JEPPIAAR ENGINEERING COLLEGE

Jeppiaar Nagar, Rajiv Gandhi Salai – 600 119

DEPARTMENT OF
ELECTRONICS AND COMMUNICATION ENGINEERING

QUESTION BANK

IV SEMESTER

EC6402 – Communication Theory

Regulation – 2013 (Batch: 2016 - 2020)

Academic Year 2017 – 18

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SUBJECT : EC6402 – Communication Theory
YEAR /SEM: II /IV

UNIT-I
AMPLITUDE MODULATION

Generation and detection of AM wave-spectra-DSBSC, Hilbert Transform, Pre-envelope & complex envelope - SSB and VSB –comparison -Super heterodyne Receiver.

PART-A

CO Mapping : C211.1

Q. NO	Questions	BT Level	Competence	PO
1.	Determine the Hilbert Transform of cos ωt.	BTL 2	Understanding	PO1,PO2
2.	What is VSB? Where is it used?	BTL 1	Remembering	PO1
3.	Do the modulation techniques decide the antenna height?	BTL 3	Applying	PO1,PO3
4.	Define carrier swing.	BTL 1	Remembering	PO1
5.	Suggest a modulation scheme for the broadcast video transmission.	BTL 6	Creating	PO1,PO3
6.	What are the advantages of converting low freq signal in to high freq signal?	BTL 2	Understanding	PO1
7.	What theorem is used to calculate the average power of a periodic signal $g_p(t)$? State the Parsevals Theorem.	BTL 2	Understanding	PO1,PO2
8.	What is pre envelope and complex envelope?	BTL 1	Remembering	PO1
9.	What are the advantages of conventional DSB-AM over DSB-SC and SSB-SC AM?	BTL 1	Remembering	PO1
10.	Draw the block diagram of SSB-AM generator.	BTL 3	Applying	PO1,PO3
11.	Draw the AM modulated Wave for modulation Index = 0.5 and its spectra.	BTL 5	Evaluating	PO1,PO3
12.	Define heterodyning.	BTL 1	Remembering	PO1
13.	Define modulation?	BTL 1	Remembering	PO1
14.	Define amplitude Modulation.	BTL 1	Remembering	PO1
15.	What are the types of analog modulation?	BTL 2	Understanding	PO1
16.	Define Modulation index and percent modulation for an AM wave.	BTL 1	Remembering	PO1
17.	What are the degrees of modulation?	BTL 2	Understanding	PO1
18.	Give the bandwidth of AM?	BTL 2	Understanding	PO1,PO2
19.	Give the formula for AM power distribution.	BTL 1	Remembering	PO1,PO2
20.	Give the expression for total current.	BTL 1	Remembering	PO1,PO2
21.	Give the types of AM Modulation.	BTL 1	Remembering	PO1,PO2
22.	A transmitter radiates 9 KW without modulation and 10.125 KW after modulation. Determine depth of modulation.	BTL 5	Evaluating	PO1,PO3

23.	What are the disadvantages of conventional (or) double side band full carrier system?	BTL 1	Remembering	PO1,PO2
24.	Define Single sideband suppressed carrier AM.	BTL 1	Remembering	PO1
25.	Draw the circuit of Envelope detector.	BTL 3	Applying	PO1,PO3
26.	What is the mid frequency of IF section of AM receivers and its Bandwidth.	BTL 2	Understanding	PO1,PO3
27.	Define AM Vestigial sideband	BTL 1	Remembering	PO1
28.	What are the advantages of single sideband transmission?	BTL 1	Remembering	PO1
29.	What are the disadvantages of single side band transmission?	BTL 1	Remembering	PO1
30.	SSB is suitable for speech signals and not for video signals .why?	BTL 1	Remembering	PO1
31.	Give the expression for AM modulated wave.	BTL 1	Remembering	PO1,PO3
32.	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.	BTL 5	Evaluating	PO1,PO3
33.	What are the advantages of VSB-AM?	BTL 2	Understanding	PO1,PO3

PART B &C

Q. NO	Questions	BT Level	Competence	PO
1.	Explain about super heterodyne receiver with neat block diagram. (13)	BTL 2	Understanding	PO1,PO3
2.	(i)In AM system, the transmitter gives a output power of 5kW when modulated to a depth of 95%. If after modulation by a data signal which produces an average modulation depth of 20%, the carrier and one sideband are suppressed, Calculate the average power in the remaining output. (6) (ii) As SSB signal is generated by modulating an 800 kHz carrier by the signal m (t)=cos2000πt+2sin1200πt. The amplitude of the carrier is Ac=10. Obtain the magnitude spectrum of the lower sideband SSB signal. (7)	BTL 3 BTL 6	Applying Creating	PO1,PO,PO4 PO1,PO3,PO4
3.	The output voltage of a transmitter is given by This voltage is fed to a load of 600ohm. Find i) Carrier frequency ii) Modulating frequency iii) Carrier power iv) Mean power output (13)	BTL 3	Applying	PO1,PO3,PO4
4.	What is the need for carrier suppression in AM system? Draw and explain the functioning of such system. (13)	BTL 1	Remembering	PO1,PO3
5.	(i) Explain the generation of SSBSC signal using phase shift method. (6) (ii) Suggest a scheme for recovering the message signal from the signal s(t)=2m(t)cos2πfct. Explain the same. (7)	BTL 2 BTL 2	Understanding Understanding	PO1,PO3 PO1,PO3
6.	(i) Explain with suitable diagrams the generation of AM using square law detector method. Also derive its efficiency. (7) (ii) Analyze when Negative peak clipping takes place in envelope detector.	BTL 2 BTL 2	Understanding Understanding	PO1,PO3 PO1,PO3
7.	Explain in detail vestigial sideband modulation (VSB) generation and also mention the role of VSB in commercial TV broadcasting.	BTL 1	Remembering	PO1,PO3
8.	Explain the Hilbert transform with an example.	BTL 1	Remembering	PO1,PO3
9.	Explain with suitable diagrams the generation of AM using square law method. Derive its efficiency.	BTL 1	Remembering	PO1,PO3

UNIT-II
ANGLE MODULATION

Phase and frequency modulation-Narrow Band and Wind band FM - Spectrum - FM modulation and demodulation – FM Discriminator- PLL as FM Demodulator - Transmission bandwidth.

PART-A

CO Mapping : C211.2

Q. NO	Questions	BT Level	Competence	PO
1.	A frequency modulated signal is given as $s(t) = 20\ \cos[2\pi f_c t + \sin(200\pi t)]$. Determine the required transmission bandwidth. .	BTL 5	Evaluating	PO1,PO3,PO4
2.	How is narrowband signal distinguished from wideband signal?	BTL 4	Analyzing	PO1,PO3,PO4
3.	State the carson's rule.	BTL 1	Remembering	PO1
4.	Distinguish the feature of Amplitude Modulation (AM) and Narrow Band Frequency Modulation (NBFM).	BTL 4	Analyzing	PO1,PO3,PO4
5.	Define modulation index of frequency modulation and phase modulation.	BTL 1	Remembering	PO1
6.	What is the need for pre-emphasis?	BTL 2	Understanding	PO1
7.	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 wideband FM.	BTL 5	Evaluating	PO1,PO3
8.	Compare amplitude and angle modulation schemes.	BTL 2	Understanding	PO1
9.	Define lock in range and Dynamic range of PLL.	BTL 1	Remembering	PO1
10.	A Carrier is frequency modulated with a sinusoidal signal of 2 KHz resulting in a maximum deviation of 5 KHz. Find the bandwidth of modulated signal.	BTL 5	Evaluating	PO1,PO2
11.	What is single tone and multi tone modulation?	BTL 2	Understanding	PO1
12.	Define direct & indirect frequency modulation.	BTL 1	Remembering	PO1
13.	Define instantaneous frequency deviation & frequency deviation.	BTL 1	Remembering	PO1
14.	Define phase modulation	BTL 1	Remembering	PO1
15.	What is Phase deviation?	BTL 1	Remembering	PO1
16.	Define modulation index of frequency modulation.	BTL 1	Remembering	PO1 ,PO2
17.	What are the advantages of angle modulation and also list its disadvantages.	BTL 2	Understanding	PO1
18.	Give the average power of an FM signal	BTL 5	Evaluating	PO1 ,PO2
19.	Define the deviation ratio D for non-sinusoidal modulation.	BTL 2	Understanding	PO1
20.	Define transmission bandwidth of FM wave.	BTL 2	Understanding	PO1
21.	List the properties of the Bessel function.	BTL 1	Remembering	PO1
22.	A 80 MHz carrier is frequency modulated by a sinusoidal signal of 1V amplitude and the frequency sensitivity is 100Hz /v. Find the approximate bandwidth of Fm waveform if the modulating signal has a frequency of 10 kHz.	BTL 5	Evaluating	PO1,PO3,PO4
23.	An FM transmitter has a rest frequency f_c =96MHz and a deviation sensitivity K_1 = 4 KHz/V. Determine the frequency deviation for a modulating signal $V_m(t)$ = 8sin(2π 2000t). Determine the modulation index.	BTL 5	Evaluating	PO1,PO3,PO4
24.	What are the types of Frequency Modulation?	BTL 2	Understanding	PO1
25.	Draw the phasor diagram of Narrowband FM	BTL 1	Remembering	PO1,PO4
26.	What are the two methods of producing an FM wave?	BTL 2	Understanding	PO1
27.	What is meant by detection? Name the methods for detecting FM signals?	BTL 2	Understanding	PO1
28.	What are the disadvantages of balanced slope detector?	BTL 2	Understanding	PO1
29.	What are the types of phase discriminator?	BTL 2	Understanding	PO1
30.	What is a PLL?	BTL 1	Remembering	PO1
31.	What are the applications of Phase Locked Loop?	BTL 2	Understanding	PO1,PO4
32.	Why is frequency modulation preferable for voice transmission?	BTL 2	Understanding	PO1,PO2

PART:B & C

Q. NO		BT Level	Competence	PO
1.	Derive the expression for frequency modulated signal. Explain what is meant by narrow-band FM and wide-band FM using the expression.	BTL 2	Understanding	PO1,PO2
2.	Explain with diagrams the generation of FM using direct method.	BTL 2	Understanding	PO1,PO2
3.	Explain the principle of indirect method of generating a wide-band FM	BTL 2	Understanding	PO1,PO2

	signal with a neat block diagram.			
4.	With relevant diagrams [2], explain how the frequency discriminator and PLL are used as frequency demodulators?	BTL 3	Applying	PO1,PO2
5.	Write about the principle of FM detection and explain about Ratio detector.			PO1,PO3
6.	Draw the circuit diagram of a Foster – seelay discriminator & balanced slope detector and explain its working with relevant phasor diagrams.	BTL 2	Understanding	PO1,PO2
7.	Explain in detail the transmission bandwidth of FM signals with suitable diagrams.	BTL 2	Understanding	PO1,PO3
8.	Write about the principle of FM detection.	BTL 2	Understanding	PO1,PO2
9.	Derive an expression for a single tone FM signal with necessary diagrams and draw its frequency spectrum.	BTL 2	Understanding	PO1,PO2

UNIT-III
RANDOM PROCESS

Random variables, Central limit Theorem, Random Process, Stationary Processes, Mean, Correlation & Covariance functions, Power Spectral Density, Ergodic Processes, Gaussian Process,Transmission of a Random Process Through a LTI filter.

PART-A

CO Mapping : C211.3

Q. NO	Questions	BT Level	Competence	PO
1.	State central limit theorem.	BTL 1	Remembering	PO1
2.	What is meant by ergodic process?	BTL 2	Understanding	PO1,PO2
3.	List the necessary and sufficient conditions for the process to be WSS.	BTL 1	Remembering	PO1
4.	State Wiener Khintchine theorem.	BTL 1	Remembering	PO1
5.	Define Auto correlation function.	BTL 1	Remembering	PO1
6.	Define random variable.	BTL 1	Remembering	PO1
7.	State Baye's rule.	BTL 1	Remembering	PO1
8.	Define the Q factor of a receiver.	BTL 1	Remembering	PO1
9.	Write the equ.for the mean square value of thermal noise voltage in a resistor.	BTL 2	Understanding	PO1,PO2
10.	What is a sample space?	BTL 2	Understanding	PO1
11.	Define random process.	BTL 2	Understanding	PO1
12.	Differentiate Random variable and random process.	BTL 4	Analyzing	PO1,PO2,PO4
13.	What is stationary process?	BTL 2	Understanding	PO1,PO2
14.	Define strict sense stationary process.	BTL 1	Remembering	PO1
15.	List the properties of stationary random process.	BTL 1	Remembering	PO1
16.	List the properties of autocorrelation	BTL 1	Remembering	PO1
17.	What is a Gaussian Process?	BTL 1	Remembering	PO1
18.	Give any two properties of Gaussian process.(NOV/DEC-2016)	BTL 2	Understanding	PO1, PO2
19.	Give the probability density function for a Gaussian random variable	BTL 2	Understanding	PO1, PO2
20.	Give Campbell’s theorem.	BTL 2	Understanding	PO1, PO2
21.	Define Continuous Random Variable.	BTL 1	Remembering	PO1, PO2
22.	Define One-dimensional Random Variables.	BTL 1	Remembering	PO1, PO2
23.	Write any four properties of normal distribution.	BTL 2	Understanding	PO1
24.	Define Variance	BTL 1	Remembering	PO1
25.	Define Joint cumulative distribution function	BTL 2	Understanding	PO1
26.	Define Conditional probability function	BTL 2	Understanding	PO1,PO2
27.	Define Co – Variance:	BTL 1	Remembering	PO1
28.	State the properties of Co – variance	BTL 2	Understanding	PO1,PO2
29.	Define uncorrelated	BTL 1	Remembering	PO1

30.	Distinguish between correlation and regression.	BTL 2	Understanding	PO1,PO2
PART:B & C				
Q. NO		**BT Level**	**Competence**	**PO**
1.	Define noise. Explain the various types of internal noise also explain with derivation the effect of noise in cascaded amplifier circuit.	BTL 4	Analyzing	PO1,PO3,PO4
2.	Explain in detail mean, autocorrelation and covariance functions in detail	BTL 2	Understanding	PO1,PO3,PO4
3.	What is a Gaussian process? Discuss the properties of Gaussian process?	BTL 4	Analyzing	PO1,PO3,PO4
4.	Derive power spectral density and discuss the properties of power spectral density**.**	BTL 4	Analyzing	PO1,PO3,PO4
5.	Explain in detail about the transmission of a random process through a linear time invariant filter.	BTL 3	Applying	PO1,PO3,PO4
6.	When is a random process said to be strict sense stationary (SSS), Wide sense stationary (WSS) and ergodic process.	BTL 4	Analyzing	PO1,PO3
7.	Define the following terms mean, correlation, covariance and ergodicity.	BTL 2	Understanding	PO1
8.	Give a random process, x(t) = Acos (wt + μ) where A and W are constants and μ is a uniform random variable. Show that X(t) is ergodic in both mean and autocorrelation.	BTL 5	Evaluating	PO1,PO3,PO4
9.	Two random process X (t) = A cos(ωt+Φ) and Y(t) = ASin(ωt+Φ), where A and ω are constants and Φ is a uniform variable(0,2π).Find the cross correlation of x(t) and Y(t).	BTL 5	Evaluating	PO1,PO3,PO4

UNIT-IV
NOISE CHARACTERIZATION

Noise sources and types – Noise figure and noise temperature – Noise in cascaded systems. Narrow band noise – PSD of in-phase and quadrature noise –Noise performance in AM systems – Noise performance in FM systems – Pre-emphasis and de-emphasis – Capture effect, threshold effect.

