AMERICAN UNIVERSITY OF BEIRUT
FACULTY OF ENGINEERING AND ARCHITECTURE
ELECTRICAL AND COMPUTER ENGINEERING DEPARTMENT
EECE 442 – Communication Systems
MIDTERM EXAM
Closed book exam
FOUR SHEETS OF FORMULAS WITH NO PROBLEM SOLUTIONS ARE ALLOWED
TIME: 1 ½ HOURS
JULY 26, 2007
INSTRUCTOR: Dr. JEAN J. SAADE

NAME : ____________________ **ID # :** ____________________

INSTRUCTIONS

- **Write your Name and ID # on this sheet, the computer card and the scratch booklet in the provided spaces.**
- **Provide your answer on the computer card and solution of each problem on the scratch booklet.**
- **Random checking will be done to find out about any inconsistency between the problem solutions on the scratch and provided answers on the computer card.**
- **Return the computer card, this question sheet and the scratch booklet when you finish the test.**
- **All questions are equally weighted in grading.**

PROBLEM # 1

Consider a stationary zero-mean white and Gaussian noise process, W(t), with spectral height $N_0/2$. Let W(t) be available at the input of an ideal BPF with center frequency ω_c rad/sec and bandwidth 2W rad/sec. Determine the variance of the random variable obtained by sampling the stationary random noise process, N(t), available at the output of the BPF.

$(a)\ \frac{2N_0W}{\pi}$ $(b)\ \frac{N_0W}{\pi}$ $(c)\ \frac{N_0W}{2\pi}$ $(d)\ 2N_0W$ $(e)\ \frac{N_0W}{2}$

PROBLEM # 2

Consider again Problem # 1 and determine the autocorrelation function, $R_N(\tau)$, of the stationary noise process available at the output of the ~~output of the~~ BPF. Use the inverse Fourier transform formula applied to the power spectral density of N(t).

$(a)\ R_N(\tau) = \frac{N_0}{\pi\tau}\sin(W\tau)\cos(\omega_c\tau)$

$(b)\ R_N(\tau) = \frac{N_0}{\pi\tau}\cos(W\tau)\sin(\omega_c\tau)$

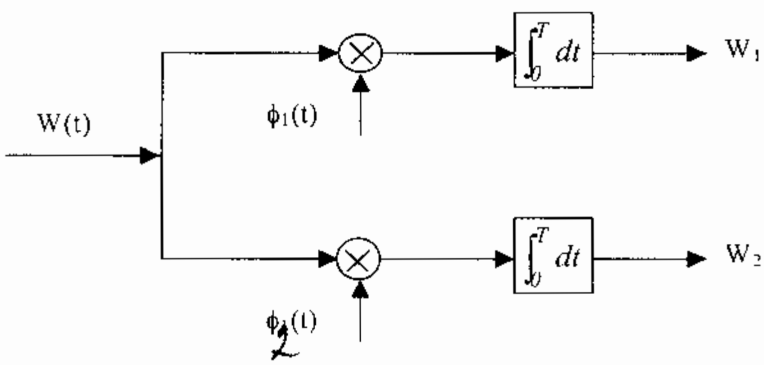
$(c)\ R_N(\tau) = \frac{N_0}{\pi\tau}\cos(W\tau)\cos(\omega_c\tau)$

$(d)\ R_N(\tau) = \frac{N_0}{\pi\tau}\sin(W\tau)\sin(\omega_c\tau)$

$(e)\ R_N(\tau) = \frac{N_0}{\pi\tau}\sin(W\tau)$

PROBLEM # 3

Consider the system shown in the figure below. The system input, W(t), is a stationary zero-mean white and Gaussian noise process with spectral height $N_0/2$. $\phi_1(t)$ and $\phi_2(t)$ are deterministic finite duration signals defined in [0,T] and have unit energy. $\phi_1(t)$ and $\phi_2(t)$ are also orthogonal; that is, $\int_0^T \phi_1(t)\phi_2(t)dt = 0$. Determine the covariance of the random variables W_1 and W_2 available at the outputs of the two integrators.



$(a)\ 2N_0$ $(b)\ \frac{N_0}{2}$ $(c)\ N_0$ $(d)\ 0$ $(e)\ \infty$

PROBLEM # 4

Consider again Problem # 3 and determine the variance of the Gaussian random variables W_1 and W_2.

$(a)\ \sigma_{W1}^2 = \sigma_{W2}^2 = 0$ $(b)\ \sigma_{W1}^2 = \sigma_{W2}^2 = N_0$ $(c)\ \sigma_{W1}^2 = \sigma_{W2}^2 = 2N_0$

$(d)\ \sigma_{W1}^2 = \sigma_{W2}^2 = \frac{N_0}{2}$ $(e)\ \sigma_{W1}^2 = \sigma_{W2}^2 = 1$

PROBLEM # 5

Consider the following DSB-SC signal plus narrowband noise at the input of an envelope detector:

$$x(t) = A_c m(t)\cos(\omega_c t + \phi) + n(t)$$

The process n(t) is the output of an ideal BPF with center frequency ω_c rad/sec and bandwidth 2W rad/sec. Determine the signal component, $s_0(t)$, and the noise component, $n_0(t)$, at the output of the envelope detector. Assume that the message signal, m(t), is always positive and that the carrier-to-noise ratio is very large.

