whole ensemble

Ensemble average= Time average of single realization

17. State the conditions for the process to be ergodic in mean

1. The time average $\mu_x(t)$ approaches the nsemble average μ_x in the limit as the observation interval T approaches infinity
2. Variance of $\mu_x(t)$ approaches 0 in the limit as the observation interval T approaches infinity.

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PART B

1. Write short notes on Shot noise, Thermal noise and white noise
 2. Write the details about narrow band noise and the properties of quadrature components of narrowband noise
 3. Given a random process $X(t)=A \cos (wt+\mu)$ where A and w are constants and μ is a uniform random variable. Show that X(t) is ergodic in both mean and autocorrelation.
(b)When is a random process said to be strict sense stationary (SSS), Wide sense stationary (WSS) and Ergodic process.
 4. (a) Two random processes $X(t)=A \cos (wt+\theta)$ where A and w are constants and θ is uniformly distributed random variable in $(0, 2\pi)$. Find the cross correlation function.
(b) Explain in detail about the transmission of a random process through a linear time invariant filter
 5. Write the details about narrow band noise and the properties of quadrature components of narrowband noise
 6. (a)What is meant by narrowband noise? Explain the characteristics of narrow band noise
(b) An AWGN of power spectral density $1 \mu W$ is fed through a filter with response

$$H(f) = \begin{cases} \frac{1}{2}; & |f| < 40kHz \\ 0 & elsewhere \end{cases}$$
- Calculate the noise power at the output of the filter.
7. (a) X is uniformly distributed as given below: may 2014
Find $E(X)$, $E[X^2]$, $E[\cos X]$, $E[(X-mx)^2]$.
 8. Define and explain the following:
 - (i) Gaussian noise and Gaussian distribution
 - (ii) Thermal noise
 - (iii) Shot noise
- What type of PDF does the Gaussian noise follow?
9. (a) Explain the following terms mean, correlation, covariance, ergodicity.
(b)How do you represent narrowband noise?
 10. State and prove various Gaussian processes
 11. Give a random process $X(t)= A \cos(\omega t + \theta)$, where A and θ are constants and θ is a uniform random variable. Show that X(t) is ergodic in both mean and autocorrelation
 12. State and discuss properties of autocorrelation function
 13. Explain the following In detail (a) Auto correlation and Cross correlation (b)Ergodic process (c) WSS random process
 14. (i) An AWGN of power spectral density $1\mu W$ is fed through a filter with frequency response $H(f) = 1/2 ; |f| < 40 kHz ; 0 ; elsewhere$ Calculate the noise power at the output of the filter.
(ii)Write a note on stationary processes and its classifications.
 15. (i)Explain about Transmission of random process through a Linear Time Invariant (LTI) filter.
(ii)Find the autocorrelation of a sequence $x(t) =A\cos(2\pi f_c(t+\theta))$ where A and f_c are constant and θ is a random variable that is uniformly distributed over the interval $[-\pi \pi]$
 16. State and prove the properties of power spectral density.

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As the carrier to noise ratio is reduced, clicks are heard in the receiver output. As the carrier to noise ratio reduces further, crackling, or sputtering sound appears at the receiver output. Near the breaking point, the theoretically calculated output signal to noise ratio becomes large, but its actual value is very small. This phenomenon is called threshold effect.

2. What is capture effect in FM?

When the noise interference is stronger than FM signal, then FM receiver locks to interference. This suppresses FM signal. When the noise interference as well as FM signal are of equal strength, then the FM receiver locking fluctuates between them. This phenomenon is called capture effect.

3. What is meant by figure of merit of a receiver?

The ratio of output signals to noise ratio to channel signal to noise ratio is called figure of merit.

4. What is the Purpose of re-emphasis and de-emphasis in FM?

The PSD of noise at the output of FM receiver increases rapidly at high frequencies but the PSD of message signal falls off at higher frequencies. This means the message signal doesn't utilize the frequency band in efficient manner. Such more efficient use of frequency band and improved noise performance can be obtained with the help of re-emphasis and de-emphasis.

