The LNM Institute of Information Technology, Jaipur
Session: 2017-18, First Semester, Mid-term Examination
Subject: Digital Communication (Core)
Date: 29th September' 2017, Full Marks: 60, Time: 90 Minutes

Answer all questions (Answer to a question should be at one place)

1. a) What are the desired properties of a line code?
b) For the data stream "1011010011", sketch the transmitted sequence of pulses for:
i) Unipolar RZ, ii) Bipolar RZ, iii) Alternate Mark Inversion (AMI).
c) A randomly generated data stream consists of equi-probable binary symbols 0 and 1. It is encoded into a polar NRZ waveform with each binary symbol being defined as follows:

$$s(t) = \begin{cases} \cos(\pi t/T_b); & -T_b/2 \le t \le T_b/2 \\ 0; & \text{elsewhere} \end{cases}$$

i) Sketch the waveform so generated, assuming that the data stream is "00101110"
ii) Derive an expression for the power spectral density of this signal and sketch it.
d) Draw the block diagram of a Digital Communication link and briefly discuss role of each block.
e).Why you need to know the generator polynomial while designing a Psuedo Random Bit Sequence (PRBS) generator? Indicate some of the inherent properties of the maximal length sequence? Give example with 4-bit shift registers.

[2+3+5+3+5 = 18]

2. a) Determine the Nyquist sampling rate and Nyquist interval for the following signals:
i) $\text{sinc}(60\pi t)\text{sinc}(150\pi t)$, ii) $\text{sinc}^2(1000\pi t)$, iii) $10\cos^3(2\pi 10^6 t)$.
b) What will be the problem if the signal is under-sampled? Can you suggest a method to partially rectify this problem? Explain.
c) A message signal $m(t)$ is transmitted by binary PCM without compression. If the signal-to-quantization-noise ratio is required to be at 47dB, determine the minimum value of L (quantization levels) required assuming that $m(t)$ is sinusoidal. Determine the SNR obtained with this minimum L.
d) An audio signal of bandwidth 4kHz is sampled at a rate 40% higher than the Nyquist rate and quantized. The quantization error should not be higher than 0.2% of the signal peak amplitude. The resulting quantized samples are then coded and transmitted by 4-ary pulses. Determine:
i) The minimum number of 4-ary pulses required to encode each sample.
ii) The minimum transmission bandwidth required to transmit this data with zero ISI.
e) A speech signal has a total duration of 10s. It is sampled at the rate of 8kHz and then encoded. The signal-to-quantization-noise ratio is required to be 40dB. Calculate the minimum storage capacity needed to accommodate this digitized speech signal.

[3+3+4+4+3 = 17]

3. a) Draw the schematic diagrams for M-Ary PSK modulator and corresponding coherent demodulator with relevant explanations.
b) Express both SER and BER for M-ary PSK as a function of (E_b/N_0) [Show relevant calculation].
c) By what amount (in dB), the SNR of an 8-ary PSK must be increased so that its SER will be same as that of a 4-ary PSK?
d) "BPSK is 3dB superior to BFSK" - True/ False? Justify your answer.
e) Draw the signal constellation for BFSK, QPSK, 8-ary PSK, and 16-ary QAM. Indicate the Gray coded bit-assignment to the message points in case of rectangular signal constellation for 16-ary QAM.
f) One of two equally likely messages, m_0 or m_1, is to be transmitted over an additive white Gaussian noise channel by means of the two signals:

$$s_0(t) = \begin{cases} \sqrt{(2E_s/T)}\cos(2\pi f_1 t); & 0 \le t \le T \\ 0 & \text{elsewhere} \end{cases}$$

$$s_1(t) = \begin{cases} \sqrt{(2E_s/T)}\cos(2\pi f_1 t + \Delta); & 0 \le t \le T \\ 0 & \text{elsewhere} \end{cases}$$

where, $T = 2$msec., $f_1 = 1$Mc, and $\Delta = 250$cps. The noise has power density spectrum of $N_0/2$. If $E_s/N_0 = 6$, calculate the probability of error.
g) Assume 10,000 bits are transmitted over a channel in which probability of error is 10^{-4}. What is the probability that the total number of errors is less than 3?

