Cpr E 489 Spring 2020
Homework #1 Solution

1. (60 points)

   a. A 22 KHz baseband channel is used by a digital transmission system. Suppose ideal pulses are sent at the Nyquist rate, and the pulses can take 1024 levels. There is no noise in the system. What is the bit rate of this system? Justify your answer.

   Answer:

   Nyquist pulses can be sent over this channel at a rate of 22 K * 2 = 44 K pulses per second. Each pulse carries $\log_2 1024 = 10$ bits of information. Thus, the bit rate is 44 K * 10 = 440 Kbps.

   b. Suppose that multi-level square pulses are used in a digital transmission system, and the maximum pulse amplitude is ±1.1V. Suppose that the amplitude of the additive noise is uniformly distributed between (–0.1V, +0.2V). What is the maximum number of levels of pulses this transmission system can use before the noise may start introducing errors? Justify your answer.

   Answer:

   If two adjacent signal levels are separated by more than 0.2 – (–0.1) = 0.3V, then it is impossible for the noise to translate one signal level into another.

   As the maximum range that the signal can span is +1.1 – (–1.1) = 2.2 Volts, the maximum number of levels is $\lfloor 2.2 / 0.3 \rfloor + 1 = 8$.

   c. Consider a noisy AWGN (Additive White Gaussian Noise) communication channel with a bandwidth of 12 KHz. Is it possible to transmit reliably over this channel at a bit rate of 150 Kbps with an SNR (Signal to Noise Ratio) of 35 dB? Justify your answer.

   Answer:

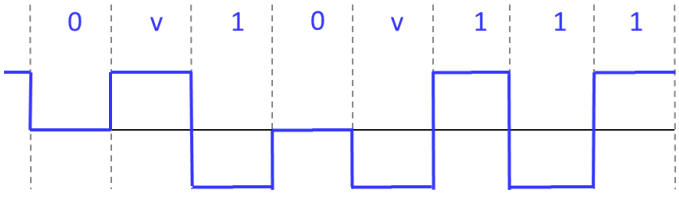
   It is not possible, because: 10 * log10 (SNR) = 35 dB $\Rightarrow$ SNR = $10^{3.5} \approx 3162$

   Therefore, the Shannon channel capacity is:
   C = W * log2 (1 + SNR) = 12 KHz * log2 (1 + 3162) ≈ 139.5 Kbps, which is smaller than 150 Kbps

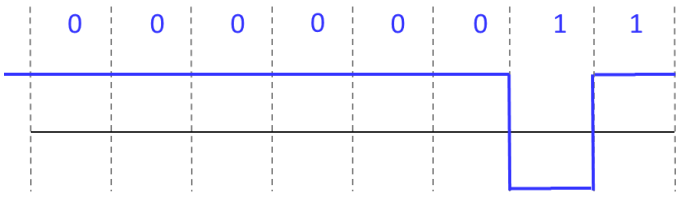
2. (40 points)

For bit stream 00000011, sketch the waveforms for B6ZS (Bipolar with 6 Zeros Substitution), NRZ-Inverted, 1B2B, and 2B1Q line coding schemes that we learned in the class. (Assume that the waveform in the bit interval prior to 00000011 ends at a positive voltage level.)

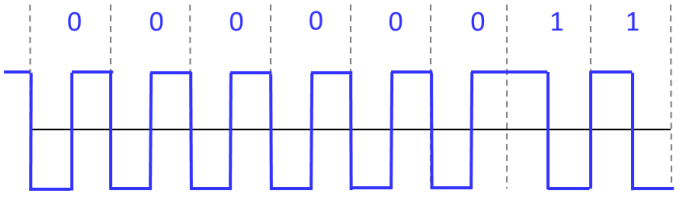
Answer:



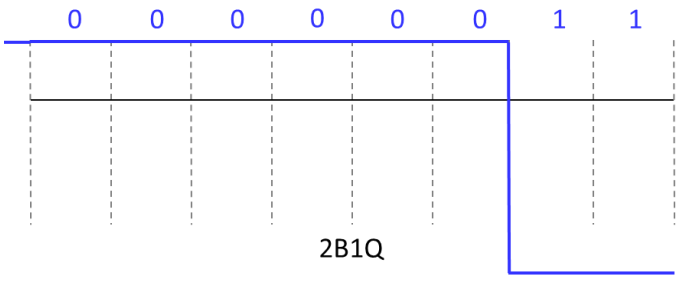

B6ZS: 00000011 → 0v10v111




NRZ Inverted




1B2B (i.e., Manchester)




2B1Q