PART-A

CO Mapping : C211.4

Q. NO	**Questions**	**BT Level**	**Competence**	**PO**
1.	Define the term noise equivalent temperature.	BTL 1	Remembering	PO1
2.	List the external sources of noise.	BTL 1	Remembering	PO1
3.	Specify the cause of threshold effect in AM system.	BTL 3	Applying	PO1, PO3
4.	Comment the role of pre-emphasis and de-emphasis circuit in SNR improvement.	BTL 3	Applying	PO1, PO3
5.	Define noise figure and noise equivalent temperature.	BTL 1	Remembering	PO1
6.	Define capture effect in FM.	BTL 1	Remembering	PO1
7.	What is pre-emphasis? Why is it needed?	BTL 2	Understanding	PO1, PO2
8.	Define noise.	BTL 1	Remembering	PO1
9.	Give the classification of noise.	BTL 1	Remembering	PO1
10.	What are the types of External noise?	BTL 1	Remembering	PO1
11.	What are the sources of internal noise?	BTL 1	Remembering	PO1
12.	What are the types of extraterrestrial noise and write their origin?	BTL 2	Understanding	PO1, PO2
13.	Draw the Autocorrelation function and power spectral density of white noise.	BTL 4	Analyzing	PO1,PO3,PO4
14.	What is shot noise?	BTL 1	Remembering	PO1
15.	Write the expression for mean-square value of thermal noise voltage in a resistor.	BTL 4	Analyzing	PO1,PO3,PO4
16.	What is white noise? State its power spectral density?	BTL 1	Remembering	PO1
17.	Give the Friss formula in terms of noise temperature.	BTL 4	Analyzing	PO1,PO3,PO4
18.	Give the expression for equivalent noise temperature in terms of hypothetical temperature	BTL 4	Analyzing	PO1,PO3,PO4
19.	What is figure of merit?	BTL 1	Remembering	PO1
20.	What is narrowband noise?	BTL 1	Remembering	PO1

21.	Give the representation of narrowband noise in terms of envelope and phase components.	BTL 4	Analyzing	PO1,PO3,PO4
22.	Draw the receiver model.	BTL 3	Applying	PO1, PO2
23.	Define input signal to noise ratio.	BTL 1	Remembering	PO1
24.	Define output signal to noise ratio.	BTL 1	Remembering	PO1
25.	Define channel signal to noise ratio.	BTL 1	Remembering	PO1
26.	Compare noise performance of AM and FM systems.	BTL 2	Understanding	PO1, PO2
27.	What is Pre-emphasis and de-emphasis?	BTL 1	Remembering	PO1
28.	What are called extended Threshold demodulators?	BTL 2	Understanding	PO1, PO2
29.	What is the purpose of Pre emphasis and De emphasis in FM?	BTL 2	Understanding	PO1, PO2
30.	What are components in a frequency discriminator?	BTL 2	Understanding	PO1, PO2
31.	What is Capture effect?	BTL 1	Remembering	PO1
32.	What is threshold effect?	BTL 1	Remembering	PO1
33.	How is threshold reduction achieved in FM system?	BTL 4	Analyzing	PO1,PO2,PO4

PART:B & C

Q. NO		BT Level	Competence	PO
1.	What do you mean by Noise? Give the different types of noise – explain.	BTL 1	Remembering	PO1
2.	Discuss the properties of the in-phase and quadrature components of narrow band noise.	BTL 2	Understanding	PO1, PO2
3.	Obtain the expression for the envelope and phase of the narrowband noise.	BTL 4	Analyzing	PO1,PO2,PO4
4.	Explain the noise in AM receiver using envelope detection.	BTL 2	Understanding	PO1, PO2
5.	Explain the noise in AM DSB-SC receiver using coherent detection.	BTL 2	Understanding	PO1, PO2
6.	What are pre emphasis and de-emphasis in FM? Draw suitable circuits and explain.	BTL 4	Analyzing	PO1,PO2,PO4
7.	Explain Capture effect and FM Threshold effect.	BTL 2	Understanding	PO1, PO2
8.	Write notes on FM threshold reduction.	BTL 2	Understanding	PO1, PO2
9.	Explain noise in FM receivers using Phasor diagram. Compare the noise performance of AM and FM systems.	BTL 4	Analyzing	PO1,PO2,PO4

UNIT-V
INFORMATION THEORY

Entropy - Discrete Memoryless channels - Channel Capacity -Hartley - Shannon law - Source coding theorem - Huffman & Shannon - Fano codes

PART-A

CO Mapping C211.5

Q. NO	Questions	BT Level	Competence	PO
1.	Using Shannon law determine the maximum capacity of 5MHz channel with S/N ratio of 10dB.	BTL 5	Evaluating	PO1,PO3,PO4
2.	Define entropy.	BTL 1	Remembering	PO1
3.	State the properties of entropy.	BTL 1	Remembering	PO1
4.	What is Shannon's limit?	BTL 1	Remembering	PO1
5.	A source generates 3 messages with probabilities of 0.5, 0.25, and 0.25. Calculate source entropy.	BTL 5	Evaluating	PO1,PO3,PO4
6.	Define mutual information and channel capacity.	BTL 1	Remembering	PO1
7.	A source is emitting symbols x1,x2 and x3 with probabilities respectively 0.6,0.3 and 0.1.What is the entropy of the source?	BTL 5	Evaluating	PO1,PO3,PO4
8.	State source coding theorem.	BTL 1	Remembering	PO1
9.	State Shannon law.	BTL 1	Remembering	PO1
10.	Define Entropy and find the entropy of a DMS with probability s1 = ½, s2 = ¼ and s3=1/4.	BTL 5	Evaluating	PO1,PO3,PO4

11.	What is memory less source? Give an example.	BTL 1	Remembering	PO1
12.	What is discrete memoryless source?	BTL 1	Remembering	PO1
13.	What is amount of information?	BTL 1	Remembering	PO1
14.	Define mutual information.	BTL 1	Remembering	PO1
15.	State the properties of mutual information	BTL 1	Remembering	PO1
16.	Write down the formula for mutual information	BTL 2	Understanding	PO1,PO2
17.	Give the relation between the different entropies.	BTL 1	Remembering	PO1
18.	Explain the significance of the entropy	BTL 2	Understanding	PO1,PO2
19.	Calculate the entropy of source with a symbol set containing 64 symbols each with a probability pi =1 64 .	BTL 5	Evaluating	PO1,PO3,PO4
20.	Define information rate	BTL 1	Remembering	PO1
21.	What is data compaction?	BTL 1	Remembering	PO1
22.	Name the two source coding techniques.	BTL 2	Understanding	PO1,PO2
23.	When is the average information delivered by a source of alphabet size 2, maximum?	BTL 2	Understanding	PO1,PO2
24.	What is source coding and entropy coding?	BTL 2	Understanding	PO1,PO2
25.	What is meant by prefix code?	BTL 1	Remembering	PO1
26.	What is information theory?	BTL 1	Remembering	PO1
27.	What is channel redundancy?	BTL 1	Remembering	PO1
28.	How is the efficiency of the coding technique measured?	BTL 2	Understanding	PO1,PO2
29.	What is the channel capacity of a BSC and BEC?	BTL 2	Understanding	PO1,PO2
30.	Give the expressions for channel capacity of a Gaussian channel.	BTL 2	Understanding	PO1,PO2
31.	State the channel coding theorem for a discrete memory less channel	BTL 1	Remembering	PO1
32.	Differentiate Lossless and lossy coding?	BTL 4	Analyzing	PO1,PO3,PO4
	PART:B & C			
Q. NO		BT Level	Competence	PO
1.	Explain the procedure of Shannon Fano Coding Algorithm and Huffman Coding algorithm	BTL 5	Evaluating	PO1,PO2
2.	Explain the different types of channel.	BTL 2	Understanding	PO1
3.	Discuss the different conditional entropies	BTL 2	Understanding	PO1,PO3,PO4
4.	Derive information capacity theorem.	BTL 2	Understanding	PO1,PO3,PO4
5.	Explain about the implications of the Information Capacity Theorem.	BTL 2	Understanding	PO1,PO3,PO4
6.	(i) State and prove mutual information and write the properties of mutual information. (ii) Derive Shannon-Hartley theorem for the channel capacity of a continuous channel having an average power limitation and perturbed by an additive band- limited white Gaussian noise.	BTL 5	Evaluating	PO1,PO3,PO4
7.	The two binary random variables X and Y are distributed according to the joint PMF given by P(X=0,Y=1)=1/4; P(X=1,Y=1)=1/2; P(X=1,Y=1)=1/4; Determine H(X,Y) , H(X) , H(Y) , H(X/Y) and H(Y/X) (ii) Define entropy and plot the entropy of a binary source. (**NOV/DEC 2017)**	BTL 5	Evaluating	PO1,PO3,PO4
8.	Derive the mutual information I(x:y)for a binary symmetric channel, when the probability of source is equally likely and the probability channel p = 0.5	BTL 5	Evaluating	PO1,PO3,PO4
9.	A discrete memoryless source has five symbols $X_{1,}$ $X_{2,}$ $X_{3,}$ X_4 and X_5 with probabilities 0.4, 0.19, 0.16, 0.15 and 0.15 respectively attached to every symbol. **(NOV/DEC 2016)** (i) Construct a Shannon-Fano code for the source and calculate code efficiency. (ii) Construct the Huffman code and compare the two source coding techniques.	BTL 5	Evaluating	PO1,PO3,PO4

UNIT-I
AMPLITUDE MODULATION

Generation and detection of AM wave-spectra-DSBSC, Hilbert Transform, Pre-envelope & complex envelope - SSB and VSB –comparison -Super heterodyne Receiver.

PART-A

1. **Determine the Hilbert Transform of cos ωt. (NOV/DEC 2017)**

If $x(t) = \cos\omega t$, then

$$H\{\cos\omega t\} = \upsilon(t)$$
$$= \frac{-1}{\pi} P\int_{-\infty}^{\infty} \frac{\cos\omega\eta}{\eta - t} d\eta$$
$$= \frac{-1}{\pi} P\int_{-\infty}^{\infty} \frac{\cos[\omega(y+t)]}{y} dy$$
$$= \frac{-1}{\pi} \left\{\cos\omega t\, P\int_{-\infty}^{\infty} \frac{\cos\omega y}{y} dy - \sin\omega t\, P\int_{-\infty}^{\infty} \frac{\sin\omega y}{y} dy\right\}$$
$$= \sin\omega t.$$

2. **What is VSB? Where is it used? (NOV/DEC 2017)**

Vestigial sideband (VSB) is a type of amplitude modulation technique that encodes data by varying the amplitude of a single frequency. Portions of one of the redundant sidebands are removed to form a vestigial sideband signal - so-called because a vestige of the sideband remains.

Application

1. VSB modulation has become standard for the transmission of Television signals. Because the video signals need a large transmission bandwidth using DSB-FC or DSF-SC techniques
2. This is a special type of AM system which is used mainly for the TV transmission all over the world. In the TV transmission it is necessary to transmit the video information and audio information simultaneously.
3. In the VSB transmission the upper sideband of video signal and picture carrier are transmitted without any suppression. Whereas a vestige i.e. a part of lower sideband is transmitted and the remaining part is suppressed

3. **Do the modulation techniques decide the antenna height? (APRIL/MAY- 2017)**

Aerial or antenna dimensions are of the same order as the wavelength, λ, of the signal (e.g. quarter wave λ/4, λ/2 dipoles). λ is related to frequency by

$$\lambda = \frac{c}{f}$$

The minimum antenna height required to transmit a base band signal of $f = 10\ k\ Hz$ is calculated as

$$Minimum\ antenna\ height = \frac{\lambda}{4} = \frac{c}{4f} = \frac{3*10^8}{4*10*10^3} = 7500\ meters$$

Consider a modulated signal at $f = 1M\ Hz$

$$Minimum\ antenna\ height = \frac{\lambda}{4} = \frac{c}{4f} = \frac{3*10^8}{4*1*10^6} = 75\ meters$$

Thus modulation reduces the height of the antenna.

4. Define carrier swing. (APRIL/MAY- 2017)

Carrier swing is defined as the total variation in frequency from the lowest to the highest point.
The carrier swing = 2* frequency deviation of the FM signal= 2* Δf

5. Suggest a modulation scheme for the broadcast video transmission. (NOV/DEC 2016)

FM modulation scheme is used for the broadcast video transmission.

6. What are the advantages of converting low freq signal in to high freq signal? (NOV/DEC 2016)

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

7. What theorem is used to calculate the average power of a periodic signal gp(t)?State the theorem. Parsevals Theorem. (May/June 2016)

Let us assume that x (t) is an energy signal. Its average normalized energy is :

$$E = \int_{\infty}^{-\infty} x\ t\ dt$$

8. What is pre envelope and complex envelope? (May/June 2016)

An analytic signal is a **complex** signal created by taking a signal and then adding in quadrature its Hilbert Transform. It is also called the **pre-envelope** of the real signal. A new quantity based on the analytic signal, called the Complex Envelope. Complex Envelope is defined as

$g+(t) = \tilde{g}(t)\ e\ j2\pi ft$

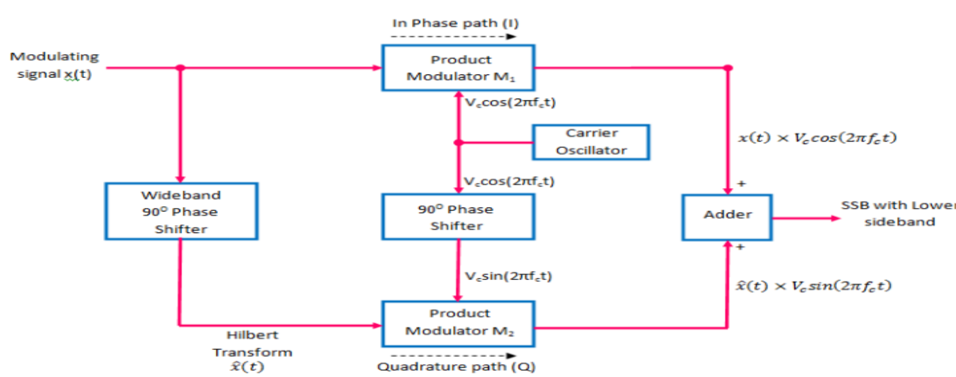
$\tilde{g}(t)$ is the the Complex Envelope.

9. What is the advantages of conventional DSB-AM over DSB-SC and SSB-SC AM? (NOV/DEC 2015)

DSB-SC is basically an amplitude modulation wave without the carrier, Double-sideband suppressed-carrier transmission (DSB-SC) is transmission in which frequencies produced by amplitude modulation (AM) are symmetrically spaced above and below the carrier frequency and the carrier level is reduced to the lowest practical level, ideally being completely suppressed.

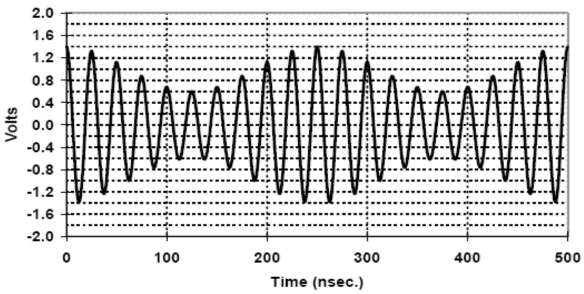
In AM both carrier as well as message signal is transmitted which results in poor efficiency i.e., 33% but in DSBSC carrier wave is suppressed and the efficiency is almost 66.6%.

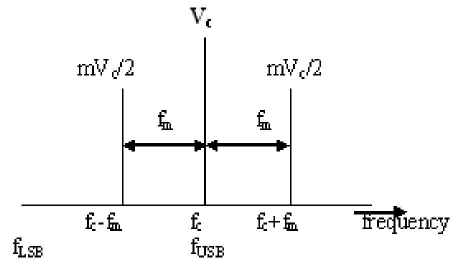
10. Draw the block diagram of SSB-AM generator. (NOV/DEC 2015)



11. Draw the AM modulated Wave for modulation Index = 0.5 and its spectra. (APRIL/MAY- 2015)

m = 0.5





12. Define heterodyning. (APRIL/MAY- 2015)

Heterodyne means to mix two frequencies together in a nonlinear device or to translate one frequency to another, using nonlinear mixing.

<u>Generation and detection of AM wave-spectra-DSBSC</u>

13. Define modulation?

Modulation is the process of changing any one parameter (amplitude, frequency or phase) of a relatively high frequency carrier signal in proportion with the instantaneous value of the modulating signal or message signal.

14. **Define amplitude Modulation.**

Amplitude Modulation is the process of changing the amplitude of a relatively high frequency carrier signal in proportion with the instantaneous value of the modulating signal.

15. What are the types of analog modulation?

- Amplitude modulation.
- Angle Modulation
    a. Frequency modulation
    b. Phase modulation.

16. **Define Modulation index and percent modulation for an AM wave.**

Modulation index is a term used to describe the amount of amplitude change present in an AM waveform .It is also called as coefficient of modulation.

Mathematically modulation index is

$$\mathbf{m = E_m / E_c}$$

Where m = Modulation coefficient

E_m = Peak change in the amplitude of the output waveform voltage.

E_c = Peak amplitude of the unmodulated carrier voltage.

