Faculty of Science
Department of Electrical and Electronic Engineering
Main Examination 2014

Title of Paper : **Communication System Principles**

University of Swaziland

Course Number : **EE442**

Time Allowed : **3 hrs**

Instructions :

1. **Answer any four (4) questions**
2. **Each question carries 25 marks**
3. **Useful information is attached at the end of the question paper**

THIS PAPER SHOULD NOT BE OPENED UNTIL PERMISSION HAS BEEN GIVEN BY THE INVIGILATOR

The paper consists of six (7) pages

Question 1 [25]

a) Find the information content of message that consist of a digital word 12 digits long in which each digit may take only one of FOUR possible levels. The probability of sending any of the four level is assumed to be equal and the level in any digit does not depend on the values taken by previous digits.[3]

b) A computer user plans to buy a higher-speed modem for sending data over his telephone line. The telephone line has a signal-to-noise ratio (SNR) of 25dB, and passes audio frequencies over the range from 300 to 3,200 Hz, calculate the maximum data rate that could be sent over the telephone line when there are no errors at the receiving end. [5]

c) The signal *w(t)*=$\cos(2\pi f_1)$ $+cos(2\pi f_2 t)$ is first ideally sampled with a sampling frequency, $f_s = 200Hz$, then low-pass filtered as shown in **figure 1.1**. Find the signal at the filter output $w_R(t)$ for the following case. [15]

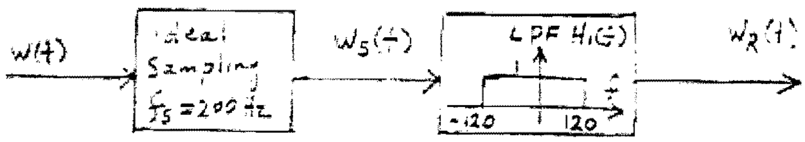

Figure 1.1

d) Define ***any two*** of the following terms [2]

i. Absolute bandwidth:

ii. 3dB bandwidth:

iii. Equivalent noise bandwidth:

iv. Null-to-Null bandwidth:

Question 2 [25]

a) An analog signal is to be converted into a PCM signal that is a binary polar NRZ line code. The signal is transmitted over a channel that is absolutely bandlimited to **4 kHz.** Assume that the PCM quantizer has 16 steps and that the overall equivalent system transfer function is of the raised cosine- roll off type with r = 0.5.

i. Find the maximum PCM bit rate that can be supported by this system without introducing ISI. [6]

ii. Find the maximum bandwidth that can be permitted for the analog signal. [4]

b) The data stream 01101000101 appears at the input of a differential encoder. Depending on the initial start-up condition of the encoder:

i. Find the 2 possible differentially encoded data streams that can appear at the output. [4]

ii. Draw a digital system that performs differential encoding. [2]

c) In a binary PCM system, if the quantization noise is not to exceed $\pm P$ percent of the peak-to-peak analog level (V_{pp}), show that the number of bits in each PCM word needs to be

$$n \geq [log_2]\left[log_{10}\left(\frac{50}{P}\right)\right] = 3.32 log_{10}(50/P) \qquad [9]$$

Hint: quantization noise $|n_q| \leq \frac{\Delta}{2}$

$\Delta = V_{pp}/M$

$M = 2^n$

Question 3 [25]

a) Determine whether each of the following signals is an energy or a power signal and evaluate the normalized energy or power, as appropriate: [6]

   i. $w(t) = \Pi(\frac{t}{T_0})$ [3]

   ii. $w(t) = cos^2(\omega_0 t)$ [3]

b) A multilevel digital communication system is to operate at a data rate of 9600 bits/s:

   i. If 4-bit words are encoded into each level for transmission over the channel, what is the minimum required bandwidth for the channel? [2]

   ii. Repeat part (i) of 8-bit encoding into each level and draw a conclusion. [2]

c) Consider the system shown in figure 3.1, the Fourier transform of the input signal $X(f)$ is given in figure 3.2.

   i. Calculate the energy of the input signal $x(t)$. [3]

   ii. Find and draw the spectrum of $V(f)$. [3]

   iii. Find and draw the spectrum of $W(f)$. [3]

   iv. Find and draw the spectrum of $Y(f)$. [3]

   v. Calculate the energies of *v(t)* and *y(t)* [3]

