DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

SUBJECT CODE: EC 1301

SUBJECT: COMMUNICATION THEORY

(FOR FIFTH SEMESTER ECE)

TWO MARKS QUESTIONS

1. Define modulation?

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?

Amplitude modulation.

Angle Modulation

1. Frequency modulation
2. Phase modulation.

3.Define depth of modulation.

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

$m=Em/Ec$

4. What are the degrees of modulation?

Under modulation. $m<1$

Critical modulation $m=1$

Over modulation $m>1$

5.What is the need for modulation?

Needs for modulation:

- Ease of transmission
- Multiplexing
- Reduced noise
- Narrow bandwidth
- Frequency assignment
- Reduce the equipments limitations.

6.What are the types of AM modulators?

There are two types of AM modulators. They are

- Linear modulators
- Non-linear modulators

Linear modulators are classified as follows

- Transistor modulator

  There are three types of transistor modulator.

  - Collector modulator
  - Emitter modulator
  - Base modulator
- Switching modulators

Non-linear modulators are classified as follows

- Square law modulator
- Product modulator
- Balanced modulator

7.Give the classification of modulation.

There are two types of modulation. They are

- Analog modulation
- Digital modulation

Analog modulation is classified as follows

- Continuous wave modulation
- Pulse modulation

Continuous wave modulation is classified as follows

- Amplitude modulation
  - Double side band suppressed carrier
  - Single side band suppressed carrier
  - Vestigial side band suppressed carrier
- Angle modulation
  - Frequency modulation
  - Phase modulation

Pulse modulation is classified as follows

- Pulse amplitude modulation
- Pulse position modulation
- Pulse duration modulation
- Pulse code modulation

Digital modulation is classified as follows

- Amplitude shift keying
- Phase shift keying
- Frequency shift keying

8.What is single tone and multi tone modulation?

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

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

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.

Solution:

Given: I_c =8A I_t=8.93A m=0.8

Formula: $I_t=I_c\,(1+m^2/2)^{½}$

$8.93=8(1+m^2/2)^{½}$

m=0.701

$It=8\,(1+0.8^2/2)^{½}$

It=9.1A

10.Compare AM with DSB-SC and SSB-SC.

AM signal	DSB-SC	SSB-SC
Bandwidth=$2f_m$	Bandwidth=$2f_m$	Bandwidth=f_m
Contains USB, LSB, carrier	Contains USB,LSB	Contains LSB or USB
More power is required for transmission	Power required is less than that of AM.	Power required is less than AM &DSB-SC

11 What are the advantages of VSB-AM?

1.It has bandwidth greater than SSB but less than DSB system.

2.Power transmission greater than DSB but less than SSB system.

3.No low frequency component lost. Hence it avoids phase distortion.

12 Compare linear and non-linear modulators.

Linear modulators	Non-linear modulators
1.Heavy filtering is not required.	1.Heavy filtering is required
2.These modulators are used in high level modulation.	2.These modulators are used in low level Modulation.
3.The carrier voltage is very much greater than modulating signal voltage.	3.The modulating signal voltage is very much greater than the carrier signal voltage.

13.How will you generating DSBSC-AM ?

There are two ways of generating DSBSC-AM such as

1.balanced modulator 2.ring modulators

14. What are advantages of ring modulator?

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.

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?

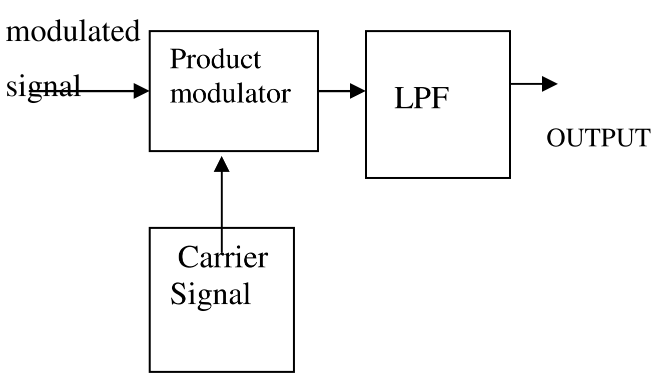
1. Nonlinear detectors
2. Linear detectors

17.What are the types of linear detectors?

1.Synchronous or coherent detector.

2 .Envelope or non coherent detector.

18.draw the block diagram of coherent detector.



19.Define multiplexing.

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

20.Define sensitivity.

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

21.Define selectivity.

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

22. Define stability.

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

23.Define super heterodyne principle.

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

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

$m=0.3; P_c=8$ kw

$P_t=P_c(1+m^2/2)$

$=8.36$ kw

25.What are the drawbacks of emitter modulator?

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.

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.

27. Define modulation index of frequency modulation.

It is defined as the ratio of maximum frequency deviation to the modulating frequency. $\beta = \delta f/fm$

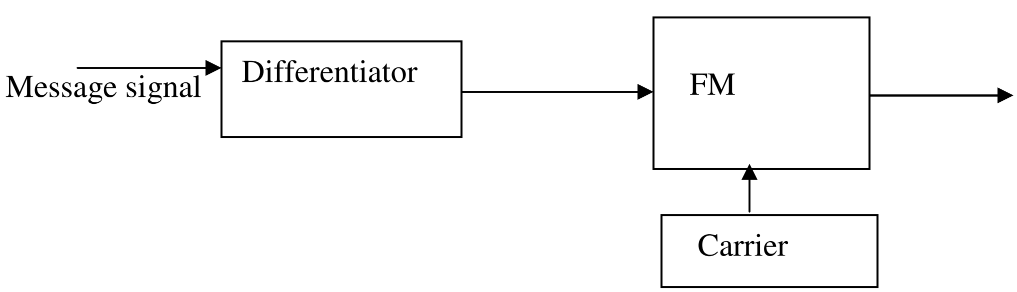
28. What do you meant by multitone modulation?