$(a)\ s_0(t) = A_c m(t); \quad n_0(t) = n_c(t)\cos\phi$

$(b)\ s_0(t) = A_c m(t); \quad n_0(t) = n_c(t)\cos\phi + n_s(t)\sin\phi$

$(c)\ s_0(t) = A_c m(t); \quad n_0(t) = n_s(t)\sin\phi$

$(d)\ s_0(t) = A_c m(t); \quad n_0(t) = n_c(t)\sin\phi + n_s(t)\cos\phi$

$(e)\ s_0(t) = A_c m(t); \quad n_0(t) = n_c(t)\cos\phi + n_s(t)\cos\phi$

PROBLEM # 6

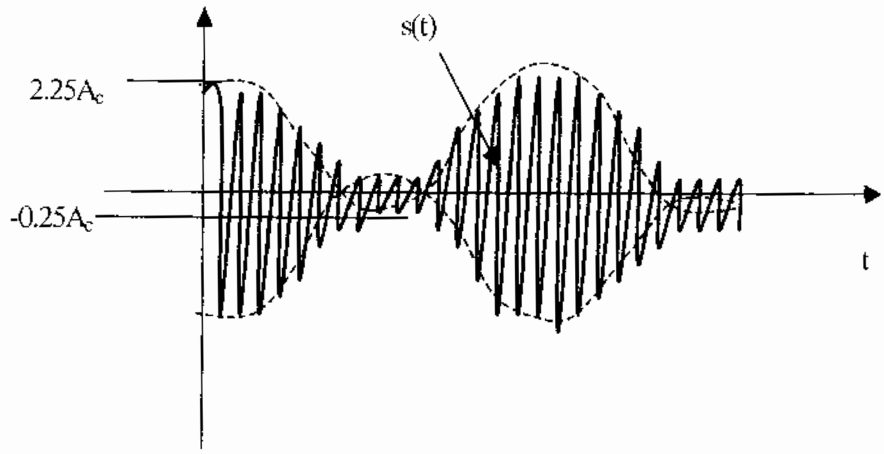
Consider again Problem # 5 with $\phi = \pi/2$. Let P be the average power of the message signal, m(t). Determine the SNR at the output of the envelope detector.

$(a)\ SNR = \dfrac{\pi A_c^2 P}{N_0 W}$ $\qquad (b)\ SNR = \dfrac{\pi A_c^2 P}{2N_0 W}$ $\qquad (c)\ SNR = \dfrac{2\pi A_c^2 P}{N_0 W}$

$(d)\ SNR = \dfrac{A_c^2 P}{2N_0 W}$ $\qquad (e)\ SNR = \dfrac{A_c^2 P}{N_0 W}$

PROBLEM # 7

Consider the single-tone DSB-LC modulated signal shown in the figure below. Obviously, the DSB-LC signal is over-modulated. Determine the percentage modulation of this DSB-LC signal.



(a) *100%* (b) 150% (c) *125%* (d) 75% (e) *80%*

PROBLEM # 8

The DSB-LC signal generated by the switching modulator has the following form:

$$s(t) = \frac{A_c}{2}\left[1 + \frac{4}{\pi A_c} m(t)\right]\cos(\omega_c t)$$

Let P be the average power of the message signal, m(t), which is assumed to be a zero-mean stationary random process. Determine the ratio of the average power of the sinusoidal carrier over the average power of the DSB-SC signal involved in the DSB-LC signal given above.

$(a)\ \frac{\pi^2 A_c^2}{8P}$ $(b)\ \frac{\pi A_c^2}{P}$ $(c)\ \frac{\pi^2 A_c^2}{P}$ $(d)\ \frac{\pi^2 A_c^2}{16P}$ $(e)\ \frac{\pi^2 A_c^2}{2P}$

PROBLEM # 9

In a super-heterodyne receiver, assume that the intermediate frequency (IF) is equal to 455 KHz. Let the RF amplifier be tuned to pick and amplify an DSB-LC signal having a carrier frequency equal to 1255 KHz. Determine the frequency to which the sinusoidal output of the variable oscillator needs to be tuned so as to permit the DSB-LC signal to be amplified a second time in the IF section of the receiver.

(a) 455 KHz   (b) 600 KHz   (c) 1710 KHz   (d) 1255 KHz   (e) 800 KHz

PROBLEM # 10

A voltage controlled oscillator (VCO) is an LC tank circuit used to generate an FM signal. This is done by replacing the capacitor in an ordinary oscillator by a special diode (varactor diode) under reverse biasing. Let the capacitance presented by the diode be given by $C=C_0[1-Km(t)]$ with $Km(t) << 1$. The sinusoidal output of the VCO has a time dependent frequency $\omega_i(t) = 1/\sqrt{LC}$. Determine the frequency sensitivity, k_f, of the FM modulator.

$(a)\ k_f = \frac{K}{\sqrt{LC_0}}$ $(b)\ k_f = \frac{K}{4\pi\sqrt{LC_0}}$ $(c)\ k_f = \frac{K}{\pi\sqrt{LC_0}}$

$(d)\ k_f = \frac{K}{2\pi\sqrt{LC_0}}$ $(e)\ k_f = \frac{K}{3\pi\sqrt{LC_0}}$

PROBLEM # 11

Consider again Problem # 10 and assume that k_f has been found and calculated using some values of L and C_0. Let $k_f = 4688\ (V.s)^{-1}$. The maximum amplitude value of the message signal, m(t), is supposed equal to 8 Volts and the bandwidth of m(t) is set at 15 KHz. Determine the bandwidth of the FM signal at the output of the VCO. Use Carson's rule for bandwidth computation.

(a) 205 KHz (b) 55 KHz (c) 105 KHz (d) 155 KHz (e) 30 KHz