AMERICAN UNIVERSITY OF BEIRUT
FACULTY OF ENGINEERING AND ARCHITECTURE
ELECTRICAL AND COMPUTER ENGINEERING DEPARTMENT
EECE 442 – Communications Systems
QUIZ # 1
Closed book exam
TWO SHEETS OF FORMULAS WITH NO PROBLEM SOLUTIONS ARE ALLOWED
TIME: 1 Hour and 15 minutes
Mondday, April 4, 2005
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PROBLEM # 1

Consider the probability space $S=\{S_1, S_2, S_3, S_4, S_5, S_6\}$ corresponding to some random experiment. Let $P\{S_i\}=P_i$, i=1, 2, 3, 4, 5, 6.

(a) Partition S into 3 mutually exclusive events subsets of S in such a way that each event contains at least one element of S. Let these events be denoted by A, B and C.
(b) Use the axioms of probability and determine the probability of each of the events you specified in Part (a).
(c) Determine [P(A)+P(B)+P(C)] in terms of P_i, i=1, 2, 3, 4, 5, 6 and determine the numerical value of this probability sum. Justify your answer.

PROBLEM # 2

Consider a Gaussian random variable, X, having a mean equal to zero and variance equal to 1.

(a) Express the cumulative distribution function of X, $F_X(x)$, using the integral of the probability density function of X.
(b) Use the approximate plot of $f_X(x)$ and obtain the approximate plot of $F_X(x)$. What are the values of $F_X(x)$ at $-\infty$, 0, ∞.

PROBLEM # 3

Consider a zero-mean stationary random process X(t) with autocorrelation function $R_X(\tau)=E[X(t+\tau)X(t)]=\exp\{-a|\tau|\}$, with $a>0$ and $-\infty<\tau<\infty$.

(a) Describe how the correlation between any two samples of X(t) varies as the time difference between them increases.
(b) Determine the time difference between any two samples of X(t) that makes these samples uncorrelated.
(c) Determine the value of the integral $\int_{-\infty}^{\infty} S_X(\omega)d\omega$, where $S_X(\omega)$ is the PSD of X(t). You do not need to find $S_X(\omega)$.

PROBLEM # 4

Consider the following modulated signal:

$$s(t)=A_c \cos(\omega_c t)+A_c k_a m(t) \sin(\omega_c t).$$

(a) Determine the spectrum of s(t), denoted $S(\omega)$, and plot its magnitude.
(b) Determine the bandwidth needed for the transmission of s(t). The message signal m(t) has a bandwidth equal to W.
(c) Suggest and describe the blocks that need to be used in the demodulation of s(t).

PROBLEM # 5

DSB-LC has an inferior performance compared to DSB-SC under the presence of noise. This requires an increase in the transmission power of DSB-LC to achieve comparable performance with DSB-SC. Despite this fact, AM stations prefer to use DSB-LC signals. Consider the issue of receiver structure and explain the reason(s) for which DSB-LC signal transmission is preferable commercially.

PROBLEM # 6

Consider the establishment of an FM radio transmission system involving different FM stations. Each radio station is supposed to generate first a stereo signal occupying a bandwidth W=52 KHz. This stereo signal is then modulated using FM modulation and transmitted. Assume that due to technical reasons, the least modulation index β that can be generated is equal to 2.

(a) Determine the least separation between the transmission frequencies of the adjacent FM signals.
(b) Let the generation of each FM signal be done by generating first a NBFM signal with $\beta=0.1$. What is the frequency multiplication factor needed to obtain the WBFM signals transmitted by the radio stations?

PROBLEM # 7

Consider the following DSB-SC signal in the presence of narrow-band noise at the input of an envelope detector.

$$s(t)= A_c m(t) \sin(\omega_c t).$$

(a) Determine the signal and noise components at the output of the envelope detector. Assume large carrier-to-noise ratio.
(b) Repeat Part (a) when $s(t)=A_c m(t) \cos(\omega_c t)$.
(c) In Parts (a) and (b) determine the signal-to-noise ratios at the output of the envelope detector.