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

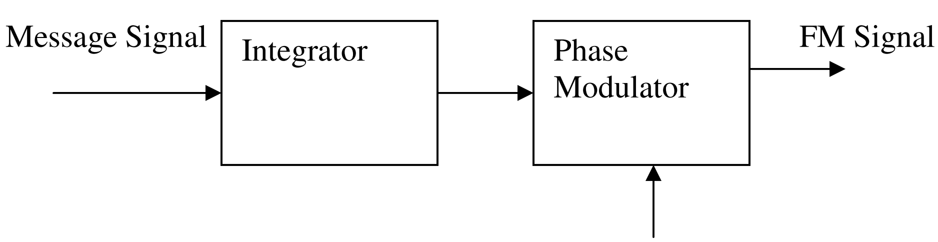
29. Define phase modulation.

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.

30. How FM wave can be converted to PM wave?



31. How PM wave can be converted to FM wave?



Carrier

32. What are the types of Frequency Modulation?

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

33. 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.

34. 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

35 . Compare WBFM and NBFM.

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 $2f_m$
Noise is more suppressed	Less suppressing of noise

36. List the properties of the Bessel function.

The properties of the Bessel function is given by,

i) $J_n(\beta)=(-1)^n J_{-n}(\beta)$ for all n, both positive and negative.

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

$J_0(\beta)=1$

$J_1(\beta)=\beta/2$

$J_n(\beta)=0, n>2.$

iii) $\sum_{n=-\infty}^{\infty} J_n^2(\beta)=1$

37. Give the average power of an FM signal.

The amplitude of the frequency modulated signal is constant .The power of the FM signal is same as that of the carrier power. $P=1/2\, E_c^2$.

38. Define phase deviation.

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

39. Define frequency Deviation.

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

40. State the Carson's rule.

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

$B = 2\,\Delta f(1+1/\beta)$

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

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

$$D = \Delta f / f_m$$

42.What is the use of crystal controlled oscillator?

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

43. What are the disadvantages of FM system?

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

44. 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.

45. What are the types of FM detectors?

Slope detector and phase discriminator.

46. What are the types of phase discriminator?

Foster seely discriminator and ratio detector.

47. What are the disadvantages of balanced slope detector?

1. Amplitude limiting cannot be provided
2. Linearity is not sufficient
3. It is difficult to align because of three different frequency to which various tuned circuits to be tuned.
4. The tuned circuit is not purely band limited.

48. Define probability.

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

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

49. What are mutually exclusive events?

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

50. Define probability density function.

Probability density function is defined as $f_x(x)$ is defined in terms of cumulative distribution function $F_x(x)$ as

$$f_x(x) = \frac{d\,F_x(x)}{dx}$$

51. Define noise.

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

52. Give the classification of noise.

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

53. What are the types of External noise?

External noise can be classified into

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

54. What are types of internal noise?

Internal noise can be classified into

1. Thermal noise
2. Shot noise
3. Transit time noise
4. Miscellaneous internal noise

55. What are the types of extraterrestrial noise and write their origin?

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.

56. Define transit time of a transistor.

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

57. Define flicker noise.

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.

58. State the reasons for higher noise in mixers.

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.

59. 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.

60. Define noise figure.

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

S/N = Signal power / Noise Power

61. Explain thermal noise.

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

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

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

63. Explain White Noise.

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.

64. 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.

65. Give the representation of narrowband noise in terms of envelope and phase components.

Narrowband noise in terms of envelope and phase components as

$n(t) = r(t) \cos(2\pi f_c t + \Phi(t))$

$r(t) = (n_I^2(t) + n_Q^2(t))^{1/2}$

$\Phi(t) = \tan^{-1}(n_Q(t) / n_I(t))$

The function r (t) and Φ (t) are called envelope and phase of n(t).

66. Give the expression for equivalent noise temperature in terms of hypothetical temperature.

The expression for equivalent noise temperature in terms of hypothetical temperature

is $T_e = (F - 1) T_0$

Where, F is the noise figure and T_0 absolute temperature.

67. Give the Friss formula in terms of noise temperature.

The Friss formula in terms of noise temperature is

$T_e = T_1 + T_2 / G_1 + T_3 / G_1 G_2 + \ldots\ldots\ldots$

G_1, G_2 ,... Gain of amplifiers

68. What is called image frequency?

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.

$f_{si} = f_s + 2 f_i$

f_{si} - image frequency

It can be eliminated by providing adequate image signal selectivity between antenna and mixer input.

69. What is intermediate frequency?

Intermediate frequency (IF) is defined as the difference between the signal frequency and the oscillator frequency.

IF = $f_s - f_o$ when $f_s > f_o$ (or)

IF = $f_o - f_s$ when $f_o > f_s$

70. Define Partition noise.

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.

