PANDIAN SARASWATHI YADAV ENGINEERING COLLEGE

DEPARTMENT OF ELECTRONICS & COMMUNICATON ENGG.

EC6402 COMMUNICATION THEORY

Branch: ECE **Semester: IV**

Part A: Question & Answers

UNIT I AMPLITUDE MODULATION

1. **What are periodic signals?**
   A signal is a periodic signal if it completes a pattern within a measurable time frame, called a period and repeats that pattern over identical subsequent periods. The completion of a full pattern is called a cycle. A period is defined as the amount of time (expressed in seconds) required to complete one full cycle. The duration of a period represented by T, may be different for each signal but it is constant for any given periodic signal.

2. **Define modulation?**
   A Modulation is a process by which some characteristics of high frequency carrier signal is varied in accordance with the instantaneous value of another signal called modulating signal.

3. **What are the types of modulation?**
   Amplitude modulation, Frequency modulation, Phase modulation.

4. **Define depth of modulation (or) modulation index.** **May/June 2013**
   It is defined as the ratio between message amplitude to that of carrier amplitude.

5. **What is communication?**
   Communication is the process of conveying or transferring messages from one Point to another.

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

7. **Define Amplitude modulation?** **May/June 2014**
   Amplitude modulation is the process by which amplitude of the carrier signal is varied in accordance with the instantaneous value of the modulating signal but frequency and phase of carrier wave is remains constant.

8. **Define Frequency modulation?**
   Frequency modulation is the process by which frequency of the carrier signal is varied in accordance with the instantaneous value of the modulating signal.

9. **Define phase modulation?**
   A Phase modulation is the process by which Phase angle of the carrier signal is varied in accordance with the instantaneous value of the modulating signal.

Part B

1. Consider the DSB-SC signal **Nov/Dec 2011**

   $S(t) = A_c \cos(2\pi f_c t)\, m(t)$

   Where $A_c \cos(2\pi f_c t)$ is the carrier wave and m(t) is the message signal. This modulated signal is applied to square law device characterized by $y(t) = s^2(t)$

   The output y(t) is next applied to band filter with passband magnitude response of one, mid band frequency $2f_c$ and bandwidth Δf . Assume Δf is small enough to treat the spectrum of y(t) as essentially constant inside the passband of the filter.

   i) Determine the spectrum of square law device output y(t) (8)

   ii) Show that the filter output v(t) is approximately sinusoidal given by

   $$v(t) \cong \frac{A^2_c}{2} E \Delta f \cos(4\pi f_c t) \quad (8)$$

   Where E is the energy of message signal.

2. Explain the detection of AM signals using envelope detector. (16) **Apr/May 2010**

   Envelope detector diagram – (10)

   Theory of detection of AM signals - (6)

3. Explain about Balanced modulator to generate DSB-SC signal. (16) **April/May 2011**

   Diagram (8)

   Theory (8)

4. Explain about coherent detector to detect SSB-SC signal. (16) **Apr/May 2010**

   Block diagram-(10)

   Explanation – (6)

5. Explain the generation of SSB using balanced modulator. (16) **Nov/Dec 2010**

6. Using the message signal

   $$m(t) = \frac{1}{1+t^2}$$

   Determine and sketch the modulated waves for the following methods of modulation:

   i) AM with 50% modulation (4)

   ii) DSB-SC modulation (4)

   iii) SSB with upper side band transmission only (4)

   iv) SSB with lower side band transmission only (4)

7. Draw the block diagram for the generation and demodulation of a VSB signal and explain the principle of operation. (16) **Nov/Dec 2010**

   Block diagram - (10)

   Explanation – (6)

UNIT II ANGLE MODULATION

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

2. **Define modulation index of frequency modulation.**
   It is defined as the ratio of maximum frequency deviation to the modulating frequency.

3. **Define frequency Deviation in FM?**
   The instantaneous frequency of FM signal varies with time around the carrier frequency. This means that the instantaneous frequency of FM signal varies according to the modulating signal. The maximum change in instantaneous frequency form the average frequency is called frequency deviation.

4. **What do you meant by multi-tone modulation, Percent modulation?**
   Modulation done for the message signal with more than one frequency component is called multi-tone modulation. The term percent modulation as it is used in reference to FM refers to the ratio of actual frequency deviation to the maximum allowable frequency deviation.

