St.JOSEPH COLLEGE OF ENGINEERING

DEPARTMENT OF ELECTRONICS AND COMMUNICATION

EC 6402-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
  - Narrowaband 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.

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)

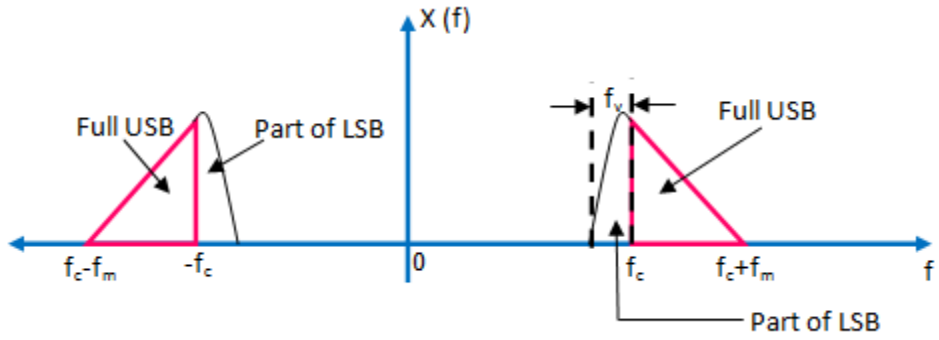
The total power $P_t = P_c(1 + \frac{\mu^2}{2})$

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

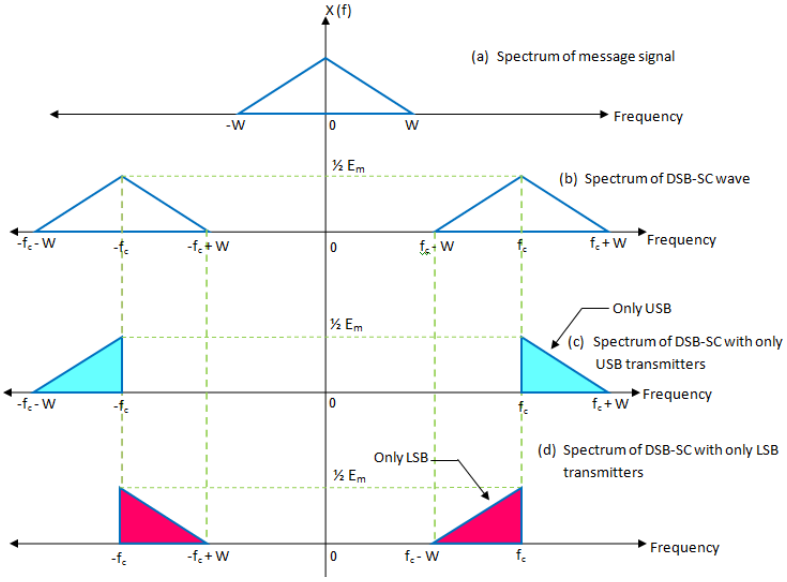
$$P_t = 13.2\ watt$$

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=1MHz

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

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.
Selctive filtering is required	Selective filtering is not required

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

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

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

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

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?

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

20. Compare bandwidth and power requirement in terms of carrier power Pc 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 amplitude 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.

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 costos 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 fc=800MHz by the signal $m(t) = \sin 3000\pi t + 0.5cos5000\pi t$. 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

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?

St.JOSEPH COLLEGE OF ENGINEERING

DEPARTMENT OF ELECTRONICS AND COMMUNICATION

EC 6402-COMMUNICATION THEORY

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 $\beta<<1$)

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

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 fc-fm (lower side frequency is 180 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 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	$P_t=P_c(1+\mu^2/2)$ μ= 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_{FM} is the modulation index of PM

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 Tramitter 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*.

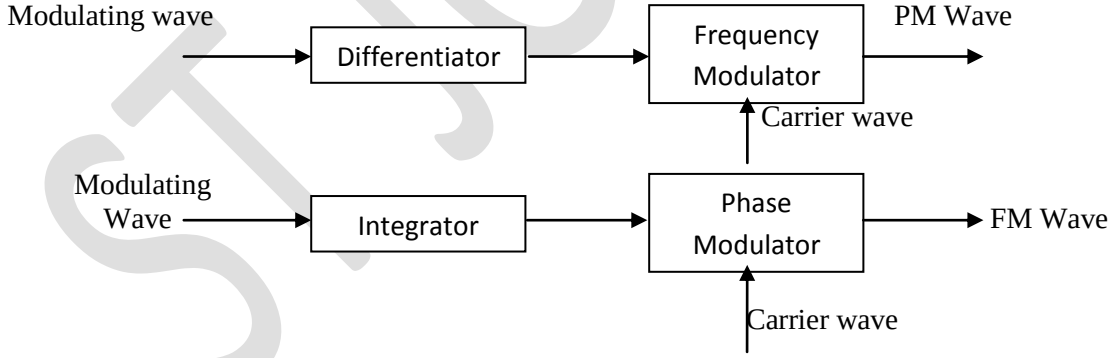
15. A carrier is frequency modulated by a sinusoidal modulating frequency 2 KHz, resulting in frequency deviation of 5 kHz. What is the bandwidth occupied by the modulated waveform?