71. Give the expression for noise voltage when several sources are cascaded.

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

72. Define random variable

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

73. Define Random process.

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.

74. Give the Laws of probability.

Additive law of probability

Case i

When events are mutually exclusive , $P(A\cap B) = \Phi$

$P(A\cup B) = P(A) + P(B)$

Case ii

When events are not mutually exclusive

$P(A\cup B) = P(A) + P(B) - P(A\cap B)$

Multiplication law of probability:

Case i When events are independent

$P(A\cap B) = P(A)\,P(B)$

Case ii When events are dependent

$P(A\cap B) = P(A)\;P(B/A)$

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

75. What is frequency translation?

Suppose that a signal is band limited to the frequency range extending from a frequency f1 to a frequency f2. The process of frequency translation is one in which the original signal is replaced with a new signal whose spectral range extends from f1' to f2' and which new signal bears, in recoverable form the same information as was borne by the original signal.

76. What are two situations identified in frequency translations?

The two situations identified in frequency translation are

i Up conversion

In this case the translated carrier frequency is greater than the incoming carrier frequency

ii Down conversion

In this case the translated carrier frequency is smaller than the incoming carrier frequency.

Thus, a narrowband FM signal requires essentially the same transmission bandwidth as the AM signal.

77. Define Tracking.

Tracking is the process of correctly tuning a number of tunable circuits in a receiver.

78. What is TRF receiver?

Tuned Radio Frequency is also called straight receiver.Here the receiver operates in straight forward manner without frequency conversion.

79.What are the advantages of superheterodyne receiver over TRF?

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

80.What is the figure of merit of DSBSC system ?

The figure of merit of DSBSC signal is unity

81.Compare the noise performance of an AM and FM system?

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.

82.What is Capture effect?

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

83.What is threshold effect?

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.

84.How is threshold reduction achieved in FM system?

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

85. What is 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.

86. Define de-emphasis.

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

87.Define Sampling theorem.

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

88.What do you infer from the receiver output of a coherent detector?

The output equation $y(t)=1/2Cacm(t) +1/2n_I(t)$ indicates that the message signal and in-phase noise component of the filtered noise appear additively at the receiver output. The quadrature component of the narrow band noise is completely rejected by the coherent detector.

89.When is the figure of merit of SSBSC system 1?

For the same average transmitted signal power and the same average noise power in the message bandwidth ,an SSB receiver will have exactly the same output signal to noise ratio as a DSB-SC receiver when both receivers use coherent detection for the recovery of the message signal.

90.Compare the noise performance of AM receiver with that of DSB-SC receiver.

The figure of merit of DSB-SC or SSB-SC receiver using coherent detection is always unity,the figure of merit of AM receiver using envelope detection is always less than unity.Therefore noise performance of AM receiver is always inferior to that of DSB-SC due to the wastage of power for transmitting the carrier.

91.What is the figure of merit of a AM system with 100 percent modulation?

The figure of merit of a 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 .

92.What are the characteristics of a receiver?

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

96.Why is equivalent noise temperature used for noise measurement?

For low noise devices the noise figure is close to unity, which makes the comparison difficult and hence it is preferable to use equivalent noise temperature.

97.What is the function of amplitude limiter in FM system?

The function of amplitude limiter in FM system is used to remove the amplitude variations by clipping the modulated wave at the filter output almost to the zero axis .The resultant wave is rounded off by another BPF that is an integral part of the limiter thereby suppressing the harmonics of the carrier frequency.

98.What are components in a frequency discriminator?

Frequency discriminator has got two components .Slope detector or differentiator with a purely imaginary frequency response that varies linearly with frequency. It produces output where the amplitude and frequency vary with the message signal. An envelope detector that recover the amplitude variations and produces message signal.

99.What is a post detection filter?

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 messge signal.

100. 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.

101. 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.

102. 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.

103. Prove that $I(x_i x_j) = I(x_i) + I(x_j)$ if x_i and x_j are independent.

If x_i and x_j are independent.

$P(x_i x_j) = P(x_i) P(x_j)$

$I(x_i x_j) = \log 1/P(x_i x_j)$

$= \log 1/ P(x_i) P(x_j)$

$= I(x_i) + I(x_j)$

104. Explain Shannon-Fano coding.

An efficient code can be obtained by the following simple procedure, known as Shannon- Fano algorthim.

1. List the source symbols in order of decreasing probability.
2. 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.
3. Continue this process, each time partitioning the sets with as nearly equal probabilities as possible until further partitioning is not possible.

105. What are the types of Correlation?

The types of Correlation are Cross Correlation and Auto Correlation

106. What is the difference between Correlation and Convolution?

1. In Correlation physical time 't' is dummy variable and it disappears after solution of an integral. But in convolution 'ι' is a dummy variable.

2. Convolution is a function of delay parameter 't' but convolution is a function of ' t'.

3. Convolution is commutative but correlation is noncom mutative.

107. Define Signal.

A signal is defined as any physical quantity carrying information that varies with time. The value of signal may be real or complex. The types of signal are continuous signal and discrete time signal.

108.Define entropy.

Entropy is the measure of the average information content per second. It is given by the expression

$H(X)=\sum_I P(xi)\log_2 P(xi)$ bits/sample.

