Course Name: Communication Theory (EC-8491)(R-2017)

S. No.	Course outcome	Statement
1	**CO211.1**	Ability to Acquire information on the various types of communication systems and different Amplitude Modulation systems
2	**CO211.2**	Ability to get knowledge about angle modulation systems pertaining to frequency modulation and phase modulation.
3	**CO211.3**	Ability to Determine mean, autocorrelation, power spectral density of a random process to design communication systems
4	**CO211.4**	Ability to Analyze the performance of a communication system under various modulation schemes through Figure of Merit parameter and Analyze different types of noise.
5	**CO211.5**	Ability to know the concepts of sampling and quantization.

EC 8491 COMMUNICATION THEORY

UNIT I – AMPLITUDE MODULATION

Amplitude Modulation-DSBSC, DSBFC, SSB, VSB -Modulation index, Spectra,Power relations and Bandwidth –AM Generation –Square law and Switching modulator, DSBSC Generation –Balanced and Ring Modulator, SSBGeneration –Filter, Phase Shift and Third Methods, VSB Generation –Filter Method, Hilbert Transform, Pre-envelope & complex envelope –comparison of different AM techniques, Superheterodyne Receiver

PART A (Question and Answer)

1. Define modulation? (MAY/JUNE 2007) [REMEMBER]

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

2. What are the types of analog modulation? (NOV/DEC 2005) [REMEMBER]

I. Amplitude modulation.

II. Angle Modulation

1. Frequency modulation
2. Phase modulation.

3. Define depth of modulation. [REMEMBER]

It is defined as the ratio between message amplitude to that of carrier amplitude.

$$m=Em/Ec$$

4. What are the degrees of modulation? [REMEMBER]

- ✓ Under modulation. m<1
- ✓ Critical modulation m=1
- ✓ Over modulation m>1

5. What is the need for modulation? [REMEMBER]

(OR)

What are the advantages of converting the low frequency signal into high frequency signal? (May/June 2013).

Needs for modulation:

1. Ease of transmission
2. Multiplexing
3. Reduced noise
4. Narrow bandwidth

5. Frequency assignment
6. Reduce the equipments limitations.

6. What are the types of AM modulators? [REMEMBER]

There are two types of AM modulators. They are

I. Linear modulators II. Non-linear modulators

I. **Linear modulators** are classified as follows
   1. Transistor modulator. There are three types of transistor modulator:
      a) Collector modulator
      b) Emitter modulator
      c) Base modulator
      d) Switching modulators

II. **Non-linear modulators** are classified as follows
   1. Square law modulator
   2. Product modulator
   3. Balanced modulator

7. Give the classification of modulation. [UNDERSTAND]

There are two types of modulation. They are

I. Analog modulation II. Digital modulation

I. Analog modulation is classified as follows
   1. Continuous wave modulation
   2. Pulse modulation

1. Continuous wave modulation is classified as follows
   a) Amplitude modulation
   b) Double side band suppressed carrier
   c) Single side band suppressed carrier
   d) Vestigial side band suppressed carrier
   e) Angle modulation
   f) Frequency modulation
   g) Phase modulation
2. Pulse modulation is classified as follows
   a) Pulse amplitude modulation

b) Pulse position modulation

c) Pulse duration modulation

d) Pulse code modulation

II. Digital modulation is classified as follows

1. Amplitude shift keying
2. Phase shift keying
3. Frequency shift keying

8. What is single tone and multi tone modulation? [REMEMBER]

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.

9 .The antenna current of an AM transmitter is 8A when only carrier is sent. It increases to 8.93A when the carrier is modulated by a single sine wave. Find the percentage modulation. [UNDERSTAND]

Solution:

Given: Ic =8A It=8.93A m=0.8

Formula: $It=Ic\ (1+m2/2)^{½}$

$8.93=8(1+m2/2)^{½}$

m=0.701

$It=8\ (1+0.82/2)^{½} = 9.1A$

10. Compare AM with DSB-SC and SSB-SC. (NOV/DEC 2005) [UNDERSTAND]

(OR)

Compare Bandwidth and Power requirement in terms of carrier power Pc for AM, DSB-SC and SSB? (May/June 2013).

AM signal	**DSB-SC**	**SSB-SC**
Bandwidth=2fm	Bandwidth=2fm	Bandwidth=fm
Contains USB, LSB, carrier	Contains USB,LSB	Contains LSB or USB
More power is required for Transmission $P_T = P_C\left[1+\frac{m_a^2}{2}\right]$	Power required is less than that of AM. $P_t' = P_C\left[\frac{m_a^2}{2}\right]$	Power required is less than AM &DSB-SC $P_t'' = P_C\left[\frac{m_a^2}{4}\right]$

11. What are the advantages of VSB-AM? (May/June 2012) [REMEMBER]

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.

12 Compare linear and non-linear modulators.(Nov/Dec 2010) [UNDERSTAND]

Linear modulators	Non-linear modulators
Heavy filtering is not required	Heavy filtering is required
These modulators are used in low level Modulation	These modulators are used in high level modulation
The carrier voltage is very much greater than modulating signal voltage.	The carrier voltage is very much greater than carrier signal voltage.

13. How will you generating DSBSC-AM ? [UNDERSTAND]

There are two ways of generating DSBSC-AM such as

1. balanced modulator 2.ring modulators

14. What are advantages of ring modulator? [REMEMBER]

1. Its output is stable.
2. It requires no external power source to activate the diodes.
3. Virtually no maintenance.
4. Long life.

15. Define demodulation. [REMEMBER]

Demodulation or detection is the process by which modulating voltage is recovered from the modulated signal. It is the reverse process of modulation.

16. What are the types of AM detectors? [REMEMBER]

1. Nonlinear detectors
2. Linear detectors

17. What are the types of linear detectors? [REMEMBER]

1. Synchronous or coherent detector.
2. Envelope or non coherent detector.

18. Define multiplexing. [REMEMBER]

Multiplexing is defined as the process of transmitting several message signals simultaneously over a single channel.

20. Define sensitivity. (MAY/JUNE 2007) [REMEMBER]

It is defined as a measure of its ability to receive weak signals.

21. Define selectivity. [REMEMBER]

Selectivity of a receiver is defined as its ability to select the desired signals among the various signals.

22. Define stability. [REMEMBER]

It is the ability of the receiver to deliver a constant amount of output for a given period of time.

23. Define super heterodyne principle. [REMEMBER]

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.

24. A transmitter supplies 8 Kw to the antenna when modulated. Determine the total power radiated when modulated to 30%. [UNDERSTAND]

m=0.3;Pc=8 kw

Pt=Pc(1+m2/2)

=8.36 kw

25. What are the drawbacks of emitter modulator? [REMEMBER]

1. The amplifier is operated in class A mode, thus the efficiency is low.

2. The output power is very small. Thus it is not suitable for generating high level modulation.

26. Define frequency modulation. [REMEMBER]

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

27. What do you meant by multitone modulation?(NOV/DEC 2005) [UNDERSTAND]

Modulation done for the message signal with more than one frequency component is called multitone modulation.

29. Define amplitude modulation. Give the expression for AM wave. [REMEMBER]

(OR)

Represent an amplitude modulated wave as a function of time with amplitude sensitivity of the modulator as constant. (November/December 2013). (**May/June 2014**).

It is the process by which the amplitude of the carrier wave is changed in Accordance with the instantaneous value of the message signal

$$V_{AM}(t) = V_C (1 + m_a \sin \omega_m t) \sin \omega_c t$$

30. What are the advantages of SSB? (MAY/JUNE 2007) (April/May 2021) [REMEMBER]

(OR)

State the differences between Single Side Band (SSB) and Vestigial Side Band (VSB) transmission system (May/June 2014)?

- ✓ Fading effect is absent
- ✓ The power of the suppressed carrier and sideband is saved
- ✓ The effect of noise at the receiver circuits is reduced

31. What are the advantages of Vestigial Side Band? (April/May 2011)[REMEMBER]

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

32. The average power of a periodic signal $g_p(t)$ is calculated using what theorem? State the theorem. (November/December 2013, May / June 2016) [REMEMBER]

In engineering, Parseval's theorem is used to find the power of a periodic signal:

$$\int_{-\infty}^{\infty} |x(t)|^2 \, dt = \frac{1}{2\pi} \int_{-\infty}^{\infty} |X(\omega)|^2 \, d\omega = \int_{-\infty}^{\infty} |X(2\pi f)|^2 \, df$$

33. For an AM system, the instantaneous values of carrier and modulating signal are

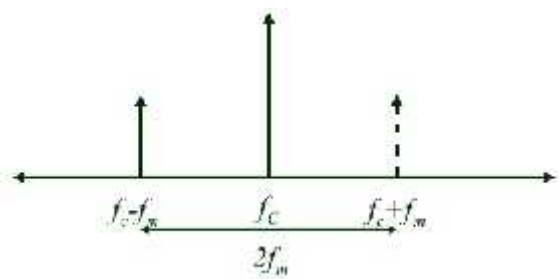
60 sin $\omega_m t$ and $40\sin\mu_c t$. Determine the modulation index. (May/June 2014). [UNDERSTAND]

m=Em/Ec

m= 60/40

m=1.5

34. Consider the signal whose spectrum is as shown in figure 1 modulates the sinusoidal carrier signal of 1 MHz. Draw the spectrum of AM signal and SSB-SC (upper sideband) signal.(NOV/DEC-2015) [ANALYSIS]



35. Suggest a modulation scheme for the broad cast video video transmission and justify. (NOV/DEC-2015) [UNDERSTAND]

Vestigial Sideband modulation (VSB) is used for the following reasons

1. Video signal exhibits a large bandwidth and significant low-frequency content which suggests the use of VSB
2. The circuitry for demodulation in the receiver should be simple and therefore cheap.

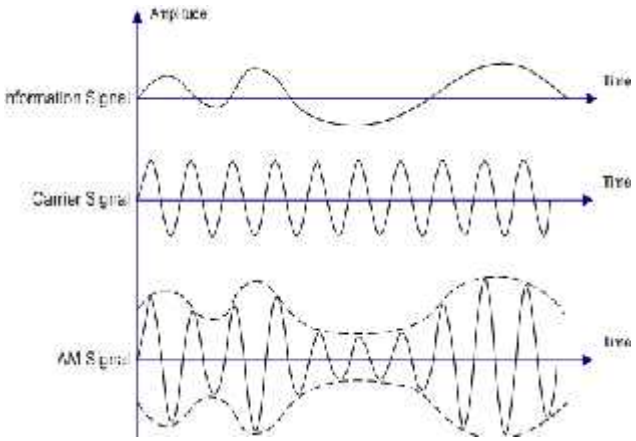
VSB demodulation uses simple envelope detection.

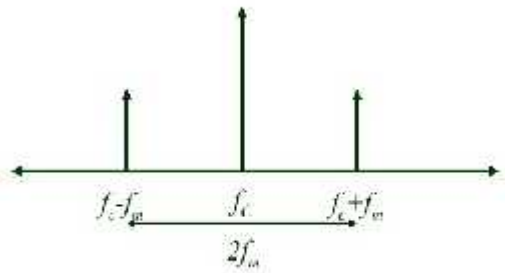
36. List the advantages of FM and AM. (NOV/DEC-2015) [REMEMBER]

AM has poorer sound quality compared with FM, but is cheaper and can be transmitted over long distances. It has a lower bandwidth so it can have more stations available in any frequency range.

FM is less prone to interference than AM. However, FM signals are impacted by physical barriers. FM has better sound quality due to higher bandwidth.

37. Draw the AM modulated wave for modulation index = 0.5 and its spectra. (APR/MAY-2015) [REMEMBER]





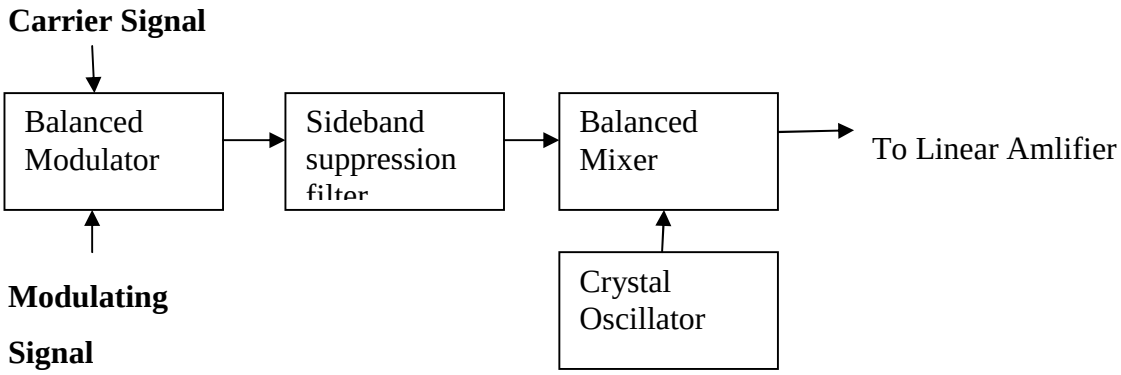
38. Define heterodyning. (Apr/May 2015) [REMEMBER]

In which new frequencies are created by combining or mixing two frequencies. The two frequencies are combined in a nonlinear signal-processing device such as a vacuum tube, transistor, or diode, usually called a mixer.

39. What is the advantages of convolutional DSB-AM over DSB-SC and SSB-SC AM? (Nov / Dec 2015) [REMEMBER]

- ✓ AM transmitters are less complex.
- ✓ AM receivers are simple, detection is easy.
- ✓ AM receivers are cost efficient.
- ✓ AM waves can travel a longer distance.
- ✓ Low bandwidth.

40. Draw the block diagram of SSB-AM generator. (Nov / Dec 2015) [REMEMBER]



41. What is Pre-envelope and complex envelope? (May / June 2016) [REMEMBER]

Useful in deriving the general expression of SSB-SC signal.

