



MACHAKOS UNIVERSITY

University Examinations for 2019/2020 Academic 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)

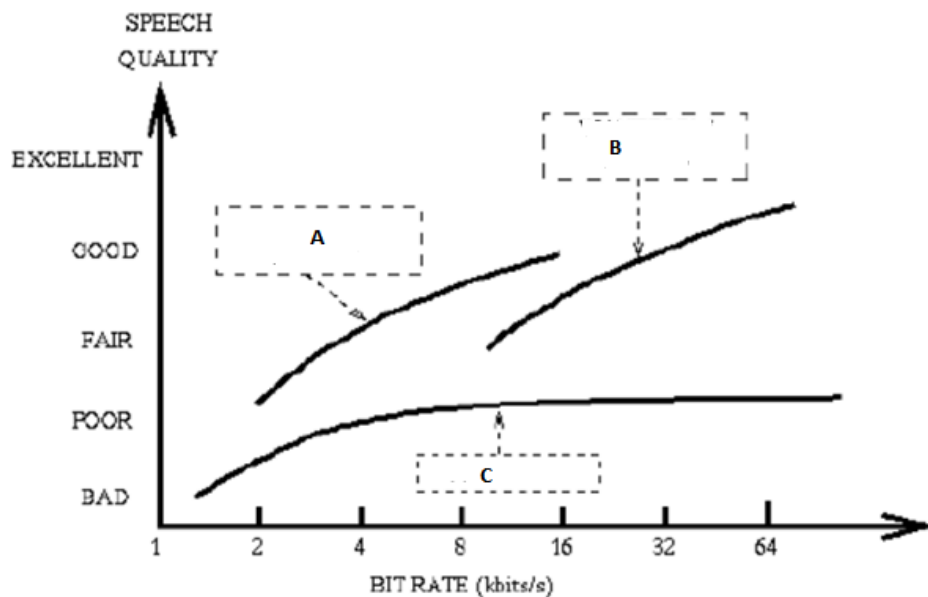


Figure 1(j)

(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 $f_m = 6\text{kHz}$ 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 $\pm 2\%$ of the peak to peak analog signal.
- What is the maximum number of bits/sample or bits/PCM word that should be used in digitizing the analog waveform?
 - What is the minimum required sampling rate and what is the resulting transmission rate?
 - What is the PAM pulse or symbol transmission rate?
 - 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 $\leq \pm 1\%$ 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.
- What is the minimum bandwidth required for detection of PAM with no ISI and with a filter roll-off characteristic of $r=2$?
 - 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.
 - Repeat part (b) using 256 quantization levels. (6 marks)

QUESTION THREE (20 MARKS)

- Explain two advantages of bandpass modulation. (4 marks)
- If bit rate for is 10 Mbps, calculate the baud/symbol rate and state the required bandwidth for:
 - BPSK
 - 16-PSK
 - 16-QAM
 - 8-FSK (4 marks)
- 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 $s_1(t)=A\cos\omega_0t$ and $s_2(t)=-A\cos\omega_0t$ 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)
- A bit error probability of $P_B = 10^{-5}$ is for a system with data rate of 100kbts/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.
 - What E_s/N_o is required for the specified P_B ?
 - What E_b/N_o is required?

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

(6 marks)

QUESTION FOUR (20 MARKS)

- a) Explain the difference between the following:
- Waveform coders and vocoders
 - Linear predictive coder LPC and codebook excited LPC. (4 marks)
- b) State two wireless technologies that use:
- Frequency hopping spread spectrum
 - 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.
- 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?
 - What is the effect of E_b/I_o if all users double their output power?
 - If the users wish to expand their service to 101 equal power users, what must be done to the spreading codes to maintain original E_b/I_o 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:

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

- Find all the valid codewords. (3 marks)
- Find H, the parity check matrix of the code. (2 marks)
- Compute the syndrome for the received vector [1 1 0 1 1 0 1]. Is this a valid codeword? (2 marks)
- What is the error correcting capability of the code? (1 mark)
- 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 X_i , $1 \leq i \leq 6$, in the BCD format with probabilities $P(X_i)$ as given in Table 1, at a rate $R_s = 9.6$ 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)