109.Define mutual information.

Mutual information I(X,Y) of a channel is defined by

$I(X,Y)=H(X)-H(X/Y)$ bits/symbol

H(X)- entropy of the source

H(X/Y)- conditional entropy of Y.

110.State the properties of mutual information.

1. $I(X,Y)=I(Y,X)$
2. $I(X,Y)>=0$
3. $I(X,Y)=H(Y)-H(Y/X)$
4. $I(X,Y)=H(X)+H(Y)-H(X,Y)$.

111.Give the relation between the different entropies.

$H(X,Y)=H(X)+H(Y/X)$

$=H(Y)+H(X/Y)$

H(X)- entropy of the source,H(Y/X),H(X/Y)-conditional entropy

H(Y)-entropy of destination

H(X,Y)- Joint entropy of the source and destination

112.Define information rate.

If the time rate at which source X emits symbols is r symbols per second. The information rate R of the source is given by

$R=r\,H(X)$ bits/second

H(X)- entropy of the source

113.What is data compaction?

For efficient signal transmission the redundant information must be removed from the signal prior to transmission .This information with no loss of information is ordinarily performed on a signal in digital form and is referred to as data compaction or lossless data compression.

114.State the property of entropy.

1.0< H(X) < $\log_2 K$, is the radix of the alphabet X of the source.

115.What is differential entropy?

The average amount of information per sample value of x(t) is measured by

$$H(X)= -\int_{-\infty}^{\infty} f_x(x)\log f_x(x)dx \text{ bit/sample}$$

H(X) –differential entropy of X.

116.What is the channel capacity of a discrete signal?

The channel capacity of a discrete signal $C= \max_{P(xi)} I(X,Y)$

I(X,Y)-mutual information.

117. What is source coding and entropy coding?

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

118.State Shannon Hartley theorem.

The capacity 'C' of a additive Gaussian noise channel is $C=B \log_2 (1+S/N)$

B= channel bandwidth ,S/N=signal to noise ratio.

119.What is the entropy of a binary memory-less source?

The entropy of a binary memory-less source $H(X)=-p_0 \log_2 p_0-(1-p_0)\log_2(1-p_0)$

p_0-probability of symbol '0',p1=(1- p_0) =probability of transmitting symbol '1'

120.How is the efficiency of the coding technique measured?

Efficiency of the code =H(X) /L

$L=\sum p(x_i)l_i$ average code word length .li=length of the code word.

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

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

122.What is channel diagram and channel matrix?

The transition probability diagram of the channel is called the channel diagram and its matrix representation is called the channel matrix.

123.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

124.What is the channel capacity of a BSC and BEC?

For BSC the channel capacity $C=1+p\log_2 p+(1-p)\log_2(1-p)$.

For BEC the channel capacity $C=(1-p)$

PART – B

1. Derive the expression for AM & its Power and Efficiency calculation:

AM – Definition

Let $m(t) = E_m \cos \omega_m t$

$c(t) = E_c \cos \omega_c t$

$E_{AM} = E_c + E_m \cos \omega_m t$

$= E_c [\, 1+ (E_m/E_c) \cos \omega_m t \,]$

$m= E_m/E_c$

$s(t)_{AM} = E_{AM} \cos \omega_c t$

$= E_c (1 + m \cos\omega_m t) \cos\omega_c t$

$= E_c \cos\omega_c t + mE_c \cos\omega_m t \cos\omega_c t$

$$= E_c \cos\omega_c t + \frac{mE_c}{2}[\cos(\omega_c + \omega_m)t + \cos(\omega_c - \omega_m)t]$$

= Carrier + USB + LSB

Power relation in AM:

Total Power, $P_t = P_C + P_{USB} + P_{LSB}$

P_C - Carrier power

P_{USB} - Upper Side Band power

P_{LSB} - Lower Side Band power

$$P_C = \frac{E^2 rms}{R}$$

$$= \frac{E_c^2}{2R}$$

$$P_{USB} = P_{LSB}$$

$$= \frac{m^2 E_c^2}{8R}$$

$$P_t = P_C (1 + m^2/2)$$

Current relation in AM:

$$P_t = I_t^2 R$$

$$P_C = I_c^2 R$$

$$I_t = I_c \text{Sqrt} (1 + m^2/2)$$

Efficiency:

$$\% \eta = \frac{\text{Power in side band}}{\text{Total Power}} \times 100$$

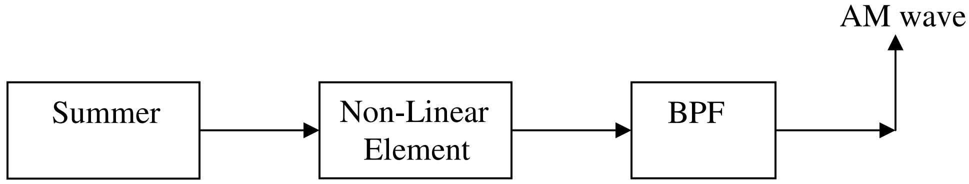
$$= \frac{m^2}{2+m^2} \times 100$$

$m = 1$

$\eta = 33.33$ %

2. Describe the generation of AM wave by Non-Linear modulators :

Square law modulator:



Summer – to add carrier & modulating signal.

