01UEF
Digital Communication Laboratory

Project #1

Build a numerical simulator to analyze a telecommunication system capable of transmitting an analog signal using a digital channel.

Analyze both the effect of quantization and of digital channel (BSC) on the integrity of the signal.

Measure the performance in terms of signal-to-noise ratio (S/N) as a function of main system parameters:

- Number of quantization bits: 4, 6 and 8 bits;
- $p_b(e)$ of the transmission channel: from 10^{-1} down to 10^{-9};

In all cases adjust the ADC range exactly to the signal range: avoid clipping the signal.

In order to improve the performance when using signal non uniformly distributed, for audio signals, try to apply:

- the companding technique evaluating the S/N improvement achieved;
- an optimized non-uniform quantization.

1. Validate your simulator against the theoretical findings obtained considering uniform quantization and an input signal with uniform probability density function (pdf).
   a) Show the pdf and the spectrum of the input signal.
   b) Compare the SNR vs. P(e) curves for different level of quantization bits.

2. Test your simulator in the same conditions, but considering now an ADC that use as output value the lower end of quantization intervals. Then test again considering and ADC that uses as output value the upper end of the quantization interval.

3. Test your simulator using audios signals, both audio and music, considering uniform quantization.
   Record your voice and upload a song from a music file to perform this analysis.
   Evaluate the loss of performance with respect to the case of a signal with uniform pdf, compare it with the theoretical estimation and discuss results.

4. Upgrade your simulator in order to consider a non-uniform quantization, optimized for the signal under analysis and based on the Lloyd algorithm.
   Test the non-uniform quantization with the audio signals used in step 2, comparing with previous results and discuss the findings. Comment on the improvement you achieve.

5. Upgrade your simulator in order to consider the companding technique: test the performance of this approach with the voice signal used in step 2 and discuss the results.