5. What are extended threshold demodulators?

Threshold extension is also called threshold reduction. It is achieved with the help of FMFB demodulator. In the local oscillator is replaced by voltage controlled oscillator (VCO). The VC frequency changes as per low frequency variations of demodulated signal. Thus the receiver responds only to narrow band of noise centered around instantaneous carrier frequency. This reduces the threshold of FMFB receiver.

6. What is threshold effect with respect to noise?

When the carrier to noise ratio reduces below certain value, the message information is lost. The performance of the envelope detector deteriorates rapidly and it has no proportion with carrier to noise ratio. This is called threshold effect.

7. Define pre-emphasis and de-emphasis.

Pre-emphasis: It artificially emphasizes the high frequency components before modulation. This equalizes the low frequency and high frequency portions of the PSD and complete band is occupied.

De-emphasis: This circuit attenuates the high frequency components. The attenuation characteristic is exactly opposite to that of pre-emphasis circuit. De-emphasis restores the power distribution of the original signal. The signal to noise ratio is improved because of pre-emphasis and de-emphasis circuits.

8. Define superheterodyne principle.

It can be defined as the process of operation of modulated waves to obtain similarly modulated waves of different frequency. This process uses a locally generated carrier wave, which determines the change of frequency.

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9. Define signal to noise ratio.

Signal to noise ratio is the ratio of signal power to the noise power at the same point in a system.

10. What is threshold effect in an envelope detector? Explain.

When a noise is large compared to the signal at the input of the envelope detector, the detected output has a message signal completely mingled with noise. It means that if the input SNR is below a certain level, called threshold level, the noise dominates over the message signal, threshold is defined as value of the input signal to noise ratio (S_o/N_o) below which the output signal to noise ratio (S_i/N_i) deteriorates much more rapidly than the input signal to noise ratio. The threshold effect in an envelope detector whenever the carrier power-to-noise power ratio approaches unity or less.

11. Define noise temperature.

The available noise power is directly proportional to temperature and it is independent of value of resistance. This power specified in terms of temperature is called as noise temperature. It is denoted by T_e .

It is given as, $T_e = (F - 1) T$

12. What is shot noise?

When current flows in electronic device, the fluctuations number of electrons or holes generates the noise. It is called shot noise. Shot noise also depends upon operating conditions of the device.

13. Give the expression for noise voltage in a resistor.

The Mean –Square value of thermal noise voltage is given by, $V_n^2 = 4 kTB$
 k – Boltzmann constant, R – Resistance T – Absolute temperature, B - Bandwidth

14. What is narrowband noise?

The receiver of a communication system usually includes some provision for preprocessing the received signal. The preprocessing may take the form of a narrowband filter whose bandwidth is large enough to pass modulated component of the received signal essentially undistorted but not so large as to admit excessive noise through the receiver. The noise process appearing at the output of such filter is called narrow band noise.

15. Define noise equivalent bandwidth.

The noise equivalent bandwidth of the filter is defined as the bandwidth of an ideal filter at which the noise power passed by real filter and ideal filter is same.

16. Define noise factor.

Noise factor (F) is defined as the ratio of signal to noise power ratio at the input to signal to noise power ratio at the output. It measures the SNR degradation caused by the network.

$$F = \frac{SNR_{in}}{SNR_{out}}$$

17. Write the composite noise figure and noise temperature of 3 cascaded systems with gains G_1 , G_2 , G_3 .

$$F_{\text{composite}} = F_1 + (F_2 - 1)/G_1 + (F_3 - 1)/G_1 G_2 + \dots$$

$$T_{\text{composite}} = T_1 + T_2/G_1 + T_3/G_1 G_2 + \dots$$

Where F_1 = noise figure of network₁

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F_2 =noise figure of network₂

F_3 =noise figure of network₃

T_1 =noise temperature of network₁

T_2 =noise temperature of network₂

T_3 =noise temperature of network₃

18. What is the need for preemphasis? Nov 2016

In an FM system the higher frequencies contribute more to the noise than the lower frequencies. Because of this all FM systems adopt a system of preemphasis where the higher frequencies are increased in amplitude before being used to modulate the carrier.