Percent modulation (M) gives the percentage change in the amplitude of the output wave when the carrier is acted on by a modulating signal. It is modulation index multiplied by 100. **M = m * 100**

17. What are the degrees of modulation?

Under modulation: m<1
Critical modulation: m=1
Over modulation: m>1

18. Give the bandwidth of AM?

Bandwidth (B) of AM DSBFC is the difference between highest upper frequency and lowest lower side frequency.

$$\mathbf{B = 2f_{m\,(max)}}$$

$f_{m\,(max)}$ – maximum modulating signal frequency.

19. Give the formula for AM power distribution.

$$\mathbf{P_{total} = P_c\,[1 + m^2 / 2]}$$

Where, P_{total} – total power

m- Modulation index P_c – carrier power

20. Give the expression for total current.

$$\mathbf{I_{total} = I_c\,[1 + m^2 / 2]^{1/2}}$$

Where, I_{total} – total Current

m- Modulation index

I_c – carrier current

21. Give the types of AM Modulation.

DSBSC-Double sideband suppressed carrier.

SSBSC- Single sideband suppressed carrier.

DSBFC - Double sideband full carrier.

VSBSC-Vestigial sideband suppressed carrier.

22. **A transmitter radiates 9 KW without modulation and 10.125 KW after modulation. Determine depth of modulation**.

P_c =9kW , P_T =10.125 kW

$P_T = P_c\,(1+m_a^2\;/2)$

$10.125*10^3=9*10^3(1+m_a^2\;/2)$

$1+m_a^2\;/2=10.125/9$

$1+m_a^2\;/2=1.125$

m_a=0.5 Depth of modulation=0.5

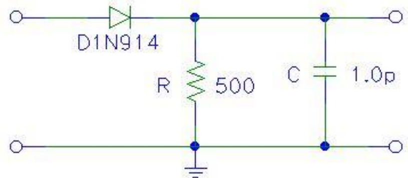
23. What are the disadvantages of conventional (or) double side band full carrier system?

In conventional AM, carrier power constitutes two thirds or more of the total transmitted power. This is a major drawback because the carrier contains no information; the sidebands contain the information. Second, conventional AM systems utilize twice as much bandwidth as needed with single sideband systems.

24. **Define Single sideband suppressed carrier AM.**

AM Single sideband suppressed carrier is a form of amplitude modulation in which the carrier is totally suppressed and one of the sidebands removed.

25. Draw the circuit of Envelope detector.



26. What is the mid frequency of IF section of AM receivers and its Bandwidth.

The mid frequency range of IF is 438 KHz to 465 KHz.The IF of 455 KHz is commonly used. Bandwidth=2 fm=10 KHz

27. **Define AM Vestigial sideband.**

AM vestigial sideband is a form of amplitude modulation in which the carrier and one complete sideband are transmitted, but only part of the second sideband is transmitted.

28. **What are the advantages of single sideband transmission?**

The advantages of SSBSC are

1. Power conservation
2. Bandwidth conservation
3. Noise reduction

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

i. Complex receivers
ii. Tuning Difficulties

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

30. SSB is suitable for speech signals and not for video signals .why? (APRIL/MAY2008)

It is not possible to send one side band exactly eliminating the carrier and other side band. While rejecting the frequency components that are close to the carrier, the frequency components that are close to the carrier on the other sides are also adversely affected. This introduces distortion in the signal which is highly objectionable in the transmission of video signals.

31. Give the expression for AM modulated wave.

$$\mathbf{V_{am} = V_c \sin \omega_c t + \frac{m V_c}{2} \cos(\omega_c - \omega_m) t - \frac{m V_c}{2} \cos(\omega_c + \omega_m) t}$$

where, V_{am} - amplitude of modulated signal

V_c - amplitude of carrier signal

$\omega_c = 2 \pi f_c$ = carrier frequency

$\omega_m = 2\pi f_m$ = modulating signal frequency.

32. 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 It=8.93A m=0.8

Formula: $I_t=I_c (1+m2/2)^{½}$

$8.93=8(1+m2/2)^{½}$

m=0.701

$I_t=8 (1+0.82/2)^{)½}$

I_t=9.1A

33. What are the advantages of VSB-AM?

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

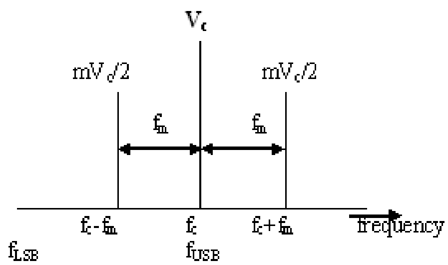
34. Define demodulation.

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

35. What are the types of AM detectors?

1. Nonlinear detectors
2. Linear detectors

36. Draw the spectrum of DSB-FC AM signal.



37. A transmitter supplies 8 KW to the antenna when modulated. Determine the total, power radiated when modulated to 30%.

m=0.3; Pc=8 kw

$Pt=Pc\ (1+m^2/2)=8.36$ KW

27. What is the limitation of amplitude modulation?

- Wastage of power.
- Wastage of bandwidth.

28. What is meant by coherent detections?

If the local oscillator signal used in receiver is exactly coherent or synchronized, in both frequency and phase, with the carrier used in the transmitter then it is called as coherent detection or synchronous demodulation.

29. What is the method used for generating VSB-modulated wave?

VSB is generated using frequency-discrimination method that consists of two stages:

- The first stage is a product modulator, which generates a DSB-SC modulated wave.
- The second stage is a band-pass filter, which is designed to pass one of the sidebands of this modulated wave and suppress the other.
-

30. What are baseband signals?

The information bearing signals are referred to as baseband signals. The term baseband is used to designate the band of frequencies representing the original signal as delivered be a source of information.

31. **If a modulated wave with an average voltage of 20Vp changes in amplitude ±5V, determine the maximum and minimum envelope amplitudes and the modulation coefficients.**

$V_m = 20Vp$

$V_c = 5$ V

$m = V_{max} – V_{min} / V_{max} + V_{min}$

$V_{max} = V_m + V_c = 20+5= 25V$

$V_{min} = V_m - V_c = 20-5= 15V$

$m= V_{max} – V_{min} / V_{max} + V_{min} =25-15 /25+15 =$ **0.25**

32. 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

Hilbert Transform:

33. Write the applications of Hilbert transform?

(i) For generation of SSB signals,
(ii) For designing of minimum phase type filters,
(iii) For representation of band pass signals.

Pre-envelope & complex envelope :

AM- DSB-SSB and VSB –comparison:

33. Compare various Amplitude Modulation systems.

S.No	Description	AM with carrier	DSB-SC AM	SSB-SC AM	VSB- AM
1.	Bandwidth	2fm	2fm	fm	Fm < BW < 2fm
2.	Power saving	33.33%	66.6%	83%	75%
3.	Generation Method	Not difficult	Not difficult	difficult	difficult
4.	S/N Ratio	$(S/N)_o = 2/3(S/N)_i$	$(S/N)_o = 2(S/N)_i$	$(S/N)_o = (S/N)_i$	$(S/N)_o = (S/N)_i$
5.	Application	AM Broadcasting	Carrier Telephony	Wireless mobile	Television and high speed data transmission
6.	Side bands	2	2	1	1

Super heterodyne Receiver.:

34. Define sensitivity of a radio receiver.

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

PART – B

1. **Derive the output expression for an AM DSBFC and also draw the AM spectrum.(APRIL/MAY-15)**
   Refer page no.90-92; Simon Haykins,"communication systems",4th Edition.

2. **Explain with suitable diagrams the generation of AM using square law method. Derive its efficiency. (APRIL/MAY-15)**
   Refer page no 145-146; J.G.Proakis, M.Salehi, "Fundamentals of Communication Systems",

3. **Draw an envelope detector circuit used for demodulation of AM and explain its operation.(APRIL/MAY-15)**
   Refer page no 67-69 Simon Haykins ,"communication systems",4th edition

4. **Derive the expression for DSB-SC AM and calculate its power & efficiency. Explain a method to generate and detect it. (NOV/DEC-15)**
   Refer page 94 Simon Haykins ,"communication systems",4th Edition.

5. **Discuss the generation of single sideband modulated signal. (NOV/DEC-17)**
   Refer page no134; Simon Haykins,"communication systems",4th Edition

6. **Explain in detail vestigial sideband modulation (VSB) generation and also mention the role of VSB in commercial TV broadcasting.**
   Refer page no.100-103; Simon Haykins, "communication systems", 4th Edition**.**
7. **Explain the Hillbert transform with an example.(APRIL/MAY-15,17)**
   Refer page no 99-101 Simon Haykins ,"communication systems",4th edition

8. **Explain with block diagram the superheterodyne receiver.(APRIL/MAY-15,16,17,NOV/DEC-15,17)**
   Refer page no 154;J.G.Proakis, M.Salehi, "Fundamentals of Communication Systems",

9. **Derive an expression for output voltage of a balanced modulator to generate DSB-SC and explain its working principle. (APRIL/MAY-17)**
   Refer page no126 Simon Haykins,"communication systems",4th Edition

UNIT-II
ANGLE MODULATION

Phase and frequency modulation-Narrow Band and Wind band FM - Spectrum - FM modulation and demodulation – FM Discriminator- PLL as FM Demodulator - Transmission bandwidth.

PART-A

1. **A frequency modulated signal is given as $s(t) = 20\ \cos[2\pi f_c t + \ \sin(200\pi t)]$. Determine the required transmission bandwidth. (NOV/DEC 2017)**

   Bandwidth=2(δ+ f_m)

2. **How is narrowband signal distinguished from wideband signal? (NOV/DEC 2017)**

WBFM	NBFM
1. Modulation index greater than 10.	1. Modulation index less than 1
2. Frequency deviation 75 KHz.	2. Frequency deviation 5 KHz
3. Noise is more suppressed.	3. Less suppression of noise.
4. Bandwidth more.	3. Bandwidth is equal to $2f_m$.
5. Used in mobile communication.	4. Used in broadcasting & entertainment.

3. **State the carson's rule. (APRIL/MAY- 2017) (May/June 2016) (NOV/DEC 2015)**

   Carson rule states that the bandwidth required to transmit an angle modulated wave as twice the sum of the peak frequency deviation and the highest modulating signal frequency. Mathematically Carson's rule is **B=2(Δf +f_m) Hz**.

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

4. **Distinguish the feature of Amplitude Modulation (AM) and Narrow Band Frequency Modulation(NBFM). (APRIL/MAY- 2017)**

Amplitude modulation	Narrow Band Frequency Modulation
1. Noise interference is more	Noise interference is less

2. Amplitude Modulation is the process of changing the amplitude of a relatively high frequency carrier signal in proportion with the instantaneous value of the modulating signal.	Frequency Modulation is the process of changing the frequency of a relatively high frequency carrier signal in proportion with the instantaneous value of the modulating signal.
3. The depth of modulation has limitation in AM.	But in FM the depth of modulation can be increased to any value by increasing the deviation.
4. Simple circuits used in transmitter and receiver.	Uses more complex circuits in transmitter and receiver.
5. Power varies in AM depending on depth of modulation.	The amplitude of FM is constant. Hence transmitter power remains constant in FM

5. **Define modulation index of frequency modulation and phase modulation. (NOV/DEC 2016)**

It is defined as the ratio of maximum frequency deviation (Δf) to the modulating frequency f_m.

$\beta = \Delta f / f_m$ where, β is modulation index

6. **What is the need for pre-emphasis? (NOV/DEC 2016) (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

7. **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 wideband FM. (May/June 2016)**

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

8. **Compare amplitude and angle modulation schemes. (NOV/DEC 2015)**

Amplitude modulation	**Frequency modulation**
1. Noise interference is more	Noise interference is less
2. Amplitude Modulation is the process of changing the amplitude of a relatively high frequency carrier signal in proportion with the instantaneous value of the modulating signal.	Frequency Modulation is the process of changing the frequency of a relatively high frequency carrier signal in proportion with the instantaneous value of the modulating signal.
3. The depth of modulation has limitation in AM.	But in FM the depth of modulation can be increased to any value by increasing the deviation.
4. Simple circuits used in transmitter and receiver.	Uses more complex circuits in transmitter and receiver.
5. Power varies in AM depending on depth of modulation.	The amplitude of FM is constant. Hence transmitter power remains constant in FM

9. **Define lock in range and Dynamic range of PLL. (APRIL/MAY- 2015)**

Lock-in Range is the frequency range over which the PLL achieves the phase-locked condition without cycle slips, i.e., $-\pi < \theta_e(t) < \pi$ during the entire lock-in process.

10. **A Carrier is frequency modulated with a sinusoidal signal of 2 KHz resulting in a maximum deviation of 5 KHz. Find the bandwidth of modulated signal. (APRIL/MAY- 2015)**

$$B = 2(\Delta f + f_m)\ Hz.$$
$$= 2(5k + 2k)$$
$$= 14\ KHz.$$

Phase and frequency modulation

11. 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.

12. Define direct & indirect frequency modulation.

In direct frequency modulation, frequency of a constant amplitude carrier signal is directly proportional to the amplitude of the modulating signal at a rate equal to the frequency of the modulating signal.

In indirect frequency modulation, phase of a constant amplitude carrier directly proportional to the amplitude of the modulating signal at a rate equal to the frequency of the modulating signal.

13. Define instantaneous frequency deviation & frequency deviation.

The **instantaneous frequency deviation** is the instantaneous change in the frequency of the carrier and is defined as the first derivative of the instantaneous phase deviation.

Frequency deviation is the change in frequency that occurs in the carrier when it is acted on by a modulating signal frequency. Frequency deviation is typically given as a peak frequency shift in Hertz (Δf). The peak-to-peak frequency deviation ($2\ \Delta f$) is sometimes called carrier swing. The peak frequency deviation is simply the product of the deviation sensitivity and the peak modulating signal voltage and is expressed mathematically as $\mathbf{\Delta f = K_f V_m}$ **Hz.**

14. Define phase modulation. (NOV/DEC 2007)

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.

15. What is Phase deviation?

The relative angular displacement (shift) of the carrier phase (rad) in respect to reference phase is called phase deviation(**$\Delta\Theta$**)

16. Define modulation index of frequency modulation.(May 13)

It is defined as the ratio of maximum frequency deviation (Δf) to the modulating frequency f_m.

$\beta = \Delta f / f_m$ where, β is modulation index

17. What are the advantages of angle modulation and also list its disadvantages.

Advantages:

i. Noise reduction.
ii. Improved system fidelity.
iii. More efficient use of power.

Disadvantages:

i. Wider Bandwidth.
ii. Uses more complex circuit in receiver and transmitter.

18. 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.

$$P=1/2\ E_c^{\ 2}$$

19. 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 .

$$\mathbf{D = \Delta f / f_m}$$

20. Define transmission bandwidth of FM wave.

It is defined as the separation between the two frequencies beyond which none of the side frequencies is greater than 1 percent of the carrier amplitude obtained when the modulation is removed.

21. 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

$J_0(\beta) = 1$

$J_1(b) = \beta / 2$

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

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

22. A 80 MHz carrier is frequency modulated by a sinusoidal signal of 1V amplitude and the frequency sensitivity is 100Hz /v. Find the approximate bandwidth of Fm waveform if the modulating signal has a frequency of 10 kHz. (APRIL/MAY2008)

f_c =80 MHz ,K_f=100Hz /v , f_m=10 kHz ,E_m=1V

Frequncy Deviation, $\delta = K_f E_m = 100$Hz

Modulation Index ,$m_f = \delta / f_m = 0.01$

Bandwidth=$2(\delta + f_m)$=20.2 kHz

23. An FM transmitter has a rest frequency f_c =96MHz and a deviation sensitivity K_1 = 4 KHz/V. Determine the frequency deviation for a modulating signal $V_m(t) = 8\sin(2\pi\ 2000t)$. Determine the modulation index.

V_m=8V, f_m =2000Hz and K_1 =4 kHz /V

Frequency deviation = $\Delta f = K_1 V_m$ = 4 kHz/v * 8V = **32kHz**

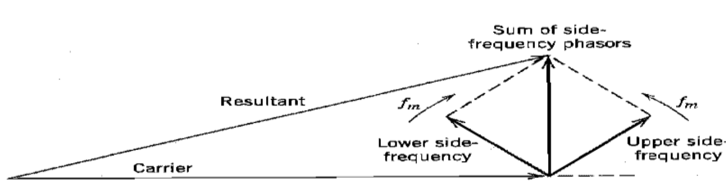
Modulation index = m = $\Delta f / f_m$ = 32 kHz/2000Hz = **16**

<u>**Narrow Band and Wind band FM – Spectrum**</u>

24. 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 Narrowband FM.

25. Draw the phasor diagram of Narrowband FM



FM modulation and demodulation

26. 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.

