ELEN90051 Advanced Communication Systems
2018 Semester 1 Tutorial 5
Modem with Bandlimited Channel

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Instructions:

Answer all tutorial questions. Do not use any solution material that you happen to have, thus simulating a genuine exam environment.

1 Determine the bit rate that can be transmitted through a 4 KHz voice-band telephone (bandpass) channel if the following modulation methods are used:

(a) binary PSK,

(b) four-phase PSK,

(c) 8-point QAM.

Assume that in each case the transmitter pulse shape has a raised cosine spectrum with $\beta = 0.5$ roll-off.

2 An ideal voice-band telephone line channel has a (ideal) bandpass frequency response characteristic spanning the frequency range 600-3000 Hz.

(a) Design an $M = 4$ PSK system for transmitting data at a rate of 2400 bits/sec and a carrier frequency $f_c = 1800$ Hz. For spectral shaping, use a raised cosine frequency-response characteristic, splitting the desired frequency response characteristic evenly between the transmit filter $G_T(f)$ and the receive filter $G_R(f)$. Write down the expression for $G_T(f)$ and sketch a block diagram of the transmitter.

(b) Repeat part (a) if the bit rate is 4800 bits/sec.

3 Consider a three level PAM system with possible transmitted levels -2, 0, 2. The channel through which the data is transmitted introduces ISI over two successive symbols. The equivalent discrete-time channel model is given below

$$u_0 = 0.8I_0 + \eta_0$$
$$u_k = 0.8I_k - 0.6I_{k-1} + \eta_k, \quad k \geq 1$$

where $\eta_k \sim \mathcal{N}(0, 1)$. Suppose that the received signals are $u_0 = 0.5, u_1 = 1.2, u_2 = -0.7$. Using the Viterbi algorithm, determine the most likely transmitted sequence $\hat{I}_0, \hat{I}_1, \hat{I}_2$

4 Data is transmitted using a signal pulse with a raised cosine spectrum through a channel with the following impulse response:

$$f_k = \begin{cases} -0.5, & k = -2 \\ 0.1, & k = -1 \\ 1, & k = 0 \\ -0.2, & k = 1 \\ 0.05, & k = 2 \\ 0, & \text{otherwise} \end{cases}$$

(a) Determine the tap coefficients of a three-tap linear equalizer based on the zero-forcing criterion, i.e. we want to set $q_{-1} = 0, q_0 = 1, q_1 = 0$.

(b) Using the equalizer tap coefficients in part (a), determine the output of the equalizer for the case of the isolated pulse, i.e. determine q_k for all k.

5 A nonideal bandlimited channel introduces ISI over three successive symbols. The (noise-free) impulse response of the matched filter demodulator sampled at the sampling time $t = kT$ is

$$\begin{cases} \mathcal{E}_g, & k = 0 \\ 0.9\mathcal{E}_g, & k = \pm 1 \\ 0.1\mathcal{E}_g, & k = \pm 2 \\ 0, & \text{otherwise} \end{cases}$$

Determine the tap coefficients of a three-tap linear equalizer that equalizes the channel (received signal) response to an equivalent partial response signal

$$g_k = \begin{cases} \mathcal{E}_g, , & k = 0, 1 \\ 0, & \text{otherwise} \end{cases}$$

also known as a duobinary signal.

End of Questions