PART B

1. (a) Derive the figure of merit for AM and FM system. Nov 2016
(b) Explain FM threshold effect
2. Define narrowband noise and explain the representation of narrow band noise in terms of in phase and Quadrature components. May 2016
(b) Explain pre emphasis and De emphasis
3. Explain the noise in DSBSC receiver using synchronous or coherent detection and calculate the figure of merit for a DSB-SC system.
4. (a) Describe Pre-emphasis and De-emphasis
(b) A certain communication channel is characterized by a 90 dB attenuation and additive white noise with the power spectral density of $N_0/2 = 0.5 \times 10^{-14}$ W/Hz. The bandwidth of the message signal is 1.5 MHz and its amplitude is uniformly distributed in the interval [-1,1]. If we require that the SNR after demodulation be 30dB, find the necessary transmitter power in (1) DSB-SC modulation and (2) Conventional AM with a modulation index of 0.5.
(b) Derive the effect of noise in AM system using envelope detection
5. (a) Suppose an amplifier is designed with three identical stages, each of which has a gain 5 and a noise figure of 6, determine the overall noise figure of the cascade of the three stages.
(b) A radio antenna pointed in the direction of the sky has a noise temperature of 50K. The antenna feeds the received signal to the pre-amplifier, which has a gain of 35dB over a bandwidth of 10MHz and a noise figure of 2 dB. Determine the effective noise temperature at the input to the pre-amplifier. Also determine the noise power at the output of the pre-amplifier.
(c) Discuss in detail about Gaussian process.
6. (a) In a binary communication system, the input bits transmitted over the channel are either 0 or 1 with probabilities 0.3 and 0.7 respectively. When a bit is transmitted over the channel, it can be either received correctly or incorrectly (due to channel noise). Let us assume that if a 0 is transmitted, the probability of it being received in error is 0.01 and if a 1 is transmitted, the probability of it being received in error is 0.1. What is the probability that the output of channel is 1? What is the probability that the input to the channel was a 1, assuming we have observed a 1 at the output of this channel?
(b) Elaborate on (1)Shot noise (2)Narrow band noise
7. Three amplifiers 1,2,and 3 have the following characteristics
 $F_1=9$ dB, $G_1=50$ dB, $F_2=6$ dB, $G_2=30$ dB; $F_3=4$ dB, $G_3=20$ dB
The amplifiers are connected in tandem. Determine which combination gives the lowest noise figure
(b) Discuss on thermal noise

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8. Derive the expression for the SNR at the output of the FM receiver. Assume that the input is corrupted by AWGN noise. Discuss the performance of the receiver based on the derived expression.

UNIT V SAMPLING & QUANTIZATION			
Low pass sampling – Aliasing- Signal Reconstruction-Quantization - Uniform & non-uniform quantization - quantization noise - Logarithmic Companding –PAM, PPM, PWM, PCM – TDM, FDM.			
PART A			
Q. No	Questions	BT Level	Domain
1.	List the advantages and disadvantage of digital communication system.	BTL 1	Remembering
2.	Define Band pass sampling.	BTL 1	Remembering
3.	Mention the definition of FDM.	BTL 1	Remembering
4.	Distinguish natural and flat top sampling.	BTL 2	Understanding
5.	Interpret the use of pre-filtering done before sampling.	BTL 3	Applying
6.	What is meant by aliasing?	BTL 1	Remembering
7.	How would you show your understanding of the components required for signal reconstruction?	BTL 3	Applying
8.	Write about non uniform quantization.	BTL 1	Remembering
9.	Illustrate the two fold effects of quantization process.	BTL 2	Understanding
10.	Illustrate the difference between uniform and non-uniform quantization.	BTL 3	Applying
11.	Construct the Nyquist sampling Theorem with equation.	BTL6	Creating
12.	A Sinusoidal signal is transmitted using PCM scheme. The target output SNR should be greater than 13 dB. Can you identify the minimum number of representation levels and minimum number of bits required to represent each sample to achieve the above performance.	BTL 4	Analyzing
13.	A pulse code modulation system uses a uniform quantizer followed by a 6 bit encoder. The bit rate of the system is 50 Mbps. Determine the message bandwidth of the system.	BTL 5	Evaluating
14.	Outline the input-output characteristic of a compressor and expander.	BTL 1	Remembering
15.	Point out the μ -law of compression.	BTL 4	Analyzing
16.	State in your own words the definition for PPM and PWM.	BTL 2	Understanding
17.	Express the Quantization noise of a PCM system.	BTL 2	Understanding
18.	Formulate the concept of PAM and PCM.	BTL 6	Creating
19.	Outline the concept of TDM.	BTL 4	Analyzing
20.	Summarize the advantages and disadvantages of FDM.	BTL 5	Evaluating

