

EENG 410 Homework #3

1. Plot the probability of a symbol error vs. E_s/N_0 for a polar NRZ waveform where E_s/N_0 ranges from 0 dB to 12 dB in 0.5 dB increments. To see the “waterfall” effect use a logarithmic scale for the vertical axis that varies from 10^{-8} to 10^{-1} . Check to see that the probability of a symbol error is 10^{-5} for E_s/N_0 equal to 9.6 dB.
2. Calculate the rate of information transmission R for a binary source with *a priori* input symbol probabilities $P(0)=0.2$ and $P(1)=0.8$ and a BSC with $p=0.05$.

Answer: 0.4916 bits/symbol

3. Calculate the capacity C of the channel in Problem 3. Verify that the capacity C is greater than the rate R calculated in Problem 3.
4. Calculate the capacity C of a discrete 4-input, 4-output channel where the transition probabilities P_{ij} are 0.75, 0.10, 0.10 and 0.05.
5. Launched in 1977, the *Voyager II* spacecraft is the second farthest man-made object from Earth. In December 2018 the spacecraft entered interstellar space. Currently it is more than 18 billion kilometers from Earth. *Voyager II* still receives routine commands and transmits data although it will run out of power for its instruments in 2025.

The 70 m parabolic dish antenna used to receive signals from the spacecraft uses a liquid helium cooled amplifier to achieve an equivalent system noise temperature of 21.1 K. The signal power of the 160 Bd polar NRZ waveform is 5.50×10^{-19} watts.

- a) Determine the E_s/N_0 ratio in decibels.
- b) Determine the symbol error rate.