The pre-envelope of a real valued signal x(t) is defined as

$$xp(t) = x(t) + jxh(t)$$

The complex envelope of a real valued signal x(t) is defined as

$$x^*p(t) = x(t) - jxh(t)$$

42. What are the advantages of superheterodyne receiver over TRF? (April/May 2010) [REMEMBER]

The advantages of superheterodyne receiver over TRF are high selectivity, improved sensitivity throughout the carrier frequency band..It eliminates image frequency.

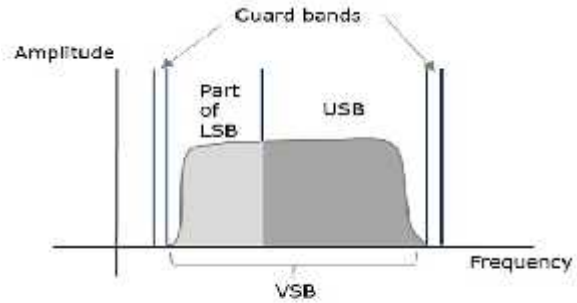
43. Determine the Hilbert Transform of Cosωt (Nov / Dec 2017) [REMEMBER]

Calculate the Hilbert transform of cos(**ωt**) by taking the Fourier transorm, applying the frequency-domain property of the Hilbert transform, and then taking the inverse Fourier transform.

$$\cos \boldsymbol{\omega t} = \sin \boldsymbol{\omega t}$$

44. What is VSB? Where is it used? (Nov / Dec 2017) [REMEMBER]

Vestigial Sideband Modulation or **VSB Modulation** is the process where a part of the signal called as **vestige** is modulated, along with one sideband. A VSB signal can be plotted as shown in the following figure. Along with the upper sideband, a part of the lower sideband is also being transmitted in this technique. A guard band of very small width is laid on either side of VSB in order to avoid the interferences. VSB modulation is mostly used in television transmissions.



VSB Modulation

The most prominent and standard application of VSB is for the transmission of **television signals**. Also, this is the most convenient and efficient technique when bandwidth usage is considered.

45. Compare and contrast DSB-SC with SSB-SC with respected to i) power and ii) bandwidth (April/May 2018) [UNDERSTAND]

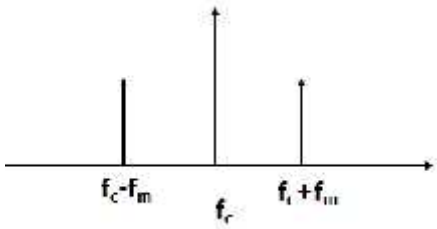
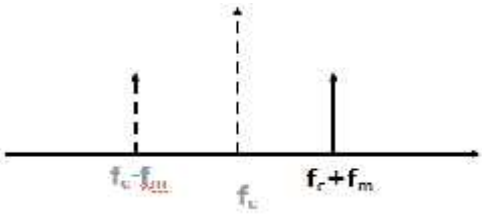
DSB-SC	**SSB-SC**
Power required is less than that of AM. $P_t' = P_C\left[\frac{m_a^2}{2}\right]$	Power required is less than AM &DSB-SC $P_t'' = P_C\left[\frac{m_a^2}{4}\right]$
Bandwidth=2fm	Bandwidth=fm
Contains USB,LSB	Contains LSB or USB

46. Mention the drawbacks of coherent detector. (April/May 2018) [REMEMBER]

i) Perfect synchronization is a requirement

ii) Noise should be maintained at low level through high SNR

47. Why DSBFC AM is bandwidth inefficient when compared with single side band AM? (April/May 2019)

DSBFC AM	**SSBSC AM**
✓ Frequency spectrum: 	✓ Frequency spectrum: 

✓ Bandwidth=2 x $f_m$max ✓ Total Power=Pcarrier+Pusb +Plsb	✓ Bandwidth=f_{mmax} ✓ Total Power=+P_{usb}
✓ Large power consumption, where carrier power constitutes >2/3 transmitted power.{remember:carrier does not contain any information} ✓ Large bandwidth utilized. ✓ Thus, DSBFC is both power and bandwidth inefficient	✓ A form of amplitude modulation in which the carrier is transmitted at full power but only one of the sidebands (either the upper or lower) is transmitted ✓ Requires less bandwidth than DSBFC but also produces a demodulated signal with a lower amplitude

48. Mention any four advantages of having RF amplifier in AM Receiver. (April/May 2019)

The RF amplifiers are used in super heterodyne receivers. The advantages of using RF receivers are:

- ✓ They have better sensitivity i.e. they have improved gain to the signal.
- ✓ They have better signal to noise ration than other amplifiers.
- ✓ The selectivity is better as they have better rejection to the adjacent undesired signals.

49. 49. **A carrier wave of frequency 10MHZ and peak value 10V is amplitude modulated by a 5 kHZ sine wave of amplitude 6V. Determine the modulation index the amplitude spectrum. (April/May 2021)**

Modulation Factor=Es/Ec = 6/10=0.6v

PART B

1. Explain the generation of AM signals using square law modulator Also derive its efficiency.(16). ***(NOV/DEC 2005,APR/MAY-2015)*** **[REMEMBER]**
2. Explain the detection of AM signals using envelope detector. (16). ***(NOV/DEC 2005, APR/MAY-2015)*** **[REMEMBER]**
3. Explain about Balanced modulator to generate DSB-SC signal. (16) **[REMEMBER]**
4. With a neat block diagram explain the SSB transmissions. ***(April/May 2021)*** **[REMEMBER]**
5. Explain the operation of a ring modulator. State its advantages. ***(NOV/DEC 2008)*** **[REMEMBER]**
6. Explain about coherent detector to detect SSB-SC signal. (16) **[REMEMBER]**
7. Explain the generation of SSB using balanced modulator. ***NOV/DEC 2006*** **[REMEMBER]**
8. Draw the circuit diagram of Ring modulator and explain with its operation? **[REMEMBER]**
9. Discus the coherent detection of DSB-SC modulated wave with a block diagram of detector and Explain. (16) **[ANALYSIS]**

10. With a neat block diagram Explain frequency translation. ***(NOV/DEC 2008)*** **[REMEMBER]**
11. Explain the working of Super heterodyne receiver with its parameters. (16) **[REMEMBER]**
12. Draw the block diagram for the generation and demodulation of a VSB signal and explain the principle of operation. (16) ***(MAY/JUNE 2007)*** **[REMEMBER]**
13. Write short notes on frequency translation and FDM? (16) **[REMEMBER]**
14. Explain about AM transmitters. (16) **[REMEMBER]**
15. Define sensitivity, selectivity and image frequency of a Receiver system. **[REMEMBER]**
16. A commercial AM station is broadcasting with an demodulated carrier power of 10kW. The modulation index is set at 0.7 for a sinusoidal message signal. Find the total transmitter power and efficiency.***(MAY/JUNE 2007)*** **[APPLY]**
17. With a help of a neat diagram, explain the operation of an envelope detector. Why does negative peak clipping take place? ***(April/May 2011)*** **[REMEMBER]**
18. Compare the characteristics of DSBFC, DSBSC, SSBFC, SSBSC, VSB schemes***(April/May 2011)*** **[UNDERSTAND]**
19. Explain the concept of FDM with a suitable block diagram. ***(April/May 2011)*** **[REMEMBER]**
20. Draw an envelope detector circuit used for demodulation of AM and ex-plain its operation. 10 marks ***(April/May 2010)*** **[REMEMBER]**
21. How SSB can be generated using Weaver's method? Illustrate with a neat block diagram. 6 marks***(April/May 2010)*** **[UNDERSTAND]**
22. Discuss in detail about frequency translation and frequency division multiplexing technique with diagrams. ***(April/May 2010)*** **[ANALYSIS]**
23. Compare Amplitude Modulation and Frequency modulation.***(April/May 2010)*** **[UNDERSTAND]**
24. (i)With the help of a neat diagram, explain the generation of DSB-SC using balanced modulator.

    (ii) Write about the coherent detection method in detail for DSB-SC and SSB-SC. What happens when there is phase mismatch? ***(Nov/Dec 2010)*** **[REMEMBER]**
25. (i) Explain the concept of Frequency Translation

    (ii) With aid of block diagram explain the principle of FDM

    (iii) Illustrate the formation of Basic group and super group ***(Nov/Dec 2010)*** **[REMEMBER]**
26. (i) Draw an envelope detector circuit used for demodulation of AM and explain its operation.

    (ii) How SSB can be generated using Weaver's method? Illustrate with a neat block diagram.

(April/May 2012) **[REMEMBER]**

27. What is frequency division multiplexing? Explain. (ii) Compare various amplitude modulation systems. ***(April/May 2012)*** **[REMEMBER]**
28. Discuss on the frequency components present in a periodic and non periodic signal? **[ANALYSIS]** ***(May/June 2013).***
29. Derive the equation of an AM wave. Also draw the modulated AM wave for various modulation index. ***(May/June 2013).*** **[REMEMBER]**
30. The antenna current of an AM transmitter is 8 ampere when only the carrier is sent. The current increases to 8.93 a when the carrier is modulated by a single sine wave. Find the percentage modulation. ***(May/June 2013).*** **[APPLY]**
31. Draw the VSB spectrum and explain the significance ***(May/June 2013)*** **[REMEMBER]**
32. A 1000 kHz carrier is simultaneously AM modulated with 300 Hz, 800 Hz and 1.5 kHz audio sine waves. What will be the frequencies in the output? ***(May/June 2013)*** **[UNDERSTAND]**
33. With suitable block diagrams and equations show how will you generate DSBSC signals and VSB signals **[REMEMBER]** ***(November/December 2013).***
34. A sine wave frequency 10Hz is applied to a product modulator together with a carrier wave frequency of 1 MHz. The modulator output is next applied to a resonant circuit. Determine the modulated wave after transmission through the circuit. Assume suitable data.**[UNDERSTAND]** ***(November/December 2013)***
35. Explain the need for carrier suppression in an AM system. Draw and explain the functioning of one such system. **[REMEMBER]*****(May/June 2014)***
36. Explain the working of an AM tramsmitter and that of a receiver with a suitable block schematic. **[REMEMBER]**
37. Explain with block diagram the super heterodyne receiver. (8)***(APR/MAY-2015)(May / June 2016) (APR/MAY 2021)*** **[REMEMBER]**
38. Explain the Hilbert Transform with an example. (8)***(APR/MAY-2015)(NOV/DEC-2014)*** **[REMEMBER]**
39. a) i) Explain the generation of SSB SC signal using phase shift method. **[REMEMBER]**

    ii) suggest a scheme for recovering the message signal from the signal s(t)=2m(t)cos2πfc t. Explain the same. ***(NOV/DEC-2014)*** **[REMEMBER]**

b) i) An AM signal is generated by modulating the carrier fc=800MHz by the signal m(t) = sin 3000πt+0.5cos5000πt. the AM signal s(t)=100[1+m(t)]cos2πfct is fed to a 50 ohm load. ***(NOV/DEC-2014)*** **[ANALYSIS]**

40. Determine the average power in the carrier and in the sidebands. ***(NOV/DEC-2014)*** **[REMEMBER]**
41. Find the modulation index and peak power delivered to the load. ***(NOV/DEC-2014)*** **[REMEMBER]**
42. Explain the function of switching modulator in the generation of AM signal. **[REMEMBER]** ***(NOV/DEC-2014)***
43. With neat block diagram explain the function of super heterodyne receiver in detail. **[REMEMBER]*****(NOV/DEC-2015)(NOV/DEC-2014)(May / June 2016)***
44. Illustrate the superiority of super heterodyne receiver over single tuned receivers. **[REMEMBER]*****(NOV/DEC-2014)***
45. With relevant diagrams, describe the process of demodulation of DSB-SC AM signal **[REMEMBER]*****(NOV/DEC-2015)***
46. Derive the expression forDSB-SC AM and calculate its power & efficiency. Explain a method to generate and detect it**.** **[REMEMBER]*****(May / June 2016)***
47. i) Explain the operation of envelope detector (7) **[REMEMBER]** ***(Nov / Dec 2017)***

    ii) Discuss the generation of single sideband modulated signal. (6) **[REMEMBER]** ***(Nov / Dec 2017)***
48. Explain the operation of super heterodyne receiver with neat block diagram.Dram signal at the output of each block. (13) **[REMEMBER]** ***(Nov / Dec 2017)***
49. i) Using the concept of Hilber transform, generate the SSB-SC wave using phase shift method.

    ii) Using suitable circuit, explain the operation of envelope detector. Comment the reason for diagonal clipping and suggest the necessary conditions and expressions to overcome the same ***(April/May 2018)*** **[APPLY]**
50. i) Defend the need of VSB modulation technique in TV broadcasting. Also sketch its frequency Spectra. ***(April/May 2018)*** **[UNDERSTAND]**

    ii) With neat block diagram, elaborate the working principle of AM superheterodyne receiver. Also highlight how super heterodyne receiver rectifies the drawback of TRF receiver to receiver sensitivity. ***(April/May 2018)*** **[APPLY]**

51. i) A 10 kw carrier wave is amplitude modulated at 80% depth of modulated by a sinusoidal modulating signal. Calculate the sideband power, total power and the transmission efficiency of the AM wave.(4) **[APPLY]** ***(APR/MAY 2019)***

    ii).Explain the working of super heterodyne receiver with a neat diagram. (9) **[UNDERSTAND]** ***(APR/MAY 2019)***

52. Explain in detail the generation and demodulation of DSB-SC with a simple diagram.(13) **[UNDERSTAND]** ***(APR/MAY 2019)***

53. i). A message signal m(t)=cos 2000πt+2 cos 4000πt modulates the carrier c(t)=100 cos $2\pi f_c t$ where f_c=1MHz to produce the DSB signal m(t)c(t).(5+5).

