Introduction: This lab focuses on converting discrete time analog valued signals to discrete time discrete valued signals. We first discuss uniform quantization and see the effects of compressor /expanders (compandors). Then we compare two coding schemes: Pulse Code Modulation (PCM) and Delta Modulation (DM). We examine performance of these systems in terms of signal to quantization noise ratios.

Prelab) Do PS 4, problem 5).

1) Execute the following MATLAB commands. \( x = -2 \times \log(\text{rand}(1,10000)) \times \text{sign}(\text{randn}(1,10000)) \). Make a histogram plot of \( x \), compute the sample mean, sample deviation, and power of the signal. \( x \) represents 10000 draws of a random variable. What type of random variable is this?

a) Pass each of the 10,000 samples through a uniform quantizer and determine the MSQE and SNR for quantizers where \( L = 2, 4, 8, 16, \ldots, 512, 1024 \). Make log plots of the MSQE and SNR for the different sized quantizers.

b) This time use a \( \mu \) law compandor with \( \mu = 255 \). The compandor consists of a compressor followed by a uniform quantizer followed by an expander. The equation of the compressor is given by

\[
y = \text{sign}(x) \log\left(1 + 255|x|/\max|x|\right)/\log(256)
\]

Find the formula for the expander. Pass each of the 10,000 samples through the compandor (in the middle block use a uniform quantizer) and determine the MSQE and SNR for quantizers where \( L = 2, 4, 8, 16, \ldots, 512, 1024 \). Make log plots of the MSQE and SNR for the different sized quantizers. Discuss results and how this compares with part a) results with the uniform quantizer. Is it possible to do better than either of these quantizers?

2) Create a baseband analog signal \( m(t) \) in MATLAB. Find the power of the signal, the bandwidth of the signal, the maximum of \( |m(t)| \), and the maximum of the derivative of \( |m(t)| \). Convert \( m(t) \) into a discrete time binary signal using a delta modulator and a PCM system. Compare the SNR performance of the two systems for varying values of \( L \). Note that \( L \) is the number of bits for a PCM system and is the bandwidth expansion ratio \( L = f_s/(2B_m) \) for a delta modulator.