COM5120 Communication theory

Homework #5

Due: 12/30/2020 (Wednesday)

1. **(6%)** In communications system, the Nyquist criterion describes the conditions satisfied by a channel achieves zero ISI. Given a pulse $x(t)$ having raised-cosine spectrum, show that $x(t)$ satisfies the Nyquist criterion for any roll-off factor β.

2. The sample of a channel's impulse response are $h(-2T) = 0.01$, $h(-T) = 0.1, h(0) = 1.0, h(T) = 0.2, h(2T) = -0.02, h(kT) = 0$ for $k \neq -2, -1, 0, 1, 2$
   A. **(5%)** Determine the tsp coefficients for a three-tap zero-forcing equalizer.
   B. **(5%)** If the equalizer of A. is applied, determine the output sampled of the overall impulse response which combines channel and equalizer.

3. **(12%)** Following the previous question, if an M-ary PAM is used for transmitted, and the shape function is a raised-cosine, please determine the roll-off factor to achieve 5200 bits per second.

4. Consider a received signal $r(t) = s(t) + \alpha s(t-T) + n(t)$, where $s(t)$ is the the transmited signal, $s(t-T)$ is contributed by delay path, α is attenuation $(\alpha < 1)$, and $n(t)$ is **AWGN**.
   A. **(5%)** Calculate the output at t = 2T that applies filter matched to s(t).
   B. **(5%)** If transmitted signal $s(t)$ is binary antipodal and detector ignores ISI.

5. **(6%)** A band-limited channel introduces **ISI** over three successive symbols. The output of matched filter is sampled at the period T.

$$\int_{-\infty}^{\infty} s(t)s(t-kT)dt = \begin{cases} E_b & k = 0 \\ 0.5E_b & k = \pm 1 \\ 0.01E_b & k = \pm 2 \\ 0 & \text{otherwisw} \end{cases}$$

   Determine the three-tap equalizer that equalizes the channel to partial-response (duobinary) signal.

$$y_k = \begin{cases} E_b & k = 0, 1 \\ 0 & \text{otherwise} \end{cases}$$

6.

A. **(12%)** The binary sequence 10010110010 is the input to a precoder whose output is used to modulate a duobinary transmitting filter. (Construct a table contain I_N, B_N, D_N, P_N).

B. **(6%)** Describe the necessity of precoding for such a duobinary signaling scheme.

C. **(6%)** Describe the disadvantage of using duobinary signaling scheme.

7. A bandlimited signal can be represented as

$$x(t) = \sum_{n=-\infty}^{\infty} \frac{x_n \sin\left(2\pi W\left(t-\frac{n}{W}\right)\right)}{2\pi W\left(t-\frac{n}{W}\right)}$$

A. **(6%)**

$$x_n = \begin{cases} -1 & n = 0 \\ 2 & n = \pm 1 \\ 0 & \text{otherwisw} \end{cases}$$

Determine the spectrum $X(f)$ and plot $|X(f)|$.

B. **(2%)** Following A. , plot $x(t)$.

8. For a radio system with multipath channel response $r(t)$ of a signal $s(t)$ being $r(t) = c_1 s(t-t_1) + c_2 s(t-t_2)$

A. **(3%)** Determine the frequency response of channel

B. **(3%)** If equalization with no constraint on the equalizer structure. Find the frequency response in term of c_1, c_2, t_1, t_2

C. **(12%)** Consider linear equalization where equalizer has **three-tap filter** structure $y(t) = e_0 r(t) + e_1 r(t-T) + e_2 r(t-2T)$. Assume $c_1 \gg c_2$ and $t_1 \ll t_2$. Find the coefficients e_0, e_1, e_2 in term of c_1, c_2, t_1, t_2

D. **(6%)** Following C. , assuming that overall system transfer function is equal to $K_0 \exp(-j2\pi f\tau_o)$, where K_0, τ_o are set as desired, e.g. $K_0 = a_1, \tau_o = t_1$, determine the coefficients e_0, e_1, e_2 in term of c_1, c_2, t_1, t_2.