    a) Determine the expression for the upper sideband (USB) signal.

    b) Determine and sketch the spectrum of the USB signal. **[APPLY]** ***(APR/MAY 2019)***

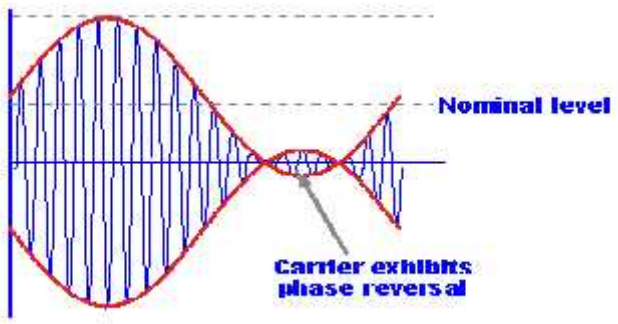
    ii). Write a brief note on VSB.(5) **[REMEMBER]** ***(APR/MAY 2019)***

54. Derive the expression for canonical form representation of an SSB-SC wave and hence deduce the block diagram of Phase discrimination method for processing sidebands. ***(APR/MAY 2021)***

55. (i) What is the need for modulation? Derive the expression for amplitude modulation and mention its merits and demerits. (ii) The output voltage of a transmitter is given by 500(1+0.4sin3140t)cos6.28×107 t. This voltage is fed to a load of 600ohms. Determine 1) Carrier frequency 2) Modulating frequency 3) Carrier power 4) Total transmitted power. ***(APR/MAY 2021)***

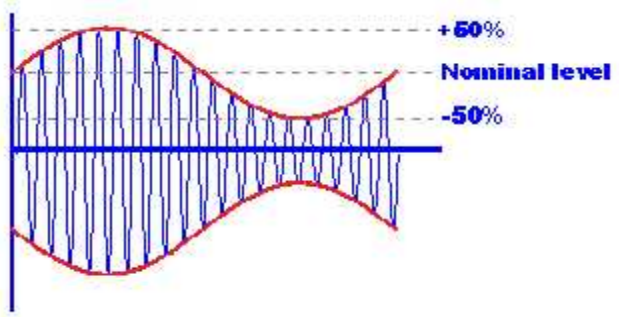
ASSIGNMENT QUESTIONS

1. From the diagram say whether what type of modulation has undergone. (CO1-PO1) **[UNDERSTAND]**



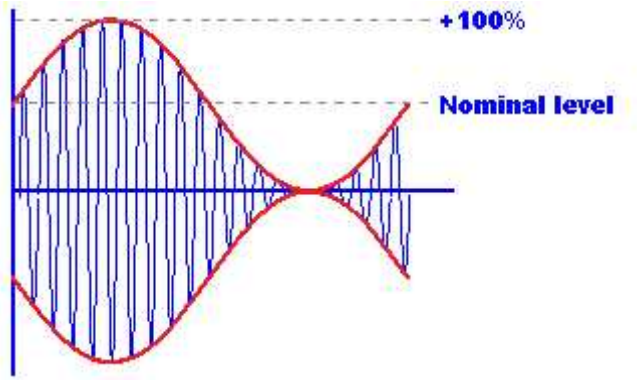
2. Draw the VSB spectrum and explain the significance. (CO1-PO1) **[REMEMBER]**

3. A 1000 KHz carrier is simultaneously AM modulated with 300 Hz, 800Hz and 1.5KHz audio sine .What will be the frequencies present in the output? (CO1-PO2) **[APPLY]**
4. A Carrier wave is represented by e(t)=12 sin 2πfct . What happens to the wave form representations under the following depth of modulation scenarios?(CO1-PO2) **[ANALYSIS]**
   a. i) m=1 ii)m=0.5 iii) m=1.75
5. Design a envelope detector for the input E(t)= E(1+ m cosωt) cosωt and time constant 1/fc<1/Rc<1/fm. (CO1-PO3) **[CREATE]**
6. Write a MATLAB program for AM modulation and de modulation (CO1-PO5) **[CREATE]**
7. Write a MATLAB program to compare single-sideband and double-sideband amplitude modulation. (CO1-PO5) **[CREATE]**
8. From the diagram say whether what type of modulation has undergone. (CO1-PO1) **[UNDERSTAND]**



9. Draw the SSB-SC spectrum and explain the significance.(CO1-PO1) **[REMEMBER]**
10. A 5000 KHz carrier is simultaneously AM modulated with 200 Hz, 600Hz and 2.5KHz audio sine .What will be the frequencies present in the output? (CO1-PO2) **[APPLY]**
11. A Carrier wave is represented by e(t)=24 sin 2πfct . What happens to the wave form representations under the following depth of modulation scenarios? (CO1-PO2) **[ANALYSIS]**
    a. i) m=1 ii)m=0.5 iii) m=1.75
12. Design a AM modulator using FET. (CO1-PO3) **[CREATE]**
13. Design a envelope detector for the input E(t)= E(1+ m sinωt) sinωt and time constant 1/fc<1/Rc<1/fm. (CO1-PO3) **[CREATE]**
14. Write a MATLAB program to compare double-sideband full carrier and single-sideband amplitude modulation. (CO1-PO5) **[CREATE]**
15. Write a MATLAB program for AM modulation and de modulation (CO1-PO5) **[CREATE]**

16. From the diagram say whether what type of modulation has undergone. (CO1-PO1) **[UNDERSTAND]**



17. Draw the DSB-SC spectrum and explain the significance. (CO1-PO1) **[REMEMBER]**
18. A 1500 KHz carrier is simultaneously AM modulated with 100 Hz, 600Hz and 2.5KHz audio sine .What will be the frequencies present in the output? (CO1-PO2) **[APPLY]**
19. A Carrier wave is represented by e(t)=25 sin 2πfct . What happens to the wave form representations under the following depth of modulation scenarios? (CO1-PO2) **[ANALYSIS]**
    a. i) m=1 ii)m=0.5 iii) m=1.75
20. Design a AM DSB-SC modulator using FET.(CO1-PO3) **[CREATE]**
21. Design a envelope detector for the input E(t)= E(1+ m cosωt) sinωt and time constant 1/fc<1/Rc<1/fm. (CO1-PO3) **[CREATE]**
22. Write a MATLAB program to compare double-sideband and single-sideband amplitude modulation. (CO1-PO5) **[CREATE]**
23. Write a MATLAB program for AM modulation and de modulation (CO1-PO5) **[CREATE]**

UNIT II – ANGLE MODULATION

Phase and frequency modulation, Narrow Band and Wide band FM–Modulation index, Spectra,Power relations and Transmission Bandwidth-FM modulation–Direct and Indirect methods, FM Demodulation–FM to AM conversion, FM Discriminator-PLL as FM Demodulator.

PART A (Question and Answer)

1**. Define phase modulation.[REMEMBER]**

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.

2. What are the types of Frequency Modulation? [REMEMBER]

Based on the modulation index FM can be divided into types. They are Narrow band FM and Wide band FM. If the modulation index is greater than one thenit is wide band FM and if the modulation index is less than one then it is Narrow band FM

3. What is the basic difference between an AM signal and a narrowband FM signal? [REMEMBER]

In the case of sinusoidal modulation, the basic difference between an AM signal and a narrowband FM signal is that the algebraic sign of the lower side frequency in the narrow band FM is reversed.

4. What are the two methods of producing an FM wave? NOV/DEC 2006. [REMEMBER]

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

5. Compare WBFM and NBFM. (April/may 2011) (Nov /Dec 2013) (Nov / Dec 2017) (APRIL/MAY 2019) (April/May 2021) [UNDERSTAND]

WBFM	NBFM
✓ Modulation index is greater than 1	✓ Modulation index less than 1
✓ Frequency deviation 75 KHz	✓ Frequency deviation 5 KHz
✓ Bandwidth 15 times NBFM	✓ Bandwidth 2fm
✓ Noise is more suppressed	✓ Less suppressing of noise

6. List the properties of the Bessel function. (NOV/DEC 2005) [REMEMBER]

The properties of the Bessel function is given by,

i) Jn (b)=(-1)nJ-n(b) for all n, both positive and negative.

ii) For small values of the modulation index b ,we have

J0 (b)=1

J1 (b)=b/2

Jn(b)=0,n>2.

7. Define frequency Deviation. [REMEMBER]

The maximum departure of the instantaneous frequency from the carrier frequency

is called frequency deviation.

8. State the Carson's rule. (April/may 2011), (May/June 2013), (Nov / Dec 2015) [REMEMBER]

An approximate rule for the transmission bandwidth of an FM Signal generated by a single tone-modulating signal of frequency fm is defined as

B =2 Df(1+1/ b)

9. Define the deviation ratio D for non-sinusoidal modulation. [REMEMBER]

The deviation ratio D is defined as the ratio of the frequency deviation Df, which corresponds to the maximum possible amplitude of the modulation signal m(t),to the highest modulation frequency . D = Df / fm

10. What is the use of crystal controlled oscillator? [REMEMBER]

The crystal-controlled oscillator always produces a constant carrier frequency there by enhancing frequency stability.

11. What are the disadvantages of FM system? (May/June 2012) [REMEMBER]

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 Define probability.

12. What is pre-emphasis? Why is it used? (April/May 2010) [REMEMBER]

(OR)

What is the need for Pre-emphasis filter. (May/June 2013)(May / June 2016)

The premodulation filtering in the transistor, to raise the power spectral density of the base band signal in its upper-frequency range is called pre emphasis (or pre distortion) Pre emphasis is particularly effective in FM systems which are used for transmission of audio signals.

13. Define phase modulation. [REMEMBER]

It is a type of modulation, used in communication systems, in which the phase of a carrier wave is varied by an amount proportional to the instantaneous amplitude of the modulating signal.

14. What are the applications of phase locked loop? .(Nov/Dec 2010) [REMEMBER]

Phase-locked loops are widely used in radio, telecommunications, computer and other electronic applications.

15. State the frequency in an FM system is 500 Hz and modulating voltage is 3 V,modulation index is 60. Calculate maximum deviation and bandwidth. [APPLY]

Modulation index m = δ/fm

60 = δ/ 500

δ = 60 x 500 = 30 kHz

Bandwidth BW = 2 δ = 2 x 30 = 60 kHz.

16. Mention advantages of angle modulation over amplitude modulation.(Nov / Dec 2015) [REMEMBER]

1. The amplitude of FM is constant. It is independent of depth of modulation.Hence transmitter power remains constant in FM whereas it varies in AM.

2. Since amplitude of FM is constant, the noise interference is minimum in FM.

3. FM uses UHF and VHF ranges, the noise interference is minimum compared to AM which uses MF and HF ranges.

17. A 80MHz carrier is frequency modulated by sinusoidal signal of 1V amplitude and the frequency sensitivity is 100Hz/V. Find the approximate bandwidth of the FM waveform if the modulating signal has a frequency of 10KHz. [APPLY]

2 (δ + fm) = 2 (100 + 10000) = 20.2 kHz.

18. What is frequency deviation in FM? (November/December 2013). [REMEMBER]

Frequency deviation is the change in frequency that occurs in the carrier when it is acted on by a modulating signal frequency. The frequency deviation is typically given as the peak frequency shift in Hertz (Δf).

19. What is the bandwidth required for an FM wave in which the modulating frequency signal is 2 KHz and the maximum frequency deviation is 12 Khz? . (NOV/DEC 2005) [APPLY]

Bandwidth = 2 (δ + fm) = 2 (12 + 2) = 28 kHz.

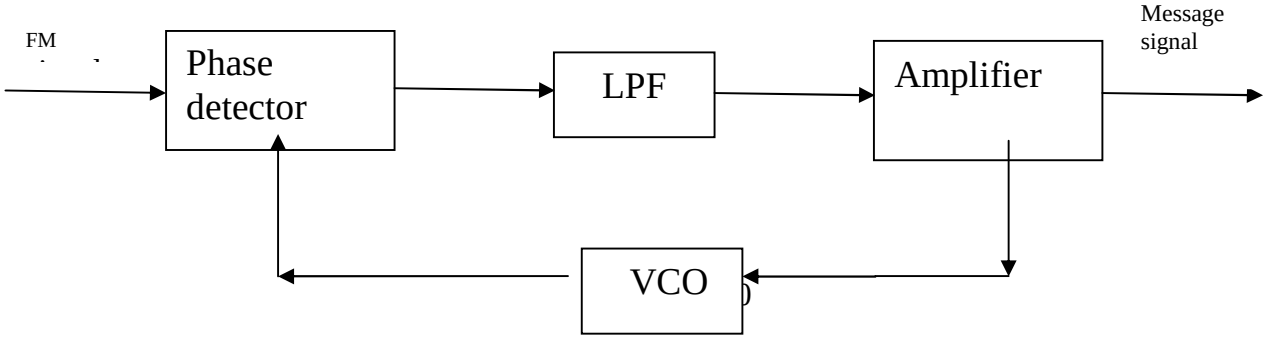
20. A carrier wave of frequency 100 MHz is frequency modulated by a signal 20sin(200π x 103t) What is bandwidth of FM signal if the frequency sensitivity of the modulation is 25kHz/v. [APPLY]

Bandwidth = 2 (δ + fm) = 2 (500 + 100) = 1.2 MHz.

27. Define modulation index of frequency modulation. (April/May 2010), (May/June 2013) [REMEMBER]

It is defined as the ratio of maximum frequency deviation to the modulating frequency. B = Δf/fm

24. Draw a simple schematic of a PLL demodulator. (November/December 2013) [REMEMBER]



25.Define lock in range and dynamic range of a PLL. (Apr/May 2015) [REMEMBER]

The range of frequencies over which the PLL can maintain lock with the incoming signal is called the lock-in range or tracking range. It is expressed as a percentage of theVCO free running frequency.