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

6. **What do you mean by angle modulation and write their types?**
   Angle modulation may be defined as the process in which the total phase angle of a carrier wave is varied in accordance with the instantaneous value of the modulating or message signal while keeping the amplitude of the carrier constant. Phase modulation (PM) and Frequency modulation (FM) are the types of angle modulation.

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

8. **What are the types of Frequency Modulation? (OR) What do you mean by Narrow Band and Wide band?**
   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 then it is wide band FM and if the modulation index is less than one then it is Narrow band FM

9. **What is the basic difference between an AM signal and a Narrowband FM signal?**
   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.

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

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

i) Direct method In this method the transmitter originates a wave whose frequency varies as function of the modulating source. It is used for the generation of NBFM

ii) Indirect method in this method the transmitter originates a wave whose phase is a function of the modulation. Normally it is used for the generation of WBFM where WBFM is generated from NBFM

11. What are the disadvantages of FM system?

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

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

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

13. Define capture effect.

With FM and PM, a phenomenon known as the capture effect allows a receiver to differentiate between two signals received with the same frequency, providing one signal at least twice as high in amplitude as the other; the receiver will capture the stronger signal and eliminate the weaker signal.

14. What is FM thresholding? April/May 2011

With the use of limiters, FM and PM demodulators can actually reduce the noise level and improve the signal to noise ratio during the demodulation process. This is called FM thresholding.

Part-B

1. Explain the indirect method of generation of FM wave and any one method of demodulating an FM wave. (16) **Nov/Dec 2011**
   Indirect method – (8)
   Demodulating method – (8)
2. Derive the expression for the frequency modulated signal. Explain what is meant by narrowband FM and wideband FM using the expression. (16) **Apr/May 2010**
   Derivation – (8)
   Narrowband FM – (4)
   wide band FM – (4)
3. Explain any two techniques of demodulation of FM. (16) **April/May 2011**
   Technique 1-(8)
   Technique 2-(8)
4. Draw the frequency spectrum of FM and explain. Explain how Varactor diode can be used for frequency modulation. (16) **Nov/Dec 2010**
   Diagram of spectrum – (8)
   Explanation – (8)
5. Explain the principle of indirect method of generating a wide-band FM signal with a neat block diagram. (8) **Nov/Dec 2010**

UNIT III RANDOM PROCESS

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

2. **What is a random variable? April/May 2010**
   In probability and statistics, a random variable or stochastic variable is a variable whose value is subject to variations due to chance (i.e. randomness, in a mathematical sense).

3. **What is a stochastic process?**
   In probability theory, a stochastic process, or sometimes random process (widely used) is a collection of random variables; this is often used to represent the evolution of some random value, or system, over time.

4. **Define shot noise?**
   A shot noise arises in active devices due to random behavior of charge carriers. In electron tubes, shot noise is generated due to random emission of electrons from cathodes, whereas in semiconductor devices shot noise is generated due to random diffusion of minority carriers or simply random generation and recombination of electron-hole pairs.

5. **Define partition noise?**
   Partition noise is generated in a circuit when a current has to divide between two or more paths. This means that partition noise results from the random fluctuations in the division.

6. **Define flicker noise (or) Low frequency noise.**
   Flicker noise is the one appearing in transistors operating at low audio frequencies. Flicker noise is produced at low frequencies (below few KHz). This noise is also called as flicker noise (1/f noise).

7. **Define transit time of a transistor.**
   Transit time is defined as the time taken by the electron to travel from emitter to the collector.

8. **Define Avalanche noise?**
   The reverse bias characteristic of a diode shows a region where the reverse current increases rapidly with a slight increase in magnitude of the reverse bias voltage. That is voltage increase current also increases. This is because the holes and electrons in the depletion region gain sufficient energy from reverse bias to ionize atoms by collision. This collision provides spikes in current in avalanche region. This noise is called as avalanche noise.

9. **Define Thermal noise? November/December 2010**
   The thermal noise or white noise or Johnson noise is the random noise which is generated in a resistor or the resistive component of complex impedance due to rapid and random motion of the molecules, atoms and electrons.

10. **Define equivalent noise bandwidth of an ideal band pass system.**

Equivalent noise band width may be defined as the bandwidth of an ideal band pass system which produces the same noise power as the actual system does.

