MACHAKOS UNIVERSITY

University Examination 2018/2019

SCHOOL OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

FOURTH YEAR SECOND SEMESTER EXAMINATION FOR

BACHELOR OF SCIENCE (ELECTRICAL AND ELECTRONICS ENGINEERING)

EEE 401: COMMUNICATION SYSTEMS II

DATE: 15/5/2019 **TIME: 8.30-10.30 AM**

INSTRUCTIONS

Answer Question ONE and any other TWO Questions.

QUESTION ONE (30 MARKS)

a) Define the follwoing terms in relation to pulse code modelation systems. Use sketches where applicable to expound your explanation. (4 marks)

i. Natural sampling

ii. Flat-top sampling

iii. Nyquist sampling rate

iv. Quantization

b) Draw the block diagram of a PCM system and explain the function of each block. (8 marks)

c) List the advantages and disadvantages of digital transmission. (4 marks)

d) List the different analogue pulse modulation systems and explain their working briefly using appropriate sketches. (6 marks)

e) The frequency which, under the sampling theorem, must be exceeded by the sampling frequency is called the Nyquist rate. Determine the Nyquist rate corresponding to each of the following signals. (4 marks)

(a) $3\cos 50\pi t + 10\sin 300\pi t - \cos 100\pi t$

(b) $\text{sinc}(200t)$

(c) $\text{sinc}^2(200t)$

(d) $\text{sinc}(200t) + \text{sinc}^2(200t)$

f) A PCM signal is sampled and encoded into 4-bits per sample. If the minimum sampling rate used is 8kHz, calculate (4 marks)

i. the frequency of the information signal

ii. the quantization level.

iii. the transmission rate

iv. The transmission bandwidth

QUESTION TWO (20 MARKS)

a) Find the Nyquist sampling rate for the signal below. (5 marks)

$$x(t) = \text{sinc}(200t)\,\text{sinc}^2(1000t)$$

b) Let $x(t)$ be modeled as the sample function of a zero mean stationary process $X(t)$ with a uniform PDF, in the range $(-a, a)$. Find the (SNR) 0, q assuming an R -bit code word per sample. (5 marks)

c) Consider bandpass digital transmission. Suppose that we are given a transmission bandwidth of 10MHz. Calculate the bit rate for each of the schemes below. (10 marks)

i. Binary PSK, full-width rectangular pulse.

ii. Binary ASK, half-width rectangular pulse.

iii. 16-ary PAM, full-width rectangular pulse.

iv. 64-ary QAM, full-width rectangular pulse.

v. 64-ary QAM, the sinc pulse g(t) = sinc(t=T)

QUESTION THREE (20MARKS)

a) Discuss briefly the different digital modulation techniques below under the following sub-headings:

i. How it works

ii. Demodulation

iii. Advantages

iv. Disadvantages

v. Application

I. ASK

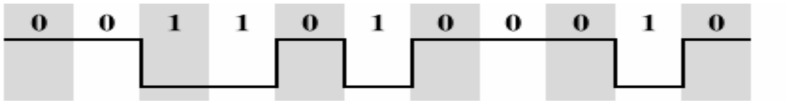
II. PSK

III. FSK

IV. QPSK

V. QAM (15 marks)

b) Show how the digital signal below would look like if it is modulated using ASK, BFSK and BPSK. (5 marks)

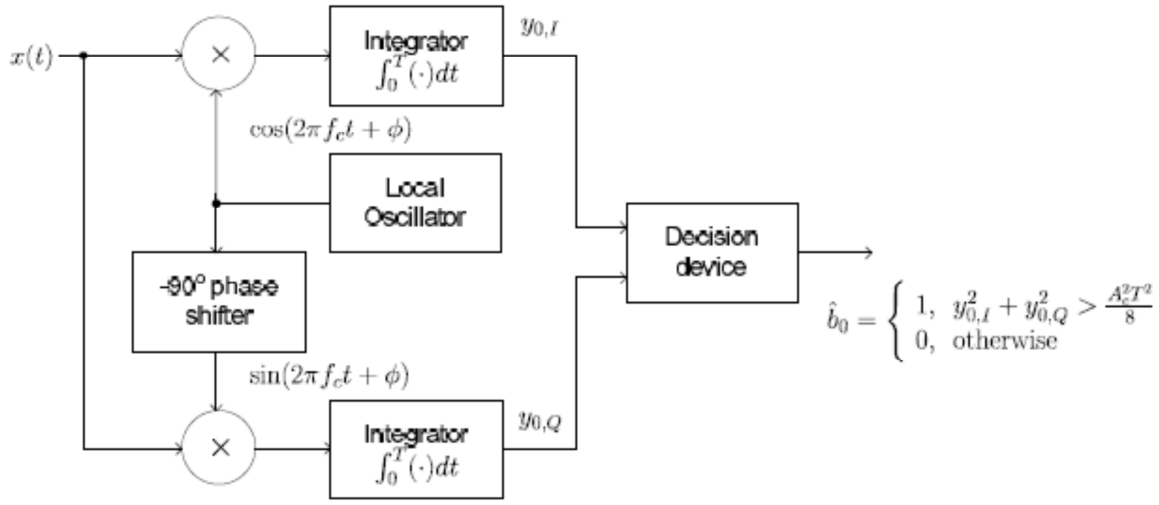


QUESTION FOUR (20 MARKS)

a) Consider ASK. For the 0th symbol interval, 0 <t < T, the received signal is modeled as:

$$x(t) = \begin{cases} A_c \cos(2\pi f_c t) + \eta(t), & b_0 = 1 \\ \eta(t), & b_0 = 0 \end{cases}.$$