* The range of frequencies over which the PLL can acquire lock with an input signal is called the capture range. It is expressed as a percentage of the VCO free running frequency.

26.A carrier is frequency – modulated with a sinusoidal signal of 2 kHz resulting in a maximum frequency deviation of 5KHz.Find the bandwidth of the modulated signal.(Apr/May 2015) [APPLY]

(Δf)= frequency deviation/Modulating Frequency
= 5 KHz/2 Khz= 2.5

27.A carrier signal is frequency modulated by a sinusoidal signal of 5 Vpp and 10 Khz. If the frequency deviation constant is 1KHz/V, determine the maximum frequency deviation and state whether the scheme is narrow band FM or wide band FM.(May / June 2016) [APPLY]

Given fm =10 kHz Bw = 2(fm+ Δf) = 22 kHz.

28. A frequency modulated signal is given as S(t) = 20 cos[2πf_ct + 4 sin (200 π t)].Determine the required transmission bandwidth. (Nov / Dec 2017) [APPLY]

Given s(t) = 20cos[2πfct + 4sin(200πt)]

Compare the given FM signal equation with standard FM signal,

s(t) = Eccos [2πfct + mf sin2πfmt)]

Here Ec = 20 V, mf = 4,

2πfmt = 200πt =>fm(or) fm(max) = 100 Hz

We know that, modulation index of FM (mf) = δ/fm

Hence δ = mffm = 4 x 100 Hz = 400 Hz.

Bandwidth of FM = 2(δ + fm(max))

= 2(400 + 100)

= 2(500)

= 1000 Hz (or) 1 kHz.

29. Differentiate narrowband FM from AM technique. (April/May 2018) [REMEMBER]

NBFM	AM
Modulation index less than 1	Modulation index is less than 1, equal to one and greater than one
Frequency deviation 5 KHz	Amplitude is varied in accordance with instantaneous value of message signal

Bandwidth 2fm	Bandwidth 2fm
Less suppressing of noise	Presence of more noise

30. What is the need of limiter circuits in FM system? (April/May 2018) [REMEMBER]

Limiter circuit is used in FMreceiver to remove the noise present in the peaks of the received signal and to remove any amplitude variation in the received signal; the output of thelimiter has constant amplitude.

31. Define transmission bandwidth. [UNDERSTAND] **(APRIL/MAY 2019)**

Transmission bandwidth is the actual width of the transmitted signal. It is often narrower than the channel bandwidth to allow practical transmit filters to be used to ensure that the modulated signal does not spread out beyond the channel bandwidth. An example, LTE has a maximum 20 MHz channel bandwidth.

32. **A 25 MHZ carrier is modulated by a 400 HZ sine wave. If the carrier voltage is 4 V and the maximum deviation is 10 KHZ, write the equation of this modulated wave for (i) FM and (ii) PM. (April/May 2021)**

Calculating the frequencies in radians, we have

$\omega_c = 2\pi \times 25 \times 10^6 = 1.57 \times 10^8$ rad/s

$\omega_m = 2\pi \times 400 = 2513$ rad/s

The modulation index will be

$$m = m_f = m_p = \frac{\delta}{f_m} = \frac{10{,}000}{400} = 25$$

This yields the equations

(a) $v = 4 \sin (1.57 \times 10^8 t + 25 \sin 2513t)$ (FM)

(b) $v = 4 \sin (1.57 \times 10^8 t + 25 \sin 2513t)$ (PM)

33. **A 500HZ modulating voltage fed into a PM generator produces a frequency deviation of 2.25 KHZ. What is the modulation index? If the amplitude of the modulating voltage is kept constant, but its frequency is raised to 6 KHZ, what is new deviation? (April/May 2021)**

According to question.....

$$mf = \frac{\delta}{f_m} = \frac{2250}{500} = 4.5$$

$$\text{New deviation} = 2(m_f f_m)$$

$$= 2 \times 4.5 \times 6$$

$$= 54\,\text{kHz}$$

PART B

1. Explain the indirect method of generation of FM wave and any one method of demodulating an FM wave. (16) ***NOV/DEC 2006*****[REMEMBER]**

2.Derive the expression for the frequency modulated signal. Explain what is meant by FM. **[REMEMBER]**

3.Explain any two techniques of demodulation of FM. . (16) ***(NOV/DEC 2006)*** **[REMEMBER]**

4.Explain the working of the reactance tube modulator and drive an expression to show how the variation of the amplitude of the input signal changes the frequency of the output signal of the modulator. (16) (MAY/JUNE 2007) **[REMEMBER]**

5.Discuss the effects of nonlinearities in FM. (8) **[ANALYSIS]**

6.Discuss in detail FM stereo multiplexing. . (8) **[ANALYSIS]**

7.(i) Derive the expression for the frequency modulated signal. Explain what is meant by narrow –band FM and wideband FM using the expression ***NOV/DEC 2006.*** **[REMEMBER]**

(ii) Discuss the indirect method of generating a wideband FM signal. **[REMEMBER]**

8.Draw the frequency spectrum of FM and explain. Explain how Varactor diode can be used for frequency modulation. . (16) **[REMEMBER]**

9.Draw the circuit diagram of Foster-Seeley discriminator and explain its working. ***(April/May 2021)*** (8).***(APR/MAY-2015)*** **[REMEMBER]**

10. Explain the principle of indirect method of generating a wide-band FM signal with a neat block diagram. (8)***(NOV/DEC 2006)*** **[REMEMBER]**

11. Differentiate narrow band and wide band FM. ***(MAY/JUNE 2007)*** **[REMEMBER]**

12. Derive an expression for the spectrum of a FM signal with single tone modulation. **[REMEMBER]**

13. Compare the performance of AM and FM. **[UNDERSTAND]**

14. Derive the expression for the single tone frequency modulation and draw its fre-quency spectrum***(April/May 2011)*** **[REMEMBER]**

15. An angle modulated wave is described by the equation $V(t)=10\cos(2\times10^{6}\pi t+10\cos 2000\pi t)$ Find (1) Power of the modulated signal (2) Maximum frequency deviation (3) Bandwidth***(April/May 2011) (May / June 2016)*** **[APPLY]**

16. With necessary diagrams explain the operation of slope detector for demodulatingFM signal ***(April/May 2011)*** **[REMEMBER]**

17. (i) Using suitable Mathematical analysis show that FM modulation produces infinite sideband. Also deduce an expression for the frequency modulated output and its frequency spectrum (ii) How can we generate FM from AM and AM from FM ***(April/May 2010)*** **[UNDERSTAND]**
18. (i)Define frequency modulation. Draw the FM waveform. Derive an expression for single tone frequency modulation. (ii) Compare narrow band and Wide band FM ***(Nov/Dec 2010)*** **[REMEMBER]**
19. Draw the circuit diagram of a Foster-Seeley discriminator and explain its working with relevant phasor diagrams. ***(April/May 2012)(May / June 2016)*** **[REMEMBER]**
20. Derive the mathematical expression for FM wave ***(May/June 2013)*** **[REMEMBER]**

    When the modulating frequency in an FM system is 400 Hz and the modulating voltage is 2.4 v, 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 3.2 V. ***(May/June 2013).***

21. (i) Explain the Armstrong method to generate FM signal. **[REMEMBER]** ***(May/June 2013) (May / June 2016)*** **(April/May 2021)**

(ii) How is the phase and frequency modulation are related? Explain (May/June 2013) A carrier wave of frequency 80 MHz is frequency modulated by a sine wave amplitude of volts and frequency of 80 kHz. The frequency sensitivity of the modulator is 20 kHz/v. **[UNDERSTAND]**

(iii) Determine the approximate bandwidth of the FM wave by Carson's rule ii) Determine the bandwidth by transmitting only those side frequencies whose amplitude exceed 1 % of the unmodulated carrier amplitude (use the universal curve/ideal condition ***(November/December 2013)*** **[REMEMBER]**

23. Describe how FM wave is generated by the indirect method and give a suitable demodulating scheme for the same ***(November/December 2013).*** **[UNDERSTAND]**
24. Explain Armstrong method of FM generation. ***(May/June 2014*****(April/May 2021)*****).*** **[REMEMBER]**
25. Explain the functions of any FM detector circuit. ***(May/June 2014).*** **[REMEMBER]**
26. Explain how FM is achieved using varactor diodes. ***(May/June 2014).*** **[REMEMBER]**
27. Make atleast five comparisons of AM and FM systems. ***(May/June 2014)*** **[REMEMBER]**

28.a) i) Derive the expression for the single tone frequency modulated signal and hence prove that is the constant envelope modulation requiring infinite bandwidth. ***(NOV/DEC-2014)*** **[REMEMBER]**

ii) Draw the typical spectrum of the FM. ***(NOV/DEC-2014)*** **[REMEMBER]**

b) i) Explain the indirect method of generating FM signal. ***(NOV/DEC-2014) (NOV/DEC-2017)***

[REMEMBER]

ii) Explain the operation of PLL as FM demodulator. ***(NOV/DEC-2014)*** **[REMEMBER]**

26. Explain with diagrams the generation of FM using direct method. (8).

(NOV/DEC 2008, APR/MAY-2015) **[REMEMBER]**

27. An angle modulated wave is described by the equation $V(t)=10\cos(2\times10^6\pi t+0.1\sin 10^3\pi t)$

Find **[APPLY]**

(1) Considering V(t) as a PM signal with Kp = 10,find m(t)

(2) Considering V(t) as a FM signal with Kp = 10π,find m(t) ***(APR/MAY-2015)***

28. With relevant diagrams, explain how the frequency discriminator and PLL are used as frequency demodulation? **(*Nov / Dec 2015)*** **[UNDERSTAND]**

29. Derive the expression for the single tone frequency modulated signal and comment on the transmission bandwidth. ***(Nov / Dec 2015)*** **[REMEMBER]**

30. Derive the expression for the single tone frequency modulated signal with necessary diagrams and draw its frequency spectrum***.(May / June 2016)*** **[REMEMBER]**

31.List the advantages of frequency modulation over amplitude modulation. ***(Nov / Dec 2017)***

[REMEMBER]

32. Explain the Fm demodulation process using frequency discrimination process. ***(Nov / Dec 2017)***

[REMEMBER]

33. i) Obtain a mathematical expression for FM using Bessel's function. And also brief the method to determine the bandwidth of FM wave. ***(April /May 2018)*** **[UNDERSTAND]**

ii) Discuss the process of FM generation using reactance modulator. ***(April /May 2018)***

[UNDERSTAND]

34. i) Highlight the process involved in obtaining amplitude variation from phase variation using suitable FM demodulator circuit. ***(April /May 2018)*** **[UNDERSTAND]**

ii) Elucidate the process of FM demodulation using PLL method. ***(April /May 2018)*** **[UNDERSTAND]**

35. Explain the characteristics and features of demodulation of FM signal with a neat diagram. (13)

[UNDERSTAND] ***(APR/MAY 2019)***

36. i). Discuss about the need for frequency translation.(5) **[UNDERSTAND]*****(APRIL/MAY 2019)***

ii). What does PLL consist of? Draw the diagram and explain.(8). **[REMEMBER]** ***(APRIL/MAY 2019)***

37. Compare FM and PM system.(3) **[ANALYSIS]** ***(APRIL/MAY 2019)***

ASSIGNMENT QUESTIONS

1. State the Carson's rule. (CO2-PO1) **[REMEMBER]**
2. Derive the mathematical representation of FM waves. (CO2-PO1) **[REMEMBER]**
3. When the modulating frequency in an FM system is 400Hz and the modulating
   a. voltage is 2.4V the modulation index is 60.Calculate the maximum deviation. What
   b. is the modulating index when the modulating frequency is reduced to 250Hz and
   c. the modulating voltage is simultaneously raised to 3.2V. (CO2-PO2) **[APPLY]**
4. An angle modulated signal with carrier frequency $\omega_c = 2\pi \times 10^5$ is described by the equation $m(t) = 10 \cos(\omega_c t + 5\sin 3000t + 10 \sin 2000\pi t)$. (CO2-PO2) **[UNDERSTAND]**
   a. Find the power of the modulated signal
   b. Find the frequency deviation Δf
   c. Find the deviation ratio β
   d. Find the Phase deviation $\Delta\varphi$
   e. Estimate the Bandwidth of m(t)
5. Design a FM modulator circuit using FET and varactor diode.(CO2-PO3) **[CREATE]**
6. Write a MATLAB program for generation and detection of FM signal. (CO2-PO5) **[CREATE]**
7. Write a MATLAB program for generation and detection of FM signal with noise. (CO2-PO5) **[CREATE]**
8. Define modulation index of FM. (CO2-PO1) **[REMEMBER]**
9. Derive the mathematical representation of PM waves. (CO2-PO1) **[REMEMBER]**
10. When the modulating frequency in an FM system is 200Hz and the modulating voltage is 1.4V the modulation index is 40.Calculate the maximum deviation. What is the modulating index when the modulating frequency is reduced to 150Hz andthe modulating voltage is simultaneously raised to 1.2V? (CO2-PO2) **[APPLY]**
11. An angle modulated signal with carrier frequency $\omega_c = 2\pi \times 10^5$ is described by the equation $m(t) = 20 \sin(\omega_c t + 5\sin 3000t + 10 \sin 2000\pi t)$. (CO2-PO2) **[UNDERSTAND]**
    a. Find the power of the modulated signal
    b. Find the frequency deviation Δf

c. Find the deviation ratio β
d. Find the Phase deviation Δφ
e. Estimate the Bandwidth of m(t)

12. Design a FM demodulator circuit using Phase discriminator. (CO2-PO3) **[CREATE]**
13. Write a MATLAB program for generation and detection of FM signal. (CO2-PO5) **[CREATE]**
14. Write a MATLAB program for generation and detection of FM signal with noise. (CO2-PO5) **[CREATE]**
15. Draw the typical spectrum of FM. (CO2-PO1) **[REMEMBER]**
16. How is Narrowband FM converted into Wideband FM? (CO2-PO1) **[UNDERSTAND]**
17. When the modulating frequency in an FM system is 100Hz and the modulating voltage is 3.4V the modulation index is 70.Calculate the maximum deviation. What is the modulating index when the modulating frequency is reduced to 150Hz and the modulating voltage is simultaneously raised to 1.6V. (CO2-PO2) **[APPLY]**
18. An angle modulated signal with carrier frequency $\omega_c = 2\pi \times 10^6$ is described by the equation
19. m (t) = 40 sin (ω_c t+5sin 6000t+10 sin 1000πt). (CO2-PO2) **[UNDERSTAND]**
    a. Find the power of the modulated signal
    b. Find the frequency deviation Δf
    c. Find the deviation ratio β
    d. Find the Phase deviation Δφ
    e. Estimate the Bandwidth of m(t)
20. Design a FM modulator circuit using Nonlinear Device.(CO2-PO3) **[CREATE]**
21. Write a MATLAB program for generation and detection of FM signal. (CO2-PO5)**[CREATE]**
22. Write a MATLAB program for generation and detection of FM signal with noise. (CO2-PO5) **[CREATE]**

UNIT III- RANDOM PROCESS

Random variables, Random Process, Stationary Processes, Mean, and Correlation & Covariance functions, Power Spectral Density, Ergodic Processes, Gaussian Process, Transmission of a Random Process through a LTI filter.

