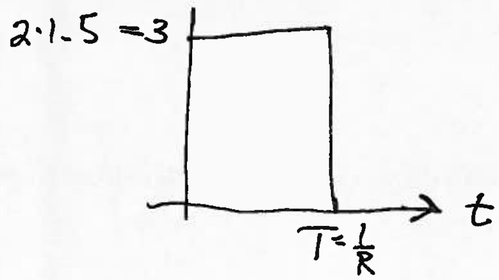
LE/EECS 4214 Digital Communication Fall 2014

Quiz #4, Thurs. Nov. 27, 2014 Name: ____________________

1. (*2 points*) **A receiver handles a bipolar NRZ binary rectangular signal of 1.5-V amplitude with a bit rate of $R = 1/T$. Sketch the impulse response of the (one and only one) matched filter needed for this receiver. Clearly indicate the size of the impulse response with numbers/symbols already given in the question where appropriate.**



2. (*4 points*) **For the problem above, what is the maximum bit rate that can be sent if I wish to achieve an error rate of about 10^{-4} and encounter a two-sided power spectral density of 10^{-3} W/Hz.**

$$P_B = Q\left(\sqrt{\frac{E_d}{2N_0}}\right) = 10^{-4} = Q(3.7) = Q\left(\sqrt{\frac{2E_b}{N_0}}\right)$$

$$\sqrt{\frac{E_d}{2N_0}} = 3.7 = \sqrt{\frac{2E_b}{N_0}}$$

$$\frac{E_d}{2N_0} = 3.7^2 = \frac{2E_b}{N_0}$$

$$\frac{(2\times 1.5)^2 \cdot T}{2\cdot(2\times 10^{-3})} = 3.7^2 = \frac{2\cdot(1.5)^2\cdot T}{2\times 10^{-3}}$$

$$\Rightarrow \quad T = 6.1\times 10^{-3}\,s$$

$$R = \frac{1}{T} = 164 \text{ bps}$$

3. (*2 points*) What is the theoretical minimum system bandwidth needed for a 25-Mbits/s signal using 32-level PAM without ISI?

$$R_{symbol} = \frac{25 \times 10^6}{\log_2 32} = 5 \text{ Msymbols/s}$$

$$W_{system} = \frac{R_{symbol}}{2} = 2.5 \text{ MHz}$$

4. (*2 points*) If the theoretical minimum is 4.3 MHz how much bandwidth do you need if your signalling employs a raised cosine with a roll-off factor equal to 0.7?

$$4.3 \times (1 + 0.7) = 7.31$$

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

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