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

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

BW = 14kHz.

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



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

Bandwidth of Narowband FM = $2f_m$

Bandwidth of WBFM or FM = $2(1+\beta)f_m$

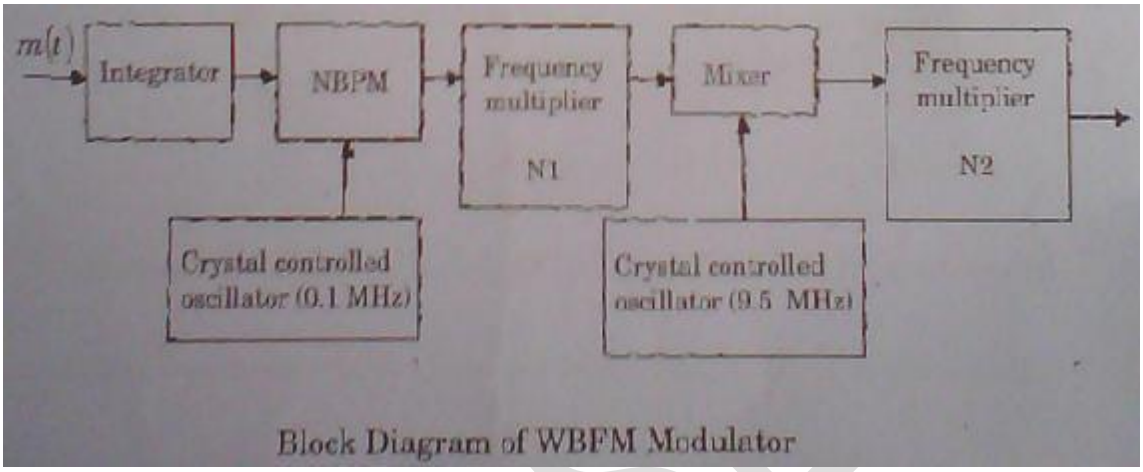
Where β is modulation index of FM

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

or

Compare narrow band FM and wide band FM.

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(Δf + fm)	2fm



Block Diagram of WBFM Modulator

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+β. (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 deption, 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.

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 2*fm*.
- 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?

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 modulating 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.

St.JOSEPH COLLEGE OF ENGINEERING

DEPARTMENT OF ELECTRONICS AND COMMUNICATION

EC 6402-COMMUNICATION THEORY

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 Ω = {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 he 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.

(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 $\check{N}(0,1)$ 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 $C_x(0)<$ infinity

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.

St.JOSEPH COLLEGE OF ENGINEERING

DEPARTMENT OF ELECTRONICS AND COMMUNICATION

EC 6402-COMMUNICATION THEORY

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+μ) 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+θ) where A and w are constants and θ is uniformly distributed random variable in (0, 2π). 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 μW 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(ot + 0),where A and 0J are constants and 0 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 1uW 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) =Acos(2πfc(t+θ)) where A and fc are constant and is a random variable that is uniformly distributed over the interval [-π π]
16. State and prove the properties of power spectral density.

St.JOSEPH COLLEGE OF ENGINEERING

DEPARTMENT OF ELECTRONICS AND COMMUNICATION

EC 6402-COMMUNICATION THEORY

UNIT-IV NOISE CHARACTERIZATION

1. State the principle behind FM threshold effect.

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 s 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.

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 (So/No) below which the output signal to noise ratio (Si/Ni) 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 Te .

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

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, $V_n^2 = 4\ kTBR$

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.

$F_{composite} = F_1+(F_2-1)/G_1+(F_3-1)/G_1G_2+$.....

$T_{composite} = T_1+T_2/G_1+T_3/G_1G_2+$.....

Where F_1=noise figure of network$_1$

F_2=noise figure of network$_2$
F_3=noise figure of network$_3$
T_1=noise temperature of network$_1$
T_2=noise temperature of network$_2$
T_3=noise temperature of network$_3$

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 threshod 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-ephasis
   (b) A certain communication channel is characterized by a 90 dB attenuation and additive white noise with the power spectral density of $N_0/2 = 0.5x10^{-14}$ 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=50dB, F_2=6 dB , G_2=30 dB; F_3=4dB, G_3=20dB
   The amplifiers are connected in tandem. Determine which combination gives the lowest noise figure
   (b) Discuss on thermal noise

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.