Non-Linear element – active element (Diode)

BPF - extracting desired modulating products

To operate diode under Non-Linear region, magnitude of carrier component is higher during positive cycle of the modulating voltage and lesser during negative half cycle of the modulating voltage.

The resulting current is,

$$I_o = a_1 V_1 + a_2 V_1^2 + \ldots\ldots$$

$$V_1 = Em \ Cos\omega_m t + Ec \ Cos\omega_c t$$

Neglecting second and higher order terms,

$$I_o = a_1 Em \ Cos\omega_m t + a_1 Ec \ Cos\omega_c t + 2a_2 EmEc \ Cos\omega_m t \ Cos\omega_c t$$

After passing through BPF,

$$I_o = a_1 Ec \ Cos\omega_c t + a_2 EmEc \ Cos\omega_c t \ Cos\omega_m t$$

Balanced Modulator:

Diagram – Refer Book

Input to the transistor T1,

$$Vbe_1 = m(t) + c(t)$$

Input to the transistor T2,

$$Vbe_2 = m(t) - c(t)$$

$$m(t) = Em\ Cos\omega_m t$$

$$c(t) = Ec\ Cos\omega_c t$$

$$ic_1 = a_1\ Vbe_1 + a_2\ Vbe_1^2 + \ldots\ldots.$$

$$ic_2 = a_1\ Vbe_2 + a_2\ Vbe_2^2 + \ldots\ldots.$$

The output is given by,

$$V_o = K[\ ic_1 - ic_2\ ]$$

$$V_o = K\ 2\ [\ a_1\ Ec\ Cos\omega_c t + 2a_2\ Em\ Ec\ Cos\omega_c t\ Cos\omega_m t\ ]$$

$m = (\ 2a_2\ Em/a_1\ )$ = modulation index

3.Write short notes on De Modulation of AM wave:

De Modulation – definition

Types:

1. Envelope detector
2. Square law detector

Envelope detector:

Requirements to use envelope detector:

1. AM wave has to be narrow band
2. Percentage of modulation should be less than 100%

Diagram - Refer book

During positive half cycle of the input signal, diode is forward biased and capacitor C charges to peak value, when the input signal fall below the peak value, the diode is reverse biased and the capacitor C discharges. The discharging process continues until the next positive half cycle.

When the input signal is greater than the voltage across the capacitor, the diode conducts again and the process is repeated.

The charging time constant $(r_f + R_S) << 1/f_c$

r_f – diode resistance

R_S – source resistance

C – capacitor value

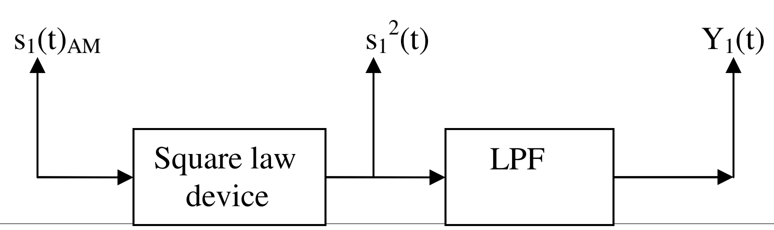
f_c – carrier frequency

Discharging time constant,

$$1/f_c << R_1 << 1/\omega$$

ω – message bandwidth

Square law detector:



$s(t)_{AM} = [A + m(t)] \text{Cos}\omega_c t$

$s^2(t)_{AM} = [A + m(t)]^2 \text{Cos}^2\omega_c t$

For larger carrier,

$[m(t)/A]^2$ is neglected

Blocking capacitor will suppress the dc term $A^2/2$

Then the output is A m(t)

4. Compare the Synchronous Detector and the Costas PLL Detector.

Synchronous or Coherent Detector.

The block diagram of synchronous detector

Operation

All types of linear modulation can be detected by using Synchronous detector.The incoming signal is first multiplied with locally generated carrier signal and then entered via a LPF.The LPF bandwidth is usually same as the message BW or sometimes larger.

It is assumed that the local oscillator is exactly synchronized with the carrier in both phase and velocity,hence the name.

Write the expression for message signal from the modulated signals using coherent detector.

Thus the synchronous detector is capable of demodulating

DSB-SC and SSB-SC AM

Costas PLL Detector (For DSB-SC-AM)

The Block diagram of costas PLL detector

Operation

It consists of two synchronous detector. 1)In phase coherent detector or I channel:- This detector is supplied with DSB-SC-AM and a locally generated carrier which is in phase with the transmitted carrier. 2)Quadrature phase coherent detector or Q channel:- This detector is fed with DSB-SC-AM and a locally generated carrier which is in phase with the transmitted carrier. Assume the local oscillator carrier signal is properly synchronized with transmitting carrier.So I-Channel output contains the desired demodulated signal whereas Q-channel output is zero. If there is a phase shift of φ ; between local oscillator carrier and transmitting carrier then I-channel output will remain in the same value but q-channel output contains some signal . Thus combining the I and Q channel outputs in phase discrimination a dc signal is obtained that automatically corrects the phase errors in VCO.

Comparison

In Synchronous detector the detection is effective only when locally generated carrier is properly synchronized with the modulated signal Any shift in phase or frequency of the locally generated carrier results in phase or delay distortion.