PART A (Question and Answer)

1. Define probability. [REMEMBER]

The probability of occurrence of an event A is defined as,

$$P(A) = \frac{\text{number of possible favorable outcomes}}{\text{Total number of equal likely outcomes}}$$

2. What are mutually exclusive events? [REMEMBER]

Two possible outcomes of an experiment are defined as being mutually exclusive if the occurrence of one outcome precludes the occurrence of the other.

3. Define probability density function. [REMEMBER]

Probability density function is defined as fx(x) is defined in terms of cumulative distribution function Fx (x) as

$$fx(x) = \frac{d\,Fx\,(x)}{dx}$$

4. Define random variable (April/May 2010)(Nov / Dec 2015) [REMEMBER]

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 _es and whose range is R, is the real line.

5. Define Random process. (May/June 2012) [REMEMBER]

A Random process X (s,t) is a function that maps each element of a samples space into a time function called sample function. Random process is a collection of time functions.

6. Define Auto correlation function. (May / June 2016) [REMEMBER]

Defined as a measure of similarity between signal or processand its replica by avariable amount.

7. What is meant by ergodic process? (Nov / Dec 2017) [REMEMBER]

A random process is called ergodic process if time averages are equal to ensemble averages. Thus for ergodic process, $mx(t) = m_x(T)$ and $Rx(t_1, t_2) = R_x(\tau,T)$. Where mx(t) is ensemble mean, $m_x(T)$ is time mean, $Rx(t_1, t_2)$ is ensemble autocorrelaion and $R_x(\tau,T)$ is time autocorrelation.

8. Give the mathematical definition for random process. (April / May 2018) [REMEMBER]

Random process is defined as the ensemble (collection) of time functions together with a probability rule. $x_1(t)$ is an outcome of experiment 1 $x_2(t)$ is the outcome of experiment 2 . . . $x_n(t)$ is the outcome of experiment n. Each sample point in S is associated with a sample function x(t). X(t, s) is a random process.

9. What is narrow band noise? (April / May 2018) [REMEMBER]

If the bandwidth of bandlimited noise is relatively small compared to the carrier frequency it is called as Narrow-band noise (NBN) is a type of noise that is centered on a small range of frequencies. It is produced by filtering a 1/3 octave range from a broad-band noise stimulus.

10. What is the difference between random variable and random process? (April / May 2019) [REMEMBER]

Random Variable	Random Process
A function of the possible outcomes of an experiment is X(s)	A function of the possible outcomes of an experiment and also time i.e, X(s, t)
Outcome is mapped into a number x.	Outcomes are mapped into wave from which is a fun of time 't'.

11. When a random process is said to be strict sense or strictly stationary? (April / May 2019) [REMEMBER]

Strict-sense stationarity: – A process is nth order stationary if the joint distribution of any set of n time samples is independent of the placement of the time origin. – A process that is nth order stationary for every integer n > 0 is said to be strictly stationary, or just stationary for short.

12. When is a random process called deterministic? (April / May 2021)

When the future values of any sample fuction can be predicted from a knowledge of past values then the random process is called deterministic random process.

PART B

1. Derive the effective noise temperature of a cascade amplifier. Explain how the various noise are generated in the method of representing them.(16) **[REMEMBER]**
2. Show how a narrow band noise can be represented as n(t) = nc(t) coswct - ns(t) sinwct where nc(t) and ns(t) are the in-phase and quadrature phase components of noise respectively. **[UNDERSTAND]** ***(NOV/DEC 2006)***
3. Derive the Friis formula. Explain noise effect on bandwidth. ***(NOV/DEC 2008)*** **[REMEMBER]**
4. What is noise temperature? Deduce the expression for effective noise temperature for a cascaded system. Explain narrow band noise. **[REMEMBER]** ***(NOV/DEC 2008)***
5. Explain how the various noises are generated and the method of representing them. **[REMEMBER]**
6. Explain concept of noise equivalent Bandwidth **[REMEMBER]*(NOV/DEC 2007)***
7. Write notes on noise temperature and noise figure. (8) **[REMEMBER]**
8. What is meant by noise equivalent bandwidth? Illustrate it with a diagram. ***(NOV/DEC 2006)*** **[REMEMBER]**
9. What is a narrow band noise ? Discuss the properties of the quadrature components of a narrowband noise.**[REMEMBER]*(NOV/DEC 2006)***
10. Derive the expression for output signaltonoise for a DSBSC receiver using coherent detection. **[REMEMBER]**
11. Write short notes on noise in SSB receivers. **[REMEMBER]*(NOV/DEC 2006)***
12. Derive the noise figure for cascade stages. (8) **[REMEMBER]**

13. Write short notes on:**[REMEMBER]**
    (i)Shot noise.(4)
    (ii)Thermal noise.(4)
    (iii) Noise figure and Noise temperature. (8) ***(MAY/JUNE 2007)***
14. What is narrowband noise discuss the properties of the quadrature components of a narrowband noise. (8) **[REMEMBER]**
15. What is meant by noise equivalent bandwidth? Illustrate it with a diagram(8) **[REMEMBER]**
16. Derive the expression for output signal to noise for a DSB-SC receiver using coherent detection. **[REMEMBER]**
17. Write short notes on noise in SSB. (16) **[REMEMBER]**
18. Discuss the following: (16) **[UNDERSTAND]**
    a) noise equivalent bandwidth (4)
    b) narrow band noise (4)
    c) noise temperature (4)
    d) noise spectral density (4)
19. How sine wave plus noise is represented? Obtain the joint PDF of such noise component. **[UNDERSTAND]**
20. State and prove four properties of Gaussian process**[REMEMBER]**
21. Derive the representation of narrowband noise in terms of envelope and phase components and list outits properties. **[REMEMBER]**
22. Write the details about narrow band noise and the properties of quadrature components of narrowband noise.**[REMEMBER]*(April/May 2010)***
23. List the different types of random process and give the definitions. **[REMEMBER]**
24. Write short notes on Shot Noise. ***(Nov/Dec 2010)*** **[REMEMBER]**
25. State and prove four properties of Gaussian process **.*(April/May 2011)*** **[REMEMBER]**
26. Derive the representation of narrowband noise in terms of envelope and phase components and list out its properties. **[REMEMBER]**
27. Consider two amplifiers are connected in cascade. First stage amplifier has gain and noise figure as 10 dB and 2 dB. Second stage has noise figure of 3 dB. Calculate total noise power .***(April/May 2011)*** **[UNDERSTAND]**
28. Derive the representation of narrowband noise in terms of envelope and phase components and list out its properties. **[REMEMBER]**

29. List the different types of random process and give the definitions. **[REMEMBER]**
30. Write short notes on shot noise. **[REMEMBER]** ***(April/May 2012) (May/June 2013).***
31. Write the definition, power spectral density and autocorrelation function for white noise and narrow band noise (filtered white noise). **[REMEMBER]**
32. What causes thermal noise in a material? Write the expression for RMS value of the noise. ***(April/May 2012)*** **[REMEMBER]**
33. Derive relationship between noise figure and equivalent noise temperature ***(May/June2013)*** **[REMEMBER]**
34. Explain the following terms mean, correlation, covariance and ergodicity.***(May/June 2013).*** **[REMEMBER]**
35. How do you represent narrowband noise? ***(May/June 2013)*** **[UNDERSTAND]**
36. Summarise the characteristics of various noise found in a communication channel. ***(November/December 2013)*** **[REMEMBER]**
37. Derive the equation for finding the probability density function of a one to one differentiable function of a given random variable.***(November/December 2013).*** **[REMEMBER]**
38. Define and Explain the following: i) Gaussian Noise and Gaussian Distribution ii)Thermal Noise iii) Shot Noise. What type of PDF does Gaussian noise follow.***(May/June 2014)*** **[REMEMBER]**
39. If X is a uniformly distributed $f_X(x) = \begin{cases} 1/2® & ;0 \le x \le 2® \\ 0 & ;otherwise \end{cases}$ find E(X),E(X2), E[cos X] and E[(X-mx)2] ***(May/June 2014).*** **[APPLY]**
40. Let X and Y be real random variables with finite second moments.Prove the Cauchy-Schwarz inequality.(E[XY])2 ≤ E[X2] E[Y2] (8) (APR/MAY-2015) [ANALYSIS]
41. Differentiate the Strict-sence stationary with that of wide sense stationary process.(8) ***(APR/MAY-2015)*** **[UNDERSTAND]**
42. In a binary communication system,let the probability os sending a 0 and 1 be 0.3 and 0.7 respectively.let us assume that a 0 being transmitted,the probability of it being received as 1 is 0.01 and the probability of error for a transmission of 1 is 0.1.

    (i).What is the probability that the output of this channel is 1?

    (ii).If a 1 is received, then what is the probability that the input to the channel was 1? ***(Nov / Dec 2015)*** **[CREATE]**
43. What is CDF and PDF? State their properties. Also discuss them in detail by giving examples of CDF and PDF for different types of random variables. ***(Nov / Dec 2015)*** **[REMEMBER]**

44. Two random process X(t)= A cos (ωt + ɵ) and Y(t)= A sin (ωt + ɵ) where A and ω are constants and ɵ is the uniformly distributed random variable in(0,2®). Find the cross correlation function.***(May / June 2016)*** **[APPLY]**
45. Explain in detail about the transmission of random process through LTI filter.***(May / June 2016) (Nov / Dec 2017)*** **[REMEMBER]**
46. Whae is a random process said to be strict sense stationary (SSS), Wide sense stationary (WSS) and Ergodic process. ***(May / June 2016)*** **[REMEMBER]**
47. Give a random process,X(t) = A cos (ωt + μ) where A and ω are constants and μ is a uniform random variable. Show that X(t) is ergodic in both mean and auto correlation. ***(May / June 2016)*** **[APPLY]**
48. i) Discuss the properties of Gaussian noise process. ***(Nov / Dec 2017)*** **[REMEMBER]**

    ii) Consider a random process defined as X(t) = Acosωt, where ω is a contant and A is random Uniformly distributed over [0,1]. Find the autocorrelation and auto covariance of X (t). ***(Nov / Dec 2017)*** **[REMEMBER]**

48. Distinguish between random variable and random process.Give examples to each. ***(Nov / Dec 2017)*** **[REMEMBER]**
50. i) Consider the quadrature-amplitude modulated signal:Y(t) = X(t)cos(w_0t)-Z(t)sin(w_0t) where X(t) and Z(t) are zero mean independent processes with identical autocorrelatios, R_x=R_z. Determine $R_Y(t_1,t_2)$ and show that if $R_x(t_1,t_2)$= $R_x(t_1-t_2)$, then $R_Y(t_1-t_2)$. ***(April / May 2018)*** **[APPLY,EVALUATE]**

    ii) Discuss the properties of autocorrelation function. ***(April /May 2018)*** **[UNDERSTAND]**
51. i) State and explain the properties of Gaussian Process. ***(April/May 2018)*** **[UNDERSTAND]**

    ii) Using suitable sketches, expression, explain the transmission of random process through a LTI filter. ***(April/May 2018)*** **[UNDERSTAND]**
52. i). Describe the central limit theorem.(8). **[UNDERSTAND]** ***(April/May 2019)***

    ii). Assuming X is a Gaussian random variable with m=0 and σ = 1, find the probability density function of the random variable Y=aX+b.(5). **[APPLY]** ***(April/May 2019)***
53. Describe the properties of power spectral density.(13). **[UNDERSTAND]** ***(April/May 2019)***
54. A random process X(t) is defined by X(t)= A cos (2πfct), Where A is a Gaussian distributed random variable of zero mean and variance σ^2_A. This random process is applied to an ideal integrator, producing the output.

$$Y(t) = \int_0^t X(\tau)d\tau$$

a) Determine the probability density function of the output Y(t) at a particular time t_k.

b) Determine whether or not Y(t) is stationary.

c) Determine whether or not Y(t) is ergodic. (12). **[APPLY]** ***(April/May 2019)***

55. (i)State the properties of a Gaussian process. (ii)For the sine wave process X (t) = Y cos t, –∞ < t< ∞ where ω = constant, the amplitude Y is a random variable with uniform distribution in the interval 0 and 1. Check whether the process is stationary or not. ***(April/May 2021)***

56. (i)State any four properties of power spectral density. (ii) The ACF of the random telegraph signal process is given by R(t)=e–2λt. Determine the power density spectrum of the random telegraph signal. ***(April/May 2021)***

ASSIGNMENT QUESTIONS

1. Derive Central Limit Theorem. (CO3-PO1) [REMEMBER]
2. 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].(CO3-PO2) [APPLY]
3. State and prove the properties of Gaussian Process. (CO3-PO2) [REMEMBER]
4. Given a random process, X(t)= A cos(ωt+θ), where A and ω are constants and θ is a uniform random variable. Show that X(t) is ergodic in mean and autocorrelation.(CO3-PO2) [UNDERSTAND]
5. Design an LTI filter for transmission of random process.(CO3-PO3) [CREATE]
6. Write a MATLAB program to analyze probability density function, autocorrelation function and power spectral density of White Noise following Gaussian distribution. (CO3-PO5) [CREATE]
7. Write a MATLAB program to find crosscorrelation for a signal (CO3-PO5) [CREATE]
8. Define random variable (CO3-PO1)
9. How will you define narrow-band noise m(t) at the IF filter output in terms of its inphase and quadrature components.(CO3-PO2)
10. Write a MATLAB program to generate a random signal. (CO3-PO5) [CREATE]
11. Write a MATLAB program to find mean, variance for random numbers. (CO3-PO5) [CREATE]

UNIT IV – NOISE CHARACTERIZATION

Noise sources –Noise figure, noise temperature and noise bandwidth –Noise in cascaded systems. Representation of Narrow band noise –In-phase and quadrature, Envelope and Phase –Noise performance analysis in AM &FM systems –Threshold effect, Pre-emphasis and de -emphasis for FM.