27. What is meant by detection? Name the methods for detecting FM signals?(APRIL/MAY2011)

Detection is a process of recovering information signal from the modulated wave.

Methods:

a. Slope detectors –simple Slope detectors
-- Balanced Slope detectors

b. Phase difference discriminator – Foster Seeley discriminator
-- Radio detector.

28. 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

FM-PM Discriminator:

29. What are the types of phase discriminator?

The types of phase discriminator are (i) Foster seeley discriminator and (ii) Ratio detector.

PLL as FM Demodulator

30. What is a PLL?

PLL is Phase-locked loop consist of three components: a multiplier, a loop filter and voltage-controlled oscillator (VCO).

31. What are the applications of Phase Locked Loop?

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

(i)Automatic frequency correction in FM transmitter uses PLL to keep carrier frequency constant.

(ii)PLL is used direct FM Tramitter uses PLL to keep carrier frequency constant.

(iii) PLL is also used in FM demodulators.

Transmission bandwidth.

32. Why is frequency modulation preferable for voice transmission?

It is not possible to send one side band exactly eliminating the carrier and other side band. While rejecting the frequency components that are close to the carrier, the frequency components that are close to the carrier on the other sides are also adversely affected. This introduces distortion in the signal which is highly objectionable in the transmission of video signals.

33. **Obtain the bandwidth of the FM signal.** $c(t) = 10 \times \cos[2 \times 10^7 \times \pi t + 8\cos(1000 \times \pi t)]$

Ans: Compare the given FM signal equation with standard FM signal equation,

c (t) = Ec cos (ωc t + m cos ωm t) Here, m = 8 ,ωm =1000 π , Hence 2 π f m =1000 π or f m = 500 Hz 2π δ = m f m = 8× 500 Hz = 4000 Hz BW = 2 (δ + f) m (max) = 2 (4000 + 500) = 9000 Hz or 9 kHz

PART B & C

1. **Derive the expression for frequency modulated signal. Explain what is meant by narrow-band FM and wide-band FM using the expression. (NOV/DEC 2015) (May/June 2016)**

   Refer page no109-111; Simon Haykins ,"communication systems",4th Edition
2. **Explain with diagrams the generation of FM using direct method.**
   1. FET Reactance Modulator
   2. Varactor diode Modulator (APRIL/MAY- 2015) (NOV/DEC 2017)
   Refer page no115-120; Simon Haykins ,"communication systems",4th Edition

3. **Explain the principle of indirect method of generating a wide-band FM signal with a neat block diagram. (May/June 2016)**
   Refer page no120-121 Simon Haykins ,"communication systems",4th Edition

4. **With relevant diagrams [2], explain how the frequency discriminator and PLL are used as frequency demodulators? (APRIL/MAY- 2017)**
   Refer page no124; Simon Haykins,"communication systems",4th Edition

5. **Write about the principle of FM detection and explain about Ratio detector.(NOV/DEC 2016)**
   Refer page no120; Simon Haykins,"communication systems",4th Edition

6. **Draw the circuit diagram of a Foster – seelay discriminator & balanced slope detector and explain its working with relevant phasor diagrams. APRIL/MAY- 2015) (May/June 2016)**
   Refer page no 135; Simon Haykins,"communication systems",4th Edition

7. **Explain in detail the transmission bandwidth of FM signals with suitable diagrams.**
   Refer page no117-119; Simon Haykins ,"communication systems",4th Edition

8. **Write about the principle of FM detection . (NOV/DEC 2016)**
   Refer page no120; Simon Haykins,"communication systems",4th Edition

9. **Derive an expression for a single tone FM signal with necessary diagrams and draw its frequency spectrum. (APRIL/MAY- 2017)**
   Refer page 108 – 111 Simon Haykins ,"communication systems",4th Edition.

UNIT-III
RANDOM PROCESS

Random variables, Central limit Theorem, Random Process, Stationary Processes, Mean, Correlation & Covariance functions, Power Spectral Density, Ergodic Processes, Gaussian Process, Transmission of a Random Process Through a LTI filter.

PART-A

1. **State central limit theorem. (NOV/DEC 2017,16, APRIL/MAY- 2016)**

   The central limit theorem states that the probability distribution of V_N approaches a normalized Gaussian distribution N (0, 1) in the limit as the number of random variables N approaches infinity.

2. **What is meant by ergodic process? (NOV/DEC 2017)**

   A stochastic process is said to be ergodic if its statistical properties can be deduced from a single, sufficiently long, random sample of the process.

3. **List the necessary and sufficient conditions for the process to be WSS. (APRIL/MAY- 2017)**

   1. that $E[X_t]$ is a number independant of t, say μ.
   2. that the autocovariance $E[(X_t - \mu)(X_{t+h} - \mu)]$ is only a function of h (the lag) and not t.

4. **State Wiener Khintchine theorem. (APRIL/MAY- 2017)**

   It states that the autocorrelation function of a wide-sense-stationary random process has a spectral decomposition given by the power spectrum of that process.

   Power spectrum density is basically Fourier transform of auto-correlation function of power signal. This property is helpful for calculating power of any power signal.

   $S_x(f) = \int_{-\infty}^{\infty} Rx(\tau) \exp(-j2\pi f\tau)d\tau \quad R_x(\tau) = \int_{-\infty}^{\infty} Sx(f) \exp(j2\pi f\tau)d\tau$

   Where, $S_x(f)$ is power spectral density
   $R_x(\tau)$ is autocorrelation function

5. **Define Auto correlation function. (May/June 2016)**

   Autocorrelation function of the process X(t) is defined as the expectation of the product of two random variables $X(t_1)$ and $X(t_2)$,obtained by observing the process X(t) at times t_1 and t_2 respectively .

   $$R_x(t_1, t_2) = E[X(t_1) X(t_2)]$$

6. **Define random variable. (NOV/DEC 2015)**

   The outcome of a random experiment is mapped into a number is called as Random variable.

7. **State Baye's rule. (NOV/DEC 2015)**

   Bayes' theorem describes the probability of an event, based on prior knowledge of conditions that might be related to the event.

8. **Define the Q factor of a receiver. (APRIL/MAY- 2015)**

   The Q-factor provides a qualitative description of the receiver performance.

9. **Write the equ.for the mean square value of thermal noise voltage in a resistor.(APRIL/MAY- 2015)**

   $$E[V^2_{TN}] = 4KTR\Delta f \text{ volts}^2$$

   Where, k is Boltzmann's constant = $1.38*10^{-23}$ joules per degree Kelvin
   T is absolute temperature in degrees Kelvin
   R is resistance in ohms.

Random variables,Central limit Theorem,

Random Process, Stationary Processes, Mean, Correlation& Covariance functions

10. What is a sample space?

The totality of sample points corresponding to the aggregate of all possible outcomes of the experiment is called the sample space. Each outcome of experiment is associated with a sample point. Each sample point of sample space is function of time.

11. **Define random process.**

Random process X(t) is an ensemble of time functions together with a probability rule that assigns a probability to any meaningful event associated with an observation of one of the sample functions of the random process. The sample space or ensemble composed of functions of time is called a random or stochastic process.

Mean of the process X(t), is defined as the expectation of the random variable obtained by observing the process at some time t,

$$\mu_X(t) = E[X(t)] = \int_{-\infty}^{\infty} x\, f_{x(t)}(x)dx$$

12. Differentiate Random variable and random process.

Random variable: the outcome of a random experiment is mapped into a number.

Random process: the outcome of a random experiment is mapped into a waveform that is a function of time.

13. What is stationary process?

Random processes often have statistical characteristics of process independent of time at which observation of process is initiated and if such a process is divided into a number of time intervals, the various sections of the process exhibit essentially the samestatistical properties. Such a process is called stationary. Otherwise, it is non-stationary.

14. Define strict sense stationary process.

A random process X(t), initiated at time t = -∞, is strictly stationary if the joint distribution of any set of random variable obtained by observing the random process X(t) is invariant with respect to the location of the origin t=0.

15. List the properties of stationary random process.

- The first order distribution function of a stationary random process is independent of time.

  for k=1, $F_{X(t)}(x) = F_{X(t+\tau)}(x) = F_X(x)$ for all t and τ
- the second – order distribution function of a stationary random process depends only on the time difference between the observation times and not on the particular times at which the random process is observed.

  for k=2 & $\tau = -t_1$, $F_{X(t_1),X(t_2)}(x_1,x_2) = F_{X(0),X(t_2-t_1)}(x_1,x_2)$ for all $t_1$and t_2

16. List the properties of autocorrelation.

- The mean-square value of the process may be obtained from $R_x(\tau)$ simply by putting τ = 0

  $R_x(0) = E[X^2(t)]$
- The autocorrelation function $R_x(\tau)$ is an even function of τ,

  $R_x(\tau) = R_x(-\tau)$
- The autocorrelation function $R_x(\tau)$ has its maximum magnitude at τ = 0,

  $|R_x(\tau)| \leq R_x(0)$.

.**Power Spectral DensityErgodic Processes Gaussian Process**

17. What is a Gaussian Process?

In the equation Y= $\int_0^T g(t)X(t)dt$,the weighting function g(t) is such that the mean-square value of the random variable Y is finite, and if the random variable Y is a Gaussian-distributed random variable for every g(t) in this class of functions ,then the process X(t) is said to be a Gaussian process. In other words, process X(t) is a Gaussian process if every linear functional of X(t) is Gaussian random variable.

18. Give any two properties of Gaussian process.(NOV/DEC-2016)

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

19. Give the probability density function for a Gaussian random variable.

$$f_Y(y) = \frac{1}{\sqrt{2\pi}\sigma_y} \exp[- (y-\mu_y)^2 / 2\sigma_y^2]$$

Where, σ_y^2 is variance of random variable Y

μ_y is mean of random variable Y

20. Give Campbell's theorem.

The autocovariance function of $X(t)$ is

$$C_X(\tau) = \lambda \int_{-\infty}^{\infty} h(t)h(t+\tau)\,dt$$

Transmission of a Random Process Through a LTI filter.

21. Define Continuous Random Variable.

If X is a random variable which can take all values (i.e., infinite number of values) in an interval, then X is called a continuous RV. Ex. The time taken by a lady who speaks over a telephone.

22. **Define One-dimensional Random Variables**.

If a random variable X takes on single value corresponding to each outcome of the experiment, then the random variable is called one-dimensional random variables.it is also called as scalar valued RVs.

23. **Write any four properties of normal distribution.**

(1) The curve is Bell shaped (2) Mean, Median, Mode coincide (3) All odd moments vanish (4) x -axis is an asymptote of the normal curve

24. Define Variance

The second moment about the mean is called variance

25. **Define Joint cumulative distribution function** (joint cdf)

If (X,Y) is a two dimensional RV then $F(x,y) = P(X \le x, Y \le y)$ is called joint cdf of (X,Y)

In the discrete case,

$$F(x,y) = \sum_{\substack{j \\ y_j \le y}} \sum_{\substack{i \\ x_i \le x}} p_{ij}$$

In the continuous case,

$$F(x,y) = P(-\infty < X \le x, -\infty < Y \le y) = \int_{-\infty}^{y}\int_{-\infty}^{x} f(x,y)\,dx\,dy$$

26. **Define Conditional probability function**

If $p_{ij}=P(X=x_i,Y=y_j)$ is the Joint probability function of a two dimensional discrete RV(X,Y) then the conditional probability function X given $Y=y_j$ is defined by

$$P\left[X=x_i / Y=y_j\right]=\frac{P\left[X=x_i \cap Y=y_j\right]}{P\left[Y=y_j\right]}$$

The conditional probability function Y given $X=x_i$ is defined by

$$P\left[Y=y_j / X=x_i\right]=\frac{P\left[X=x_i \cap Y=y_j\right]}{P\left[X=x_i\right]}$$

27. Define Co – Variance:

If X and Y are two two r.v.s then co – variance between them is defined as

Cov (X, Y) = E {X – E (X)} {Y – E (Y)}

(ie) Cov (X, Y) = E (XY) – E(X) E (Y)

28. State the properties of Co – variance;

1. If X and Y are two independent variables, then Cov (X,Y) = 0. But the Converse need not be true
2. Cov (aX, bY) = ab Cov (X,Y)
3. Cov (X + a, Y + b) = Cov (X,Y)
4. $Cov\left(\frac{X-\overline{X}}{\sigma_X},\frac{Y-\overline{Y}}{\sigma_Y}\right)=\frac{1}{\sigma_X\sigma_Y}Cov(X,Y)$

29. **Define uncorrelated**

Two RVs are uncorrelated with each other, if the correlation between X and Y is equal to the product of their means. i.e.,E[XY]=E[X].E[Y]

30. Distinguish between correlation and regression.

By correlation we mean the casual relationship between two or more variables. By regression we mean the average relationship between two or more variables.

PART B&C

1. **Define noise. Explain the various types of internal noise also explain with derivation the effect of noise in cascaded amplifier circuit. (APRIL/MAY- 2015)**

   Refer page 260- Simon Haykins ,"communication systems",4th Edition.

2. **Explain in detail mean, autocorrelation and covariance functions in detail.(May/June 17)**

   Refer page no 35-41; Simon Haykins,"communication systems",4th edition

3. **What is a Gaussian process? Discuss the properties of Gaussian process?**

   Refer page no 54-58; Simon Haykins,"communication systems",4th edition

4. **Derive power spectral density and discuss the properties of power spectral density.(May/June 17)**

   Refer page no 44-47; Simon Haykins,"communication systems",4th edition .

5. **Explain in detail about the transmission of a random process through a linear time invariant filter.) (May/June 2016) (NOV/DEC 16,17)**

   Refer page 42-43- Simon Haykins ,"communication systems",4th Edition

6. **When is a random process said to be strict sense stationary (SSS),Wide sense stationary(WSS)**

and ergodic process. (May/June 2016) (NOV/DEC 2015) (APRIL/MAY- 2015)

Refer page 31-42- Simon Haykins ,"communication systems",4th Edition.

7. **Define the following terms mean, correlation , covariance and ergodicity. (NOV/DEC 2016)**

   Refer page no 708; Simon Haykins,"communication systems",4th Edition

8. **Give a random process,x(t) = Acos (wt + μ) where A and W are constants and μ is a uniform random variable. Show that X(t) is ergodic in both mean and autocorrelation. May/June 2016**

   Refer page 42-43- Simon Haykins ,"communication systems",4th Edition.

9. **Two random process X(t) = A cos(ωt+Φ) and Y(t) = ASin(ωt+Φ), where A and ω are constants and Φ is a uniform variable(0,2π).Find the cross correlation of x(t) and Y(t). May/June 2016**

UNIT-IV
NOISE CHARACTERIZATION

Noise sources and types – Noise figure and noise temperature – Noise in cascaded systems. Narrow band noise – PSD of in-phase and quadrature noise –Noise performance in AM systems – Noise performance in FM systems – Pre-emphasis and de-emphasis – Capture effect, threshold effect.

PART-A

1. **Define the term noise equivalent temperature. (NOV/DEC 2017)**

   The equivalent noise temperature of a system is 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.

2. **List the external sources of noise. (NOV/DEC 2017)**

   External noise can be classified into

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

3. **Specify the cause of threshold effect in AM system. (APRIL/MAY- 2017,15, (NOV/DEC 2015))**

   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.

4. **Comment the role of pre-emphasis and de-emphasis circuit in SNR improvement. (APRIL/MAY-2017,15)**

   pre-emphasis:

   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.

   De-emphasis.

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

5. **Define noise figure and noise equivalent temperature. (NOV/DEC 2016,15) (May/June 2016)**

Noise figure: The signal to noise ratio of input to the output is called noise figure.

$$F = \frac{\frac{S}{N}\ \ at\ the\ input}{\frac{S}{N}\ \ at\ the\ output}$$

Noise equivalent temperature: The equivalent noise temperature of a system is 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.

6. **Define capture effect in FM. (May/June 2016)**

When the interference is a stronger than FM signal, the receiver locks onto stronger signal and thereby suppresses the desired FM input. 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.

7. **What is preemphasis? Why is it needed?**

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.

<u>Noise sources and types</u>

8. **Define noise.**

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

9. **Give the classification of noise.**

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

10. **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

11. **What are the sources of internal noise?**

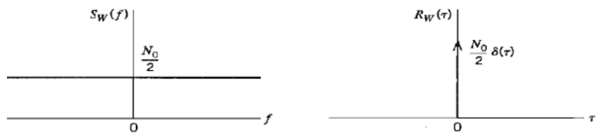
Internal noise arises from spontaneous fluctuations of current or voltage in electrical circuits. The most common spontaneous fluctuations are in electrical circuits are shot noise and thermal noise.

12. **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.

13. **Draw the Autocorrelation function and power spectral density of white noise. (APRIL/MAY2017)**

$$R_W(\tau) = \frac{N_0}{2}\,\delta(\tau)$$



14. What is shot noise?(Nov/Dec 2016)

Shot noise arises in electronic devices such as diodes and transistors because of the discrete nature of current flow in these devices. E.g. Photo detector circuit a current pulse is generated every time an electron is emitted by the cathode due to incident light form a source of constant intensity.

15. Write the expression for mean-square value of thermal noise voltage in a resistor.(May/June 2015)

Thermal noise is the name given to the electrical noise arising form the random motion of electrons in a conductor. The mean-square value of the thermal noise voltage V_{TN} appearing across the terminals of a resistor, measured in a bandwidth of Δf hertz, is given by

$$E[V_{TN}^2] = 4kTR\,\Delta f \text{ volts}^2$$

Where, k is Boltzmann's constant = $1.38*10^{-23}$ joules per degree Kelvin
T is absolute temperature in degrees Kelvin
R is resistance in ohms.

16. What is white noise? State its power spectral density (Apr/May 2011)(Nov/Dec 2016) ?

The power spectral density is independent of operating frequency. The adjective White is used in the sense that white light contains equal amount of all frequencies within the visible band of electromagnetic radiation. The power spectral density of white noise is given by

$$S_W(f) = \frac{N_0}{2}$$

Where, $N_0 = k\,T_e$ watts per hertz
K - Boltzmann's constant
T_e – equivalent noise temperature.

Noise figure and noise temperature":

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

The Friss formula in terms of noise temperature is

Te = T1 + T2 / G1 + T3 / G1 G2 + ………

G1, G2,… Gain of amplifiers

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

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

19. What is figure of merit?

$$\text{Figure of merit} = \frac{(\text{SNR})_O}{(\text{SNR})_C}$$

Noise in cascaded systems.

Narrow band noise PSD of in-phase and quadrature noise

20. 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.

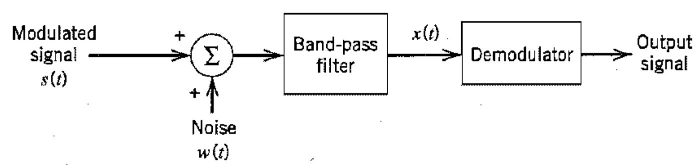
21. Give the representation of narrowband noise in terms of envelope and phase components.

Depending on application of interest, there are two specific representations of narrowband noise:

- The narrowband noise is defined in terms of a pair of components called the *in-phase* and *quadrature* components.
- The narrowband noise is defined in terms of two other components called the *envelope* and *phase components*.

22. Draw the receiver model.

Receiver model, consists of an ideal band-pass filter followed by an ideal demodulator, the band-pass filter is used to minimize the effect of channel noise.



23. Define input signal to noise ratio.

Input signal – to-noise ratio $(SNR)_I$, is defined as the ratio of average power of the modulated signal s(t) to the average power of the filtered noise n(t).

24. Define output signal to noise ratio.

Output signal – to-noise ratio $(SNR)_O$, is defined as the ratio of average power of the demodulated message signal to the average power of noise ,both measured at the receiver output.

25. Define channel signal to noise ratio.

Channel signal – to-noise ratio $(SNR)_C$,is defined as the ratio of average power of the modulated signal to the average power of channel noise in the message bandwidth, both measured at the receiver input.

Noise performance in AM systems Noise performance in FM systems

26. Compare noise performance of AM and FM systems. (APRIL/MAY2008)

AM	FM
$\left.\frac{(SNR)_O}{(SNR)_C}\right\|_{AM} \simeq \frac{k_a^2 P}{1 + k_a^2 P}$	$\left.\frac{(SNR)_O}{(SNR)_C}\right\|_{FM} = \frac{3k_f^2 P}{W^2}$
Noise performance poor.	Noise performance good.

Pre-emphasis and de-emphasis

27. What is Pre-emphasis? .(May/June 2015)

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.

28. Define de-emphasis.

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

29. What are called extended Threshold demodulators? (Nov/Dec 2006)

Threshold reduction or extension can be achieved in FM demodulators with negative feedback. Such demodulators are called extended threshold demodulators.

30. What is the purpose of Pre emphasis and De emphasis in FM? (Nov/Dec 2006)

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

31. 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 recovers the amplitude variations and produces message signal.

<u>Capture effect, threshold effect.</u>

What is Capture effect?(April/May 2008/ 2012)

When the interference is a stronger than FM signal, the receiver locks onto stronger signal and thereby suppresses the desired FM input. 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.

32. What is threshold effect? .(May/June 2015)

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.

33. 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.

34. What is threshold?

The value of carrier-to–noise ratio below which the noise performance of a detector deteriorates much more rapidly than proportionately to the carrier-to-noise ratio.

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<u>PART B</u>

1. **What do you mean by Noise? Give the different types of noise – explain.(Apr/May 17)**

   Refer page no 58-64; Simon Haykins,”communication systems”,4th edition
2. **Discuss the properties of the in-phase and quadrature components of narrow band noise.(Apr / May 2016)**

   Refer page no 64-66; Simon Haykins ,”communication systems”,4thedition
3. **Obtain the expression for the envelope and phase of the narrowband noise.(Nov/Dec-17)**

   Refer page no 67-69 Simon Haykins ,”communication systems”,4th edition**.**
4. **Explain the noise in AM receiver using envelope detection. .(Apr/May 17)**

   Refer page no 135-137, Simon Haykins, ”communication systems”,4th edition.

5. **Explain the noise in AM DSB-SC receiver using coherent detection. .(Apr/May 15)**
   Refer page 132-136- Simon Haykins ,"communication systems",4th Edition.

6. **What are pre emphasis and de-emphasis in FM? Draw suitable circuits and explain. (Apr/May16)**
   Refer page no 154-156, Simon Haykins ,"communication systems",4th edition.
7. **Explain Capture effect and FM Threshold effect.**
   Refer page no 148-152, Simon Haykins ,"communication systems",4th edition.

8. **Write notes on FM threshold reduction. (Nov/Dec-17)**
   Refer page no 152-153Simon haykins,"communication systems", 4th edition

9. **Explain noise in FM receivers using Phasor diagram. Compare the noise performance of AM and FM systems. (Apr / May 2016)**
   Refer page no 143-147 Simon haykins,"communication systems", 4th edition

.UNIT-V
INFORMATION THEORY

Entropy - Discrete Memoryless channels - Channel Capacity -Hartley - Shannon law - Source coding theorem - Huffman & Shannon - Fano codes

PART-A

1. **Using Shannon law determine the maximum capacity of 5MHz channel with S/N ratio of 10dB. (NOV/DEC 2017)**
   Capacity 'C' of a additive Gaussian noise channel is C**=B log2 (1+S/N)**
   $$C=5\ M \log_2 (1+10)$$

2. **Define entropy. (NOV/DEC 2017)**
   Entropy is the measure of the average information content per second. It is given by the expression
   $$H(k)= \sum_{k=0}^{K-1} p_k \log_2 \frac{1}{p_k}\ bits\ /symbols$$

3. **State the properties of entropy. (APRIL/MAY- 2017)**
   1. $H(\mathscr{S}) = 0$, if and only if the probability $p_k = 1$ for some k, and the remaining probabilities in the set are all zero; this lower bound on entropy corresponds to *no uncertainty*.
   2. $H(\mathscr{S}) = \log_2 K$, if and only if $p_k = 1/K$ for all k (i.e., all the symbols in the alphabet $\mathscr{S}$ are *equiprobable*); this upper bound on entropy corresponds to *maximum uncertainty*.

4. **What is Shannon's limit? (APRIL/MAY- 2017,15) (NOV/DEC 2016)**
   Channel capacity (C) of a discrete memoryless channel as the maximum mutual information I(X,Y) in any single use of the channel, where the maximization is over all possible input probability distributions $p(x_j)$ on X.C is bits per channel use or bits per transmission.
   $$C = \max_{\{p(x_j)\}} I(\mathscr{X}; \mathscr{Y})$$

5. **A source generates 3 messages with probabilities of 0.5, 0.25, and 0.25. Calculate source entropy. (NOV/DEC 2016)**
   $$H(k)= \sum_{k=0}^{K-1} p_k \log_2 \frac{1}{p_k}\ bits\ /symbols$$

6. **Define mutual information and channel capacity. (May/June 2016**

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.

Channel capacity (C) of a discrete memoryless channel as the maximum mutual information I(X,Y) in any single use of the channel, where the maximization is over all possible input probability distributions $p(x_j)$ on X.C is bits per channel use or bits per transmission. C = max I (x,y)

7. **A source is emitting symbols x1,x2 and x3 with probabilities respectively 0.6,0.3 and 0.1.What is the entropy of the source? (May/June 2016**

$$\boldsymbol{H(x) = 0.6\log_2(1/0.6) + 0.3\log_2(1/0.3) + 0.1\log_2(1/0.1)}$$

8. **State source coding theorem. (NOV/DEC 2015)**

Given a discrete memoryless source of entropy H(X) , the average code-word length $\bar{L}$ for any distortionless source encoding scheme is bounded as

$$\bar{L} \geq H(X)$$

9. **State Shannon law. (NOV/DEC 2015)**

Shannon's third theorem, the information capacity theorem states as the information capacity of a continuous channel of bandwidth B hertz, perturbed by additive white Gaussian noise of power spectral density $N_0/2$ and limited to B is given by

$C = B\log_2\left(1+\frac{P}{N_o\,B}\right)$ bits per second.

10. **Define Entropy and find the entropy of a DMS with probability s1 = ½, s2 = ¼ and s3=1/4. (APRIL/MAY- 2015)**

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

$H(k)= \sum_{k=0}^{K-1} p_k \log_2 \frac{1}{p_k}$ bits/sample

11. **What is memory less source? Give an example.**

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

12. **What is discrete memoryless source?**

The symbols emitted by the source during successive signaling intervals are statistically independent. That source is called discrete memoryless source.

13. **What is amount of information?**

The amount of information gained after observing the event $S = s_k$, which occurs with probability p_k , as the logarithmic function

$$I(s_k) = \log\frac{1}{p_k}$$

14. **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.

15. State the properties of mutual information.

- I(X,Y)=I(Y,X)- symmetric
- I(X,Y)>=0 – is always nonnegative
- I(X,Y)=H(Y)-H(Y/X)
- I(X,Y)=H(X)+H(Y)-H(X,Y).

16. Write down the formula for mutual information.

The mutual information is defined as the amount of information transferred when xi is transmitted and y j is received. It is represented I (x , y). And it is given as, by i j)= log P y j) I (x , y (xi bits P (xi) ij Average mutual information is defined as the amount of source information gained per received symbol. It is denoted by I (X ;Y). n m P (x y) I (X ;Y)= ∑ ∑ p(xi , y j) log i j i =1 2 P (xi) j =1

17. 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.

18. Explain the significance of the entropy

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

19. **Calculate the entropy of source with a symbol set containing 64 symbols each with a probability pi =1 64** .

Here, there are M = 64 equally likely symbols. Hence entropy of such source is given as,H = log 2 M = log 2 64 = 6 bits / symbol.

20. State any four properties of entropy.

a) For sure event or impossible event entropy is zero.

b) For M number of equally H max = log 2 M likely symbols, entropy is log2 M

c) Upper bound on entropy is d) Entropy is lower bound on average number of bits per symbol.

21. **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

22. 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.

23. Name the two source coding techniques.

The source coding techniques are, a) prefix coding b) Shannon-fano coding c) Huffman coding

24. When is the average information delivered by a source of alphabet size 2, maximum?

Average information is maximum, when the two messages are equally likely, i.e., 1 Then the maximum average information is given as, 2 p1 = p2.com

25. 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. The 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.

26. What is meant by prefix code?

A prefix code is defined as a code in which no code word is prefix of any other code word. It is variable length code. The binary digits (codewords) are assigned to the messages as per their probabilities of occurrence.

27. 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.

28. What is channel redundancy?

Redundancy (γ) = 1 – code efficiency Redundancy should be as low as possible.

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

Efficiency of the code =H(X) /L

L= average code word length

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

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

For BEC the channel capacity $\mathbf{C=(1-p)}$

31. Give the expressions for channel capacity of a Gaussian channel.

Channel capacity of a Gaussian channel is given as, C = B log 1+S2 bits / sec N Here B is Channel bandwidth S is signal power N is total noise power within the channel bandwidth.

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

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

33. Differentiate Lossless and lossy coding?

S.no	Lossless coding	Lossy Coding
	Coding that reduces the number of bits required to represent the symbol without affecting the quality of information by removing redundant information.	Lossy coding involves the loss of information due to compression in a controlled manner
2	Process is completely reversible (eg) data compaction	Process is not reversible (eg) Lempel-Ziv Algorithm.

PART B & C

1. **Explain the procedure of Shannon Fano Coding Algorithm and Huffman Coding algorithm(NOV/DEC 2017) (APRIL/MAY- 2017)**

   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. 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.

2. **Explain the different types of channel. (APRIL/MAY- 2015)**

   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 = $\max(I(X,Y)) = H(Y) = P\log_2 P + (1-P)\log_2(1-P)$

   Channel diagram – Explanation

3. **Discuss the different conditional entropies.**
Refer page no 593-596; Simon haykins ,"communication systems",4th edition

4. **Derive information capacity theorem. (APRIL/MAY- 2017) (NOV/DEC 2016)**
Refer page no 597-599; Simon Haykins ,"communication systems",4th edition.

5. **Explain about the implications of the Information Capacity Theorem. (APRIL/MAY- 2017) (NOV/DEC 2016)**
Refer page no 601-603; Simon Haykins ,"communication systems",4th edition.

6. **(i) State and prove mutual information and write the properties of mutual information.**
Refer page 581 Simon Haykins ,"communication systems",4th Edition.
(ii) Derive Shannon-Hartley theorem for the channel capacity of a continuous channel having an average power limitation and perturbed by an additive band- limited white Gaussian noise.
Refer page 591 Simon Haykins ,"communication systems",4th Edition. **(APRIL/MAY- 2017)**

7. **(a) (i) The two binary random variables X and Y are distributed according to the joint PMF given by P(X=0,Y=1)=1/4; P(X=1,Y=1)=1/2; P(X=1,Y=1)=1/4; Determine H(X,Y) , H(X) , H(Y) , H(X/Y) and H(Y/X).**
(ii) Define entropy and plot the entropy of a binary source. (NOV/DEC 2017)
8. **Derive the mutual information I(x:y)for a binary symmetric channel, when the probability of source is equally likely and the probability channel p = 0.5**
Refer page 588-589 Simon Haykins ,"communication systems",4th Edition.
9. **A discrete memoryless source has five symbols X_1, X_2, X_3, X_4 and X_5 with probabilities 0.4, 0.19, 0.16, 0.15 and 0.15 respectively attached to every symbol. (NOV/DEC 2016)**
(i) Construct a Shannon-Fano code for the source and calculate code efficiency.
(ii) Construct the Huffman code and compare the two source coding techniques.

B.E/B.Tech. Degree Examination, April/May 2015.

Regulation 2013

Fourth semester

Electronics and Communication Engineering

EC6402 Communication Theory

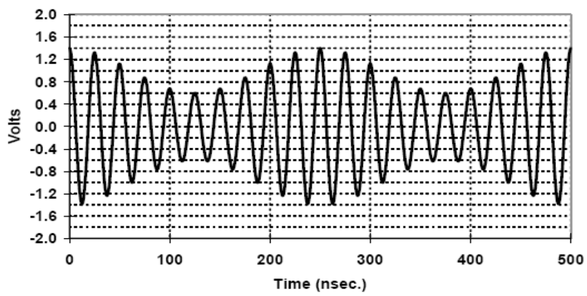
Time : 3 Hrs **Maximum : 100 Marks**

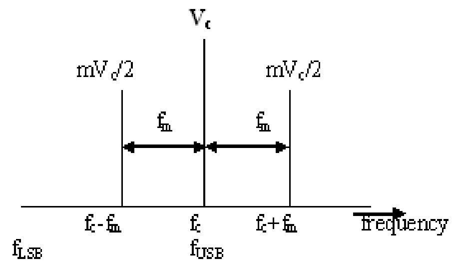
Answer all questions

Part: A (10 x 2=20 marks)

1 .Draw the AM modulated Wave for modulation Index = 0.5 and its spectra.

m = 0.5





2. Define heterodyning.

Heterodyne means to mix two frequencies together in a nonlinear device or to translate one frequency to another, using nonlinear mixing.

3. Define lock in range and Dynamic range of PLL.

Lock-in Range is the frequency range over which the PLL achieves the phase-locked condition without cycle slips, i.e., $-\pi < \theta e (t) < \pi$ during the entire lock-in process.

4. A Carrier is frequency modulated with a sinusoidal signal of 2 KHz resulting in a maximum deviation of 5 KHz. Find the bandwidth of modulated signal.

$B = 2(\Delta f + f_m)$ Hz.

$= 2(5k + 2k)$

= 14 KHz.

5. Define the Q factor of a receiver.

The Q-factor provides a qualitative description of the receiver performance.

6. Write the equation for the mean square value of thermal noise voltage in a resistor.

$E [V^2_{TN}] = 4KTR\Delta f$ volts^2

Where, k is Boltzmann's constant = $1.38*10^{-23}$ joules per degree Kelvin

T is absolute temperature in degrees Kelvin

R is resistance in ohms.

7. What is preemphasis? Why is it needed?

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.

8. Define threshold effect in AM systems.

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.

9. Define Entropy and find the entropy of a DMS with probability s1 = ½, s2 = ¼ and s3=1/4.

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

$$H(k)= \sum_{k=0}^{K-1} p_k \log_2 \frac{1}{p_k} \text{ bits/sample}$$

10. State Shannon's channel capacity theorem.

Channel capacity (C) of a discrete memoryless channel as the maximum mutual information I(X,Y) in any single use of the channel, where the maximization is over all possible input probability distributions $p(x_j)$ on X.C is bits per channel use or bits per transmission.

$$C = \max_{\{p(x_j)\}} I(\mathscr{X}; \mathscr{Y})$$

Part B

11. (a).(i). Explain with suitable diagrams the generation of AM using square law method. Derive its efficiency.

Refer page no 145-146;J.G.Proakis, M.Salehi, "Fundamentals of Communication Systems",

(ii). Explain the demodulation of AM using envelope detection.

Refer page no 67-69 Simon Haykins ,"communication systems",4th edition

Or

b.(i) Explain with block diagram the superheterodyne receiver.

Refer page no 154;J.G.Proakis, M.Salehi, "Fundamentals of Communication Systems",

(ii) Explain the Hillbert transform with an example.

Refer page no 99-101 Simon Haykins ,"communication systems",4th edition.

12.(a).An angle modulated signal is given by

$X_c(t) = 10 \cos [\, 2\pi(10^6)t + 0.1\sin(10^3)\, \pi t]$

(i) Considering Xc(t) as a PM signal with Kp=10,find m(t).

(ii) Considering Xc(t) as a FM signal with Kp=10 π,find m(t).

Or

b.(i). Explain with diagrams the generation of FM using direct method.

1. FET Reactance Modulator

2. Varactor diode Modulator

(ii). With the phasor representation explain the Foster see lay discriminator.

13.a.(i)Define noise. Explain the various types of internal noise.

(ii).Explain with derivation the effect of noise in cascaded amplifier circuit.

Refer page 260- Simon Haykins ,"communication systems",4th Edition.

Or

b. Derive the SNR performance of DSB system and the AM system. Also prove that the output SNR in AM is at least 3dB worse than that DSB system.

Refer page 132-136- Simon Haykins ,"communication systems",4th Edition.

14 .(a)(i). Let X and Y be random variables with finite second moments. Prove that Cauchy-Schwarz inequality. $E[XY])^2 \leq E[X^2]E[Y^2]$.

(ii). Differentiate the strict sense stationary with that of wide sense stationary process.

Or

(b)(i) Let X(t) and Y(t) be Zero-mean and WSS random process. Consider the random process z(t) = X(t) + Y(t).Determine the auto correlation and power spectrum of z(t) if X(t) and Y(t) are jointly WSS.

Refer page 52-53- Simon Haykins ,"communication systems",4th Edition.

(ii).Let X(t) = A cos(ωt+Φ) and Y(t) = ASin(ωt+Φ), where A and ω are constants and Φ is a uniform variable(0,2π).Find the cross correlation of x(t) and Y(t).

Refer page 40-41- Simon Haykins ,"communication systems",4th Edition.

15.(a).(i)A DMS has six symbols x_1,x_2,x_3,x_4,x_5,x_6 with probability of emission .2,0.3,0.11,0.16,0.18,0.05 encode the source with Huffman and Shannon- fano codes. Compare its efficiency.

Refer page 579-580 Simon Haykins ,"communication systems",4th Edition.

(b)(i). Derive the mutual information I(x:y)for a binary symmetric channel, when the probability of source is equally likely and the probability channel p = 0.5

Refer page 588-589 Simon Haykins ,"communication systems",4th Edition.

(ii). For a source emitting three symbols with probabilities p(x) = {1/8 5/4 1/8} and p(Y/X) as given in the table, where X and Y represent the set of transmitted and received symbols respectively, compute H(X),H(X/Y) and H(Y/X).

	Y1	y2	y3
P(Y/X) = x1	**2/5**	**2/5**	**1/5**
X2	**1/5**	**2/5**	**2/5**
X3	**2/5**	**1/5**	**2/5**

B.E. / B.Tech DEGREE EXAMINATION, NOV/DEC 2015
Fourth Semester
Electronics and Communication Engineering
EC6402- COMMUNICATION THEORY
(Regulation 2013)

Time: Three Hours   Maximum:100 Marks

Answer ALL questions.

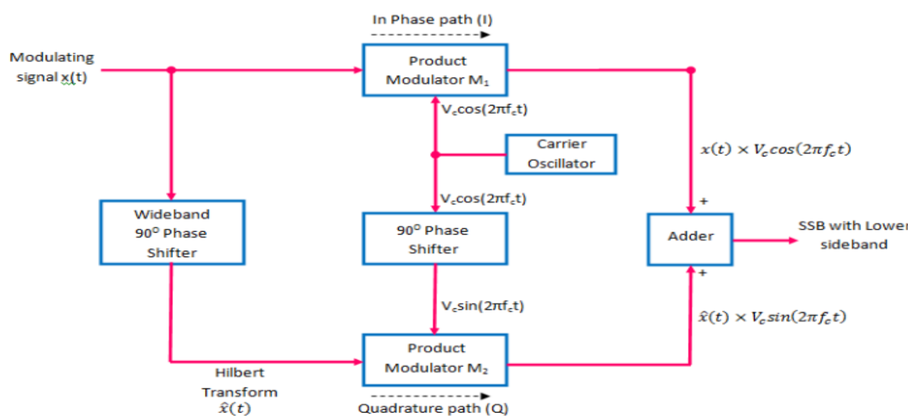
Part A—(10 * 2 =20 marks)

1. What is the advantages of conventional DSB-AM over DSB-SC and SSB-SC AM ?

DSB-SC is basically an amplitude modulation wave without the carrier, Double-sideband suppressed-carrier transmission (DSB-SC) is transmission in which frequencies produced by amplitude modulation (AM) are symmetrically spaced above and below the carrier frequency and the carrier level is reduced to the lowest practical level, ideally being completely suppressed.

In AM both carrier as well as message signal is transmitted which results in poor efficiency i.e., 33% but in DSBSC carrier wave is suppressed and the efficiency is almost 66.6%.

2. Draw the block diagram of SSB-AM generator.



3. Compare amplitude and angle modulation schemes.

Amplitude modulation	**Frequency modulation**
1. Noise interference is more	Noise interference is less
2. Amplitude Modulation is the process of changing the amplitude of a relatively high frequency carrier signal in proportion with the instantaneous value of the modulating signal.	Frequency Modulation is the process of changing the frequency of a relatively high frequency carrier signal in proportion with the instantaneous value of the modulating signal.
3. The depth of modulation has limitation in AM.	But in FM the depth of modulation can be increased to any value by increasing the deviation.
4. Simple circuits used in transmitter and receiver.	Uses more complex circuits in transmitter and receiver.
5. Power varies in AM depending on depth of modulation.	The amplitude of FM is constant. Hence transmitter power remains constant in FM

4. **Write the carson's rule.**

Carson rule states that the bandwidth required to transmit an angle modulated wave as twice the sum of the peak frequency deviation and the highest modulating signal frequency. Mathematically Carson's rule is **$B=2(\Delta f + f_m)$ Hz**.

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

5. **Define random variable.**

The outcome of a random experiment is mapped into a number is called as Random variable.

6. **State Baye's rule.**

Bayes' theorem describes the probability of an event, based on prior knowledge of conditions that might be related to the event.

7. **Define noise figure.**

The signal to noise ratio of input to the output is called noise figure.

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

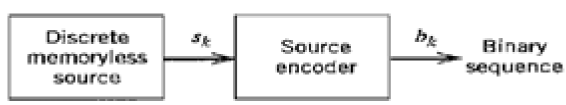
8. **What is threshold effect?**

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.

9. **State source coding theorem.**

Given a discrete memoryless source of entropy H(X) , the average code-word length $\bar{L}$ for any distortionless source encoding scheme is bounded as

$$\bar{L} \geq H(X)$$



10. **State Shannon law.**

Shannon's third theorem, the information capacity theorem states as the information capacity of a continuous channel of bandwidth B hertz, perturbed by additive white Gaussian noise of power spectral density $N_0/2$ and limited to B is given by

$$C = B\log_2\left(1+\frac{P}{N_o B}\right)$$ bits per second.

PART B—(5*16 =80 marks)

11. (a) **With relevant diagrams, describe the process of demodulation of DSB-SC AM signal.**

Refer page no 126-133 J.G.Proakis, M.Salehi, "Fundamentals of Communication Systems",

12. (OR)

(b) With a neat block diagram, explain the function of superheterodyne receiver.

Refer page no 154;J.G.Proakis, M.Salehi, "Fundamentals of Communication Systems",

13. **(a) Derive the expression for frequency spectrum of FM modulated signal and comment on the transmission bandwidth.**

Refer page no120 Simon Haykins,"communication systems",4th Edition

(OR)

(b) With relevant diagrams ^{2}, explain how the frequency discriminator and PLL are used as frequency demodulators?

Refer page no124; Simon Haykins,"communication systems",4th Edition

14. (a) In a binary communication system, let the probability of sending a o 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 0.001 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?

(OR)

(b) 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.

Refer page no120-125; Simon Haykins,"communication systems",4th Edition

15. (a) Consider a message which is a wide-sence stationary random process with the autocorrelation function $R_M(\tau) = 16\, sinc^2(10000\,\tau)$ .All the realization of the message process satisfy the condition max$|m(t)| = 6$.This message needs to be transmitted via a channel with a 50 dB attenuation and additive white noise with the power spectrum density $S_n(f) = \frac{N_o}{2} = 10^{-12}\ \frac{W}{Hz}$. The SNR at the modulator output should be at least 50 dB .What is the transmitter power and channel bandwidth if the following modulation schemes are employed?

(i) DSB-SC AM

(ii) SSB-SC-AM

(iii) Conventional AM with a modulation index of 0.8

(b) Give a detailed account on impact of noise on angle modulation schemes. What is the required received power in an FM system with modulation index, β=5 if W =15 kHz and $N_o = 10^{-14}$ W/Hz? The power of the normalized message signal is assumed to be 0.1 Watt and the required SNR after demodulation is 60dB.

16. (a) (i) The two binary random variables X and Y are distributed according to the joint PMF given by P(X=0,Y=1)=1/4; P(X=1,Y=1)=1/2; P(X=1,Y=1)=1/4; Determine H(X,Y) , H(X) , H(Y) , H(X/Y) and H(Y/X).

(ii) Define entropy and plot the entropy of a binary source.

Refer page no117-119; Simon Haykins,"communication systems",4th Edition

(Or)

(b) Explain the Huffman coding algorithm with a flow chart and illustrate it using an example.

B.E./B.Tech Degree Examination, May/June 2016
EC6402- COMMUNICATION THEORY
(Regulation 2013)

Time: Three Hours Maximum:100 Marks

Answer ALL questions.

Part A—(10 * 2 =20 marks)

8. What theorem is used to calculate the average power of a periodic signal gp(t)?State the theorem.

Parsevals Theorem.

Let us assume that x (t) is an energy signal. Its average normalized energy is :

$$E = \int_{\infty}^{-\infty} x\ t\ dt$$

12. What is pre envelope and complex envelope ?

An analytic signal is a **complex** signal created by taking a signal and then adding in quadrature its Hilbert Transform. It is also called the **pre-envelope** of the real signal. A new quantity based on the analytic signal, called the Complex Envelope. Complex Envelope is defined as

$g+(t) = \tilde{g}(t)\ e\ j2\pi ft$

$\tilde{g}(t)$ is the the Complex Envelope.

13. 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 wideband FM.

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

14. What is the need for 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

15. State central Limit Theorem.

The central limit theorem states that the probability distribution of V_N approaches a normalized Gaussian distribution N (0, 1) in the limit as the number of random variables N approaches infinity.

16. Define Auto correlation function.

Autocorrelation function of the process X(t) is defined as the expectation of the product of two random variables $X(t_1)$ and $X(t_2)$,obtained by observing the process X(t) at times t_1 and t_2 respectively .

$$R_x(t_1, t_2) = E[X(t_1)\ X(t_2)]$$

17. Give the definition of noise equivalent temperature.

The equivalent noise temperature of a system is 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.

18. Define capture effect in FM.

When the interference is a stronger than FM signal, the receiver locks onto stronger signal and thereby suppresses the desired FM input. 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.

19. Define mutual information and channel capacity.

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.

Channel capacity (C) of a discrete memoryless channel as the maximum mutual information I(X,Y) in any single use of the channel, where the maximization is over all possible input probability distributions $p(x_j)$ on X.C is bits per channel use or bits per transmission. C = max I (x,y)

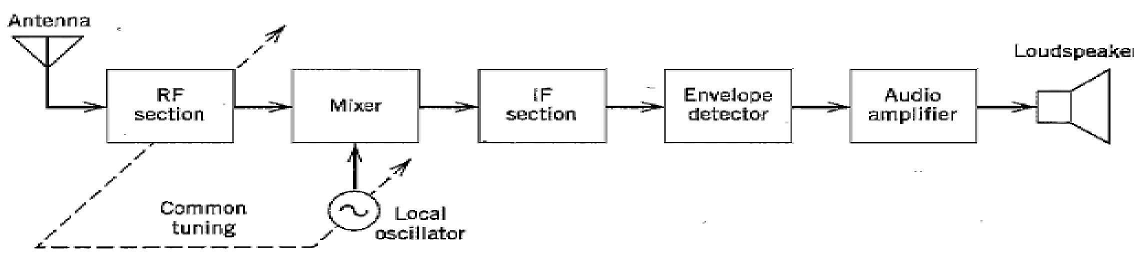
20. A source is emitting symbols x1,x2 and x3 with probabilities respectively 0.6,0.3 and 0.1.What is the entropy of the source?

$$H(x) = 0.6\log_2(1/0.6) + 0.3\log_2(1/0.3) + 0.1\log_2(1/0.1)$$

$$H(x) =$$

PART B

11.(a) Explain about Super Heterodyne Receiver with neat diagram. (16)



Refer page 128 Simon Haykins ,"communication systems",4th Edition.

OR

(b) Derive the expression for DSB-SC AM and calculate its power & efficiency. Explain a method to generate and detect it. (16)

Refer page 94 Simon Haykins ,"communication systems",4th Edition.

12.(a)(i)Derive an expression for a single tone FM signal with necessary diagrams and draw its frequency spectrum. (10)

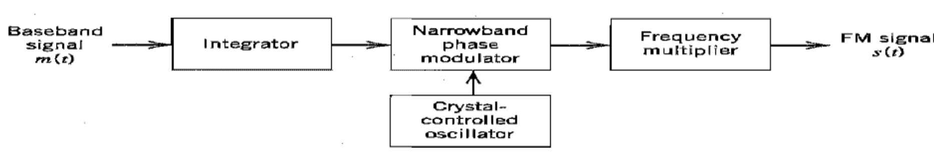
Refer page 108 – 111 Simon Haykins ,"communication systems",4th Edition.

(ii) An angle modulated wave is described by$V(t) = 100\cos(2*10^6\pi t + 10\cos 2000\pi t)$. Find (i) power of the modulating signal (ii) Maximum frequency deviation (iii) Band width (6)

Refer page 111-116 Simon Haykins ,"communication systems",4th Edition.

OR

(b) (i) Explain the Armstrong method of FM generation. (8)



Refer page 120 Simon Haykins ,"communication systems",4th Edition.