[5+4+2+3+5+3+3 = 25]

The LNM Institute of Information Technology, Jaipur
Session: 2017-18, ODD Semester, End-term Examination
Subject: Digital Communication (Core)
Date: 5th December' 2017, Full Marks: 100, Time: 3 Hours

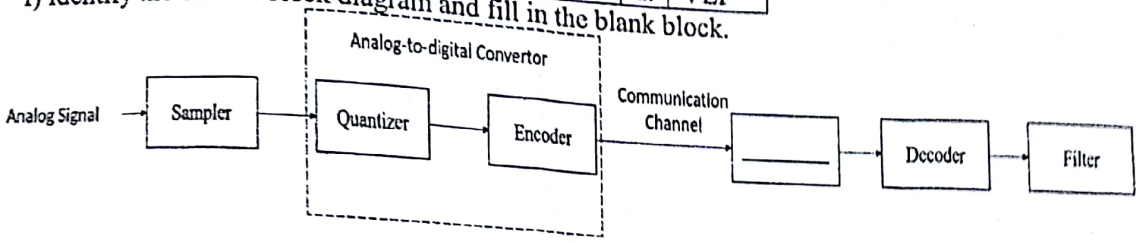
Meenakshi Hodi
ISUCC09

Answer all questions (Answer to a question should be at one place)

1. a) How will you calculate the Channel Capacity? Indicate relevant parameters.
b) When a line code will be termed as 'transparent'? Give an example of transparent line code.
c) A signal $x(t)$ has the bandwidth of B Hz. What will be the bandwidth of the signal $x''(t)$? Indicate the Nyquist interval and sampling rate for the signal $x''(t)$.
d) What is the fundamental difference between source coding and error correction coding?
e) Match the following frequency bands with their names:

Frequency Band		Name	
1.	3.0-30 MHz	a.	UHF
2.	0.3-3.0 GHz	b.	MF
3.	3.0-30 kHz	c.	HF
4.	0.3-3.0 MHz	d.	VLF

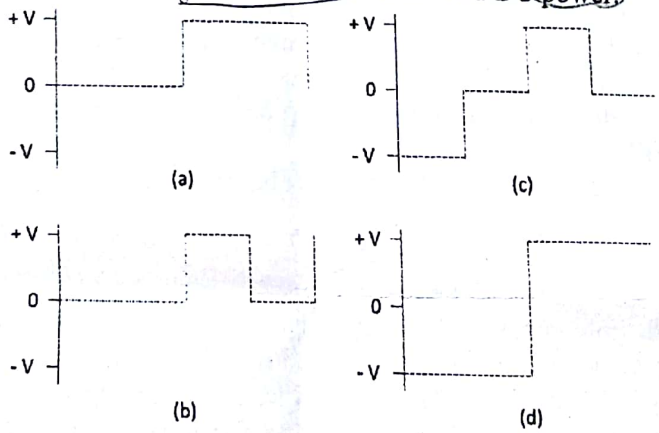
f) Identify the overall block diagram and fill in the blank block.



2. a) Who had demonstrated the first FM radio transmission? [2×6=12]
b) Differentiate between dBm and dBW.
c) What is the physical significance of negative frequency?
d) Find the bandwidth requirement for a 512kbps channel with required SNR being 20dB?
e) Define roll-off factor.
f) When a block code will be termed as linear?
g) Draw the PSD for additive white Gaussian noise (AWGN) bandlimited to B Hz.
h) The random variable X has variance σ^2 and mean m. The random variable Y is related to X as follows: $Y = aX+b$, where a & b are constants. Find the mean and variance of Y.