11. Explain why thermal noise is also called as Johnson noise?

Thermal noise is also called as Johnson noise after the scientist J.B. Johnson who presented a detailed investigation of it.

12. Define signal to noise ratio.

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

13. What is narrowband noise?

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

Part-B

1. i)Consider a random process X(t) defined by

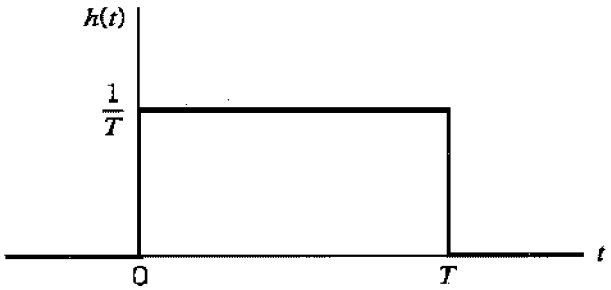
   $X(t) = \sin(2\pi f_c t)$

   In which frequency f_c is a random variable uniformly distributed over the interval [0,W]. Show that X(t) is non-stationary. (8)

   ii) A stionary Gaussian process X(t) has zero mean and power spectral density Sx(f) . Determine the PDF of random variable obtained by observing the process X(t) at some time t_k. (8)

   Nov/Dec 2011

2. a) A stationary Gaussian process X(t) with zero mean and PSD $S_x(f)$ is applied to a linear filter whose impulse response h(t) is given in figure



   i) Determine the mean and variance of Y (4)

   ii) What is the PDF of Y? (4)

b) Why is the shot noise given in equation stationary?

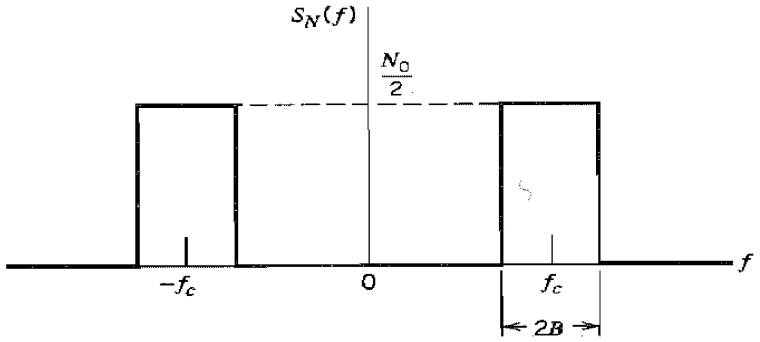
$$X(t) = \sum_{k=-\infty}^{\infty} h(t-\tau_k) \quad (8)$$

Apr/May 2010

3. Derive the noise figure for cascade stages. (8)
4. How sine wave plus noise is represented? Obtain the joint PDF of such noise component. (16)

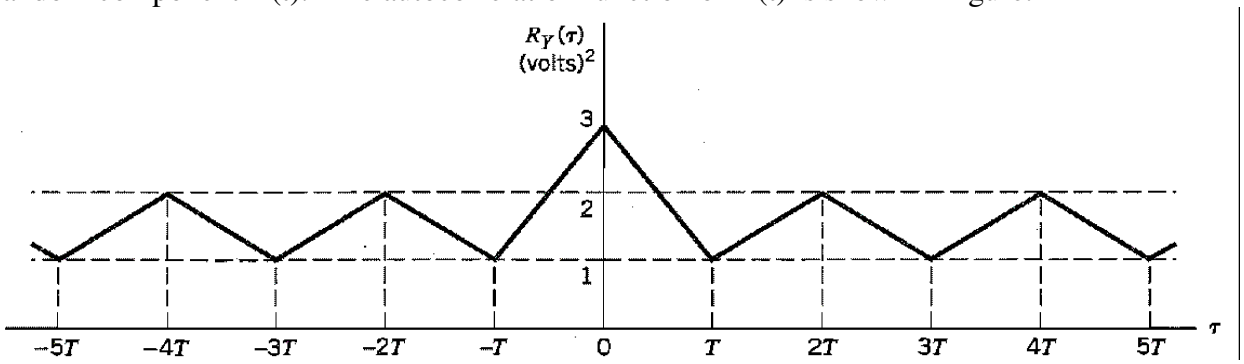
Sine plus noise equation (6)
Diagram of sine, noise and combined sine plus noise (2)
Joint PDF (8) **April/May 2011**

