ECE 5630/4630 Exam I October 15, 2021 Name:

***Take-Home* Exam Honor Code**

This being a take-home exam a strict honor code is assumed. Each person is to do his/her own work with no consultation with others regarding these problems. Bring any questions you have about the exam to me. Please be clear and concise in your answers. You may use Python or Julia or Mathematica where appropriate. The exam is due no later than 12:00 PM Monday October 25, 2021.

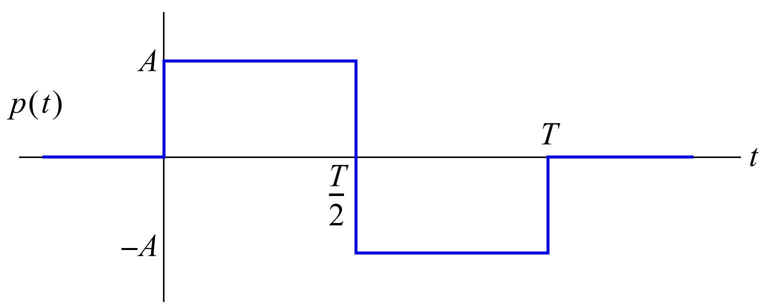
1.) Certain digital communications schemes use redundancy in the form of an error control code to improve the reliability of communication. The compact disc recording media is one such example. Assume a code can correct two or fewer errors in a block of N coded bits. Assume each bit detection is independent with a probability of bit error of $P_E = 10^{-3}$.

10 pts. a.) Plot the probability of correct block detection as a function of N. Note: it is most useful to have log scaling on the y-axis of the plot. For your plot choose $2 \le N \le 50$.

10 pts. b.) How small must N be so that the probability the block is detected incorrectly is less than 10^{-6}?

15 pts. 2.) Consider Z&T 7.23. Work parts (b), (c) and (e). Note steady-state is assumed, so the mean of the output RP is zero mean as the input is zero by definition.

3.) One variant of the original 10 Mbps Ethernet (10BASE5) uses a baseband modulation scheme known as *biphase* or Manchester modulation to transmit the data bits. Biphase modulation is a linear modulation scheme where each data bit is transmitted as either $p(t)$ or $-p(t)$ (see the figure below). Assume an AWGN channel and equally likely data bits.



10 pts. a.) Compute the resulting BEP. Hint: Use the matched filter theory of the Z&T text to make short work of this problem.

10 pts. b.) If the bit rate $R_b = 1/T = 10$ MHz and the Ethernet signal at the transmitter has a peak value of 1v (assume a 50 ohm system) and the value of $N_0 = -160$ dBm/Hz, find the amount of cable loss, L_c, in dB that can be tolerated and still achieve a 10^{-9} error rate. Hint: Make sure you take into account the impedance level and properly calculate the received signal power given that the signal is composed of rectangular pulse shapes, not a sinusoid.

15 pts 4.) Text Z&T 9.6.

5.) In the simulation code developed in the notes consider

```
psk_sim(SNR,m,theta,Nbits,timing)
```

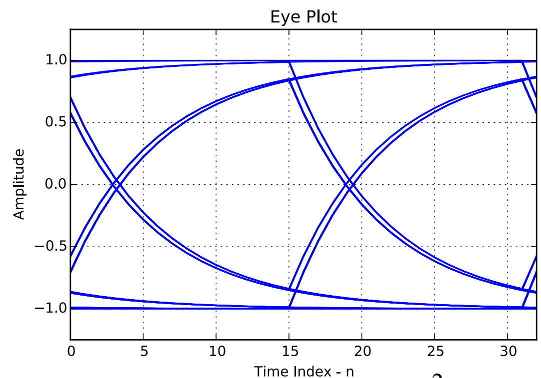
a Python function in the Jupyter notebook *Data Transmission in Noise*. In this problem you will obtain simulated BEP results for an AWGN channel (the simulation is currently configured this way) with the ideal matched filter replaced by a discrete-time approximation to the RC lowpass filter. You have an idea from Z&T Problem 9.9 how the 3dB frequency should be chosen. Adjustments will likely be needed since the text problem ignores filter memory, that is it ignores intersymbol interference (ISI). A first-order digital lowpass filter having difference equation

$$y[n] = ay[n-1] + (1-a)x[n]$$

will work. This filter has unity dc gain and is related to the RC lowpass by choosing $a = e^{-2\pi f_3/f_s}$, where f_s is the sampling rate. In the simulation we assume that $f_s = 16 \cdot R_b$. For convenience just assume that $R_b = 1$ bps. Set $m = 0$, and $\theta = 0$. Leave $N_s = 16$.

10 pts. a.) Configure the new sub-optimum matched filter in the simulation to have $f_3 = 0.199967R_b$ (per Z&T problem 9.9). Obtain an eye plot using `eyeplot()` (Python or MATLAB) with SNR=100 dB. Use the `eyeplot` function to optimize sampling time.

- At the right is a representative eyeplot example when using the RC filter model. This result is not however for $f_3 = 0.1999967R_b$



10 pts. b.) Record four BEP simulation data points for values ranging from 10^{-2} down to 10^{-4} (or lower if you have the time). An error count of at least 100 is required for good confidence in the P_E estimate. Compare your results with the ideal receiver by overlaying the known $P_E = Q(\sqrt{2z})$ curve.

10 pts. c.) Do you think there is a better choice for f_3? I encourage you to investigate this.

Hints:

1.) No comments at this time.

2.) No comments at this time.

3.) No comments at this time.

4.) No comments at this time.

5.) No comments at this time.