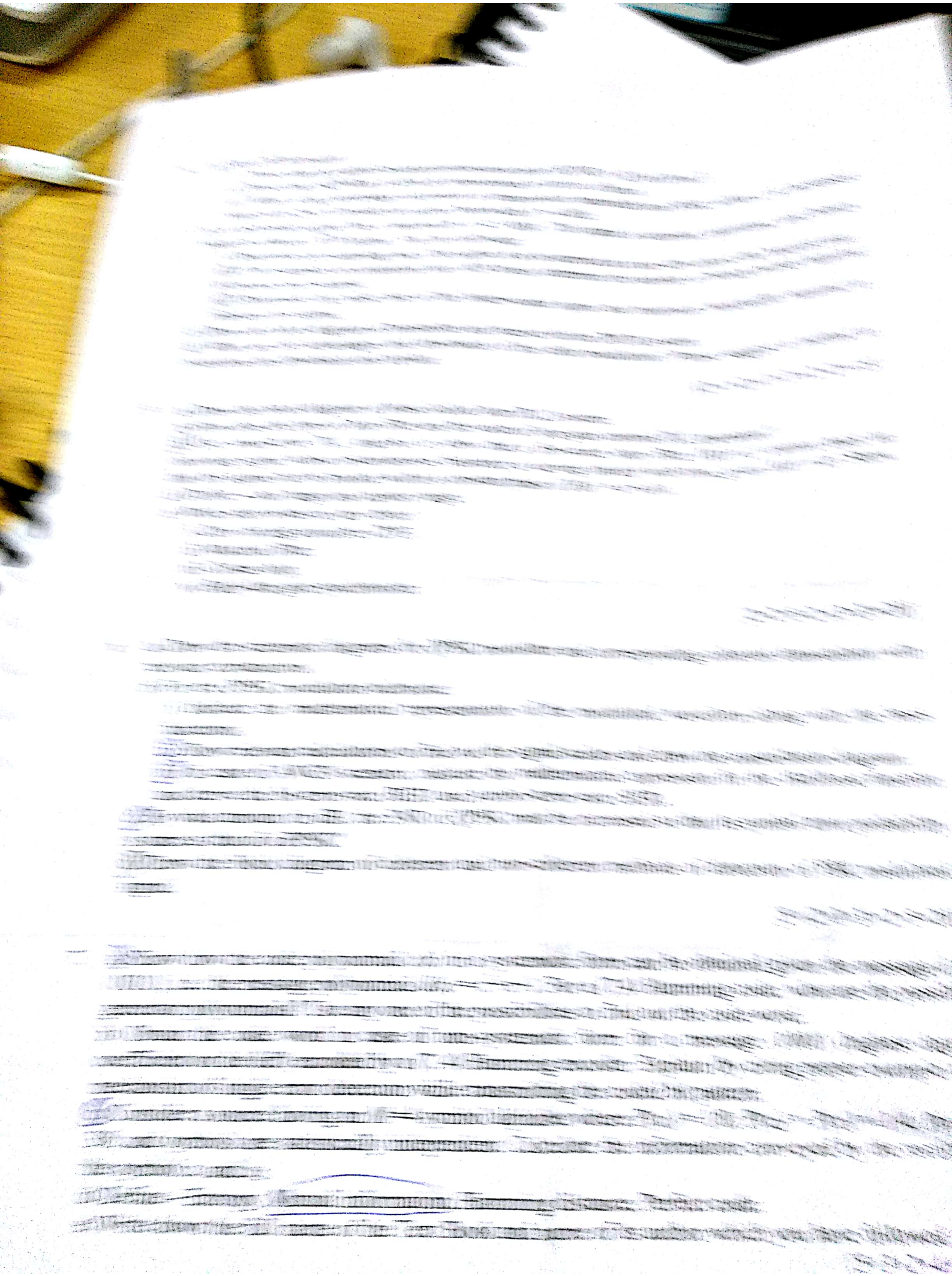
[1×8=8]

3. a) Identify the line codes in the figure given below for the data stream '01'. Prepare a comparative table of these line codes w.r.t. their null-to-null bandwidth and DC power.



b) Given the data stream in NRZ format and clock signal, how would you generate RZ and Manchester coded data streams?
c) Clock recovery is easier for which of the following line coding techniques and why? - RZ and Manchester.

