BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE, PILANI
SECOND SEMESTER 2016-2017
EEE F416 DIGITAL COMMUNICATION
MID-SEMESTER TEST [OPEN-BOOK]
March 09, 2017

MAX. MARKS: 60 **Time: 90 min.**

Note:- Answer in sequence of questions. State your valid assumptions clearly

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1. A signal in the frequency range 300 to 3000 Hz is sampled at 8000 samples/s and the samples are quantized to 64 evenly spaced levels.
(a) Calculate and compare bandwidths and SQNR if the quantized samples are transmitted either as binary pulses or four-level pulses. Assume that the system bandwidth is defined by the main spectral lobe of the signal.
(b) We may transmit these samples directly as PAM pulses. If the quantization distortion ≤ ±0.1% of peak-to-peak signal voltage, find theoretical minimum system bandwidth that avoids ISI when a multilevel PAM waveform scheme with M=32 levels is used. What is the minimum system bandwidth with a filter roll off factor, r = 0.5?
(c) Using the same filter roll off characteristic, what is the minimum bandwidth required for detection of PCM waveforms?

2. Calculate the difference in required signal power between two PCM waveforms, NRZ and RZ, assuming that each signaling scheme has the same requirements for data rate and error probability. Assume equally likely signaling and same difference between higher and lower voltage levels for both RZ and NRZ schemes. Comment on results.
(a) Assume that equally likely RZ binary pulses are coherently detected over a Gaussian channel with $N_0 = 10^{-6}$ Watt/Hz. Assume that synchronization is perfect and the received pulses have an amplitude of 100 mV. If the bit error probability specification is $P_B = 10^{-3}$, find highest data rate that can be achieved by this scheme.
(b) Consider that NRZ binary pulses are transmitted along a cable that attenuates the signal power by 3 dB (from transmitter to receiver). The pulses are coherently detected at the receiver and the data rate is 56 kbps. Assume Gaussian Noise with $N_0 = 10^{-6}$ Watt/Hz. What is the minimum amount of power needed at the transmitter in order to maintain a bit error probability of $P_B = 10^{-3}$?

3. The result of a single pulse transmission is a received sequence of samples with values 0.1, -0.1, 0.4, 1.0, -0.2, 0.3, 0.1, where the leftmost sample is the earliest. The value 1.0 corresponds to the main-lobe of the pulse, and the other entries correspond to adjacent samples. Design a 3-tap transversal equalizer that forces the ISI to be zero at one sampling point on each side of the main lobe. Calculate the values of equalized output pulses at times k = 0, ±1, ±2, ±3. After equalization, what is the largest magnitude sample contributing to ISI, and what is the sum of all the ISI magnitudes?

4. (a) Design a binary Huffman code for a discrete source of three independent symbols A, B, and C with probabilities 0.9, 0.08, and 0.02, respectively. Determine the average code length for the code, and redundancy. (b) Design a binary first order extension code (two symbols at a time) for the same discrete source in part (a). Determine the average code length for the code, and redundancy.

5. (a) Given a constraint length, K = 3; rate ½ binary convolutional code with partially completed state diagram shown in Fig. P5, find the complete state diagram and sketch the encoder. Also, Sketch the trellis diagram for the encoder. (b) The encoder in part (a) is used over a binary symmetric channel (BSC). Assume that the initial encoder state is the 00 state. At the output of BSC, the sequence "**11 00 00 10 11 rest all 0**" is received. Find the maximum likelihood path through the trellis diagram and determine the first decoded information bits. Identify the error in decoded bits, if any.

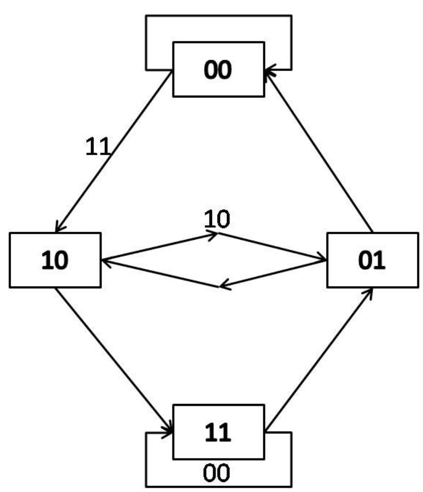

Fig. P5