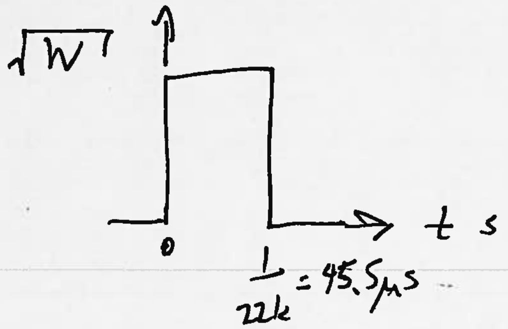
LE/EECS 4214 Digital Communication Fall 2015
Quiz #3, Thurs. Nov. 19, 2015 Name: ______________________

1. (*2 points*) For a binary communication scheme intended to operate at 22-kbps with an average signal power of 5-mW at the detector (i.e. just before sampling) and no ISI sketch the possible Nyquist pulse (vs. time) that could be sent. Clearly label your axes. Complete (i.e. reduce) any calculations needed to label your axes.



$$E_b = \frac{1}{2}A^2 T + \frac{1}{2}(-A)^2 T = A^2 T$$

$$P = \frac{E_b}{T} = A^2 = 5\ mW$$

$$A = \sqrt{5\times10^{-3}}\ [\sqrt{W}]$$

$$= 0.0707\ [\sqrt{W}]$$

2. (*3 points*) Sketch the frequency spectrum of binary signals sent in the form of raised cosine pulses. The data rate is 10-kbps and the roll-off factor is 0.4.

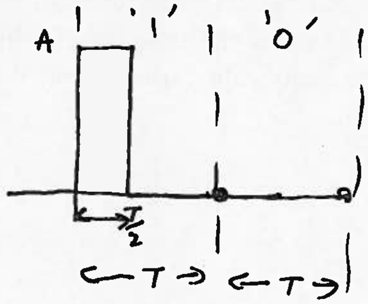
$$W_{RC} = (1+r)W_0$$

$$= 1.4\ W_0$$

$$= 1.4\times5k$$

$$= 7k$$

3. (*5 points*) A binary unipolar RZ signal using rectangular waves with equally likely 1's and 0's is corrupted by white noise with (double-sided) PSD of 3×10^{-8} W/Hz. The pulses are received with amplitude of 75 mV at the detector. Find the largest data rate that can be used in this system while maintaining an error rate of 10^{-4}.



$$E_d = \int_0^T (s_1 - s_2)^2 dt$$

$$= \int_0^{\frac{T}{2}} A^2 dt = \frac{A^2 T}{2}$$

$$P_B = Q\left(\sqrt{\frac{E_d}{2N_0}}\right) = Q\left(\sqrt{\frac{A^2 T}{4N_0}}\right)$$

$$10^{-4} = Q(x) \Rightarrow x \approx 3.7$$

$$\frac{A^2 T}{4N_0} = (3.7)^2$$

$$T = \frac{(3.7)^2 \cdot 4 \cdot N_0}{A^2} = \frac{(3.7)^2 \cdot 4 \cdot (2 \times 3 \times 10^{-8})}{(75 \times 10^{-3})^2}$$

$$= 5.84 \times 10^{-4} \text{ s/b}$$

$$R = \frac{1}{T} = 1.712 \text{ kbps}$$

$Q(3) = 0.0013$, $Q(3.1) = 9.676\text{E-}04$, $Q(3.2) = 6.871\text{E-}04$, $Q(3.3) = 4.834\text{E-}04$, $Q(3.4) = 3.369\text{E-}04$, $Q(3.5) = 2.326\text{E-}04$, $Q(3.6) = 1.591\text{E-}04$, $Q(3.7) = 1.078\text{E-}04$, $Q(3.8) = 7.235\text{E-}05$, $Q(3.9) = 4.810\text{E-}05$, $Q(4) = 3.167\text{E-}05$

$$\mathcal{F}\{\text{rect}(t/T)\} = T\text{sinc}(fT) = T\sin(\pi fT)/\pi fT$$
$$\mathcal{F}\{\text{sinc}(t/T)\} = T\text{rect}(fT)$$
$$\mathcal{F}\{1 - |\tau|/T\} = T\text{sinc}^2(fT)$$
$$\psi_x(f) = |X(f)|^2, G_x(f) = \sum |c_n|^2 \delta(f - nf_o), G_x(f) = \lim_{T\to\infty} \tfrac{1}{T}|X_T(f)|^2$$
$$R_x(\tau) = \int_{-\infty}^{\infty} x(t)x(t+\tau)\text{d}t, R_x(\tau) = \lim_{T\to\infty} \tfrac{1}{T}\int_{-\infty}^{\infty} x(t)x(t+\tau)\text{d}t$$
$$c_n = \int_{-\infty}^{\infty} x(t)\exp(-j2\pi n f_o t)\text{d}t$$
$$\text{SNR [dB]} = 10\log(\text{SNR}), SNR_{q,dB} = 6.02b + 10.8 + 10\log(\sigma_x^2/V_{pp}^2), SNR_j = 3/(\sigma_t^2 + f_H^2)$$
$$P_B = Q[(a_1 - a_2)/(2\sigma_0)], P_B = Q[\sqrt{E_d/(2N_0)}]$$