MACHAKOS UNIVERSITY

University Examinations for 2020/2021

SCHOOL OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

THIRD YEAR FIRST SEMESTER EXAMINATIONS FOR

BACHELOR OF SCIENCE (TELECOMMUNICATION AND INFORMATION TECHNOLOGY)

SPH 310: SIGNAL PROCESSING

DATE: 10/8/2021 **TIME:2:00 – 4:00 PM**

INSTRUCTIONS:

ANSWER QUESTION ONE AND ANY OTHER TWO

QUESTION ONE (COMPULSORY) (30 MARKS)

(a) Differentiate between analog and digital signals. (4 marks)

(b) Explain how Pulse code modulation works. Use suitable sketches to back your explanation. (8 marks)

(c) Compute the energy and power of the signal below. (4 marks)

$$x(t) = e^{-t}u(t)$$

(d) Explain how transmission impairments affect transmission of analog and digital signals. (4 marks)

(e) Assume we want to transmit human voice in digitized form. Prove that channel a whose bit rate is 64Kbps can support such transmission. Explain any assumptions clearly. (4 marks)

(f) A digital signal is designed to permit 160 kbps for a bandwidth of 0.02 MHz. Determine (i) number of signal levels required and (ii) signal to noise ration in decibels. (6 marks)

QUESTION TWO (20 MARKS)

(a) Explain how analog data can be transmitted in a digital transmission system. (4 marks)

(b) Compute the energy and the power of the signal given below. (6 marks)

$$x(n) = \left(\frac{1}{4}\right)^n u(n)$$

(c) Noise in communication channels can be categorized into thermal Noise, Intermodulation Noise, Cross talk, and Impulse Noise. Describe each of these noise types briefly. (6 marks)

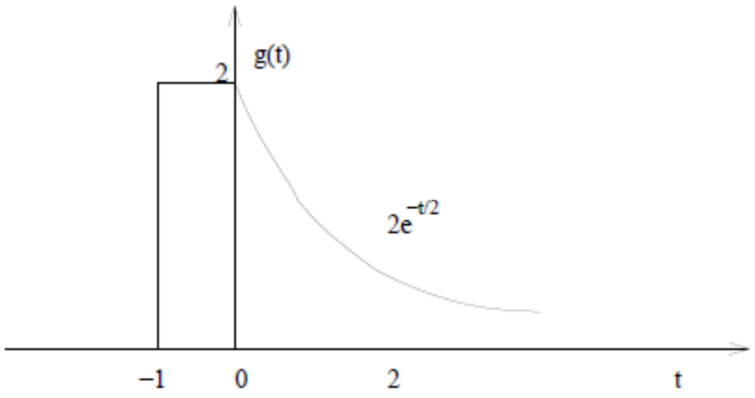
(d) Explain the Fourier series representation of periodic composite signals. (4 marks)

QUESTION THREE (20 MARKS)

(a) Explain the following as they relate to analog signals. (3 marks)

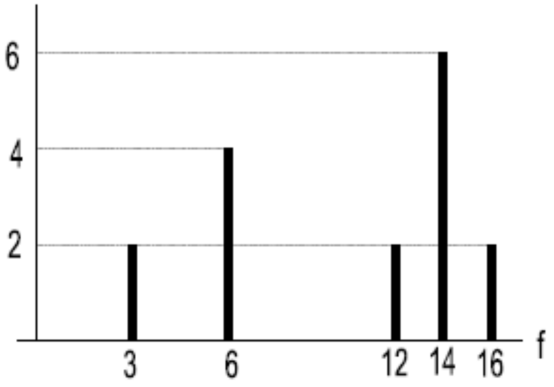
i) Frequency Spectrum
ii) Absolute Bandwidth
iii) Effective Bandwidth

(b) Determine the energy of the signal whose profile is given below. (5 marks)



(c) Given the frequency-domain graph below, answer the following questions:

i) What is the frequency spectrum?
ii) What is the bandwidth?
iii) Is this an analog or digital signal? Why? (6 marks)



(d) Claude Shannon (then at Bell Telephone Laboratories) discovered an equation that gives the highest possible channel capacity of a communication system that can be achieved in the presence of noise (white Gaussian noise to be specific). The equation is known as the Shannon channel capacity relationship, where B is the channel bandwidth (in Hz) and SNR is signal-to-noise as a power ratio. In the equation the SNR is a numerical value in the equation; but SNR is generally stated in decibels. Consider the old landline telephone communication system with a bandwidth B = (3,400– 300) