LNMIIT
The LNM Institute of Information Technology

Principles of Communication
Mid Term Exam

Date: 23rd Feb. 2018 **Time: 90 Minutes** **Max Marks. 30**

Instructions: 1). Please check there are six questions in the paper.
2). All questions are compulsory.

1. In a DSB-SC system, the carrier is $c(t) = A\cos(\omega_c t)$ and the message signal is given by $m(t) = \text{sinc}(t) + \text{sinc}^2(t)$.
   i) Determine and sketch the spectrum of the modulated signal $\varphi(t) = c(t)m(t)$.
   ii) Identify the upper sideband (USB) and the lower sideband (LSB) spectra.
   iii) Find the bandwidth (in Hz) of the modulated signal $\varphi(t)$. [3+1+1]

2. A baseband signal $g(t)$ band limited to 100 Hz modulates a carrier of frequency f_c Hz. The modulated signal $g(t)\cos(2\pi f_c t)$ is transmitted over a channel whose input x and output y are related by $y = 2x + x^2$. The spectrum of $g(t)$ is shown in Fig. 1. Sketch the spectrum of the transmitted signal and the spectrum of the received signal. [5]

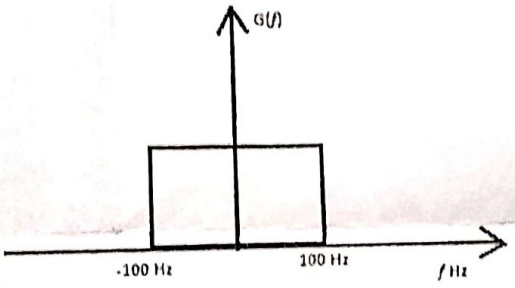


Fig. 1

3. A random variable X has PDF=$f_X(x) = ae^{-b|x|}$ for all x, $-\infty < x < +\infty$ and $a = 3$. Find:
   i) relationship between a and b.
   ii) CDF
   iii) probability that the random variable X lies between -1 and +2. [5]

4. i) A random variable X having auto correlation function $R_{XX}(\tau) = e^{-\sigma|\tau|}$ is passed through a system whose impulse response is given as $h(t) = \frac{\mu}{2}e^{-\mu t}u(t)$. Find the power spectral density of the output signal.
   ii) For a random process $X(t) = A\cos(w_c t + \theta)$, where θ is an random variable uniformly distributed in the range $(0,2\pi)$, find the mean and autocorrelation function for this random process. [3+3]

5. a) A super heterodyne receiver is tuned to 650 KHz frequency, corresponding image frequency is given by 1750 KHz. Find
   i) Local Oscillator Frequency and Intermediate frequency.

ii) Image rejection ratio if two tuned amplifiers having Q-60 & 70 are connected in cascade.

b) An amplitude modulated signal is expressed as :

$$X(t) = 6\cos 1700\pi t + 8\cos 1800\pi t + 6\cos 1900\pi t$$

Determine the following:

i) message and carrier signal

ii) modulation index

iii) power efficiency [2+3]

6. Find out the expression for band-pass filter output $V_2(t)$ as shown in Fig. 2. When $V(t) = 5\cos(2400\pi t) + 2\sin(200\pi t)$ is applied as an input to a non-linear device. Assume that $V_1(t) = V(t) + 0.1V^2(t)$ and band-pass filter as an ideal filter with unity gain and pass band 1100 Hz to 1300 Hz. Also draw the frequency spectrum of $V_2(t)$. [4]

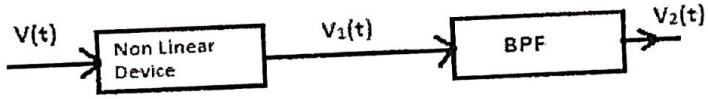


Fig. 2

The LNM Institute of Information Technology, Jaipur
End-Term Examination, Spring Semester (2017-18)
Principles of Communication (ECE 220)

Time: 3 Hr. M.M.: 50

Instructions to students: All questions are compulsory. Do the questions in order and all parts of the questions should be at the same place. Explanation should be given with proper block diagrams, waveforms and mathematical support.

1. Fill in the blanks. [1×12=12]

   a) The theoretical bandwidth of an angle modulated system is _____.

   b) In an FDM system, 50 baseband signals are multiplexed using DSBSC modulation technique. Each baseband signal bandwidth is 44.1 kHz. The total transmission bandwidth of the FDM system _____.

   c) Given a PCM scheme where the first four quantized amplitude values of a message signal is -5, -1, +3, +7. If the following code word table to encode the quantized message:

Level	-7	-5	-3	-1	1	3	5	7
Codeword	000	001	011	010	110	111	101	100

   The binary encoded signal is _____.

   d) A signal $m(t) = 2cos(2000\pi t)$ phase modulates a 1 MHz carrier to produce a peak frequency deviation of 4 kHz. The PM signal $\varphi_{PM}(t)$ =_____. (*Assume the amplitude of PM signal is 1 Volt*).

   e) The Nyquist sampling rate of the signal $sinc(200\pi t) + 5sinc^2(120\pi t)$ is _____.

   f) If the signal $cos(2 \times 10^3\pi t) + cos(4 \times 10^3\pi t)$ is sampled at 3 kHz. The plot of spectrum of the signal is _____.

   g) In a uniform quantizer, each additional bit provides a signal to quantization noise ratio increase of _____ dB.

   h) A signal $m(t) = 2cos(200\pi t) + 4sin(400\pi t)\ Volt$ is sampled at 4 times the Nyquist sampling rate and uniformly quantized to 8 bits/sample. The data rate in kbps is _____.

   i) Compression and expansion combinedly known as _____.

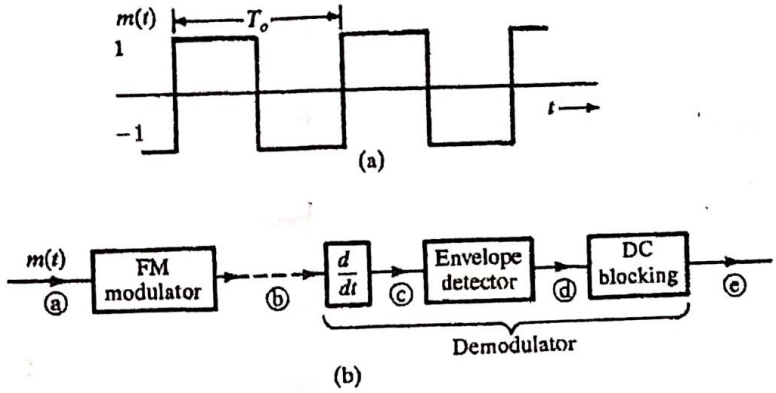
   j) Preemphasis circuit is a _____ filter. Deemphasis circuit is a _____ filter.

   k) Given $\varphi_{FM}(t) = 10cos(2\pi \times 10^6 t + 40sin\ 500\pi t + 10sin2000\pi t)$ and $k_f = 10{,}00\pi\ \frac{rad}{sec-Volt}$. The baseband signal $m(t)$ = _____.

2. a. A tone modulated FM signal has the following characteristics: The baseband signal is $m(t) = 4cos(200\pi t)$, the carrier frequency is 1 MHz, the frequency sensivity constant $k_f = 500\pi\ \frac{rad}{sec-Volt}$, and the FM signal power is 50 W. (*Bessel's function Table is given on page 2*)
   i. Find the FM signal equation in time domain. (NOTE: Equation should be in simplified form)
   ii. Find the bandwidth of the FM signal.
   iii. If the FM signal passes through an ideal BPF with center frequency of 1 MHz and a bandwidth of 300 Hz to produce $z(t)$. Find $z(t)$ and plot it magnitude spectrum.
   iv. What percentage of FM signal power is present in the $z(t)$. [10]

b. A periodic square signal $m(t)$, shown in the Fig.1 (a), frequency modulates a carrier of frequency f_c = 10kHz with $\Delta f = 1\,kHz$. The carrier amplitude is A. The resulting FM signal is demodulated, as shown in the Fig.1 (b). Evaluate the expression of signal at points b and c. Also, sketch the waveforms at points b, c, d, and e. Clearly mark the time boundaries with proper labeling. [6]

Fig. 1



3. a. Explain the generation of flat top PAM signal. (Explain only with the help of block diagram, mathematical equations and waveforms.) [4]

   b. A signal $m_1(t)$ is bandlimited to 3.6 kHz. There are three more signals $m_2(t), m_3(t), m_4(t)$ which are bandlimited to 1.2 kHz each. These signals are to be transmitted by time division multiplexed system.
   i. Set up a scheme for accomplishing this multiplexing requirement with each signal sampled at its Nyquist rate.
   ii. What must be the speed of the commutator (in samples per second)?
   iii. What must be the minimum bandwidth of the channel?
   iv. If the commutator output is quantized with L=1024 and the result is binary-coded, what is the output bit-rate? [6]

4. Explain the generation of PWM and PPM waveforms using flattop PAM signal. Explain with the help of block diagram, waveforms and with mathematical equations (if any) only. Cleary mark the time boundaries and axes. [4]

5. A uniform quantizer for PCM has L levels. The input signal is $m(t) = A[cos(\omega_m t) + sin(\omega_m t)]$. Assume the dynamic range of the quantizer matches that of the input signal.
   a. Find the signal to quantization noise ratio in dB.
   b. Find the value of n such that the output SNR is about 62 dB. [4]

6. A sinusoidal signal $m(t) = 3sin(500t) + 4\sin(1000t) + 4\sin(1500t)$ is transmitted using Delta modulation technique.
   a. Find the signal power.
   b. Find the quantization step-size to avoid slope overload distortion. [4]

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Bessel's Function Table

n	$\beta = 0.1$	$\beta = 0.2$	$\beta = 0.5$	$\beta = 1$	$\beta = 2$	$\beta = 5$	$\beta = 8$	$\beta = 10$
0	0.997	0.990	0.938	0.765	0.224	−0.178	0.172	−0.246
1	0.050	0.100	0.242	0.440	0.577	−0.328	0.235	0.043
2	0.001	0.005	0.031	0.115	0.353	0.047	−0.113	0.255
3				0.020	0.129	0.365	−0.291	0.058
4				0.002	0.034	0.391	−0.105	−0.220
5					0.007	0.261	0.186	−0.234
6					0.001	0.131	0.338	−0.014
7						0.053	0.321	0.217
8						0.018	0.223	0.318
9						0.006	0.126	0.292
10						0.001	0.061	0.207
11							0.026	0.123
12							0.010	0.063
13							0.003	0.029
14							0.001	0.012
15								0.004
16								0.001