[(2×3)+2+2=10]



4. a) For a PCM system:
   i) Prove that the signal to quantization-noise ratio (SQNR) = $3L^2/m^2(p/m_p)^2$.
   ii) Prove that (SQNR)dB is directly proportional to the no. of bits n.
   iii) What is the percentage increment in transmission bandwidth and SNR, when L is increased from 64 to 256? Consider the signal bandwidth $B = 4$ kHz.
   b) A television signal has a bandwidth of 4.5 MHz. This signal is sampled, quantized, and binary coded to obtain a PCM signal. Find the following:
   i) Determine the sampling rate if the signal is to be sampled at a rate 40% above the Nyquist rate.
   (ii) If the samples are quantized into 1024 levels, determine the number of binary pulses required to encode each sample.
   (iii) Determine the pulse rate of the binary-coded signal and minimum bandwidth required to transmit this signal.
   c) Draw the block diagram of transmitter and receiver for the DPCM system.
   d) What are the advantages and drawbacks of the delta modulation? Please suggest a method to overcome the drawbacks and explain.

[(2+1+2)+3+3+(2+2)=15]

5. a) Draw the block diagram of phase locked loop (PLL) system.
   b) How does the type of loop filter and the value of loop gain controls PLL operation?
   (c) Use small-error PLL analysis to show that a first-order loop filter [$H(s)=1$] cannot track an incoming signal whose instantaneous frequency is varying linearly with time, given $\theta(t) = kt^2$. Show that this signal can be tracked within a constant phase if $H(s) = (s+a)/s$.
   d) Define – lock range and capture range.
   e) Write short notes on (any three):
      i) Zero forcing equalizer (ZFE),
      ii) Matched filter,
      iii) Costas loop,
      iv) Early-late gate synchronizer.

[2+2+5+2+(3×3)=20]

6. a) Draw the schematic diagrams for QPSK modulator and corresponding coherent demodulator with relevant explanations.
   b) For the QPSK modulation technique:
      i) Indicate the mathematical representation of the modulated waveform along with the basis functions.
      (ii) Show relevant calculations to find out the signal scalars and draw the constellation diagram.
      (iii) In case of AWGN scenario, indicate the mathematical expression for the likelihood function and derive the bit-error-rate (BER) and symbol-error-rate (SER).
   (c) By what amount (in dB), the SNR of QPSK must be increased so that its symbol error probability is same as that of a BPSK?
   (d) Draw the block diagram of coherent and non-coherent methods of detection of FSK modulated signal.

[5+(2+3+3)+2+5=20]

7. (a) Show how the code polynomial $c(x)$ in a systematic form can be obtained given the message d = (1011), i.e., the message polynomial $d(x) = x^3+x+1$. For a (7,4) Hamming code, what are the possible generator polynomials? Use any one of the possibilities to find out the code word.
   b) Obtain the code word in case of non-systematic form for a message (1001) (highest degree coefficient on the left) encoded by a (7, 4) Hamming encoder. Explain (by citing proper example) the mechanism of single error detection while transmitting the coded bit pattern.
   (c) Consider a source having an M =4 symbol alphabet where $P(x_1) = 1/8$; $P(x_2) = P(x_3) = 1/4$, $P(x_4) = 3/8$; and symbols are statistically independent. Calculate the information conveyed by the receipt of the symbol x_1 and x_2.
   d) Define – Entropy, Mutual information, Hamming distance, Perfect code.
   e) Write down the full name of the Text Book and name of its author which you have followed.

[5+3+2+4+1=15]