(ii) Draw the circuit diagram of a Foster – seelay discriminator and explain its working with relevant phasor diagrams. (8)

13.(a) (i) Two random process $X(t) = A\cos(\omega t+\Phi)$ and $Y(t) = A\sin(\omega t+\Phi)$, where A and ω are constants and Φ is a uniform variable(0,2π).Find the cross correlation of x(t) and Y(t).

Refer page 40-41- Simon Haykins ,"communication systems",4th Edition.

(ii) *Explain in detail about the transmission of a random process through a linear* time invariant filter.

Refer page 42-43- Simon Haykins ,"communication systems",4th Edition.

OR

(b) (i) When is a random process said to be strict sense stationary (SSS),Wide sense stationary(WSS) and ergodic process.

Refer page 31-42- Simon Haykins ,"communication systems",4th Edition.

(ii) Give a random process,x(t) = Acos (wt + μ) where A and W are constants and μ is a uniform random variable. Show that X(t) is ergodic in both mean and autocorrelation.

Refer page 42-43- Simon Haykins ,"communication systems",4th Edition.

14.(a)(i) Define Narrow band noise and explain the representation of Narrow Band noise in terms of In-phase and quadrature Components.

Refer page 64 Simon Haykins ,"communication systems",4th Edition.

(ii) Explain Pre-emphasis and De-emphasis in FM.

Refer page 154 Simon Haykins ,"communication systems",4th Edition.

OR

(b) Explain the noise in DSB –SC receiver using synchronous or coherent detection and calculate the figure of merit for a DSB-SC system?

Refer page 135 Simon Haykins,"communication systems",4th Edition.

15.(a)(i) State and prove mutual information and write the properties of mutual information.

Refer page 581 Simon Haykins ,"communication systems",4th Edition.

(ii) Derive Shannon-Hartley theorem for the channel capacity of a continuous channel having an average power limitation and perturbed by an additive band- limited white Gaussian noise.

Refer page 591 Simon Haykins ,"communication systems",4th Edition.

OR

(b) Consider a discrete memoryless source with seven possible symbols Xi= {1,2,3,4,5,6,7} with associated probabilities P ={0.37,0.33,0.16,0.04,0.02,0.01}.Construct the Huffman's code and Shannon Fano code and determine the coding efficiency and redundancy.

(i) Symbol Probability Code Word

(ii) Average Code word Length L

(iii) Entropy H(s)

Refer page 578 Simon Haykins,"communication systems",4th Edition.

B.E. / B.Tech DEGREE EXAMINATION, NOV/DEC 2016
Fourth Semester
Electronics and Communication Engineering
EC6402- COMMUNICATION THEORY
(Regulation 2013)

Time: Three Hours Maximum: 100 Marks

Answer ALL questions.

Part A—(10 * 2 =20 marks)

1. **Suggest a modulation scheme for the broadcast video transmission.**

   FM modulation scheme is used for the broadcast video transmission.

2. **What are the advantages of converting low frequency signal in to high frequency signal?**
   - Ease of transmission
   - Multiplexing
   - Reduced noise
   - Narrow bandwidth
   - Frequency assignment
   - Reduce the equipments limitations.

3. **Define modulation index of frequency modulation and phase modulation.**

   It is defined as the ratio of maximum frequency deviation (Δf) to the modulating frequency f_m.

   $\beta = \Delta f / f_m$ where, β is modulation index

4. **What is the need for 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

5. **State Central limit theorem.**

   The central limit theorem states that the probability distribution of V_N approaches a normalized Gaussian distribution N (0, 1) in the limit as the number of random variables N approaches infinity.

6. **Write Einstein –Wiener-Khintchine relation.**

   It states that the autocorrelation function of a wide-sense-stationary random process has a spectral decomposition given by the power spectrum of that process.

   Power spectrum density is basically Fourier transform of auto-correlation function of power signal. This property is helpful for calculating power of any power signal.

   $S_x(f) = \int_{-\infty}^{\infty} Rx(\tau) \exp(-j2\pi f\tau) d\tau$ $R_x(\tau) = \int_{-\infty}^{\infty} Sx(f) \exp(j2\pi f\tau) d\tau$

   Where, $S_x(f)$ is power spectral density

   $R_x(\tau)$ is autocorrelation function

7. **Two resistors of 20k , 50 k are at room temperature (290k).For a bandwidth of 100 khz. Calculate the thermal voltage generated by two resistors in series.**

8. Define noise figure and noise equivalent temperature.

Noise figure: The signal to noise ratio of input to the output is called noise figure.

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

Noise equivalent temperature: The equivalent noise temperature of a system is 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.

9. State Shannon's channel capacity theorem, for a power and band limited channel.

Channel capacity (C) of a discrete memoryless channel as the maximum mutual information I(X,Y) in any single use of the channel, where the maximization is over all possible input probability distributions $p(x_j)$ on X.C is bits per channel use or bits per transmission.

$$C = \max_{\{p(x_j)\}} I(\mathscr{X}; \mathscr{Y})$$

10. A source generates 3 messages with probabilities of 0.5, 0.25, and 0.25. Calculate source entropy.

PART B-(5*16=80 MARKS)

11. (a**) Derive the expression for amplitude wave and explain any one method and demodulate it. (16)**

Refer page no 146-148;J.G.Proakis, M.Salehi, "Fundamentals of Communication Systems",

12. (Or)

(b) Derive the expression for DSB-SC AM. Explain a method and detect it. (16)

Refer page no 126-133;J.G.Proakis, M.Salehi, "Fundamentals of Communication Systems",

13. (a) (i) Derive an expression for a single tone FM signal with necessary diagrams and draw its frequency spectrum. (10)

Refer page no 182;J.G.Proakis, M.Salehi, "Fundamentals of Communication Systems",

(ii) Explain the working operation of balanced slope detector. (6)

Refer page no150; Simon Haykins,"communication systems",4th Edition

(Or)

(b) (i) Explain the direct method of FM generation. (8)

Refer page no120; Simon Haykins,"communication systems",4th Edition

(ii) Write about the principle of FM detection and explain about Ratio detector. (8)

Refer page no120; Simon Haykins,"communication systems",4th Edition

14. (a) (i) Define the following terms mean, correlation , covariance and ergodicity. (8)

Refer page no 708; Simon Haykins,"communication systems",4th Edition

(ii) Explain in detail about the transmission of a random process through a linear time invariant filter.

Refer page no710; Simon Haykins,"communication systems",4th Edition

(or)

(b) (i) When is a random process said to be Strict Sense Stationary (SSS).Wide Sense Stationary (WSS) and Ergodic process. (8)

Refer page no110-114; Simon Haykins,"communication systems",4th Edition

(ii) What is Gaussian random process and mention its properties. (8)

Refer page no112-119; Simon Haykins,"communication systems",4th Edition

15. (a) (i) Define noise and write notes on Shot noise , Thermal noise and White noise.(8)

Refer page no117-119; Simon Haykins,"communication systems",4th Edition

(ii) Derive the figure of merit for AM system .Assume coherent detection. (8)

Refer page no134; Simon Haykins,"communication systems",4th Edition

(or)

(b) Explain the noise in FM receiver and calculate the figure of merit for a FM system.

Refer page no134; Simon Haykins,"communication systems",4th Edition

16. (a) State Shannon's various theorems and explain.

Refer page no611,433,616,599 Simon Haykins,"communication systems",4th Edition

(or)

(b) A discrete memoryless source has five symbols X_1, X_2, X_3, X_4 and X_5 with probabilities 0.4, 0.19, 0.16, 0.15 and 0.15 respectively attached to every symbol.

(i) Construct a Shannon-Fano code for the source and calculate code efficiency.

(ii) Construct the Huffman code and compare the two source coding techniques.

B.E. / B.Tech DEGREE EXAMINATION, APRIL/MAY- 2017
Fourth Semester
Electronics and Communication Engineering

EC6402- COMMUNICATION THEORY
(Regulation 2013)

Time: Three Hours Maximum:100 Marks

Answer ALL questions.

Part A—(10 * 2 =20 marks)

1. Do the modulation techniques decide the antenna height?

Aerial or antenna dimensions are of the same order as the wavelength, λ, of the signal (e.g. quarter wave λ/4, λ/2 dipoles). λ is related to frequency by

$$\lambda = \frac{c}{f}$$

The minimum antenna height required to transmit a base band signal of $f = 10\ k\ Hz$ is calculated as

$$Minimum\ antenna\ height = \frac{\lambda}{4} = \frac{c}{4f} = \frac{3*10^8}{4*10*10^3} = 7500\ meters$$

Consider a modulated signal at $f = 1M\ Hz$

$$Minimum\ antenna\ height = \frac{\lambda}{4} = \frac{c}{4f} = \frac{3*10^8}{4*1*10^6} = 75\ meters$$

Thus modulation reduces the height of the antenna.

2. **Define carrier swing**.

Carrier swing is defined as the total variation in frequency from the lowest to the highest point. The carrier swing = 2* frequency deviation of the FM signal= 2* Δf

3. State the carson's rule.

Carson rule states that the bandwidth required to transmit an angle modulated wave as twice the sum of the peak frequency deviation and the highest modulating signal frequency. Mathematically Carson's rule is $\mathbf{B=2(\Delta f + f_m)}$ **Hz**.

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

4. Distinguish the feature of Amplitude Modulation (AM) and Narrow Band Frequency Modulation(NBFM).

Amplitude modulation	Narrow Band Frequency Modulation
1. Noise interference is more	Noise interference is less
2. Amplitude Modulation is the process of changing the amplitude of a relatively high frequency carrier signal in proportion with the instantaneous value of the modulating signal.	Frequency Modulation is the process of changing the frequency of a relatively high frequency carrier signal in proportion with the instantaneous value of the modulating signal.

3. The depth of modulation has limitation in AM.	But in FM the depth of modulation can be increased to any value by increasing the deviation.
4. Simple circuits used in transmitter and receiver.	Uses more complex circuits in transmitter and receiver.
5. Power varies in AM depending on depth of modulation.	The amplitude of FM is constant. Hence transmitter power remains constant in FM

5. **List the necessary and sufficient conditions for the process to be WSS.**
   1. that $E[X_t]$ is a number independant of t, say μ.
   2. that the autocovariance $E[(X_t - \mu)(X_{t+h} - \mu)]$ is only a function of h (the lag) and not t.

6. **State Wiener Khintchine theorem.**

   It states that the autocorrelation function of a wide-sense-stationary random process has a spectral decomposition given by the power spectrum of that process.

   Power spectrum density is basically Fourier transform of auto-correlation function of power signal. This property is helpful for calculating power of any power signal.

   $S_x(f) = \int_{-\infty}^{\infty} Rx(\tau) \exp(-j2\pi f\tau)d\tau \quad R_x(\tau) = \int_{-\infty}^{\infty} Sx(f) \exp(j2\pi f\tau)d\tau$

   Where, $S_x(f)$ is power spectral density

   $R_x(\tau)$ is autocorrelation function

7. **Specify the cause of threshold effect in AM system.**

   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.

8. **Comment the role of pre-emphasis and de-emphasis circuit in SNR improvement.**

   pre-emphasis:

   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.

   De-emphasis.

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

9. **State the properties of entropy.**
   1. $H(\mathcal{S}) = 0$, if and only if the probability $p_k = 1$ for some k, and the remaining probabilities in the set are all zero; this lower bound on entropy corresponds to *no uncertainty*.
   2. $H(\mathcal{S}) = \log_2 K$, if and only if $p_k = 1/K$ for all k (i.e., all the symbols in the alphabet $\mathcal{S}$ are *equiprobable*); this upper bound on entropy corresponds to *maximum uncertainty*.

10. **What is Shannon's limit?**

    Channel capacity (C) of a discrete memoryless channel as the maximum mutual information I(X,Y) in any single use of the channel, where the maximization is over all possible input probability distributions $p(x_j)$ on X.C is bits per channel use or bits per transmission.

$$C = \max_{\{p(x_j)\}} I(\mathscr{X}; \mathscr{Y})$$

PART B (5*13=65 Marks)

11. (a) (i) **Derive an expression for output voltage of a balanced modulator to generate DSB-SC and explain its working principle.**

Refer page no126 Simon Haykins,"communication systems",4th Edition

(ii) Discuss the detection process of DSB-SC and SSB-SC using coherent detector. Analyze the drawback of the suggested methodology. (8)

Refer page no 126-133;J.G.Proakis, M.Salehi, "Fundamentals of Communication Systems",

(Or)

(b) (i) Comment the choice of IF selection and image frequency elimination.(5)

Refer page no 154 ;J.G.Proakis, M.Salehi, "Fundamentals of Communication Systems",

(ii) Elucidate the working principle of super heterodyne receiver with the neat block diagram.(8)

Refer page no 154 ;J.G.Proakis, M.Salehi, "Fundamentals of Communication Systems",

12. (a) (i) Obtain the mathematical expression for WBFM. Also compare and contrast its characteristics with NBFM.

Refer page no120; Simon Haykins,"communication systems",4th Edition

(ii) Suggest and discuss the method for the generation of FM using direct method.

Refer page no125; Simon Haykins,"communication systems",4th Edition

(Or)

(b) (i) Analyze and brief how the ratio detector suppresses the amplitude variation caused by the communication media without using amplitude limiter circuit.

Refer page no117-119; Simon Haykins,"communication systems",4th Edition

(ii) Explain the detection of FM wave using PLL detector.

Refer page no 169 ;J.G.Proakis, M.Salehi, "Fundamentals of Communication Systems",

13. (a) Consider two linear filters connected in cascade as shown in Fig. 1.Let X(t) be a stationary process with a auto correlation function $R_x(\tau)$, the random process appearing at the first filter is V(t) and the second filter is Y(t).

(i) Find the autocorrelation function of Y(t)

(ii) Find the cross correlation Function $R_{vy}(\tau)$, of V(t) and Y(t).

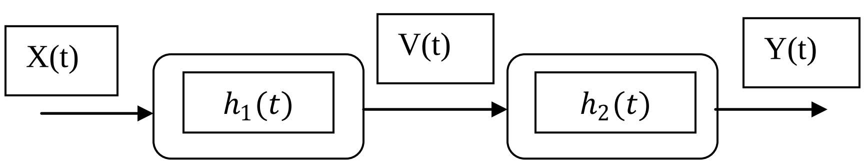


Fig .1

(Or)

(b) The amplitude modulated signal is defined as $X_{AM}(t) = A\, m(t) \cos(\omega_c t + \theta)$ where m(t) is the baseband signal and $A \cos(\omega_c t + \theta)$ is the carrier. The baseband signal m(t) is modeled as a zero mean stationary random process with the autocorrelation function $R_{xx}(\tau)$ and the PSD $G_x(f)$.The carrier amplitude A and the frequency ω_c are assumed to be constant and the initial carrier phase θ is assumed to be uniformly distributed in the interval (-π, π) Furthermore ,m(t) and θ are assumed to be independent.

(i) Show that $X_{AM}(t)$ is Wide Sense Stationary.

(ii) Find PSD of $X_{AM}(t)$.

14. (a) (i) Classify the different noise sources and its effects in real time scenario.(7)

Refer page no 260; Simon Haykins,"communication systems",4th Edition

(ii) Discuss the effects of noise in cascaded system. (6)

Refer page no265; Simon Haykins,"communication systems",4th Edition

(Or)

(b) Derive an expression for signal to noise ratio for an AM signal, with assumption that the noise added in the channel is AWGN .Compare its performance with FM system.(13)

Refer page no117-119; Simon Haykins,"communication systems",4th Edition

15. (a) (i) Consider a binary memoryless source X with two symbols x_1 and x_2 .Prove that H(X) is maximum when both x_1 and x_2 equiprobable.(6)

Refer page no 706 ;J.G.Proakis, M.Salehi, "Fundamentals of Communication Systems",

(ii) Given a telegraph source having two symbols dot and dash. The dot duration is 0.2 sec. The dash duration is 3 times the dot duration. The probability of the dot's occurring is twice that of the dash, and the time between symbols is 0.2 sec. Calculate the information rate of the telegraph source. (7)

(Or)

(b) (i) Find the channel capacity of the binary r=erasure channel as shown in Fig 2 (7)

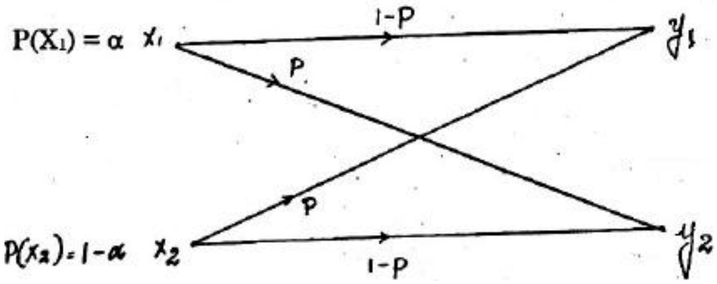


Fig. 2

(ii) A source is emitting equiprobable symbols. Construct a Huffman code for source.(6)

PART C-(1*15=15 MARKS)

16. (a) The AM signal $s(t) = A_c[1 + K_a m(t)] \cos 2\pi f_c t$ is applied to the system shown in Fig 3.Assuming that $|K_a m(t)| < 1$ for all t and the message signal m(t) is limited to the interval -W ≤f≤ W and that the carrier frequency $f_c > 2W$ show that m(t) can be obtained from the square rooter output $V_3(t)$.

