MACHAKOS UNIVERSITY

University Examinations for 2020/2021

SCHOOL OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

THIRD YEAR FIRST SEMESTER EXAMINATION FOR

BACHELOR OF SCIENCE (TELECOMMUNICATION AND INFORMATION ENGINEERING)

SPH 405: COMMUNICATION SYSTEMS

DATE: 13/8/2021 **TIME: 8:30 -10:30 AM**

INSTRUCTIONS:

Answer Question One and Any Other Two Questions

QUESTION ONE (30 MARKS) COMPULSORY

a) Explain two benefits of a digital communication system.

(2 marks)

b) State four reasons why modulation is necessary.

(2 marks)

c) Explain the difference between:

i) Pulse amplitude modulation and pulse code modulation.

ii) Baseband signal vs bandpass signal

(4marks)

d) Suppose the spectrum of a channel is between 6 MHz and 9 MHz, and SNR_{dB} = 20dB.

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)

e) Draw constellation diagrams for the following modulation schemes:

i) QPSK

ii) 16 -PSK

iii) Binary ASK

iv) 16 – QAM

(4 marks)

f) Define the following terms:
   i) Noise figure
   ii) Thermal noise

(3 marks)

g) State three advantages of spread spectrum.

(3 marks)

h) Assume that equally-likely return to zero pulses are coherently detected over a Gaussian channel with $N_o = 10^{-8}$ Watt/Hz. Assume that synchronization is perfect, and that the received pulses have an amplitude of 100mV. If the bit error probability specification is $P_B = 10^{-3}$, find the largest data rate that can be transmitted using the system.

(4 marks)

i) Explain the difference between frequency modulation and phase modulation. Use diagrams and formulas for illustration. (4 marks)

QUESTION TWO (20 MARKS)

a) Explain three types of external noise to a communication system. (4 marks)

b) Explain two sources of signal corruption during sampling, quantization and transmission.

(4 marks)

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

(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=1?
   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 128 quantization levels.

(6 marks)

QUESTION THREE (20 MARKS)

a) State one advantage and one disadvantage high order (high M e.g 64-QAM) modulation schemes.

b) Draw an example waveform to show the output modulated signal for the following modulation schemes:
   i. 4-ASK
   ii. PSK
   iii. Q-PSK
   iv. FSK (4 marks)

c) 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)

d) Find the number of expected bit errors made in one day by following continuously operating BPSK receiver. The data rate is 4000 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 = 3 mV and the single sided noise power spectral density is $N_o = 10^{-11}$ W/Hz. Assume that signal power and energy per bit are normalized relative to 1 ohm resistive load. (6 marks)

e) A bit error probability of $P_B = 10^{-5}$ is for a system with data rate of 200kbits/s to be transmitted over an AWGN channel using coherently detected MPSK modulation. The system bandwidth is 60kHz. 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) An FM wave is given by $s(t) = 20cos\left(8\pi \times 10^6 t + 9sin(2\pi \times 10^3 t)\right)$. Calculate the following:
   i. Frequency deviation
   ii. Bandwidth and power of the FM wave.

(4 marks)

b) Explain the frequency discrimination method of demodulating FM signals.

(4 marks)

c) Explain the operation of indirect method of generating a wideband FM signal. (3 marks)

d) Distinguish between direct sequence spread spectrum and frequency hopping spread spectrum. Use diagrams for illustration.

(3 marks)

e) Explain the operation of CDMA network.

(4 marks)

f) State two wireless network technologies that use:
   i. Frequency hopping spread spectrum
   ii. Direct sequence spread spectrum

(2 marks)

QUESTION FIVE (20 MARKS)

a) Explain the operation of the following:
   i. Envelope detector
   ii. Square law modulator

(8 marks)

b) A modulating signal $m(t) = 10cos(2\pi \times 10^3 t)$ is amplitude modulated with a carrier signal $c(t) = 50cos(2\pi \times 10^5 t)$. Calculate the following:
   i. Modulation index
   ii. Carrier power
   iii. Power required for transmitting the AM wave.

(6 marks)

c) The equation of amplitude wave is given by $s(t) = 20[1 + 0.8cos(2\pi \times 10^3 t)]cos(4\pi \times 10^5 t)$. Calculate the following:
   i. Carrier power
   ii. The total sideband power
   iii. Band width of AM wave.

(6 marks)