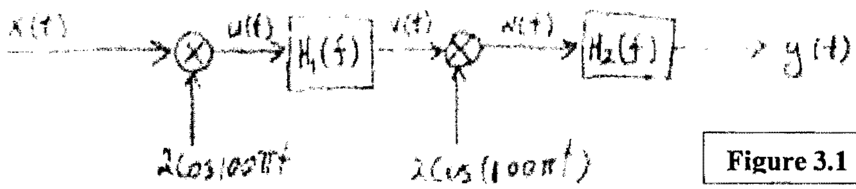

Figure 3.1

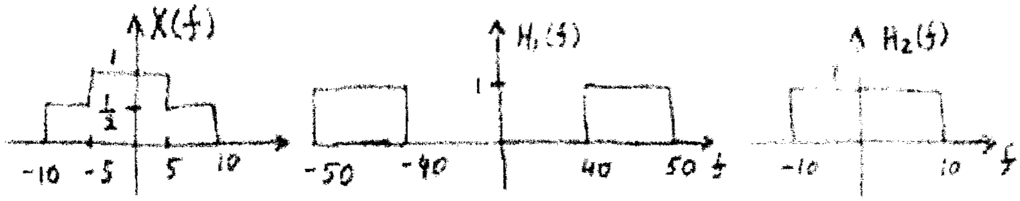

Figure 3.2

Question 4 [25]

a) A double-sided band suppressed carrier (DSB-SC) signal, *s(t)*, with a carrier frequency of 3.8 MHz has a complex envelop $g(t) = A_c m(t)$. $A_c = 50V$, and the modulation is a 1kHz sinusoidal test tone described by $m(t) = 2\sin(2\pi 1000t)$.

   i. Evaluate the voltage spectrum for this DSB-SC signal. [7]

   ii. Assume that *s(t)* appear across a 50Ω resistive load, compute actual average power dissipated in the load. [5]

   iii. And compute the actual PEP. [3]

b) An FM radio is tuned to receive an FM broadcasting station of frequency 96.9 MHz. The radio is of the superheterodyne type with the LO operating on the high side of the 96.9 MHz input and using a 10.7 MHz IF amplifier.

   i. Determine the LO frequency. [3]

   ii. If the FM signal has a bandwidth of 180 kHz, determine the filter characteristics for the RF and IF filters. [4]

   iii. Calculate the frequency of the image response. [3]

Question 5 [25]

a) An FM has a block diagram as shown in figure 5.1. The audio frequency response is flat over the 20 Hz to 15 kHz audio band. The FM output signal is to have a carrier frequency of 103.7 MHz and a peak deviation of 75 kHz.

i. Find the bandwidth and center frequency required for the band pass filter. [5]

ii. Calculate the frequency f_0 of the oscillator. [4]

iii. What is the required peak deviation capability of the FM exciter? [3]

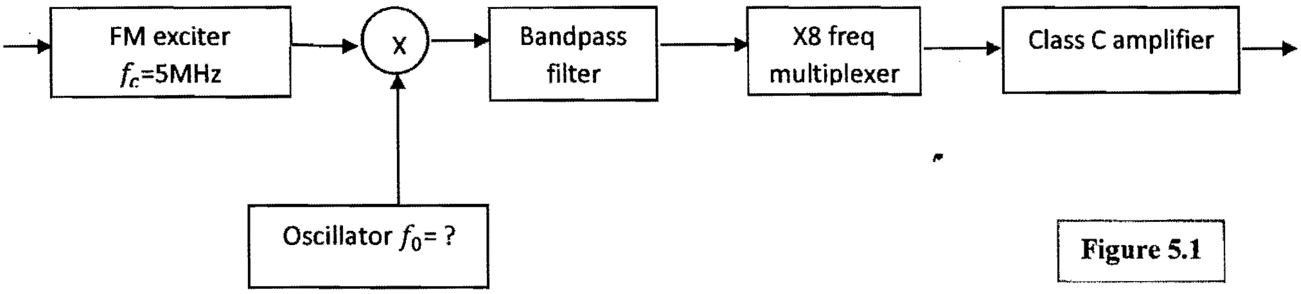

Figure 5.1

b) A 50,000W AM broadcast transmitter is being evaluated by means of a two-tone test. The transmitter is connected to a 50 Ω load and $m(t) = A_1 \cos(\omega_1 t) + A_1 \cos(2\omega_1 t)$, where $f_1 = 500\ Hz$. Assume that a perfect AM signal is generated.

