Introduction to Telecommunications (EN1052)

Assignment 1
January 2021

You are supposed to answer the problems listed below. The deadline for the submission of answers: 2021.01.31.

Problem 1

Suppose You want to transmit the word 'EN1052' by using a M-ary system.

1. The source encoder encodes the word 'EN1052' into a sequence of bits, using 7-bit ASCII coding followed by an eighth bit for error detection, per character. How many bits are there in the message?

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2. The channel encoder partitions the bit stream into $k = 1$ bit segments and nth segment is mapped into a real number x_n, where $x_n \in \{-1, +1\}$. See the table below for details.

bit segment from source encoder	mapping into real numbers (binary symbols)
0	-1
1	$+1$

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This is called as a 2-ary or binary system, where we have $M = 2$. In this respect, how many binary symbols are there in the *message*?

3. Next consider the case where the channel encoder partitions the bit stream into $k = 4$ bit segments and each of the segment is mapped to a real numbers x_n where $x_n \in \{-15, -13, \ldots, 13, 15\}$. This is an 16-ary system (i.e., $M = 16$). In this respect, how many 16-ary symbols are there in the *message*?

12

Problem 2

We want to transmit 800 characters/sec, where each character is represented by its 7-bit ASCII codeword, followed by an eighth bit for error detection, per character. A multilevel PAM waveform is generated by the channel encoder with $M = 16$.

6400 bits/s

1. What is the effective transmission bit rate?

1600 symbols/s

2. What is the resulting 16-ary symbol rate?

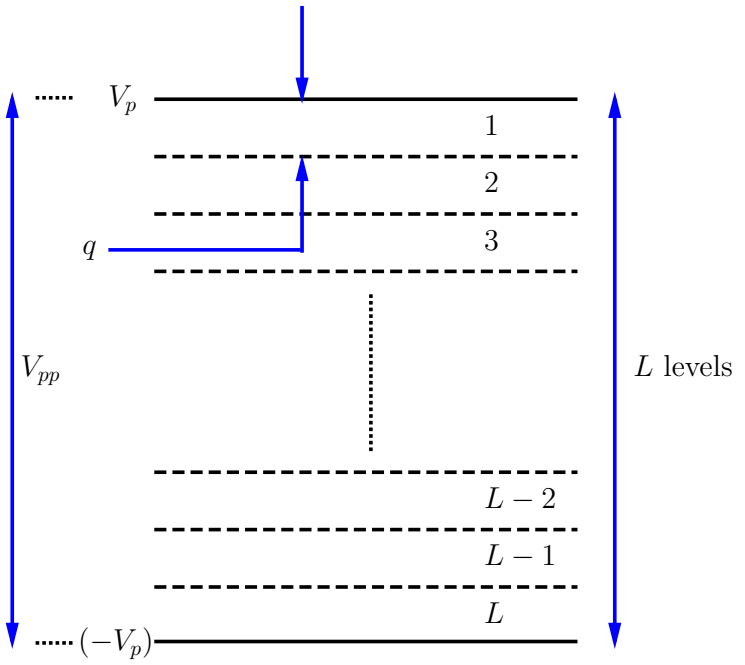


Figure 1: Quantization Levels

Problem 3

Let V_{pp} denote the peak-to-peak voltage of the analog signal $x(t)$. That is $V_{pp} = V_p - (-V_p) = 2V_p$ volts, where V_p is a positive number such that $|x(t)| \leq V_p$ for all t. The step size between quantization levels, called the quantile interval, is denoted by q. The number of (uniform) quantization levels are denoted by L. An illustration of the aforementioned parameters are depicted in Figure 1.

1. The peak power S of the analog signal (normalized to 1Ω) is given by $V_{pp}^2/2$ (Watt). Express the peak power in terms of L and q.

2. In a context of sampling and quantization, each sample value of the analog waveform is approximated by its quantized value. The approximation will result in an *absolute* error no larger than $q/2$ associated with each sample. Under some mild assumptions, the *average* quantization noise power N is given by $q^2/12$ (Watt). Express the ratio of *peak* signal power to *average* quantization noise power [i.e., (S/N)] in terms of the number od quantization levels L.

Problem 4

Consider an (analog) audio signal with spectral components limited to the frequency band 3300Hz. Assume that a sampling rate of 8000 samples/sec will be used at the source encoder. The resulting bit stream of the source encoder is then sent to the channel encoder in which a 8-ary PPM waveform is generated. Assume that the ratio of *peak* signal power to *average* quantization noise power should be 30dB, i.e., $10\log_{10}(S/N) = 30$.

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1. What is the minimum number of uniform quantization levels needed?

4

2. What is the minimum number of bits per sample needed? 4

10666.7 sym/sec

3. What is the resulting 8-ary symbol rate?

$$\frac{8000 \times 4 \ \frac{\text{bits}}{\text{sec}}}{3 \ \frac{\text{bits}}{\text{symbol}}} =$$