**AMERICAN UNIVERSITY OF BEIRUT**
**FACULTY OF ENGINEERING AND ARCHITECTURE**
**ELECTRICAL AND COMPUTER ENGINEERING DEPARTMENT**
**EECE 442 – Communications Systems**
**Midterm**
**Closed book exam**
**FOUR SHEETS OF FORMULAS WITH NO PROBLEM SOLUTIONS ARE ALLOWED**
**TIME: 1 Hour and 30 minutes**
**Friday, September 8, 2006**
**INSTRUCTOR: Dr. JEAN J. SAADE**

**NAME**____________________________ **ID #:**________________________

## INSTRUCTIONS

- WRITE YOUR ID # AND NAME ON THE COMPUTER CARD, ON THIS SHEET AND ON 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 and the provided answers on the computer card.**
- RETURN THE COMPUTER CARD ATTACHED ON TOP OF THE QUESTION SHEET AND SCRATCH BOOKLET.
- **ONLY YOUR ANSWER PROVIDED ON THE COPMUTER CARD WILL BE CONSIDERED IN GRADING.**
- All QUESTIONS ARE EQUALLY WEIGHTED IN GRADING.

## PROBLEM # 1

Consider the signal s(t) in additive stationary white and Gaussian noise process N(t). N(t) has a mean equal to zero and spectral height $N_0/2$. The signal s(t) is a deterministic finite duration energy signal defined in [0,T] and having an energy equal to E. The signal plus noise are available at the input of an integrator that integrates between 0 and T. Determine the mean and variance of the Gaussian random variable, $R_0$, available at the output of the integrator.

$(a)\ E(R_0) = \int_0^T s(t)dt,\ \sigma_{R_0}^2 = \frac{N_0 E}{2}$ $(b)\ E(R_0) = \int_0^T s(t)dt,\ \sigma_{R_0}^2 = \frac{N_0 T}{2}$

$(c)\ E(R_0) = \int_0^T s(t)dt,\ \sigma_{R_0}^2 = \frac{N_0}{2}$ $(d)\ E(R_0) = \int_0^T s(t)dt,\ \sigma_{R_0}^2 = \frac{N_0 E}{2T}$

$(e)\ E(R_0) = \int_0^T s(t)dt,\ \sigma_{R_0}^2 = N_0$

## PROBLEM # 2

Consider a stationary white and Gaussian noise process, W(t), at the input of an ideal LPF with bandwidth equal to W rad/sec. W(t) has a mean equal to zero and spectral height $N_0/2$. Let N(t) be the noise process available at the output of the LPF. Select from what is given below the expression that can be the autocorrelation function of N(t).

$(a)\ R_N(\tau) = \frac{2N_0W}{\pi} e^{-2|\tau|}$ $(b)\ R_N(\tau) = \frac{N_0W}{2} e^{-2|\tau|}$ $(c)\ R_N(\tau) = \frac{N_0W}{2\pi} e^{-2|\tau|}$

$(d)\ R_N(\tau) = \frac{N_0W}{\pi} e^{-2|\tau|}$ $(e)\ R_N(\tau) = \frac{N_0W}{2\pi} e^{-2\tau}$

## PROBLEM # 3

Consider again the given in Problem # 2 and determine the mean and variance of the Gaussian random variable obtained by sampling the random process N(t) at any time instant.

$(a)\ E[N(t)] = 0,\ \sigma_N^2 = \frac{2N_0W}{\pi}$ $(b)\ E[N(t)] = 0,\ \sigma_N^2 = \frac{N_0W}{2}$

$(c)\ E[N(t)] = 0,\ \sigma_N^2 = \frac{N_0W}{\pi}$ $(d)\ E[N(t)] = 0,\ \sigma_N^2 = \frac{N_0W}{2\pi}$

$(e)\ E[N(t)] = 0,\ \sigma_N^2 = \frac{N_0W}{4\pi}$

## PROBLEM # 4

Consider the following two representations of narrow-band noise:

$$N(t) = N_c(t)\cos(\omega_c t) - N_s(t)\sin(\omega_c t) = R(t)\cos[\omega_c t + \Psi(t)].$$

Let N(t) have a bandwidth equal to 2W rad/sec and spectral height $N_0/2$. Determine the average power of the random process available at the output of an envelope detector when N(t) is available at its input.

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

## PROBLEM # 5

Consider again Problem # 4 and determine the average power of R(t).

