EE 5837: Principles of Digital Communications
EE 2320: Digital Modulation Techniques

Assignment 3 - Sampling, Quantization and PAM,
Posted on: 18th September 2020, Due on: 22nd September 2020.

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1. (PAM Bit and Symbol rate) We wish to transmit a 50-character alphanumeric message in 0.5 seconds, using 7-bit ASCII coding, followed by an eighth bit for error detection, per character. The eight bit is chosen so that the number of ones in the 8 bits is an even number. This is called as parity check codes.

   (a) If 32-PAM is used for baseband transmission, calculate the effective transmitted bit rate and the symbol rate.

   (b) Repeat part(1) for 16-level PAM, 8-level PAM, 4-level PAM, and 2 PAM waveforms.

2. (Aliasing) As discussed in class, aliasing will not occur if the sampling rate is greater than twice the signal bandwidth. But, perfectly bandlimited signals are not realizable, so some aliasing is always present.

   (a) Suppose that an ideal signal with a rectangular spectrum is passed through a lowpass Butterworth filter of order $n = 5$ and upper cutoff frequency $f_o = 4000$ Hz. Find the sampling rate so that this filtered signal has aliasing that is below -50 dB.

   (b) Repeat for a Buttherworth filter with order $n = 10$.

   Note that a Butterworth filter is given by $|H_n(f)| = \frac{1}{\sqrt{1+\left(\frac{f}{f_o}\right)^{2n}}}$.

3. (Quantizter and PCM Design) An analog signal whose maximum frequency is $f_m = 4$ KHz, is to be transmitted using a 4-level PAM system. The quantization distortion must not exceed $\pm 1\%$ of the peak-to-peak analog signal.

   - Assuming a uniform quantizer, find the minimum number of bits per sample that should be used in this PAM transmission system?
   - What is the minimum required sampling rate, and what is the resulting bit and symbol transmission rate?

4. (Matlab Exercise) Simulate the baseband digital communication system designed in the previous problem using Matlab (not simulink). Specifically,

   - first generate a random PCM sequence of length 100 (that takes letters from the quantizer alphabet).
   - Assuming an ideal rectangular pulse, generate the transmitter wave form, sampled at 4 times the designed baseband sample frequency.
   - Add AWGN noise so that the SNR is 6 dB at the output of the matched filter.
   - Implement the matched filter and sampler at the channel sample frequency.
   - Make a decision at the output of the Matched filter.
   - Compare the transmitted and decoded PAM symbols and find the symbol error rate.
   - find the PCM symbol error rate and bit error rate. What is the SQNR?