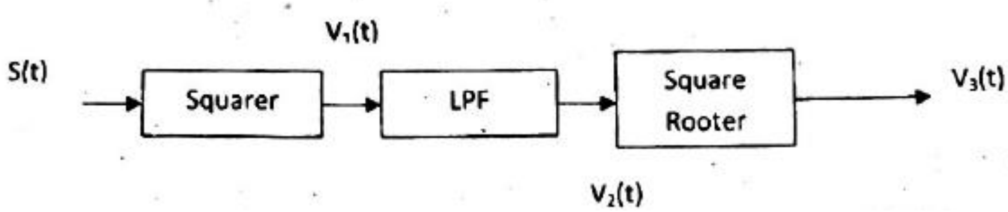


Fig.3

Consider a square law detector , using a non linear device whose transfer characteristics is defined by $V_2(t) = a_1 V_1(t) + a_2 V_1^2(t)$ where a_1 and a_2 are constants, $V_1(t)$ is the input and $V_2(t)$ is the output .The input consists of the AM wave $V_1(t) = A_c[1 + K_a m(t)] \cos 2\pi f_c t$.

(i) Evaluate the output $V_2(t)$

(ii) Find the conditions for which the message signal m(t) may be recovered from $V_2(t)$

Refer page no193; Simon Haykins,"communication systems",4th Edition

(or)

(b) The discrete Hilbert Transform is a process by which a signal's negativefrequencies are phase - advanced by 90 degrees and the positive frequencies are phase-delayes by 90 degrees. Shifting the results of the Hilbert Transform (+j) and adding it to the original signal creates a complex signal as mentioned in the equation. If $m_i[n]$ is the hilbert transform of $m_r[n]$, then $m_e[n] = m_r[n] + jm_i[n]$.Apply the concept of Hiltert transform to generate and detect SSB-SC signal.

Refer page no 99-101 ;J.G.Proakis, M.Salehi, "Fundamentals of Communication Systems",

B.E. / B.Tech DEGREE EXAMINATION, NOV/DEC 2017
Fourth Semester
Electronics and Communication Engineering
EC6402- COMMUNICATION THEORY
(Regulation 2013)

Time: Three Hours — Maximum: 100 Marks

Answer ALL questions.

Part A—(10 * 2 =20 marks)

1. **Determine the Hilbert Transform of cos ωt.**

If $x(t) = \cos\omega t$, then

$$H\{\cos\omega t\} = \upsilon(t)$$
$$= \frac{-1}{\pi} P\int_{-\infty}^{\infty} \frac{\cos\omega\eta}{\eta - t} d\eta$$
$$= \frac{-1}{\pi} P\int_{-\infty}^{\infty} \frac{\cos[\omega(y+t)]}{y} dy$$
$$= \frac{-1}{\pi}\left\{\cos\omega t\, P\int_{-\infty}^{\infty} \frac{\cos\omega y}{y} dy - \sin\omega t\, P\int_{-\infty}^{\infty} \frac{\sin\omega y}{y} dy\right\}$$
$$= \sin\omega t.$$

2. **What is VSB? Where is it used?**

Vestigial sideband (VSB) is a type of amplitude modulation technique that encodes data by varying the amplitude of a single frequency. Portions of one of the redundant sidebands are removed to form a vestigial sideband signal - so-called because a vestige of the sideband remains.

Application

1. VSB modulation has become standard for the transmission of Television signals. Because the video signals need a large transmission bandwidth using DSB-FC or DSF-SC techniques
2. This is a special type of AM system which is used mainly for the TV transmission all over the world. In the TV transmission it is necessary to transmit the video information and audio information simultaneously.
3. In the VSB transmission the upper sideband of video signal and picture carrier are transmitted without any suppression. Whereas a vestige i.e. a part of lower sideband is transmitted and the remaining part is suppressed

3. **A frequency modulated signal is given as $s(t) = 20\ \cos[2\pi f_c t +\ \sin(200\pi t)]$. Determine the required transmission bandwidth.**

Bandwidth=2(δ+ f_m)

4. **How is narrowband signal distinguished from wideband signal?**

WBFM	NBFM
1. Modulation index greater than 10.	1. Modulation index less than 1
2. Frequency deviation 75 KHz.	2. Frequency deviation 5 KHz
3. Noise is more suppressed.	3. Less suppression of noise.
4. Bandwidth more.	3. Bandwidth is equal to $2f_m$.
5. used in mobile communication.	4. used in broadcasting & entertainment.

5. **State central limit theorem.**

The central limit theorem states that the probability distribution of V_N approaches a normalized Gaussian distribution N (0, 1) in the limit as the number of random variables N approaches infinity.

6. **What is meant by ergodic process?**

A stochastic process is said to be ergodic if its statistical properties can be deduced from a single, sufficiently long, random sample of the process.

7. **Define the term noise equivalent temperature.**

The equivalent noise temperature of a system is 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.

8. **List the external sources of noise.**

External noise can be classified into

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

9. **Using Shannon law determine the maximum capacity of 5MHz channel with S/N ratio of 10dB.**

Capacity 'C' of a additive Gaussian noise channel is C**=B log2 (1+S/N)**

$$C=5\ M \log_2 (1+10)$$

10. **Define entropy.**

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

$$H(k)= \sum_{k=0}^{K-1} p_k \log_2 \frac{1}{p_k}\ bits\ /symbols$$

PART-B (5*13=65 MARKS)

11. (a) (i) Explain the operation of envelope detector. (7)

Refer page no 139;J.G.Proakis, M.Salehi, "Fundamentals of Communication Systems",

(ii) Discuss the generation of single sideband modulated signal. (6)

Refer page no134; Simon Haykins,"communication systems",4th Edition

(Or)

(b) Explain the operation of superheterodyne receiver with neat block diagram. Draw signal at the output of each block. (13)

Refer page no 154;J.G.Proakis, M.Salehi, "Fundamentals of Communication Systems",

12. (a) (i) Explain the generation of FM signal using direct method. (8)

Refer page no121.-124 Simon Haykins,"communication systems",4th Edition

(ii) List the advantages of frequency modulation over amplitude modulation. (5)

(Or)

(b) Explain the FM demodulation process using frequency discrimination process.

Refer page no117-119; Simon Haykins,"communication systems",4th Edition

13. (a) (i) Discuss the properties of Gaussian process. (6)

Refer page no 245-247;J.G.Proakis, M.Salehi, "Fundamentals of Communication Systems",

(ii) Derive the input and output relationship of a random process applied through a LTI filter.

Refer page no 21 ;J.G.Proakis, M.Salehi, "Fundamentals of Communication Systems",

(Or)

(b) (i) Consider a random process defined as $X(t) = A\cos\omega t$.where ω is a constant and A is random uniformly distributed over [0,1] .Find the autocorrelation and auto covariance of X(t).

Refer page no 76; J.G.Proakis, M.Salehi, "Fundamentals of Communication Systems",

(ii) Distinguish between random variable and random process .Give examples to each.

Refer page no 210-214; J.G.Proakis, M.Salehi, "Fundamentals of Communication Systems",

14. (a) Obtain the expression for the figure of merit of the AM receiver. (13)

Refer page no 134; Simon Haykins,"communication systems",4th Edition

15. (Or)

(b) (i) Explain the operation of pre emphasis and de emphasis in the FM communication system. (9)

Refer page no 294-297;J.G.Proakis, M.Salehi, "Fundamentals of Communication Systems",

(ii) An amplifier has three stages with gain 5dB, 20 dB and 12 dB. The noise figures of the stages 7 dB, 13 dB and 12 dB respectively. Determine the overall noise figure and the noise equivalent temperature.(4)

15. (a) (i) A source emits one of the four symbols A,B,C and D with probabilities 1/3, 1/6, ¼ and ¼ respectively. The emissions of symbols by the source are statistically independent. Determine the average code length and coding efficiency if the Shannon Fano coding is used.

(Or)

(b) (i) Discuss about discrete memoryless channels.(6)

Refer page no 724 ;J.G.Proakis, M.Salehi, "Fundamentals of Communication Systems",

(ii) Explain the properties of entropy. (7)

Refer page no 706-708;J.G.Proakis, M.Salehi, "Fundamentals of Communication Systems",

PART- C (1*15=15 MARKS)

16. (a) Which modulation will be suitable for transmitting your audio file? Assume your audio frequency and obtain its spectrum response? Is there any transformation needed for transmission .Summarize the modulation analysis and explain. Why and how this modulation suits.

(Or)

(b) Compile your favorites song modulate it and favorites it .During the transmission what are the noises may occur and how can you reduce noise at the receiver end. Obtain the PSD of your signal.

COURSE DELIVERY PLAN-THEORY

Faculty Name : Mrs.C.Anitha	**Programme/Branch:B.E/ECE**
Academic Year:2017-2018	**Year/Semester/Batch:II/IV/2016-2020**
Subject Code/Subject Name: EC6402 /Communication Theory	**Regulation:2013**

A. Details of the relevant POs & PSOs supported by the course	
PO1	**Engineering Knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and electronics engineering specialization to the solution of complex engineering problems.
PO2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	**Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4	**Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO12	**Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.
PSO II	Promote excellence in professional career and higher education by gaining knowledge in the field of Electronics and Communication Engineering
PSO III	Understand social needs and environmental concerns with ethical responsibility to become a successful professional.

B. Details of COs Mapping with PO/PSOs identified for the course

Course Outcome	**Course Description**	**Program Outcomes/Program Specific Outcome**														
		PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
C211.1	**Design** AM communication system.	3	3	3	3	-	3	-	-	1	1	-	1	-	2	2
C211.2	**Construct** angle modulated communication system.	3	2	2	2	-	2	-	-	-	1	-	1	-	1	1
C211.3	**Apply** the concepts of random process to communication system.	3	3	2	2	-	2	-	-	-	2	-	1	-	2	1
C211.4	**Analyze** the noise performance of AM and FM systems.	3	3	2	2	-	2	-	-	2	2	-	2	-	2	1

C211.5	**Explain** the concepts of information theory and Implement source coding theorem.	3	3	2	2	-	1	-	-	2	2	-	2	-	2	1

C. Syllabus of the course

UNIT I AMPLITUDE MODULATION **9**

Generation and detection of AM wave-spectra-DSBSC, Hilbert Transform, Pre-envelope & complex envelope - SSB and VSB –comparison -Super heterodyne Receiver.

UNIT II ANGLE MODULATION **9**

Phase and frequency modulation-Narrow Band and Wind band FM - Spectrum - FM modulation and demodulation – FM Discriminator- PLL as FM Demodulator - Transmission bandwidth.

UNIT III RANDOM PROCESS **9**

Random variables, Central limit Theorem, Random Process, Stationary Processes, Mean, Correlation & Covariance functions, Power Spectral Density, Ergodic Processes, Gaussian Process, Transmission of a Random Process Through a LTI filter.

UNIT IV 4. NOISE CHARACTERIZATION **9**

Noise sources and types – Noise figure and noise temperature – Noise in cascaded systems. Narrow band noise – PSD of in-phase and quadrature noise –Noise performance in AM systems – Noise performance in FM systems – Pre-emphasis and de-emphasis – Capture effect, threshold effect.

UNIT V INFORMATION THEORY **9**

Entropy - Discrete Memoryless channels - Channel Capacity -Hartley - Shannon law - Source coding theorem - Huffman & Shannon - Fano codes .

. Content Beyond Syllabus:

F. Delivery Resources:

Text Book(s):

1. J.G.Proakis, M.Salehi, “Fundamentals of Communication Systems”, Pearson Education 2006.
2. S. Haykin, “Digital Communications”, John Wiley, 2005.

Reference Book(s):

1. B.P.Lathi, “Modern Digital and Analog Communication Systems”, 3rd Edition, Oxford University Press, 2007.
2. B.Sklar, “Digital Communications Fundamentals and Applications”, 2nd Edition Pearson Education 2007
3. H P Hsu, Schaum Outline Series - “Analog and Digital Communications” TMH 2006
4. Couch.L., "Modern Communication Systems", Pearson, 2001.

On line learning materials (and Others if any):

1.
2.

UNIT I AMPLITUDE MODULATION				
Topic to be Covered	Delivery Resources			Delivery Method
	Text Book with Pg.No	Reference Book (if any with Pg.No)	Online Resource (Web Link of the Specific Topic)	
Generation and detection of AM wave	T1.P.No.			
DSBSC	T1.P.No.			
Hilbert Transform	T1.P.No.			
Pre-envelope & complex envelope	T1.P.No.			
SSB	T1.P.No.			
VSB	T1.P.No.			
comparison	T1.P.No.			
Super heterodyne Receiver	T1.P.No.			
Course Outcome: C211.1: **Design** AM communication system				
No of hours in the syllabus : 9				
No of hours planned : 9				
No of hours taught : 9				

UNIT II ANGLE MODULATION				
Topic to be Covered	Delivery Resources			Delivery Method
	Text Book with Pg.No	Reference Book (if any with Pg.No)	Online Resource (Web Link of the Specific Topic)	
Phase and frequency modulation	T1.P.No.			
Narrow Band and Wide band FM	T1.P.No.			
Spectrum	T1.P.No.			
FM modulation and demodulation	T1.P.No.			
FM Discriminator	T1.P.No.			
PLL as FM Demodulator	T1.P.No.			
Transmission bandwidth	T1.P.No.			
Course Outcome: C211.2: **Construct** angle modulated communication system				
No of hours in the syllabus : 9				
No of hours planned : 9				
No of hours taught : 9				

UNIT III RANDOM PROCESS				
Topic to be Covered	Delivery Resources			Delivery Method
	Text Book with Pg.No	Reference Book (if any with Pg.No)	Online Resource (Web Link of the Specific Topic)	
Random variables	T1.P.No.			
Central limit Theorem	T1.P.No.			
Random Process, Stationary Processes	T1.P.No.			
Mean, Correlation & Covariance functions,	T1.P.No.			
Power Spectral Density,	T1.P.No.			
Ergodic Processes	T1.P.No.			
Gaussian Process	T1.P.No.			
Transmission of a Random Process Through a LTI filter	T1.P.No.			
Course Outcome: C211.3: **Apply** the concepts of random process to communication system				

No of hours in the syllabus	:	9
No of hours planned	:	9
No of hours taught	:	9

UNIT IV **NOISE CHARACTERIZATION**				
Topic to be Covered	Delivery Resources			Delivery Method
	Text Book with Pg.No	Reference Book (if any with Pg.No)	Online Resource (Web Link of the Specific Topic)	
Noise sources and types	T1.P.No.			
Noise figure and noise temperature	T1.P.No.			
Noise in cascaded systems	T1.P.No.			
Narrow band noise	T1.P.No.			
PSD of in-phase and quadrature noise	T1.P.No.			
Noise performance in AM systems	T1.P.No.			
Noise performance in FM systems	T1.P.No.			
Pre-emphasis and de-emphasis	T1.P.No.			
Capture effect	T1.P.No.			
Threshold effect	T1.P.No.			
Course Outcome: C211.4: **Analyze** the noise performance of AM and FM systems.				
No of hours in the syllabus : 9				
No of hours planned : 9				
No of hours taught : 9				

UNIT V **INFORMATION THEORY**				
Topic to be Covered	Delivery Resources			Delivery Method
	Text Book with Pg.No	Reference Book (if any with Pg.No)	Online Resource (Web Link of the Specific Topic)	
Entropy	T1.P.No.			
Discrete Memoryless channels	T1.P.No.			
Channel Capacity	T1.P.No.			
Hartley	T1.P.No.			
Shannon law	T1.P.No.			
Source coding theorem	T1.P.No.			
Huffman codes	T1.P.No.			
Shannon - Fano codes	T1.P.No.			
Course Outcome: C211.5: **Explain** the concepts of information theory and Implement source coding theorem.				
No of hours in the syllabus : 9				
No of hours planned : 9				
No of hours taught : 9				