MURANG'A UNIVERSITY OF TECHNOLOGY

SCHOOL OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

UNIVERSITY ORDINARY EXAMINATION

2021/2022 ACADEMIC YEAR

FOURTH YEAR **SECOND** SEMESTER EXAMINATION FOR BACHELOR OF TECHNOLOGY IN ELECTRICAL AND ELECTRONICS ENGINEERING

EET 414: TELECOMMUNICATION AND INTERNET

DURATION:2 HOURS

Instructions to candidates:

1. Question One is compulsory
2. Attempt any other Two questions in section B
3. Mobile phones are not allowed in the examination room
4. You are not allowed to write on this examination question paper

QUESTION ONE

(a) Differentiate between application layer and transport layer of the internet protocol stack. (2 marks)

(b) A microstrip antenna with a gain of 8 (9.03 dB) on a cubesat transmits with an input power of 1W at 10.0 GHz from a distance of 50,000,000 Km. Calculate the power that will be received by an earth station with dish of diameter 70m. Assume an aperture efficiency of 0.75 (75%). (5 marks)

(c) A modulating signal m(t) is given by:

a) $m(t) = cos100\pi t + 2cos300\pi t$

b) $m(t) = sin100\pi t + sin500\pi t$

In each case:

i) Sketch the spectrum of m(t) (4 marks)

ii) Find and sketch the spectrum of the DSB-SC signal $2m(t)cos1000\pi t$ (4 marks)

iii) From the spectrum obtained in part iii), suppress the LSB spectrum to obtain the USB spectrum. (2 marks)

iv) Knowing the USB spectrum in iii), write the expression φ_{USB}(t) for the USB signal. (2 marks)

(d) The Fourier transform P(f) of the basic pulse p(t) used in a binary communication system is shown in figure 1(d), (***see appendix***)

i) From the shape of P(f), explain at what pulse rate this pulse would satisfy Nyquist first criterion. (3 marks)

ii) Explain why using this pulse does not cause inter bit interference (ISI) (2 marks)

iii) Explain how much the excess bandwidth is and find the roll-off factor. (3 marks)

(e) An angle modulated signal with the carrier frequency ω_c=2πx10^5 is described by:

φ_{FM}=5cos[ω_ct+10sin(200πt)]

i) Find the power of the modulated signal (1 mark)

ii) Find the frequency deviation Δf (2 marks)

QUESTION TWO

(a) The capacity in bits per second of an additive white Gaussian noise (AWGN) channel is

$$C=B log_2(1+\frac{P}{N_0 B})$$

where P is the received signal power, B is the signal bandwidth, and $\frac{N_0}{2}$ is the noise power spectral density (PSD). (The total noise power N_0B). Consider a wireless channel where received power falls off with distance d according to the formula P(d)= $P_t(\frac{d_0}{d})^3$.

Given d_0=10 m, transmitter power P_t= 10 W, .noise PSD=N_0=10^{-9} W/Hz and channel bandwidth B = 30 kHz, find the capacity of this channel for transmitter-receiver distances of 100m and 1Km. (5 marks)

(b) In a PAM scheme with M=16, do the following:

i) Determine the minimum transmission bandwidth required to transmit data at a rate of 12,000 bit/s with zero ISI. (5 marks)

ii) Determine the transmission bandwidth if Nyquist criterion pulses with a roll-off factor r = 0.2 are used to transmit data. (5 marks)

(c) Polar pulses are used to transmit data at a rate of 100 Kbps. The detection error probability is required to be less than 10^{-7}. The rms value of the channel noise at the receiver input is 1 mV. The signal attenuation over the channel is 40 dB:

i) Determine the minimum required pulse amplitude and power at the receiving input. (2 marks)

ii) Determine the minimum signal power that must be transmitted. (2 marks)

ii) Determine the average number of errors in one hour. (1 mark)

QUESTION THREE

(a) The message signal m(t) with power of 20 mWatts is applied to an analog-to digital converter with dynamic range -1 volt to 1 volt.

i) To transmit this signal by PCM, uniform quantization is adopted. If the SQNR is required to be at least 43 dB determine the minimum number of bits required to code the uniform quantizer. (4 marks)

ii) Determine the SNR obtained with a quantizer (2 marks)

iii) Repeat part (i), if μ- law compander is applied with $\mu = 100$ to achieve a uniform quantizer (3 marks)

(b) Assume that the range of frequencies assigned to an AM broadcasting service is from 650 kHz to 1650 kHZ and each station is assigned a bandwidth of 10kHz.

i) Find the maximum number of stations possible (3 marks)

ii) If the intermediate frequency (IF) is 550 kHz, find the frequency range of the local oscillator. (5 marks)

iii) Find the image station for the station transmitting at 1210 kHZ (3 marks)

QUESTION FOUR

(a) Satellite orbits are classified by their distance from the earth's surface:

LEO (low earth orbit or 160-2000Km), MEO (medium earth orbits, 2000 – 20,000 Km), GEO (geostainery earth orbit, 35786 Km). Find the round- trip delay of data sent between satellite and the earth for LEO, MEO and GEO satellite assuming the speed of light is $3x10^8$ m/s. If the maximum acceptable delay for a voice system is 30 ms, determine the satellite system that would be acceptable two-way voice communication. (9 marks)

(b) A balanced mixer modulator exploits a non- linearity to modulate a signal to a carrier frequency. Assume that the non-linearity has a cubic term, so

$y(t)=ax(t)+bx^2(t)+cx^3(t)$

Again assume the inputs are:

$x_1(t)=\cos(2\pi f_c t)+x(t)$

$x_2(t)=\cos(2\pi f_c t) - x(t)$

Determine:

i) The output $y_1(t) - y_2(t)$ of the balanced mixer. (3 marks)

ii) The usability of the mixer. (2 marks)

iii) The output frequencies of the mixer (2 marks)

(c) Given $m(t)= \sin 2000\pi t$, $K_f=200{,}000\pi$, and $K_p=10$. Estimate the bandwidths of $\varphi_{FM}(t)$ and $\varphi_{PM}(t)$ (4 marks)