To avoid this distortions a pilot carrier is inserted. Costas PLL detector consists of two coherent detectors. These two detectors are coupled together to form a negative feedback system designed in such a way to maintain the local oscillator synchronise with the carrier.

5. Compare Phase shift method and modified Phase shift method

Phase Shift Method:(SSB-SC-AM)

Block diagram for phase shift method

Analysis

The undesired side band is removed by generating two side band components out of phase.If the undesired sideband is LSB then the two LSB are generated such that they are 180º out of phase with each other.So that the USB's get added and the LSB's cancel each other.

Show the analysis using Expressions

Thus one of the sideband is cancelled whereas the other is reinforced.

Modified Phase Shift Method or Weaver's method.

Block diagram

Operation

Here a phase shift is applied to AF carrier frequency only and after the resulting vge has been applied to BM1 and BM2.

Show the analysis using Expressions

Comparison

Phase shift Method:

- It can switch from one Side Band to other
- Low audio modulating frequency is used

- Generates SSB at any frequency

Weavers Method:

- It does not require a SB filter or any wide band audio phase shift n/w
- Low frequency signals r used.
- Side bands may be easily switched & System is complex

6.Explain the Narrow Band Frequency Modulation

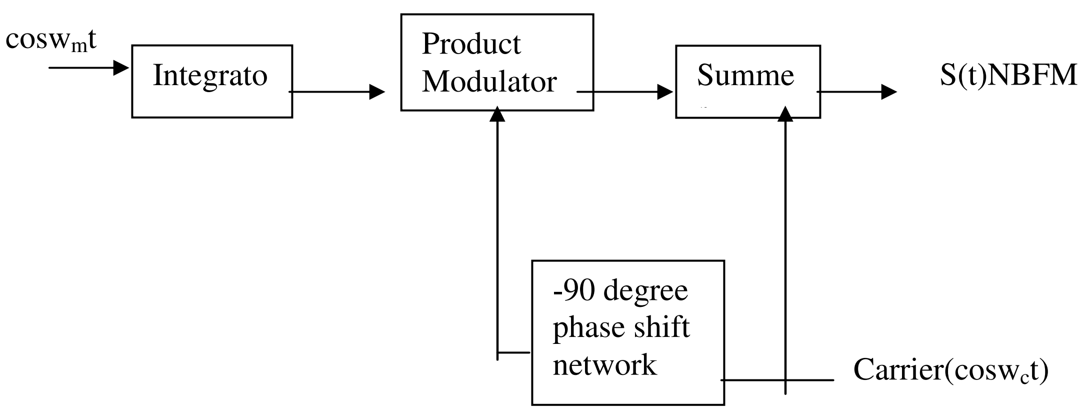
Frequency Modulation.

Frequency modulation is defined as the process of changing the frequency of the carrier wave in accordance with respect to the message signal keeping the amplitude and phase as a constant one.

Narrow Band Frequency Modulation: Definition

If the modulation index is less than one, then the FM signal is narrow and frequency modulated signal.

BLOCK DIAGRAM



$S(t)FM = Ec\cos[w_c t + (Kf\, Em/w_m)\sin w_m t]$;

Here $m(t) = Em\cos w_m t$.

Modulation index(β)=$Kf\, Em/w_m$.

$S(t)FM = Ec\cos[w_c t + \beta\sin w_m t]$

Derivation

Since B<1,

$$S(t)NBFM = Ec[\cos w_c t - \beta\sin w_c t\sin w_m t]$$

7. **Explain the Wide Band Frequency Modulation**

Definition:

If the modulation index is greater than one, then the FM signal is wide band frequency modulated signal.

Fourier Series Representation(aperiodic).

$S(t)=Ec\ cos(w_c t+\beta sinw_m t)$

$=Re\{Ec.e\text{^}jw_c t.e\text{^}j\beta sinw_m t\}$

Let $S\text{^}(t)=(Ec.e\text{^}j\beta sinw_m t)$

$S\text{^}(t)=\Sigma Cn.e\text{^}j2\Pi f_m nt$ (Complex Fourier Series representation of periodic function)

$Cn=\int S\text{^}(t).e\text{^}-j2\Pi f_m nt.\ dt$

Solving,

$Cn=Ec\ J_n(\beta)$

$S\text{^}(t)=\Sigma Ec\ J(\beta).e\text{^}j2\Pi f_m nt$

$$S(t)_{WBFM}=\Sigma Ec\ Jn(\beta).cos(w_c t+nw_m t)$$

8.Explain the method of Generation of FM signal .

(1) Direct FM generation

(2) Indirect FM generation

(1) Direct FM generation

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

(a)Varactor diode implementation of angle modulation.

(b)Reactance tube implementation of angle modulation.

Diagram - explanation

Analysis

(2) Indirect FM generation

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

Diagram - explanation

Analysis

9. Write short notes on Foster seeley Discriminator.

It is used for FM Detection

Circuit Diagram – Operation

Advantages

1. It is much easier to design
2. Only two tuned circuits are necessary and they are tuned to same frequency
3. Linearity is better

Disadvantages:

It requires Amplitude limiting circuit

10. What do you meant by Noise. Give the different types of noise – explain.

Noise – Definition

Noise Classification

1. Internal Noise
2. External Noise

Internal noise - Explanation

Internal Noise – types

a. Thermal nose – Explanation
b. Shot noise - Explanation
c. Transist time noise – Explanation
d. Miscellaneous noise – Explanation

External Noise – Explanation

1. Natural noise – Explanation
2. Man made noise – Explanation

Natural noise – types

a. Terrestial noise – Explanation
b. Extra tyerrestian noise – Explanation

11. Explain in detail about Noise temperature:

Noise performance of any system is indicated by noise figure. Noise figure is not applicable when we are dealing with VHF & microwave amprs. Because noise power and signal power obtained in these devices are close to unity. Hence comparison is rather difficult. So Noise temperature is used.