i. Evaluate the complex envelop for the AM signal in terms of A_1 and ω_1. [3]

ii. Determine the value of A_1 for 90% modulation. [7]

iii. Find the values for the peak current and average current into the 50 Ω load for the 90% modulation case. [3]

Type of Modulation	Mapping Functions $g(m)$	Corresponding Q
		$x(t)$
AM	$A_c[1 + m(t)]$	$A_c[1 + m(t)]$
DSB-SC	$A_c m(t)$	$A_c m(t)$
PM	$A_c e^{jD_p m(t)}$	$A_c \cos[D_p m(t)]$
FM	$A_c e^{jD_f \int_{-\infty}^{t} m(\sigma)\, d\sigma}$	$A_c \cos\left[D_f \int_{-\infty}^{t} m(\sigma)\, d\sigma\right]$
SSB-AM-SC[b]	$A_c[m(t) \pm j\hat{m}(t)]$	$A_c m(t)$
SSB-PM[b]	$A_c e^{jD_p[m(t) \pm j\hat{m}(t)]}$	$A_c e^{\mp D_p \hat{m}(t)} \cos[D_p m(t)]$
SSB-FM[b]	$A_c e^{jD_f \int_{-\infty}^{t} [m(\sigma) \pm j\hat{m}(\sigma)]\, d\sigma}$	$A_c e^{\mp D_f \int_{-\infty}^{t} \hat{m}(\sigma)\, d\sigma} \cos\left[D_f \int_{-\infty}^{t} m(\sigma)\, d\sigma\right]$
SSB-EV[b]	$A_c e^{\{\ln[1+m(t)] \pm j\hat{\ln}[1+m(t)]\}}$	$A_c[1 + m(t)] \cos\{\hat{\ln}[1 + m(t)]\}$
SSB-SQ[b]	$A_c e^{(1/2)\{\ln[1+m(t)] \pm j\hat{\ln}[1+m(t)]\}}$	$A_c \sqrt{1 + m(t)} \cos\{\frac{1}{2} \hat{\ln}[1 + m(t)]\}$
QM	$A_c[m_1(t) + jm_2(t)]$	$A_c m_1(t)$

TABLE 4–1 COMPLEX ENVELOPE FUNCTIONS FOR VARIOUS TYPES OF MODULATION *(cont.)*

Type of Modulation	Corresponding Amplitude and Phase Modulation		Linearity
	$R(t)$	$\theta(t)$	
AM	$A_c\lvert 1 + m(t)\rvert$	$\begin{cases} 0, & m(t) > -1 \\ 180^\circ, & m(t) < -1 \end{cases}$	L[c]
DSB-SC	$A_c\lvert m(t)\rvert$	$\begin{cases} 0, & m(t) > 0 \\ 180^\circ, & m(t) < 0 \end{cases}$	L
PM	A_c	$D_p m(t)$	NL
FM	A_c	$D_f \int_{-\infty}^{t} m(\sigma)\, d\sigma$	NL
SSB-AM-SC[b]	$A_c\sqrt{[m(t)]^2 + [\hat{m}(t)]^2}$	$\tan^{-1}[\pm\hat{m}(t)/m(t)]$	L
SSB-PM[b]	$A_c e^{\pm D_p \hat{m}(t)}$	$D_p m(t)$	NL
SSB-FM[b]	$A_c e^{\pm D_f \int_{-\infty}^{t} \hat{m}(\sigma)\, d\sigma}$	$D_f \int_{-\infty}^{t} m(\sigma)\, d\sigma$	NL
SSB-EV[b]	$A_c\lvert 1 + m(t)\rvert$	$\pm\hat{\ln}[1 + m(t)]$	NL
SSB-SQ[b]	$A_c\sqrt{1 + m(t)}$	$\pm\frac{1}{2} \hat{\ln}[1 + m(t)]$	NL
QM	$A_c\sqrt{m_1^2(t) + m_2^2(t)}$	$\tan^{-1}[m_2(t)/m_1(t)]$	L