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

## PROBLEM # 6

Consider the following over-modulated DSB-LC signal:

$$s(t) = A_c[1 + 2\cos(\omega_m t)]\cos(\omega_c t).$$

with $\omega_c >> \omega_m$. Let s(t) be present at the input of an envelope detector. Determine the output of the envelope detector for one period of the message signal, which is the same as the period of $\cos(\omega_m t)$. Let $\omega_m = 2\pi \times 10^3\ rad/\text{sec}$.

***HINT:*** The envelope detector output is given by:

$$\begin{cases} A_c[1 + 2\cos(\omega_m t)], \textit{ when } [1 + 2\cos(\omega_m t)] > 0, \\ -A_c[1 + 2\cos(\omega_m t)], \textit{ when } [1 + 2\cos(\omega_m t)] < 0. \end{cases}$$

$$(a)\ \begin{cases} -A_c[1 + 2\cos(\omega_m t)], & 0.22ms \le t \le 0.77ms \\ A_c[1 + 2\cos(\omega_m t)], & \textit{otherwise.} \end{cases}$$

$$(b)\ \begin{cases} -A_c[1 + 2\cos(\omega_m t)], & 0.25ms \le t \le 0.75ms \\ A_c[1 + 2\cos(\omega_m t)], & \textit{otherwise.} \end{cases}$$

$$(c)\ \begin{cases} -A_c[1 + 2\cos(\omega_m t)], & 0.44ms \le t \le 0.56ms \\ A_c[1 + 2\cos(\omega_m t)], & \textit{otherwise.} \end{cases}$$

$$(d)\ \begin{cases} -A_c[1 + 2\cos(\omega_m t)], & 0.33ms \le t \le 0.66ms \\ A_c[1 + 2\cos(\omega_m t)], & \textit{otherwise.} \end{cases}$$

$$(e)\ \begin{cases} -A_c[1 + 2\cos(\omega_m t)], & 0.15ms \le t \le 0.85ms \\ A_c[1 + 2\cos(\omega_m t)], & \textit{otherwise.} \end{cases}$$

## PROBLEM # 7

Consider the generation of a DSB-SC signal by the instantaneous sampling of the message signal, m(t), and the use of a BPF. It is desired to have the carrier frequency of the DSB-SC signal equal to 500KHz. Determine the sampling period, $T_s$, of the message signal and the maximum bandwidth, W, of the message that allows the sampling and band-pass filtering to be applied for the generation of the DSB-SC signal.

(a) Ts=4μsec. W=500KHz
(b) Ts=2μsec. W=500KHz
(c) Ts=5μsec. W=500KHz
(d) Ts=4μsec. W=250KHz
(e) Ts=2μsec. W=250KHz

**PROBLEM # 8**

In a super-heterodyne receiver, the mixing operation is represented by multiplying the selected and amplified modulated signal, assumed DSB-SC and given by $A_c m(t)\cos(\omega_c t)$, by $\cos(\omega_p t)$. The objective is to translate the carrier frequency to a fixed IF frequency, $\omega_{IF}$. Consider two modulated signals with frequencies $f_{c1}$=1200KHz and $f_{c2}$=900KHz. Determine $f_{p1}$ and $f_{p2}$ that need to be used in the mixing operation to translate the carrier frequencies of the noted modulated signals to $f_{IF}$=500KHz.

(a) $f_{p1}$=700KHz, $f_{p2}$=400KHz
(b) $f_{p1}$=1700KHz, $f_{p2}$=1200KHz
(c) $f_{p1}$=500KHz, $f_{p2}$=1400KHz
(d) $f_{p1}$=1700KHz, $f_{p2}$=1400KHz
(e) $f_{p1}$=1700KHz, $f_{p2}$=400KHz

**PROBLEM # 9**

Consider the approximated form of a NBFM signal:

$$s_{app}(t) = A_c \cos(\omega_c t) - \beta A_c \sin(\omega_m t)\sin(\omega_c t).$$

Let $\beta$=0.1 and determine the maximum deviation of the envelope of $s_{app}(t)$ from the envelope, $A_c$, of the NBFM signal.

(a) 0.1$A_c$
(b) 0.005$A_c$
(c) 0.001$A_c$
(d) 0.004$A_c$
(e) 0.04$A_c$

**PROBLEM # 10**

The bandwidth allowed for the transmission of an FM radio signal is 200KHz. Assume that the FM radio station wants to transmit a stereo message signal of bandwidth equal to 52 KHz. Determine the maximum value of the message signal. Use $k_f$ = 4000 $(V.s)^{-1}$ and Carson's rule for bandwidth computation.

(a) 15 Volts (b) 10 Volts (c) 12 Volts (d) 18 Volts (e) 20 Volts