PART A (Question and Answer)

1. Define noise. [REMEMBER]

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

2. Give the classification of noise. [REMEMBER]

Noise is broadly classified into two types. They are External noise and internal noise.

3. What are the types of External noise? [REMEMBER]

External noise can be classified into

1. Atmospheric noise
2. Extraterrestrial noises
3. Man –made noises or industrial noises

4. What are types of internal noise[REMEMBER]

Internal noise can be classified into 1. Thermal noise 2. Shot noise 3. Transit time noise

4. Miscellaneous internal noise

5. What are the types of extra terrestrial noise and write their origin? [REMEMBER]

The two type of extraterrestrial noise are solar noise and cosmic noise Solar noise is the electrical noise emanating from the sun. Cosmic noise is the noise received from the center part of our galaxy, other distant galaxies and other virtual point sources.

6. Define transit time of a transistor. **[REMEMBER]**

Transit time is defined as the time taken by the electron to travel from emitter to the collector.

7. Define flicker noise. [REMEMBER]

Flicker noise is the one appearing in transistors operating at low audio frequencies. Flicker noise is proportional to the emitter current and junction temperature and inversely proportional to the frequency.

8. State the reasons for higher noise in mixers. [REMEMBER]

1. Conversion transconductance of mixers is much lower than the transconductance of amplifiers.
2. If image frequency rejection is inadequate, the noise associated with the image frequency also gets accepted.

9. Define signal to noise ratio. [REMEMBER]

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

10. Define noise figure. (**May/June 2014**), (**May/June 2013**). **[REMEMBER]**

$$\text{Nose figure } F = \frac{\text{S/ N at the input}}{\text{S/ N at the output}}$$

S/N = Signal power / Noise Power

11. Explain thermal noise. . (NOV/DEC 2008), (NOV/DEC 2006) [REMEMBER]

Thermal noise is the name given to the electrical noise arising from the random motion of electrons in a conductor.

12. Give the expression for noise voltage in a resistor. [REMEMBER]

The mean –square value of thermal noise voltage is given by V_n^2= 4 K T B R

K – Boltz man constant
R – resistance
T – obsolute temperature
B – Bandwidth

13. Explain White Noise. (NOV/DEC 2007) (May/June 2013). (May/ June 2014) (April / May 2021) [REMEMBER]

Many types of noise sources are Gaussian and have flat spectral density over a wide frequency range. Such spectrum has all frequency components in equal portion, and is therefore called white noise. The power spectral density of white noise is independent of the operating frequency.

14. What is narrowband noise? [REMEMBER]

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. Give the expression for equivalent noise temperature in terms of hypothetical temperature. (May/June 2012) [REMEMBER]

The expression for equivalent noise temperature in terms of hypothetical temperature is

Te = (F- 1) T0

Where, F is the noise figure and T0 absolute temperature.

16. Give the Friss formula in terms of noise temperature. [REMEMBER]

The Friss formula in terms of noise temperature is

Te = T1 + T2 / G1 + T3 / G1 G2 + ……

G1 , G2 ,… Gain of amplifiers

17. What is called image frequency? [REMEMBER]

Image frequency is defined as the signal frequency plus twice the intermediate frequency. This has the effect of two stations being received simultaneously and hence it is undesirable. fsi = fs + 2 fi fsi - image frequency It can be eliminated by providing adequate image signal selectivity between antenna and mixer input.

18. What is intermediate frequency? . (NOV/DEC 2006) [REMEMBER]

(OR)

What is meant by image frequency in super heterodyne receiver?(November/December 2014)

Intermediate frequency (IF) is defined as the difference between the signal frequency and the oscillator frequency. IF = fs – fo when fs > fo (or) IF = fo –fs when fo > fs

19. Define Partition noise. [REMEMBER]

In an electron tube having one or more positive grids, this noise is caused by irratic partition of the cathode current among the positive electrodes. In a transistor, the partition noise is created from the random fluctuation in the division of current between the collector and base.

20. Give the expression for noise voltage when several sources are cascaded. [REMEMBER]

Enr = Sqrt (4 KTB (R1 + R2 + …..)

Where R1, R2 --- are the resistances of the noise resistors.

K – Boltz man constant

T – Absolute temperature

B – Bandwidth

21. Define equivalent B.W (May/June 2008) (April / May 2021) [REMEMBER]

It is defined as B.W of an ideal filter at which the noise power passed by real filter and ideal filter is same.

22. How will you define narrow-band noise m(t) at the IF filter output in terms of its inphase and quadrature components. (November/December 2013). [UNDERSTAND]

The band pass filters have narrow bandwidths in the sense that bandwidth is small as compared to center frequency outputof this kind of band pass filter as narrow band noise.

$$n(t) = n_c(t)\cos 2\pi f_c t - n_s \sin 2\pi f_c t$$

23. **Define the term noise equivalent temperature (November/December 2014) (May / June 2016) [REMEMBER]**

Defined as the temperature at which a noisy resistor has to be maintained such that, by connecting the resistor to the input of a noiseless version of the system, it produces the same available noise power at the output of the system as that produced by all the source of noise in the actual system.

$$T_{eq}=(F-1)T_o$$

24. **Define the Q factor of a receiver. (APR/MAY-2015) [REMEMBER]**

$Q=R/\omega L$

R- Resistance

ω-Angular frequency

L-Inductance

25. **Write the equation for the mean square value of thermal noise voltage in a resister. (APR/MAY-2015) [REMEMBER]**

$P_n=4KTRB$

K-Boltzmann's constant K=1.38*10^-23

T-Temperature

B-Bandwidth

26. **. State Baye's Rule. (Nov / Dec 2015) [REMEMBER]**

Bayes' theorem is stated mathematically as the following equation

$$P(A / B) = (P(B / A) * P(A)) / P(B),$$

where A and B are events and $P(B) \neq 0$.

- P(A) and P(B) are the probabilities of observing A and B without regard to each other.
- P(A | B), a conditional probability, is the probability of observing event A given that B is true.
- P(B | A) is the probability of observing event B given that A is true.

27. What is the figure of merit of DSBSC system ? [REMEMBER]

The figure of merit of DSBSC signal is unity

28. Compare the noise performance of an AM and FM system? (NOV/DEC 2008) [UNDERSTAND]

The figure of merit of AM system is 1/3 when the modulation is 100 percent and that of FM is(3/2)mf 2.The use of FM offers improved noise performance over AM when (3/2)mf 2 > 1/3.mf –modulation index in FM.

29. What is Capture effect? (May/June 2012) (or) [REMEMBER] Define capture effect in FM.(May / June 2016)

When the interference signal and FM input are of equal strength, the receiver fluctuates back and front between them .This phenomenon is known as the capture effect.

30.What is threshold effect? (May/June 2012) [REMEMBER]

As the input noise power is increased the carrier to noise ratio is decreased the receiver breaks and as the carrier to noise ratio is reduced further crackling sound is heard and the output SNR cannot be predicted by the equation. This phenomenon is known as threshold effect.

31.How is threshold reduction achieved in FM system? [UNDERSTAND]

Threshold reduction is achieved in FM system by using an FM demodulator with negative feedback or by using a phase locked loop demodulator.

32. What is Pre-emphasis? (APR/MAY-2015) [REMEMBER]

The premodulation filtering in the transistor, to raise the power spectral density of the base band signal in its upper-frequency range is called pre emphasis (or pre distortion) Pre emphasis is particularly effective in FM systems which are used for transmission of audio signals.

33. Define de-emphasis. **[REMEMBER]**

The filtering at the receiver to undo the signal pre-emphasis and to suppress noise is called de-emphasis.

34. What are the characteristics of a receiver? [REMEMBER]

The characteristics of a receiver are sensitivity, selectivity, fidelity, signal to noise ratio.

35. What is a post detection filter? [REMEMBER]

The post detection filter named as"base-band low pass filter" has a bandwidth that is just large enough to accommodate the highest frequency component of the message signal.

36. Define SNR. [REMEMBER]

It is defined as the ratio of signal power to the noise power.

37. How to achieve threshold reduction in FM receiver? [UNDERSTAND]

When the carrier to noise ratio reduces tocertain value, tyhe message information is lost.The performance of the envelope detector deteriorates rapidly and it has no proportion with carrier to noise ratio.

38. What is threshold effect with respect to noise? [REMEMBER]
(Or)
Define threshold effect in AM systems. (Nov / Dec 2015)(APR/MAY-2015)

The loss of message signal in the output of the envelope detector due to low carrier to nois ratio is called as threshold effect.

39. What is FM threshold effect?(Nov/Dec 2010) [REMEMBER]

As the input noise power is increased the carrier to noise ratio is decreased the receiver breaks and as the carrier to noise ratio is reduced further crackling sound is heard and the output SNR cannot be predicted by the equation. This phenomenon is known as threshold effect.

40. Define Pre-emphasis and De-emphasis. .(Nov/Dec 2010) (**November/ December 2013**). **[REMEMBER]**

Pre-emphasis

The premodulation filtering in the transistor, to raise the power spectral density of the base band signal in its upper-frequency range is called pre-emphasis (or pre distortion) Pre emphasis is particularly effective in FM systems which are used for transmission of audio signals.

De-emphasis

The filtering at the receiver to undo the signal pre-emphasis and to suppress noise is called de-emphasis.

41. What is Coherent System (May/June 2013) [REMEMBER]

The local carrier generated at the receiver phase locked with the transmitter carrier is known as coherent detection.

42. When carrier to noise ratio is high, how will you get the figure of merit of FM systems? (Nov / Dec 2013). [UNDERSTAND]

$$FOM = 3K_F^2P/W^2$$

43.Define noise figure. (**May/June 2014**), (**May/June 2013**).**(Nov / Dec 2015) [REMEMBER]**

$$\text{Nose figure } F = \frac{\text{S/ N at the input}}{\text{S/ N at the output}}$$

S/N = Signal power / Noise Power Ratio

44. Define the term noise equivalent temperature(Nov /Dec 2014) (May / June 2016) (Nov /Dec 2017) [REMEMBER]

Defined as the temperature at which a noisy resistor has to be maintained such that, by connecting the resistor to the input of a noiseless version of the system, it produces the same available noise power at the output of the system as that produced by all the source of noise in the actual system.

45. List the external sources of noise. (Nov /Dec 2017) [REMEMBER]

Often **external noise** is called interfering signals. **External noise** sources are either natural (such as solar **noise**, galactic **noise**, and atmospheric **noise**) or man-made (which include industrial **noise**, elec- tric motors, arc welders, switches, broadcast **communication** systems, mobile phones, etc.).

46. Defend the reason why, the SNR of the receiver should be high. (April /May 2018) [UNDERSTAND]

SNR of the receiver should be high so that good sensitivity, selectivity and fidelity can be obtained. Noise and interference can also be reduced through high SNR.

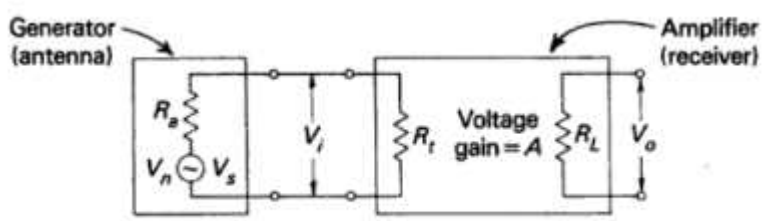
47. How does Pre-emphasis and De-emphasis process provide overall SNBR improvement in FM systems? (April /May 2018) [UNDERSTAND]

Preemphasis provides improvement of SNR as at increases the energy content of high frequency signals and it will be stronger than high frequency noise components. This improves signal to noise ratio and increases intelligibility and fidelity. To return the frequency response to normal level deemphasis is used in the receiver. This combination increases FM reception quality.

48. Give the formula for finding the Noise Figure. [REMEMBER] (APRIL/MAY 2019)

The noise figure is defined as the ratio of the signal to noise power supplied to the input terminals of a receiver or amplifier to the signal to noise power supplied to the output or load resistor. Thus

$$F = \frac{Input\ \frac{S}{N}}{Output\ \frac{S}{N}}$$



Block diagram for noise figure calculation.

