MACHAKOS UNIVERSITY

University Examinations for 2019/2020Academic Year

SCHOOL OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

FOURTH YEAR SECOND SEMESTER EXAMINATION FOR

BACHELOR OF SCIENCE IN ELECTRICAL AND ELECTRONICS ENGINEERING

EEE 401: COMMUNICATION SYSTEMS II

DATE: 16/11/2020 **TIME: 8.30-10.30 AM**

INSTRUCTIONS

Answer Question One and Any Other Two Questions

QUESTION ONE (30 MARKS) COMPULSORY

a) Draw constellation diagrams for the following modulation schemes:

i. BPSK

ii. Q-PSK

iii. Binary ASK

iv. 32 –QAM (2 marks)

b) State four benefits of a digital communication system (4 marks)

c) Define the following terms

i. Quantization

ii. Encoding (4 marks)

d) Explain the term intersymbol interference (ISI) and describe how an equalizer can be used to counter the effect of ISI. Use diagrams for illustration. (3 marks)

e) Suppose the spectrum of a channel is between 5 MHz and 20 MHz, and SNR_{dB} = 22dB.

i. Calculate the capacity limit of the channel

ii. Use Nyquist formula to calculate the required number of signaling levels to achieve the limit. (4 marks)

f) State two advantages of spread spectrum (2 marks)

g) Briefly describe the operation of direct sequence spread spectrum (4 marks)

h) Briefly explain the basic principle behind text compression. (4 marks)

i) There are three major types of speech coders. State the type of coders represented by A, B, and C in Fig 1(j). (3 marks)

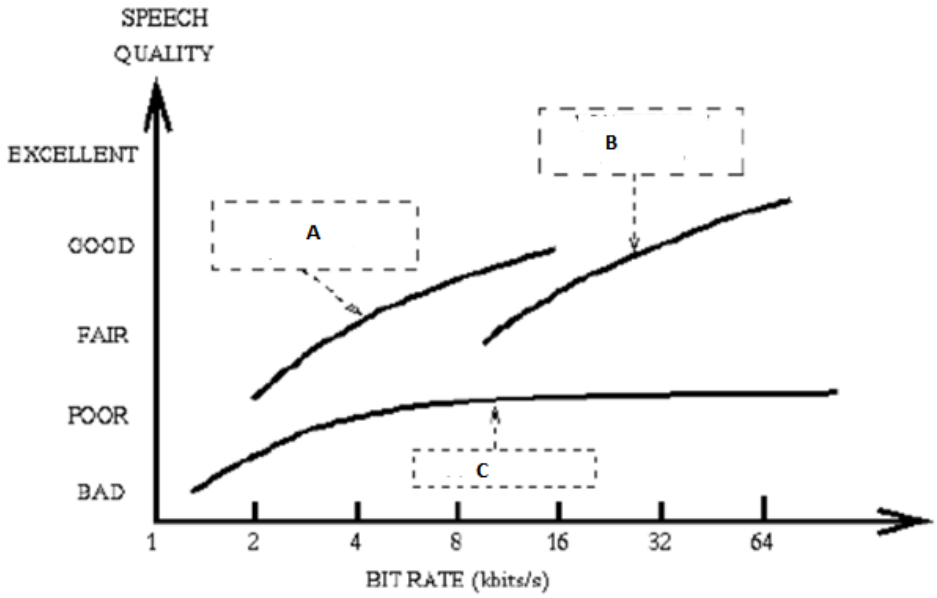

Figure 1(j) (3 marks)

QUESTION TWO (20 MARKS)

a) With the aid of a diagram, explain how a signal is sampled, quantized and encoded.(4 marks)

b) The information in an analog waveform with maximum frequency f_m=6kHz is to be transmitted over an M-ary PAM system where the number of pulse levels is M=32. The quantization distortion is specified not to exceed ±2% of the peak to peak analog signal.

i. What is the maximum number of bits/sample or bits/PCM word that should be used in digitizing the analog waveform?

ii. What is the minimum required sampling rate and what is the resulting transmission rate?

iii. What is the PAM pulse or symbol transmission rate?

iv. If the transmission bandwidth (including filtering) equals 12kHz, determine the bandwidth efficiency of the system? (6 marks)

c) A voice signal (300 to 3300 Hz) is digitized such that quantization distortion is ≤ ±1% of the peak-to-peak signal voltage. Assume a sampling rate of 16000 samples/s and multi-level PAM waveform with M=16 levels. Find the theoretical minimum system bandwidth that

avoids ISI. (4 marks)

d) A voice signal in the range of 300 to 3300 Hz is sampled at 8000 samples/s. We may transmit signals directly as PAM pulses or we may first convert each sample to a PCM format and use binary (PCM) waveforms for transmission.