St.JOSEPH COLLEGE OF ENGINEERING

DEPARTMENT OF ELECTRONICS AND COMMUNICATION

EC 6402-COMMUNICATION THEORY

UNIT-V INFORMATION THEORY

1. What is entropy?
Entropy is also called average information per message. It is the ratio of total information to number of messages. i.e.,E-Entropy, H = Total information,N-Number of messages

2. What is channel redundancy?
Addition of bits to add noise immunity
Redundancy (γ) = 1 – code efficiency
Redundancy should be as low as possible.

3. **Name the two source coding techniques**.
The source coding techniques are, a) prefix coding b) Shannon-fano coding c) Huffman coding

4. What is memory less source? Give an example.
The alphabets emitted by memory less source do not depend upon previous alphabets.Every alphabet is independent. For example a character generated by keyboard represents memory less source.

5. Explain the significance of the entropy H(X/Y) of a communication system where X is the transmitter and Y is the receiver.
a) H(X/Y) is called conditional entropy. It represents uncertainty of X, on average,when Y is known.
b) In other words H(X/Y) is an average measure of uncertainty in X after Y is received.
c) H(X/Y) represents the information lost in the noisy channel.

6. What is prefix code?
In prefix code, no codeword is the prefix of any other codeword. It is variable length code. The binary digits (codewords) are assigned to the messages as per their probabilities of occurrence.

7. Define information rate.
Information rate(R) is represented in average number of bits of information per second. It is calculated as, R = Information bits / sec

8. Calculate the entropy of source with a symbol set containing 64 symbols each with probability p = 1/64 .
Here, there are M = 64 equally likely symbols.
Hence entropy of such source is given as, $H = \log_2 M = \log_2 64 = 6$ bits / symbol

9. State any four properties of entropy.
a) For sure event or impossible event entropy is zero.
b) For M number of equally $H_{max} = \log_2 M$ likely symbols, entropy is $\log_2 M$
c) Entropy is lower bound on average number of bits per symbol.

10. Give the expressions for channel capacity of a Gaussian channel.
Channel capacity of a Gaussian channel is given as,
C = B log (1+S/N) bits / sec
Here B is Channel bandwidth
S is signal power
N is total noise power within the channel bandwidth.

11. State the channel coding theorem for a discrete memory less channel.

Given a source of 'M' equally likely messages, with M >>1, which is generating information at a rate. Given channel with capacity C. Then if, R ≤ C there exits a coding technique such that the output of the source may be transmitted over the channel with a probability of error in the received message which may be made arbitrarily small.

12. State source coding or Shannon's first theorem

Given a discrete memory less source, the source entropy H(I), the average code word length L for any source encoding is bounded as L>=H(I)

13.A source generates three messages with probabilities of 0.5. 0.25 & 0.25. Calculate source entropy.

Source entropy $H(x) = \sum_i p(i) log_2 \frac{1}{p(i)}$

$$H(x) = p_1 \, log \frac{1}{p_1} + p_2 \, log \frac{1}{2} + p_3 \, log \frac{1}{p_3}$$

$$H(x) = 0.5 log \frac{1}{0.5} + 0.25 log \frac{1}{0.25} + 0.25 log \frac{1}{0.25}$$

PART B

1. Determine the coding efficiency ,redundancy of a source which is transmitting six of a messages with probabilities 0.30,0.25,0.15,0.12,0.10 and 0.08 by Huffman coding
2. Derive the expression for channel capacity of a continuous channel. Find also the expression for channel capacity of continuous channel of infinite bandwidth. Comment on the results
3. Discuss Source coding theorem, give the advantage and disadvantage of channel coding in detail, and discuss the data compaction
4. What do you mean by binary symmetric channel? Derive channel capacity formula for symmetric channel.
5. (i) Explain in detail Huffman coding algorithm and compare this with the other types of coding
   (ii)Write short note on S/N trade off.
6. Explain the properties of entropy and with suitable example, explain the entropy of binary memory less source
7. (i) What is Entropy? Explain the important properties of entropy.
   (ii)Prove how you use the source coding to increase average information per bit.
8. (i)Explain how channel capacity could be improved. Explain the S/N trade off in detail.
   (ii)Explain the need for source coding and channel coding.
9. Construct binary optical code for the following probability symbols using Huffman procedure and calculate entropy of the source, average code Length, efficiency, redundancy and variance 0.2, 0.18, 0.12, 0.1, 0.1, 0.08, 0.06, 0.06, 0.06, 0.04.