AMERICAN UNIVERSITY OF BEIRUT
FACULTY OF ENGINEERING AND ARCHITECTURE
ELECTRICAL AND COMPUTER ENGINEERING DEPARTMENT

EECE 442 – Communication Systems
FINAL EXAM
Closed book exam
SIX SHEETS OF FORMULAS WITH NO PROBLEM SOLUTIONS ARE ALLOWED
TIME: 2 Hours
Saturday, August 13, 2005
INSTRUCTOR: Dr. JEAN J. SAADE

NAME:________________________ **ID #:**____________________

Problem # 1

Consider an analog message signal, *m(t)*, with a dynamic range equal to 10 Volts and bandwidth equal to 4 KHz. The message *m(t)* is sampled at the Nyquist rate.

(a) Let *m(t)* be applied to a PCM transmitter supplied with a uniform quantizer having 256 levels. Determine the bit rate.
(b) Let *m(t)* be applied to a DPCM transmitter, which is also supplied with a uniform quantizer. The step size of the DPCM quantizer is considered equal to the step size of the PCM quantizer used in Part (a). But, the DPCM transmitter reduces the bit rate by 25%. Determine the dynamic range of the input to the DPCM quantizer.

Problem # 2

Consider again the given in Problem # 1 with *m(t)* being a sinusoidal signal expressed as:

$$m(t) = A_m \cos(\omega_m t) \text{ Volts.}$$

(a) Determine A_m and ω_m.
(b) Consider the application of *m(t)* to a PCM quantizer and a DPCM quantizer separately. The DPCM and PCM quantizers are uniform and have the same number of levels. The DPCM quantizer provides an output SNR equal to 100 times the output SNR of the PCM quantizer. Determine the dynamic range of the input to the DPCM quantizer.

Problem # 3

Consider the following analog message signal:

$$m(t) = A\sin(2\pi t) + 2A\sin(\pi t) \ \ Volts.$$

Let $m(t)$ be sampled at a rate, f_s, that is much greater than the Nyquist rate and applied to a Delta modulator with step size Δ.

(a) Determine the maximum value of $\left|\frac{dm(t)}{dt}\right|$

(b) Determine the highest usable value of A (in terms of f_s and Δ) that results in no slope overload distortion.

(c) The maximum value of the message $m(t)$, A_{max}, is approximately equal to (2.5A). Use the result in Part (b), to obtain the highest usable value of A_{max} for no slope overload distortion. Compare the highest A_{max} value to $\Delta f_s/W$, where $W=2\pi$ rad/s is the bandwidth of $m(t)$. Can this comparison be used to justify the use of 800Hz instead of 3.2 KHz to determine the maximum usable amplitude for voice signals to avoid slope overload distortion? Discuss this matter.

Problem #4

Consider the reception of the signal g(t), as given below, in additive, zero-mean white noise process with spectral height $N_0/2$. The receiver is a matched filter followed by a sampler that samples the signal + noise at the matched filter output at time t= T.

$$g(t) = \begin{cases} A, & 0 \le t \le T \\ 0, & elsewhere. \end{cases}$$

The matched filter impulse response is given by:

$$h(t) = g(T-t) \Leftrightarrow H(\omega) = G^*(\omega)e^{-j\omega T}$$

(a) Determine $|g_o(T)|^2$, where $g_0(t)$ is the signal component at the output of the matched filter.

(b) Determine the average power of the noise process at the matched filter output and the signal-to-noise ratio at the output of the matched filter.

(c) Let g(t), as above, be replaced by

$$g_{new}(t) = \begin{cases} A, & 0 \le t \le T/2 \\ -A, & T/2 < t \le T \\ 0, & elsewhere \end{cases}$$

and $h(t)$ be replaced by

$$h_{new}(t) = g_{new}(T-t) \Leftrightarrow H_{new}(\omega) = G^{*}_{new}(\omega)\, e^{-j\omega T}$$

Repeat Parts (a) and (b) and compare the matched filter output signal-to-noise ratio in this case to that obtained in Part (b). Draw a conclusion based on the SNR's comparison.

Problem #5

Consider the base-band transmission of a binary sequence under the form of a PNRZ line code, and using rectangular pulses each of duration T_b and height equal to A for bit 1 representation and $-A$ for bit 0 representation. Let the transmitted sequence be 101101 with the bit 1 on the right as the first transmitted bit.

(a) Assume that the sequence is transmitted over an ideal channel and ignore time delay and attenuation as well as the presence of noise. Plot the signal at the output of the matched filter before sampling and then show that the sampled signal at $t=iT_b$ does not present ISI.

(b) Now assume that the transmission is done over a non-ideal channel and that the signal representing the reception of the first bit at the receiver output is given by

$$y(t) = \begin{cases} (1-e^{-t}), \; 0 \le t \le T_b \\ (e^{T_b}-1)e^{-t}, \; t \ge T_b \\ 0, \; elsewhere \end{cases}$$

Plot the signal without the noise at the output of the receiver before sampling and then show the ISI effect obtained when the signal is sampled at $t=iT_b$.

Problem #6

Consider the 4-ary transmission of a binary sequence where the 4 possible dibits, 00, 01, 10 and 11 are represented by pulses having 2A, A, -A, -2A as their respective amplitudes. The 4 dibits are equally probable and the pulse duration is $T=2T_b$, where T_b is the bit duration.

(a) Let the dibits representing pulses be rectangular and transmission is over an ideal base-band channel. Ignore attenuation and time delay due to transmission and determine the detector, the decision rule that applies to the detector output (use maximum likelihood principle) and the symbol probability of error. The corruptive noise process at the receiver input is additive, white and Gaussian with zero-mean and spectral height equal to $N_0/2$.

(b) Let the dibits representing pulses be sinusoidal with frequency ω_c rad/s and transmission is over an ideal band-pass channel. Ignore attenuation of time-delay due to transmission and determine the detector, the decision rule that applies to the detector output (use maximum likelihood principle) and the symbol probability of error. Consider $\omega_c=2\pi k/T$, where k is a positive integer. The corruptive noise process at the receiver input is additive, white and Gaussian with zero-mean and spectral height equal to $N_0/2$.

(c) Express the symbol probability of error in Part (a) using E_1, which is the energy of the rectangular pulse of amplitude A. Also, express the symbol probability of error in Part (b) using E_2, which is the energy of the sinusoidal pulse of amplitude A. Compare the obtained error probabilities and draw a conclusion regarding the signal quality at the receiver output as it relates to the amount of transmission power.

(d) Discuss and emphasize the use of base-band and band-pass data transmissions regarding application areas and communication links situations.