5. A)Consider a Gaussian noise n(t) with zero mean and PSD $S_N(f)$ as shown in figure:



i) Find the pdf of envelope of n(t) (4)
ii) What are the mean and variance of n(t)? (4)

b) A random process Y(t) consist of a DC component of $\sqrt{3/2}$ volts, a periodic component g(t) and random component X(t). The autocorrelation function of Y(t) is shown in figure.



i) What is the average power of the periodic component g(t)? (4)
ii) What is average power of the random component? (4) **Nov/Dec 2010**

UNIT IV NOISE CHARACTERIZATION

1. **Define Noise-Quieting effect?**
   Noise power of FM detector varies inversely with carrier power. The decrease in noise power with an increase in carrier power is called noise-quieting effect.

2. **Define capture effect in FM?**
   When the interference is stronger then it will suppress the desired FM input. When the interference signal and FM input are of equal strength, the receiver fluctuates back and forth between them .This phenomenon is known as the capture effect. We may also define as in low noise case; the distortion produced by the noise at the o/p of FM detector is negligible in comparison to the desired modulating signal. And noise almost suppressed by the signal. This phenomenon is called as capture effect.

3. **How is threshold reduction achieved in FM systems? November/December 2010**
   Threshold reduction is achieved in FM system by using an FM demodulator with negative feedback or by using a phase locked loop demodulator. Such devices are referred to as extended-threshold demodulators.

4. **What is Pre-emphasis? May/June 2013**
   November/December 2010
   The pre modulation 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.

5. **Define de-emphasis.**
   A de-emphasis in the receiver used to restore relative magnitude of different improvement in AF signal and to suppress noise is called de-emphasis.

6. **What is the figure of merit of an AM system with 100 percent Modulation?**
   The figure of merit of an AM system with 100 percent modulation is 1/3.This means that other factors being equal an AM system must transmit three times as much average power as a suppressed system in order to achieve the same quality of noise performance.

7. **What is Nyquist rate?**
   The sampling rate of must be twice that of highest frequency in the spectrum. This is Nyquist rate.

Part-B

1. Discuss the noise performance of AM system using envelope detection. (16) **Nov/Dec 2011**
   Envelope detector block diagram (6)
   Explanation – (10)
2. Compare the noise performance of AM and FM systems. (16) **April/May 2011**
3. Explain the significance of pre-emphasis and de-emphasis in FM system? (8)
4. Derive the noise power spectral density of the FM demodulation and explain its performance with diagram. (16) **Nov/Dec 2010**
5. Explain the working of superheterodyne receiver with its parameters. (16)
   Superheterodyne receiver block diagram-(6)
   Characteristics – (4)
   Explanation – (6)
6. Draw the block diagram of FM demodulator and explain the effect of noise in detail.
   Diagram (8)
   Theory (8)
7. Discus the coherent detection of DSB-SC modulated wave with a block diagram of Detector and Explain. (16) **April/May 2011**
   Block diagram-(10)
   Explanation – (6)
8. Explain the FM threshold effect and capture effect in FM? (16)
   Diagram (8)
   Theory (8)
9. Explain the FM receiver with block diagram. (8)
   Diagram (8)
   Theory(8)
6. Explain how the various noises are generated and the method of representing them. (16)
7. Write notes on noise temperature and noise figure. (8)
8. Derive the effective noise temperature of a cascade amplifier. Explain how the various noise are generated in the method of representing them. (16) **April/May 2011**
   Diagram (8)
   Theory (8)
9. What is narrowband noise discuss the properties of the quadrature components of a narrowband noise. (8) **April/May 2011**
   What is meant by noise equivalent bandwidth? Illustrate it with a diagram (8)
10. Discuss the following: (16)
    i) noise equivalent bandwidth (4)
    ii) narrow band noise (4)
    iii) noise temperature (4)
    iv) noise spectral density (4)

UNIT V INFORMATION THEORY

1. **What is discrete memory less source?**
   The symbols emitted by the source during successive signaling intervals are statistically independent. That source is called discrete memory less source. Here memory less, means that the symbol emitted any time is independent of previous choices.