The carrier frequency f_c is assumed to satisfy $f_c = \frac{m}{T}$ for some integer *m*. Can the system in Figure below detect the bit b_0? If yes, is the system a coherent detector, or non-coherent? In the figure below, ϕ denotes the phase error of the local oscillator at the receiver. Provide your answer with justification, for example, by checking the case of $b_0 = 1$ and $b_0 = 0$ respectively. For ease of exposition you may assume the noiseless case. (5 marks)



b) A television signal (video and audio) has a bandwidth of 4.5 MHz. This signal is sampled, quantized, and binary coded to obtain a PCM signal.

i. What is the sampling rate if the signal is to be sampled at a rate 20% above the Nyquist rate.

ii. If the samples are quantized into 1024 levels, determine the number of binary pulses required to encode each sample.

iii. Determine the binary pulse rate (bits per second) of the binary-coded signal, and the minimum bandwidth required to transmit this signal. (5 marks)

c) Five telemetry signals, each of bandwidth 1 kHz, are to be transmitted simultaneously by binary PCM. The maximum tolerable error in sample amplitudes is 0.2% of the peak signal amplitude. The signals must be sampled at least 20% above the Nyquist rate. Framing and synchronizing requires an additional 0.5% extra bits. Determine the minimum possible data rate (bits per second) that must be transmitted, and the minimum bandwidth required to transmit this signal. (5 marks)

d) A signal in the frequency range 300 to 3300 Hz is limited to a peak-to-peak swing of 10V. It is sampled at 8000 samples/s and the samples are quantized to 64 evenly spaced levels. Calculate and compare the bandwidths and ratio of peak signal power to rms quantization noise if the quantized samples are transmitted either as binary pulses or as four-level pulses. Assume that the system bandwidth is defined by the main spectral lobe of the signal. (5 marks)

QUESTION FIVE (20 MARKS)

a) A compact disc (CD) records audio signal digitally by using PCM. Assume the audio signal bandwidth to be 15 kHz.

i. What is the Nyquist rate?

ii. If the Nyquist samples are quantized into L= 65,536 levels and then binary coded, determine the number of binary digits required to encode a sample.

iii. Determine the number of binary digits per second (bit/s) required to encode the audio signal.

iv. For practical reasons, signals are sampled at a rate well above the Nyquist rate. Practical CDs use 44,100 samples per second. If L = 65; 536, determine the number of bits per second required to encode the signal. (5 marks)

b) Consider FDM. Suppose that the total transmission bandwidth of the system is 2MHz, and each message signal has bandwidth 20kHz and maximum amplitude = 5. What is the maximum number of message signals we can support if:

i. DSB-SC is employed at each subcarrier;

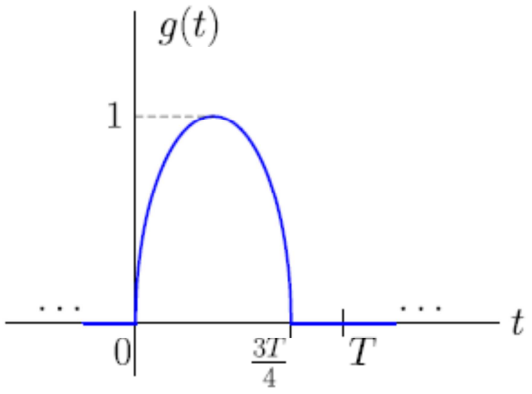
ii. SSB is employed at each subcarrier;

iii. QAM is employed at each subcarrier;

iv. FM with frequency sensitivity k_f = 96; 000 is employed at each subcarrier.

(5 marks)

c) Sketch a PAM waveform under the assumption that 8-ary PAM is adopted. The pulse shape and the bit-to-symbol map is shown below. The bit stream is converted from your student ID. For example, suppose your student ID is 1155123456. Take the first nine digit, 115512345, and for each digit convert it to 0 if the number is less than or equal to 4, and 1 otherwise. So, from 115512345, we get 001100001 as the bit stream. (10 marks)



(a)

a_n	$b_{3n}, b_{3n+1}, b_{3n+2}$
-7	000
-5	001
-3	011
-1	010
+1	110
+3	111
+5	101
+7	100

(b)

You may sketch on the graph provided below.