PART – B			
1.	(i) Explain the following terms with respect to sampling Aliasing, Signal Reconstruction and Aperture effect distortion (7) (ii) Outline Time Division Multiplexing system for N-number of channels. (6)	BTL 1	Remembering
2.	Illustrate the following sampling procedures with proper details for Natural Sampling and Flat top Sampling.(13)	BTL 2	Understanding
3.	(i) Find the sampling rate for the following signal $m(t)=2[\cos(500*\pi*t).\cos(1000*\pi*t)]$. (7) (ii) Determine the the Nyquist Rate for $m(t)=5*\cos(5000*\pi*t).\cos^2(8000*\pi*t)$. (6)	BTL 3	Applying
4.	Let the maximum spectral frequency component (f_m) in an analog information signal be 3.3khz .Can you identify the frequency spectra of sampled signal under the following relationships between the sampled frequency (f_s) and maximum analog signal frequency (f_m) (i) $f_s=2f_m$ (7) (ii) $f_s>2f_m$ & $f_s<2f_m$ (6)	BTL 4	Analyzing
5.	Compare the concept of Uniform and Non Uniform Quantisation. (13)	BTL 4	Analyzing
6.	The T1 carrier system used in digital Telephony multiplexes 24 voice channels based on 8 bit PCM. Each voice signal is out through a LPF with cut off frequency of 3.4KHz.The LPF output is sampled at 8 KHz. Then a single bit is added at the end of the frame for the purpose of synchronization. Calculate (i) Bit duration (5) (ii) Transmission Rate (5) (iii) Nyquist bandwidth (3)	BTL 5	Evaluating
7.	A signal $m(t)$ band limited to 4 KHz is sampled at the rate of 50% higher than Nyquist rate, the maximum acceptable error in the sample amplitude is 1% of peak amplitude. The quantized samples are binary coded. Find minimum bandwidth of a channel required to transmit the encode binary signal. (13)	BTL 2	Understanding
8.	Illustrate and describe the types of Quantizer. Describe the mid tread and midrise type characteristics of uniform quantizer with suitable diagram. (13)	BTL 3	Applying
9.	Distinguish various Pulse Modulation Techniques. (13)	BTL 4	Analyzing

10.	(i) Elaborate in detail about logarithmic companding of speech signals (7) (ii) Point out the sampling rate for the signal, given $m(t) = (1/2 * \pi) [\cos(4000 * \pi * t) \cos(1000 * \pi * t)]$ (6)	BTL 6	Creating
11.	(i) Describe PCM system with neat block diagram? (7) (ii) What is TDM and mention its applications. Explain the difference between analog TDM and digital TDM. (6)	BTL 1	Remembering
12.	Write about Frequency Division Multiplexing system for N- number of channels with neat diagrams. (13)	BTL 1	Remembering
13.	The bandwidth of TV, Video + audio signal is 4.5 MHz. If the signal is converted to PCM bit stream with 1024 quantization levels. Determine the number of bits per second generated by the PCM system. Assume that signal is sampled at the rate of 20% above Nyquist rate. (13)	BTL 1	Remembering
14.	(i) Illustrate the principle of quantization and obtain the expression for the signal to quantization noise ratio in PCM system. (7) (ii) The information in an analog signal with maximum frequency of 3 KHz is required to be transmitted using 16 quantization levels in PCM systems. Interpret the maximum number of bits per sample that should be used, the minimum sampling rate required and the resulting transmission data rate. (6)	BTL 2	Understanding
PART – C			
1.	Deduce the concept of Low pass sampling, Aliasing and Signal Reconstruction. (15)	BTL 5	Evaluating
2.	Propose the ideas about Uniform Quantization and its types. (15)	BTL 6	Creating
3.	Determine the purpose of Non Uniform Quantization and mention the Laws for implementing the same. (15)	BTL 5	Evaluating
4.	Elaborate the concept of PCM with diagram and discuss the various pulse modulation schemes. (15)	BTL 6	Creating