- **Diagram**
- **Explanation**
- **Calculation**.
- Equivalent noise temperature $T_e = T(F-1)$

obtain an expression for Noise figure when networks are in cascade

- Diagram
- Calculation

$$F = F1 + \frac{F2-1}{G1} + \frac{F3-1}{G1G2} + \frac{F4-1}{G1G2G3} + ...$$

12. Explain the effect of Noise when amplifiers are connected in cascade

Fig. shows a number of amplifier stages in cascade each having a resistance at its input and output. We proceed to find the equivalent input noise voltage and its equivalent noise resistance for the complete receiver.

Diagram

Consider the first two stages of the multi-stage amplifier having gains A_1 and A_2 and input resistances R_1 and R_2 respectively R_3forms the output resistance. The rms noise voltage at the output due to R_3 is given by,

$$V_{n3}\sqrt{4kTBR_3}$$

The same noise voltage is present in the output if instead of R_3 we have resistance R'$_3$ at the input of stage 2, where R'$_3$ is given by,

$V_{n3}' = \frac{V_{n3}}{A_2}$ Substituting vn3 and simplify

Hence $R_3' = \frac{R_3}{A_2^2}$

The noise resistance already present at the input of the second stage is R_2. Hence the net noise resistance.

$$R_{2t} = R_2 R_3^{'} = R_2 + \frac{R_3}{A_2^2}$$

This resistance R_{2t} may be transferred to the input of the first stage.

$$R_2^{'} = \frac{R_{2t}}{A_1^2} = \frac{R_2 + \frac{R_3}{A_2^2}}{A_1^2} = \frac{R_2}{A_1^2} + \frac{R_3}{A_1^2 A_2^2}$$

Substitute R_{2t} and simplify.

Hence the not noise resistance at the input of the first stage is given by

$$R_0 = R_1 + R_2^1 = R_1 + \frac{R_2}{A_1^2} + \frac{R_3}{A_1^2 A_2^2}$$

13. Describe the effect of noise in reactive circuits

Consider the circuit of Fig. in which a physical resistor R is placed in parallel with a parallel tuned circuit. The tuned circuit is theoretically noiseless. The presence of this tuned circuit does not affect the noise generated by the resistor R.

Diagram

Next consider the practical case when this tuned circuit is non-ideal i.e. the inductor L of the tuned circuit possesses a small resistive element R_s an shown in Fig. This resistive element R_s generates noise.

In preceding sections, we have considered physical input resistor as the source of noise. It may, however, be clearly understood that the noise producing resistance need not necessarily be a physical resistor. Thus the series resistance R_s of the coil forms the noise source generating a noise voltage V_n as shown in Fig. We are required to calculate the noise voltage across the capacitor O.

Calculation

$$V = \sqrt{4 kT\bar{B}R_s}$$

.

14. Define Noise figure and obtain an expression for Noise figure of an amplifier

The noise figure F is defined aqs the ratio of signal-to-noise power supplied to the input terminals of the system (amplifier or receiver) to the signal-to-noise power supplied by the system to the output load impedance.

Thus Noise Figure $F = \frac{S/N}{S/N}$ at the input/ at the output.

Calculation of Noise Figure
Diagram

i. Determine input signal power S_i
ii. Determine the input noise power N_i
iii. Calculate the input signal-to-noise power ratio S_i/N_i
iv. Determine the output signal power S_o
v. Determine the output noise power N_o
vi. Calculate the output signal-to-noise power ratio S_o/N_o
vii. From steps (iii) calculate the noise figure F.

Calculation.

$$F = \frac{R_L N_o (R_a + R_t)}{4\bar{k}TBA^2 R_a T_t}$$

15. Obtain an expression for Noise Figure in Terms of Equivalent Noise Resistance

In order to correlate the noise figure and the equivalent noise resistance we define the term R_{eq}' as the noise resistance not including R_t.

$$R_{eq}' = R_{eq} - R_t$$

The total equivalent noise resistance of this receiver is then given by,

$$R = R_{eq}' + \frac{R_a R_t}{R_a + R_t}$$

The equivalent noise voltage effective at the input of the receiver is given by,

$$V_{ni} = \sqrt{4\bar{k}TBR}$$

Calculate the output noise power and calculate Noise Figure.

$$F = 1 + R_{eq}' \frac{R_a + R_t}{R_a . R_t}$$

extreme condition $R_t > R_{as}$ the ratio $(R_a + R_i)$ R_t approaches unity and

$$F = 1 + \frac{R_{eq}}{R_a}$$

16. Explain in detail how noise figure is measured ?

At high frequencies where transit time becomes dominant, such a calculation is not possible. In such a case, it becomes necessary to make measurements which enable us to determine the noise figure. One such method makes use of the diode noise generator.

