S-72.245 Transmission Methods in Telecommunication Systems
Tutorial 7

Objectives

- Notice advantages of digital communications over analog communications
- Getting familiar with baseband transmission system including PAM signal, PAM PSD and binary error probability
- To investigate bandlimited digital PAM systems: cos roll-off signalling, matched filtering, optimal terminal filters and equalization

Quizzes

Q7.1 Explain briefly the purpose of matched filter and optimum terminal filter. Express their receiving filter design and receiving SNR formulas.

Q7.2 Find and sketch the power spectrum of a binary PAM signal with polar RZ format, assuming independent and equal probable message bits. Then show that the time-domain and frequency-domain calculation of are in agreement.

Q7.3 In a random NRZ-signal the bits '0' and '1' have the same probabilities. The noise n is added to the channel and n has an exponential distribution.

$p(n) = \frac{1}{\sigma\sqrt{2}} e^{-\sqrt{2}|n|/\sigma}$, where the noise's rms-value is σ.

a) Find out the formula for the error probability when the received signal voltage without noise is $-s$ for bit '0' and $+s$ for bit '1'
b) Calculate by giving formulas the SNR values in dB's when the error probability is 10^{-6}
c) By using the same error probability as in the b), calculate by giving formulas the SNR values in dB's when the white Gaussian is added to the signal.

Q7.4 Let the $x(t)$ be the unipolar RZ signal. Confirm that matched filtering yields $\left(\frac{A}{2\sigma}\right)^2 = \gamma_b$ even though $\sigma^2 = N_0 r_b$ so $N_R > \frac{N_0 r_b}{2}$

Q7.5 Find the tap gains for a three-tap zero-forcing equalizer when $\tilde{p}_{-1} = 0.4,\ \tilde{p}_0 = 1.0, \tilde{p}_1 = 0.2 \quad and \quad \tilde{p}_k = 0 \quad for \quad |k| > 1.$ Then find and plot $p_{eq}(t_k)$

Matlab assignments

M7.1 Assume a bandlimited digital PAM system in Figure 1. Given a NRZ binary message of 10110110, D=0.5 seconds and additional noise is white noise with $(S/N)_R = 10dB$. *H(f)* is designed as a matched filter. Compare the input and output signals of matched filter by plotting them and matched filter in time domain signal.

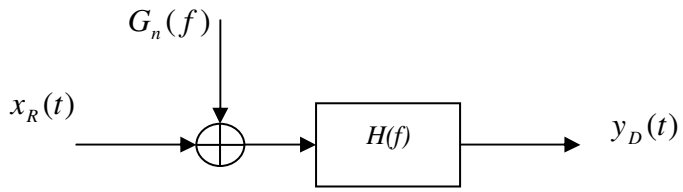

Figure 1

M7.2 Two signal waveforms are *antipodal* if one signal waveform is the negative of the other. Suppose we use antipodal signal waveforms $s_0(t) = s(t)$ and $s_1(t) = -s(t)$ to transmit binary information, where *s(t)* is some arbitrary waveform having energy E. The received signal waveform from an AWGN channel may be expressed as

$$r(t) = \pm s(t) + n(t), \qquad 0 \le t \le T_b$$

Use Monte Carlo simulation to estimate and plot the error probability performance of a binary antipodal communication system. The model of the system is illustrated in Figure 2.

Hints: Monte Carlo simulation is usually performed in practice to estimate the probability of error of a digital communication system, especially in cases where the analysis of the detector performance is difficult to perform.

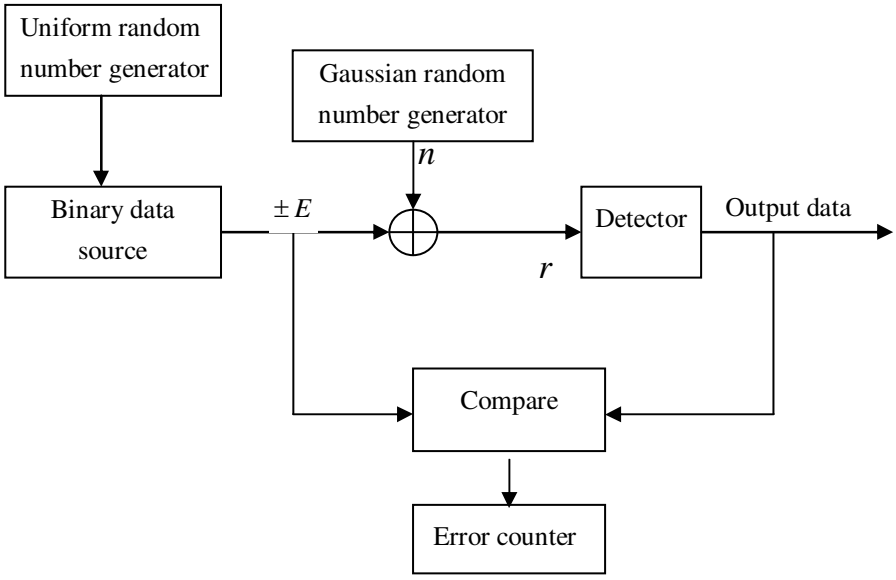
Uniform random number generator
Gaussian random number generator
n
Binary data source
± E
Detector
Output data
r
Compare
Error counter

Figure 2