The LNM Institute of Information Technology
Subject: Digital Communication (Academic Year: 2017 - 18)
Tutorial Problems (Set - #1, Date: 18.09.2017)

1. Specify the Nyquist rate and the Nyquist interval for each of the following signals:
   a. $g(t) = sinc(200t)$
   b. $g(t) = sinc^2(200t)$
   c. $g(t) = sinc(200t) + sinc^2(200t)$
2. Derive the power spectral density of the following line codes, assume the binary data stream is being generated randomly with equal probability of both states and the symbols have their usual significance:
   a. Unipolar NRZ

$$S(f) = \frac{A^2T_b}{4} sinc^2(fT_b)\left(1 + \frac{1}{T_b}\delta(f)\right)$$

   b. Polar NRZ

$$S(f) = A^2T_b sinc^2(fT_b)$$

   c. Unipolar RZ

$$S(f) = \frac{A^2T_b}{16} sinc^2\left(\frac{fT_b}{2}\right)\left(1 + \frac{1}{T_b}\delta\left(f - \frac{n}{T_b}\right)\right)$$

   d. Bipolar RZ

$$S(f) = \frac{A^2T_b}{4} sinc^2\left(\frac{fT_b}{2}\right) sinc^2(\pi fT_b)$$

   e. Manchester-Encoded

$$S(f) = A^2T_b sinc^2\left(\frac{fT_b}{2}\right) sinc^2\left(\frac{\pi fT_b}{2}\right)$$

3. A randomly generated data stream consists of equiprobable binary symbols 0 and 1. It is encoded into a polar NRZ waveform with each binary symbol being defined as follows:

$$s(t) = \begin{cases} \cos\left(\frac{\pi t}{T_b}\right), & -\frac{T_b}{2} < t \leq \frac{T_b}{2} \\ 0, & otherwise \end{cases}$$

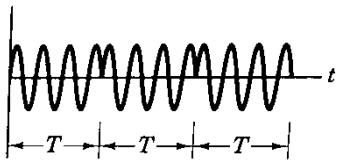
   Sketch the waveform so generated, if the data stream is 00101110.

4. A PCM system uses a uniform quantizer followed by a 7-bit binary encoder. The bit rate of the system is equal to: $50 \times 10^6 b/s$.
   a. What is the maximum message bandwidth for which the system operates satisfactorily?
   b. Determine the output signal-to-(quantization) noise ratio when a full-load sinusoidal modulating wave of frequency 1MHz is applied to the input.
5. The information in an analog waveform, with maximum frequency f_m = 3KHz, is to be transmitted over an M-ary PAM system, where the number of pulse levels is M = 16. The quantization distortion is specified not to exceed $\pm 1\%$ of the peak-to-peak analog signal.

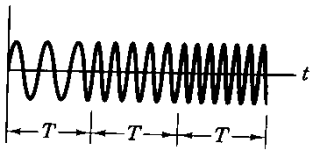
a. What is the minimum number of bits/sample that should be used in digitizing the analog waveform?
b. What is the minimum required sampling rate and what is the resulting bit transmission rate?
c. What is the PAM pulse of symbol transmission rate?
d. If the transmission bandwidth (including filtering) equals 12 KHz, determine the bandwidth efficiency for the system.

6. Compare the system bandwidth requirements for a terrestrial 3KHZ analog telephone voice channel with that of a digital one. For the digital channel, the voice is formatted as a PCM bit stream, where the sampling rate for the analog-to-digital (A/D) conversion is 800samples/sec and each voice sample is quantized to one of 256 levels. The bit stream is then transmitted using a PCM waveform and received with zero ISI.
7. Find the bit error probability for a BPSK system with a bit rate of 1Mbit/s. The received waveform $s_1(t) = A\cos\omega_0 t$ and $s_2(t) = -A\cos\omega_0 t$ are coherently detected with a matched filter. The value of A is 10mV. Assume that the single-sided noise power spectral density is $N_0 = 10^{-11}\,{}^{W}/_{Hz}$ and the signal power and energy per bit are normalized relative to a 1-Ω load.
8. Assume 10,000 bits are transmitted over a channel in which the error probability is 10^{-3}. What is the probability that the total number of errors is less than 3?
9. Draw the constellation diagram for 4-PSK and 16-QAM modulation.
10. Find the transmission rate a 12–bit PCM coded voice signal which is band-limited to 4KHz.
11. A unipolar RZ signal of time-period T has its first spectral null occurring at which frequency?
12. In the figure given below identify the modulation for the given waveforms

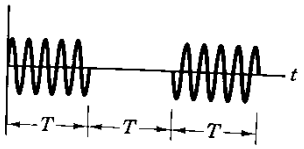
a.



b.



c.



d.