i. What is the minimum bandwidth required for detection of PAM with no ISI and with a filter roll-off characteristic of r=2?

ii. Using the same roll-off characteristic, what is the minimum bandwidth required for detection of binary (PCM) waveforms if the samples are quantized to eight levels.

iii. Repeat part (b) using 256 quantization levels. (6 marks)

QUESTION THREE (20 MARKS)

a) Explain two advantages of bandpass modulation. (4 marks)

b) If bit rate for is 10 Mbps, calculate the baud/symbol rate and state the required bandwidth for:

i. BPSK

ii. 16-PSK

iii. 16-QAM

iv. 8-FSK (4 marks)

c) Find the number of expected bit errors made in one day by following continuously operating BPSK receiver. The data rate is 3000 bits/s. The input digital waveforms are $s_1(t)=A\cos\omega_o t$ and $s_2(t)=-A\cos\omega_o t$ where A=2 mV and the single sided noise power spectral density is $N_o = 10^{-12}$ W/Hz. Assume that signal power and energy per bit are normalized relative to 1-ohm resistive load. (6 marks)

d) A bit error probability of $P_B = 10^{-5}$ is for a system with data rate of 100kbits/s to be transmitted over an AWGN channel using coherently detected MPSK modulation. The system bandwidth is 50kHz. Assume that the system frequency transfer function is a raised cosine filter with a roll-off characteristic or r=1 and is used for symbol to bit assignment.

i. What E_s/N_o is required for the specified P_B?

ii. What E_b/N_o is required?

For MPSK $P_E = 2Q\left(\sqrt{\frac{2E_s}{N_o}}Sin\left(\frac{\pi}{M}\right)\right)$ (6 marks)

QUESTION FOUR (20 MARKS)

a) Explain the difference between the following:

i. Waveform coders and vocoders

ii. Linear predictive coder LPC and codebook excited LPC. (4 marks)

b) State two wireless technologies that use:

i. Frequency hopping spread spectrum

ii. Direct sequence spread spectrum (4 marks)

c) Draw a diagram showing the general model of a spread spectrum system. (3 marks)

d) Briefly explain the operation of frequency hopping spread spectrum. (3 marks)

e) There are 11 equal-power terminals in CDMA communication system, transmitting signals toward a central node. Each terminal transmits information at 1kbits/s on a 100 kchips/s direct sequence spreading signal using BPSK.

i. If the receiver noise is negligible with respect to interference to from other users, what is the ration of bit energy to interference power spectral density (E_b/I_o) received by a receiving terminal?

ii. What is the effect of E_b/I_o if all users double their output power?

iii. If the users wish to expand their service to 101 equal power users, what must be done to the spreading codes to maintain original Eb/Io ratio? (6 marks)

QUESTION FIVE (20 MARKS)

a) Explain the difference between lossy and lossless compression.(2 marks)

b) The generator matrix of (7,4) linear block code is given as:

$$G=\begin{pmatrix}1&1&1&1&0&0&0\\1&0&1&0&1&0&0\\0&1&1&0&0&1&0\\1&1&0&0&0&0&1\end{pmatrix}.$$

i. Find all the valid codewords. (3 marks)

ii. Find H, the parity check matrix of the code. (2 marks)

iii. Compute the syndrome for the received vector [1 1 0 1 1 0 1]. Is this a valid codeword? (2 marks)

iv. What is the error correcting capability of the code? (1 mark)

v. What is the error detecting capability of the code? (1 mark)

c) Consider the table 5(c)

Table 5(c)

X_i	$P(X_i)$	BCD word
A	0.30	000
B	0.10	001
C	0.02	010
D	0.15	011
E	0.40	100
F	0.03	101

i. A source emits symbols Xi, $1 \leq i \leq 6$, in the BCD format with probabilities P(Xi) as given in Table 1, at a rate Rs = 9.6 kbaud (baud=symbol/second). State the information rate and the data rate of the source. (2 marks)

ii. Apply Shannon-Fano coding to the source signal characterised in Table 5(c). Are there any disadvantages in the resulting code words? (2 marks)

iii. What is the original symbol sequence of the Shannon-Fano coded signal 110011110000110101100? (2 marks)

iv. What is the data rate of the signal after Shannon-Fano coding? What compression factor has been achieved? (2 marks)

v. Derive the coding efficiency of both the uncoded BCD signal as well as the Shannon-Fano coded signal.
(1 mark)