49. Define equivalent noise temperature of a system. [UNDERSTAND] (APRIL/MAY 2019)

The equivalent noise temperature of a system is defined as the temperature at which the noise resistor has to be maintained so that by connecting this resistor to the input of a noiseless version of the system, it will produce the same amount of noise power at the system output as that produced by the actual system.
The equivalent noise temperature of the amplifier is given by

$$T_{eq} = (F-1)\,T_c$$

This equation shows that Teq is just an alternative measre for F.

PART B

1. Explain how threshold improvement is done through de-emphasis. ***(NOV/DEC 2008)*** **[REMEMBER]**
2. Derive an expression for the output signal-to-noise ratio of an AM DSB-FC system. (8)***MAY/JUNE2007.*** **[REMEMBER]**
3. Discuss the noise performance of AM system using envelope detection. (16) **[UNDERSTAND]**
4. Compare the noise performance of AM and FM systems. (16) ***(NOV/DEC 2007)*** **[UNDERSTAND]**
5. Explain the significance of pre-emphasis and de-emphasis in FM system? (8) **[REMEMBER]**
6. Derive an expression for the output SNR of an FM receiver and hence obtain the figure of merit. ***(NOV/DEC 2006).*** [REMEMBER]
7. Derive the noise power spectral density of the FM demodulation and explain its performance with diagram. (16). **[REMEMBER]**
8. Draw the block diagram of FM demodulator and explain the effect of noise in detail. **[REMEMBER]**
9. Explain the FM threshold effect and capture effect in FM? (16) **[REMEMBER]**
10. Discuss the following: **[ANALYSIS]**

    (i) Noise equivalent bandwidth [MARKS 4]

    (ii) Narrow-band noise [MARKS 4]

    (iii) Noise Temperature [MARKS 4]

    (iv) Noise Power Spectral Density [MARKS 4] ***MAY/JUNE 2007***
11. Explain the noise in AM receiver using its noisy model block diagram. What are pre emphasis and de emphasis in FM? Draw suitable circuits and Explain. **[REMEMBER]** ***(NOV/DEC 2006) (Apr-May 2021)***

12. (i) Explain the capture effect and FM threshold effect. [8]
    (ii) Draw the block diagram of FM demodulator and explain the effect of noise in detail and compare the performance of AM and FM in the presence of noise. ***(NOV/DEC 2006).*** **[REMEMBER]**
13. Derive an expression for the output signal to noise ratio of an AM DSB-FC system. **[REMEMBER]**
14. Compare the performance of noise in AM and FM. **[UNDERSTAND]**
15. (i) Explain pre-emphasis *a*nd De-emphasis *i*n detail. (ii)Compare the performances o*f* AM an*d* FM systems. **[REMEMBER]*(April/May 2010)***
16. Define and explain FM Threshold effect. With suitable diagram, explain threshold reduction by FMFB demodulator. **[REMEMBER]*(Nov/Dec 2010)***
17. Derive the expression for figure of merit of AM receiver using envelope detection. What do u infer from the expression **[REMEMBER]*(Nov/Dec 2010) (Nov/Dec 2017)***
18. (i)Sketch the block diagram of DSB-SC/AM system and derive the figure of merit
    (ii) Using heterodyne principle, Draw the block diagram of AM radio receiver and briefly explain it. **[REMEMBER]*(April/May 2011)***
19. Write short notes on noise in SSB receivers. **[REMEMBER]**
20. Explain how threshold improvement is done by FMFB technique. **[REMEMBER]**
21. Discuss the effects of noise on the carrier in a FM receiver with suitable mathematical derivations. **[UNDERSTAND]*(April/May 2012)***
22. Draw the superheterodyne receiver and explain the operation of each block ***(May/June 2013 (April/May 2021).*** **[REMEMBER]**
23. Derive the figure of merit for AM system for non coherent system, with suitable assumptions. **[REMEMBER]*(May/June 2013)***
24. Explain the functioning of a superhetrodyne receiver and elist its characteristics **[REMEMBER]** ***(November/December 2013)***
25. Compare the performance of any two CW modulation scheme. **[UNDERSTAND]** ***(November/December 2013)***
26. Explain the advantages in usage of superheterodyne receivers **[REMEMBER]** ***(May/June 2014).***
27. Explain envelope detection with suitable diagram. **[REMEMBER]** ***(May/June 2014)***
28. Explain the method of coherent detection.**[REMEMBER]*(May/June 2014)***
29. Compare at least three important characteristics of various FM systems **[UNDERSTAND]** ***(May/June 2014)***

30. 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. ***(NOV/DEC-2014)*** **[REMEMBER]**
31. The three amplifiers 1,2 and 3 have the following characteristics: F1=9db, G1=50db, F2=6db,G2=30db,F3=4db, G3=20db. The amplifiers are connected in tandem. Determine which combination gives the lowest noise figure. **[APPLY]**
32. Discuss on thermal noise. ***(Nov/Dec 2014)*** **[REMEMBER]**
33. What is meant by narrow band noise? Explain the characteristics of narrow band noise. ***(Apr-May 2021)*** **[REMEMBER]**
34. 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. ***(Nov/Dec 2014)*** **[APPLY]**
35. Define noise.Explain the various types of internal noise(8).***(APR/MAY-2015)*** **[REMEMBER]**
36. Explain with derivation the effect of noise in cascaded amplifier circuit.(8). ***(APR/MAY-2015)*** **[REMEMBER]**
37. Derive the SNR performance of DSB system and the AM system.Also prove that the output SNR in AM is at least 3 DB worse than that of DSB system***(APR/MAY-2015)*** **[REMEMBER]**
38. Explain the noise in DSB-SC receiver using synchronous or coherent detection and calculate the figure of merit for a DSB-SC system? ***(May / June 2016)*** **[REMEMBER]**
39. Define narrow band noise and explain the represtation of narrow band noise interms of in phase and quadrature components.***(May / June 2016)*** **[REMEMBER]**
40. Explain Pre-emphasis and De-emphasis inFM.***(May / June 2016)*** ***(Nov/Dec 2017)***[REMEMBER]
41. An amplifier has three stages with gain 5dB,20dB and 12dB.The noise figures of the stages are 7dB, 13dB and 12dB respectively. Determine the overall noise figure and the noise equivalent temperature. ***(Nov/Dec 2017)***[REMEMBER]
42. i) Classify the different types of noise and also comment its cause and effects. ***(April/May 2018)***[UNDERSTAND]

    ii) Prove that the random band pass noise signal n(t) can be expressed as $n(t)=n_e(t).\cos w_c t+n_s(t)\sin wct$ where $n_e(t)$ and $n_s(t)$ are low frequency signal band limited to w_m radians/second. ***(April/May 2018)***[ANALYZE/EVALUATE]
43. Obtain an expression for figure of merit for an FM signal, with assumption that the noise added in the channel is Additive White Gaussian Noise. ***(April/May 2018)***[APPLY]

44. Explain pre-emphasis and de-emphasis in FM system with a neat diagram.(13) **[REMEMBER]*(APRIL/MAY 2019)***
45. i). Discuss about any four properties of in-phase and quadraturecomponents of a narrowband noise.(8). **[REMEMBER]** ***(APRIL/MAY 2019)***

    ii). Calculate the noise voltage at the input of a television RF amplifier, using a device that has a 200Ω equivalent noise resistance and 300Ω input noise resistance. The bandwidth of the amplifier is 6MHz, and the temperature is 17˚C.(5). ***(April/May 2019)*****[APPLY]**

ASSIGNMENT QUESTIONS

1. Justify the need for pre-emphasis and de-emphasis. (CO4-PO1) [REMEMBER]
2. What do you understand by 'capture effect' in FM. (CO4-PO1) [REMEMBER]
3. Three amplifiers has the following characteristics F1=9dB,F2=6dB,F3= 4dB,G1=48dB,G2=35dB,G3=20db.The amplifiers are connected in casecade. Determine the sequence of combination which gives the best noise figure and lowest noise figure referred to the input also comment on the result.(CO4-PO2) [APPLY]
4. Given a white noise of magnitude η = 0.001 μW/Hz is fed to following.(a) an RC low pass filter of R = 1000 ohm and C = 0.1 μF,(b) an ideal low pass filter of bandwidth = 1000 Hz and (c) a differentiator followed by an ideal low pass filter defined in (b).For differentiator consider proportionality constant ɣ = 0.01 unit. Find output noise power in each case. How does result change in each case if low pass cut-off frequency is doubled in each case? (CO4-PO2) [UNDERSTAND]
5. Design a Pre-emphasis filter with transfer function of Hpe(ω)= Eo(ω)/Ei(ω)(CO4-PO3) [CREATE]
6. Design a AM receiver with a noise figure of 12dB and it is fed by a low noise amplifier has a gain of 50dB, noise equivalent temperature of 90K. (CO4-PO3) [CREATE]
7. Write a MATLAB program to analyze noise performance in the following AM system DSB-Transmitter Carrier (TC) system. (CO4-PO5) [CREATE]
8. Write a MATLAB program to analyze noise performance in the following AM systems ii) DSB-SC system iii) SSB-SC system. (CO4-PO5) [CREATE]
9. What are the methods to improve FM threshold reduction? (CO4-PO1) [REMEMBER]
10. What are the methods to improve FM threshold reduction? (CO4-PO1) [REMEMBER]
11. Design a De-emphasis filter with transfer function of Hde(ω)= Eo(ω)/Ei(ω)(CO4-PO3) [CREATE]
12. Simulate the magnitude response of Pre-emphasis filter and De-emphasis filter in MATLAB(CO4-PO5) [CREATE]

UNIT V

SAMPLING AND QUANTIZATION

Low pass sampling –Aliasing-Signal Reconstruction-Quantization -Uniform & non-uniform quantization -quantization noise -Logarithmic Companding –PAM,PPM, PWM, PCM –TDM,FDM.

1. Define time limited and time unlimited signals. [REMEMBER] *(Apr-May 2011)*

A time limited signal is one that is non-zero only for a finite length time interval and time unlimited signal is one which is non-zero for infinite length time interval. A signal that is band limited is not time-limited and vice-versa.

2. Give an advantage and disadvantage of digital communication. [REMEMBER] *(Apr-May 2011)*

i) Circuitry becomes simpler than analog communication.

ii) Highly resistive to noise as binary signals are dealt.

iii) Highly secure.

iv) Can travel long distances and can store data for long time.

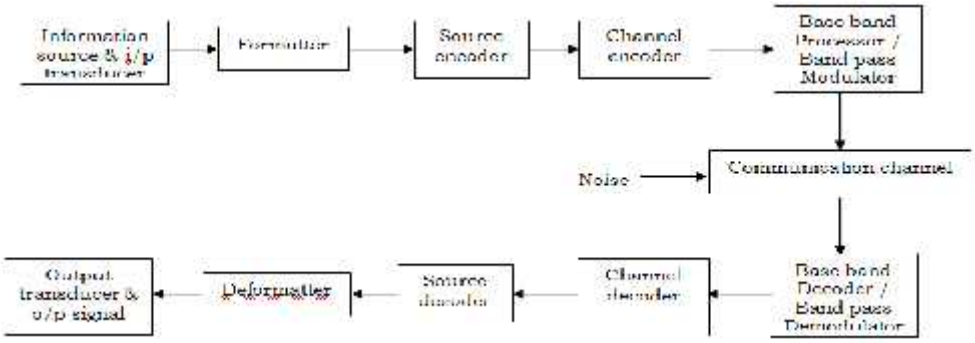
3. Which parameter is called figure of merit of a digital communication system and why? [UNDERSTAND] *(Nov-Dec 2010)*

The ratio of bit energy to noise power spectral density $\frac{E_b}{N_0}$ is called as the figure of merit of a digital communication system. This is because in digital communication system a symbol is transmitted and received by using a transmission window within a symbol tree. Since power goes to zero, symbol energy is a more useful parameter. So a energy related parameter in terms of bit level is required to compare different systems.

4. What is meant by distortionless transmission? [REMEMBER] *(Nov-Dec 2010)*

If the overall system response has constant magnitude and if its phase shift is linear with frequency then that is said to be distortionless transmission.

5. Draw the basic block diagram of digital communication system. [REMEMBER] *(Nov-Dec 2011)*



6. What is the function of formatter in digital communication system? [REMEMBER]

It converts electrical signals at the output of the transducer into a sequence of digital signals.

7. How is the performance of digital communication system evaluated? [UNDERSTAND]

The performance of digital communication system is evaluated depending upon i) Spectral efficiency ii) Bit error rate (BER).

8. Define Nyquist rate. [REMEMBER]

Let the signal be bandlimited to W Hz. Then Nyquist rate is given as,

Nyquist rate = 2W samples/sec

Aliasing will not take place if sampling rate is greater than Nyquist rate.

9. What is meant by aliasing effect? [REMEMBER] *(May / June 2016) (Nov/Dec 2016)*

Aliasing effect takes place when sampling frequency is less than Nyquist rate. Under such condition, the spectrum of the sampled signal overlaps with itself. Hence higher frequencies take the form of lower frequencies. This interference of the frequency components is called as aliasing effect.

10. What is meant by temporal waveform coding? [REMEMBER] *(Nov-Dec 2011)*

Temporal waveform coding is a scheme in which time domain waveform is encoded. Bit allocation depends upon time domain features. Bit rate is high compared to signal bandwidth and reconstruction is perfect.

11. Compare uniform and non-uniform quantization. [UNDERSTAND]*(Nov-Dec 2011)*

In uniform quantization, the stepsize or the difference between two quantization levels remain constant over the complete amplitude range.

In non-uniform quantization stepsize varies.

12. What are the two types of quantization that occur in delta modulation? [REMEMBER] *(Apr-May 2010)*

i) Slope overload distortion and ii) Granular noise.

13. Write an expression for bandwidth of binary PCM with N messages each with a maximum frequency of *fm* Hz. [REMEMBER]

If v number of bits are used to code each input sample, then bandwidth of PCM is given as, BT ≥ N.v.*fm* , Here v. *fm* is the bandwidth required by one message.