2. **What is meant by Source encoding?**
   The efficient representation of data generated by a discrete source. This process is called Source coding. The device that performs the representation is called a source encoder.

3. **Write Source encoding theorem?**
   Given a discrete memory less source of entropy H(x), the average code word length for any distortion less source encoding is bounded as H(x) Here the entropy H(x) represents the fundamental limit on the average number of bits per source symbol.

4. **Write about data compaction?**
   For efficient signal transmission, the redundant information should be removed from the signal prior to transmission. This operation with no loss of information is ordinarily performed on a signal in digital form.

5. **What is mutual information?**
   The mutual information is defined as the amount of information transferred when X is transmitted and Y is received.

6. **Define lossless channel.**
   The channel described by a channel matrix with only one nonzero element in each column is called a lossless channel. In the lossless channel no sources information is lost in transmission.

7. **Define Deterministic channel**
   A channel described by a channel matrix with only one nonzero element in each row is called a deterministic channel and this element must be unity.

8. **Define noiseless channel.**
   A channel is called noiseless if it is both lossless and deterministic. The channel matrix has only one element in each row and in each column and this element is unity. The input and output alphabets are of the same size.

9. **Explain Shannon-Fano coding.** **Nov/Dec 2011**
   An efficient code can be obtained by the following simple procedure, known as Shannon- Fano algorithm.

   - List the source symbols in order of decreasing probability.
   - Partition the set into two sets that are as close to equiprobable as possible, and sign 0 to the upper set and 1 to the lower set.

- Continue this process, each time partitioning the sets with as nearly equal probabilities as possible until further partitioning is not possible.

10. What is source coding and entropy coding? **April/may 2010**

A conversion of the output of a DMS into a sequence of binary symbols is called source coding. The design of a variable length code such that its average code word length approaches the entropy of the DMS is often referred to as entropy coding.

11. What is information theory?

Information theory deals with the mathematical modeling and analysis of a communication system rather than with physical sources and physical channels.

12. What happens when the number of coding alphabet increases?

When the number of coding alphabet increases the efficiency of the coding technique decreases.

Part-B

1. Discuss Source coding theorem, give the advantage and disadvantage of channel coding in detail, and discuss the data compaction. (16) **Nov/Dec 2011**
2. Explain in detail Huffman coding algorithm and compare this with the other types of coding. (8)
3. Explain the properties of entropy and with suitable example, explain the entropy of binary memory less source. (16) **April/May 2011**

Properties – (4)
Relevant examples – (4)
Entropy of binary memory less source (8)

4. What is entropy? Explain the important properties of entropy. (16) **Nov/Dec 2011**

Definition – (4)
Properties of entropy– (12)

5. Five symbols of the alphabet of discrete memory less source and their probabilities are given below. (8) **April/May 2010**

S = [S0, S1, S2, S3, S4]
P[S] = [0.4, 0.2, 0.2, 0.1, 0.1]
Code the symbols using Huffman coding.

6. Write short notes on Differential entropy, derive the channel capacity theorem and discuss the implications of the information capacity theorem. (16) **April/May 2010**

Short notes on DE – (4)
Derivation – (6)
Implications of channel capacity theorem (6)

7. What do you mean by binary symmetric channel? Derive channel capacity formula for symmetric channel. (16)

definition – (4)
Derivation for channel capacity formula for symmetric channel – (12)

8. Construct binary optical code for the following probability symbols using Huffman procedure and calculate entropy of the source, average code Length, efficiency, redundancy and variance? 0.2, 0.18, 0.12, 0.1, 0.1, 0.08, 0.06, 0.06, 0.06, 0.04 **April/May 2011**

Binary optical code- (6)
Entropy of source – (2)
Average code length – (2)
Efficiency – (2)
Redundancy – (2)
Variance – (2)

9. Define mutual information. Find the relation between the mutual information and the joint entropy of the channel input and channel output. Explain the important properties of mutual information. (16) **Nov/Dec 2010**

definition – (4)
Derivation – (8)
Properties – (4)

10. Derive the expression for channel capacity of a continuous channel. Find also the expression for channel capacity of continuous channel of a infinite bandwidth. Comment on the results. (16)

Derivation of channel capacity– (10)
Expression for channel capacity of continuous channel – (6)