Diagram
Calculation

$$F = \frac{R_a I_a (1.6x10^{-19})}{2x1.38x10^{-3}x300} = 19.3 R_a I_p$$

16. Super heterodyne receiver - Explanation

- Definition of receiver
- Functions of receiver
- Features of receiver
- Receiver Block Diagram
- Explanation of Block Diagram

17. Prove that the figure of merit of DSB – SC system is unity.

Block Diagram - refer Simon Haykins

S(t) DSB – SC = c Ac co ωc t m(t)

Analysis

Input signal Power = c2 Ac2 P / 2

Input noise Power = wN0

Calculate (Input signal Power / Input noise Power) -------------- (1)

Output signal Power = c2 Ac2 P / 2

Output noise Power = wN0

Calculate (Output signal Power / Output noise Power)--------(2)

(1)
---- = Figure of merit

(2)

18. Noise in AM receivers - AM system using envelope detection

Block Diagram - refer Simon Haykins

AM wave equation

Input signal Power = $A_c^2 (1 + k_a^2 P) / 2$

Average power of noise in the message bandwidth = wN_0 = Input noise Power

Filtered signal = AM signal + noise signal

Analysis

Output signal Power = $A_c^2 k_a^2 P / 2$

Output noise Power = wN_0

Calculate (Input signal Power / Input noise Power) -------------- (1)

Calculate (Output signal Power / Output noise Power)--------(2)

$$\frac{(1)}{(2)} = \text{Figure of merit}$$

19. Noise in angle modulation System

Block Diagram

Representation of FM wave

Analysis

Output signal Power = $\alpha^2 k_f^2 P$

Analysis

$$\text{Output noise Power} = \frac{\alpha^2 N_0 \, 2 \, w^3}{3A^2}$$

$$\frac{\text{Output signal Power}}{\text{Output noise Power}} = \frac{3k_f^2 P}{w}$$

OR

Figure of merit $= (3/2)\ \beta^2$

20. Explain FM threshold reduction.

Threshold effect – 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.

Reduction method:

Block diagram

Explanation .

21. Explain the procedure of Shannon Fano Coding Algorithm and Huffman Coding algorithm

Shannon Fano Coding Algorithm

1. Arrange the symbol probability in the descending order .
2. Partition the set into two sets that are as close to equiprobable as possible , and assign 0 to the upper set and 1 to the lower set
3. Continue this process, each time partitioning the sets with as nearly equal probabilities as possible until further partitioning is not possible

Huffman Coding algorithm

1. Arrange the symbol probability in the descending order .
2. Combine the probabilities of the two symbols having the lowest probabilities and reorder the resultant probabilities; this step is reduction 1 . This procedure is repeated until there are two ordered probabilities remaining.
3. Start encoding with the last reduction, which consists of exactly two ordered probabilities .Assign 0 as the first digit in the code words for all the source symbols associated with the first probability; assign 1 to the second probability

4. Now go back and assign 0 and 1 to the second digit for the two probabilities that were combined in the previous reduction step ,retaining all assignments made in step 3.
5. Keep regressing this way until the first column is reached.

22. .State and prove the properties of mutual information.

1. Mutual information I (xi yj) is symmetric. i.e. I (xi yj) = I (yj xi)

   Proof

2. Mutual information I (xi yj) is maximum when p (xi / yj) = 1

   Proof

3. I (X,Y) ≥ 0

   Proof .

4. Mutual information is related to the joint entropy of the channel input and channel output by I(X,Y) = H (X) + H (Y) – H(X,Y)

   Proof

23. Explain the different types of channel.

Loss less Channel

H (X/ Y) = 0 , I(X,Y) = H (X)

Channel capacity = Max (I(X,Y)) = H (X)

Channel diagram - Explanation

Deterministic channel

H (Y/ X) = 0

I(X,Y) = H (Y)

Channel capacity = Max (I(X,Y)) = H (Y) , Channel diagram - Explanation

Noise less Channel

H (X/ Y) = 0

H (Y/ X) = 0

Channel capacity = Max (I(X,Y)) = H (Y) = H (X)

Channel diagram - Explanation

Binary Symmetric Channel

Channel capacity = Max (I(X,Y)) = H (Y) = Plog2 P + (1- P) log2 (1-P)

Channel diagram - Explanation

24.Calculate the capacity of a gaussian channel.

State the Theorem ,Capacity = ω log2 (1 + S/N) bits/ symbol

Analysis - refer notes

25.. Find the channel capacity of binary erasure channel P (x1) = α

Draw the channel diagram of the binary Erasure channel and get the channel matrix.

P (y1/ x1) = 1-P

P (y2/ x1) = P

P (y2/ x2) = P

P (y3/ x2) = 1-P

Channel capacity = Max (I(X,Y)) = H (Y) - H (Y/ X)

i. Find H (Y/ X) using formula

$H(Y/X) = -(P\log_2 P + (1-P)\log_2(1-P))$

ii. Find H (Y) using formula

$H(Y) = -(1-P)\left[\alpha\log_2\alpha + \log_2(1-P) + \log_2(1-\alpha) - \alpha\log_2(1-\alpha)\right] - P\log_2 P$

iii . I(X,Y) = (1-P) H (Y)

iv. Channel capacity = Max (I(X,Y)) = 1-P