14. What is meant by quantization? [REMEMBER] (May-June 2012)

While converting the signal value from analog to digital, quantization is performed. The analog value is assigned to nearest digital value. This is called quantization. The quantized value is then converted into equivalent binary value. The quantization levels are fixed depending upon the number of bits. Quantization is performed in every Analog to Digital Conversion.

15. The signal to quantization noise ratio in a PCM system depends on what criteria? [UNDERSTAND]

The signal to quantisation noise ratio in PCM is given as,

$$(S/N)db \leq (4.8+6v)dB$$

Here *v* is the number of bits used to represent samples in PCM. Hence signal to quantization noise ratio in PCM depends upon the number of bits or quantization levels.

16. What should be the minimum bandwidth required to transmit a PCM channel? [REMEMBER]

The minimum transmission bandwidth in PCM is given as, $BT = vW$

Here *v* is the number of bits used to represent one pulse. W is the maximum signal frequency.

17. What is the advantage of delta modulation over PCM? [REMEMBER]

Delta modulation uses one bit to encode on sample. Hence bit rate of delta modulation is low compared to PCM.

18. Why is prefiltering done before sampling? [UNDERSTAND] (Apr-May 2011)

Prefiltering is done so that the new maximum frequency is reduced to $\frac{f_s}{2}$ or less. Thus there will be no aliased components.

19. State the advantages and disadvantages of digital communication systems over analog communication systems. [REMEMBER] ***(May-June2013). (May/June 2014)***

<u>Advantages:</u>

- In digital Communication, the speech, video and other data may be merged and transmitted over a common channel using multiplexing technique.
- The digital Communication system are simpler and cheaper because of advancement made in the IC technologies.
- Channel Coding is used in digital Communication that why it reduces the amount of errors in the detector and correct them in the receivers.
- As the transmitted signals are digital in nature thus the amount of interference is controlled in this form of Communication.

Disadvantages:

- Due to Analog to Digital Conversion the data rate become high. Therefore more transmission bandwidth is required for digital communication. This is the major disadvantage of Digital communication.
- Synchronization is required in digital communication during the process of synchronous modulation.

20. What is difference between uniform and non-uniform quantization. [UNDERSTAND]

Uniform Quantization	Non Quantization
The quantization step size remains same throughout the dynamic range of the signal	The quantization step size varies with the amplitude of the input signal
SNR ratio varies with input signal amplitude	SNR ratio can be maintained constant

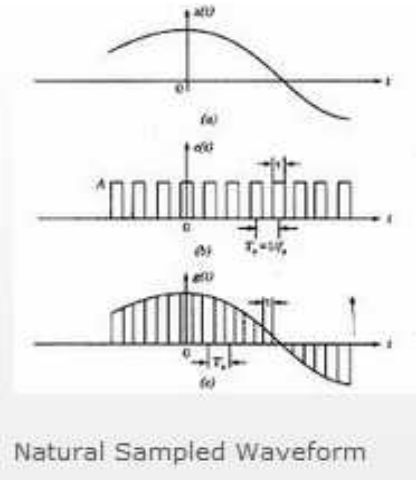
29. 21. State Sampling theorem for band limited signals and the filter to avoid aliasing. [REMEMBER] ***(Nov/Dec 2015) (May-June 2012) (Apr / May 2021)***

A band limited signal of finite energy, which has no frequency components higher than W Hz, may be completely recovered from the knowledge of its samples taken at the rate of 2W samples per second.

Low pass anti-aliasing filter is used to avoid aliasing.

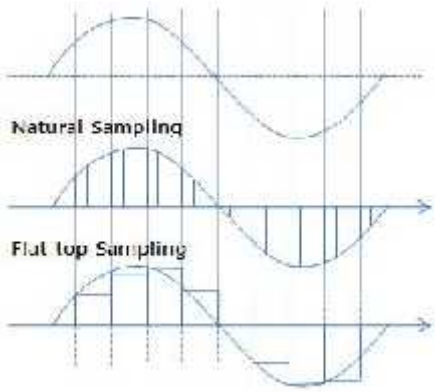
22. What is natural sampling? [REMEMBER] ***(May-June2013)***

Natural Sampling is a practical method of sampling in which pulse(rectangular) have finite width equal to τ. Sampling is done in accordance with the carrier signal which is digital in nature.



23. What is difference between natural and flat top sampling? [UNDERSTAND] ***(Nov-Dec 2014)***

Flat top sampling is like natural sampling i.e; practical in nature. In comparison to natural sampling flat top sampling can be easily obtained. In this sampling techniques, the top of the samples remains constant and is equal to the instantaneous value of the message signal x(t) at the start of sampling process. Sample and hold circuit is used in this type of sampling.



24. What is the need for non-uniform quantization? [REMEMBER] ***(May-June2014)***

In uniform quantization, step or difference between two quantization levels remains constant over the complete amplitude range. So, the maximum quantization error also remains same, which causes problems at some amplitude levels. In such cases, non uniform quantization is preferred.

25. Write the two fold effects of Quantization Process. [REMEMBER] ***(Nov/Dec 2015)***

1. The peak-to-peak range of input sample values subdivided into a finite set of decision levels or decision thresholds.

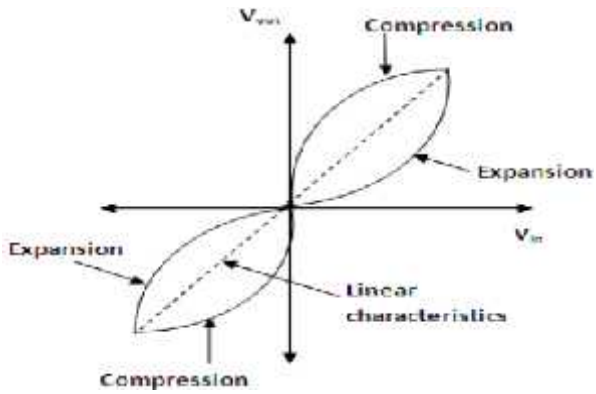
2. The output is assigned a discrete value selected from a finite set of representation levelsare reconstruction

values that are aligned with the treads of the staircase

26. Define companding. Sketch the input-output characteristics of a compressor and an expander [REMEMBER] ***(May / June 2016) (Nov / Dec 2016) (Apr / May 2017)***

Companding refers to a technique for compressing and then expanding (or decompressing) an analog or digital signal. It is a combination of the words "compressing" and "expanding."

Companding is the process of compressing and expanding.With companded systems,thehigher amplitude analog signals are compressed prior to transmission and then expanded at thereceiver.



27. A certain lowpass bandlimited signal x(t) is sampled and the spectrum of the sampled version has the first guard band from 1500 Hz to 1900Hz. What is the sampling frequency? What is the maximum frequency of the signal? ***(Apr / May 2017)*** **[REMEMBER]**

Sampling frequency = fs = $2_{fm(max}$)= 2 x 1900 = 3800 Hz

Maximum frequency = fm(max)=1900 Hz

28. What do you mean by sampling rate? ***(Apr / May 2019)*** **[REMEMBER]**

Sampling rate or sampling frequency defines the number of samples per second (or per other unit) taken from a continuous signal to make a discrete or digital signal. For time-domain signals like the waveforms for sound (and other audio-visual content types), frequencies are measured in in hertz (Hz) or cycles per second.

29. How the multiplexing of digital signals can be accomplished? ***(Apr / May 2019)*** **[REMEMBER]**

Multiplexing is a method of sending different streams of information on a link at the same time, in the form of a single, complex signal. Multiplexing can be accomplished with the following methods:

- ✓ Frequency Division Multiplexing (FDM)
- ✓ Time Division Multiplexing (TDM)
- ✓ Dense wavelength Division Multiplexing (DWDM)

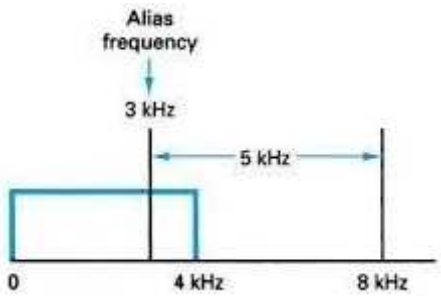
30. For a PCM system with maximum audio input frequency of 4KhZ, determine the minimum sample rate and alias frequency produced if a 5 KhZ audio were allowed to enter the sampling circuit. ***(Apr / May 2021)***

Solution:

Using Nyquist's sampling theorem ,we have

$$f_s \geq 2f_m \quad \text{therefore, } f_s \geq 8 \text{ kHz}$$

If a 5 kHz audio frequency entered the sample-and-hold circuit, the output spectrum shown in Figure 4.4 is produced. It can be seen that the 5 kHz signal produces an alias frequency of 3 kHz that has been introduced into the original audio spectrum.



PART – B Questions

1. Draw a neat block diagram of a typical digital communication system and explain the function of each blocks. **[REMEMBER]** ***(Nov-Dec 2010, May-June2012)***
2. Discuss the advantages and disadvantages of digital communication and give a functional description of a digital communication system. **[REMEMBER]** ***(Nov-Dec 2014)***
3. Draw a neat block diagram of a typical digital communication system and explain the function of the key signal processing blocks **[REMEMBER]** ***(May-June2013)***
4. Draw the block diagram of a digital communication system. Explain each block. ii) Discuss the advantages of digital communication over analog communication. **[REMEMBER]** ***(May-June2014)***
5. Define basis set. How they are useful in representing a signal? ii) With an example. Explain how the basis set is determined by gram schemidt procedure. **[REMEMBER]** ***(May-June2014)***
6. Explain non-uniform quantization process. **[REMEMBER]** ***(Apr-May 2011)***
7. State and prove Nyquist sampling theorem. **[UNDERSTAND]** ***(Nov-Dec 2010)***
8. Explain non-uniform quantization. **[REMEMBER]** ***(Apr-May 2010)***

9. Explain the operation of PCM and delta modulation systems. **[REMEMBER]** ***(Apr-May 2010) (Apr-May 2021)***
10. Explain what is natural sampling and flat-top sampling. **[REMEMBER]** ***(May-June2012)***
11. With neat block diagram, explain pulse code modulation and demodulation system. **[REMEMBER]** ***(May-June2012) (May / June 2016)***
12. Explain the working of differential PCM and hence derive the expression of signal to noise ratio. **[REMEMBER]** ***(Apr-May 2010)***
13. Explain a PCM system. Derive the expression for quantization noise of a PCM system with uniform quqntizer. **[REMEMBER]** ***(May-June2013)***
14. Compare any two speech encoding techniques. **[UNDERSTAND]** ***(May-June2013)***
15. Explain Nyquist sampling theorem and how the message can be reconstructed from its samples with an example. (ii)Explain the practical limitations in sampling and reconstruction. **[REMEMBER]** ***(May-June2013)***
16. Explain the principle of quantization and obtain the expression for the signal to quantization noise for the case of a uniform quantizer. ii) Explain the spectral waveform encoding methods. **[REMEMBER]** ***(May-June2013) (Apr-May 2021)***
17. Explain non-uniform quantization techniques. ii) Explain temporal waveform encoding technique. **[REMEMBER]** ***(May-June2014) (Apr-May 2021)***
18. Write notes on temporal waveform coding. **[REMEMBER]** ***(Apr-May 2011)***
19. Describe the process of sampling and how the message signal is reconstructed from it's samples. Also illustrate the effect of aliasing with neat sketch. **[REMEMBER]** ***(Nov/Dec 2015)***
20. Describe PCM waveform coder and decoder with neat sketch and list the merits compared with analog coders. **[REMEMBER]** ***(Nov/Dec 2015)***
21. Illustrate and describe the types of quantizer? Describe the midtread and midrise type characteristics of uniform quantizer with a suitable diagram. **[REMEMBER]** ***(Nov/Dec 2016)***
22. Draw and explain the TDM with its applications. Explain the difference between analog TDM and digital TDM. **[REMEMBER]** ***(Nov/Dec 2016) (May / June 2016)***
23. State the low pass sampling theorem and explain reconstruction of the signal from its samples. **[REMEMBER]** ***(May / June 2016)***
24. The signal $x(t) = 4 \cos 400\pi t + 12 \cos 360 \pi t$ is ideally sampled at a frequency of 300 samples per second. The sampled signal is passed through a unit gain low pass filter with a cut off frequency of 220 Hz. List the frequency components present at the output of the low pass filter? **[ANALYZE]**

(May / June 2016)

25. What is mean by quantization? Derive the expression for signal- to- quantization noise ratio in PCM system. ***(Apr / May 2017)*** **[REMEMBER]**
26. The information in an analog signal with maximum frequency of 3kHz is required to be transmitted using 16 quantization levels in PCM system.Determine (1) The maximum number of bits/sample that should be used (2) the minimum sampling rate required and (3) the resulting transmission data rate. ***(Apr / May 2017)*** **[ANALYZE]**
27. (i). Explain the following terms with respect to sampling:
    (i) Alising
    (ii) Aperture effect distortation

    (ii). Explain time division multiplexing system for N number of channels. ***(Apr / May 2017)*** **[REMEMBER]**
28. i). Explain the working of PWM with neat sketch.(9) **[REMEMBER]** ***(April/May 2019)***

    ii). Write down the corrective measures to combat the effects of aliasing.(4). **[REMEMBER]** ***(April/May 2019)***
29. i). Write the advantages and some of the applications of PCM system.(5).**[UNDERSTAND]** ***(April/May 2019)***

    ii). Briefly describe the concept of FDM.(8). **[REMEMBER]** ***(April/May 2019)***

ASSIGNMENT QUESTIONS

1. Write the function of formatter? **CO1 (PO1) Remember**
2. Why we go for Gram –Schmitt orthogonalization procedure? **CO1 (PO2) Understand**
3. Design PWM and PPM modulator using IC555. **CO1 (PO2) Analyze**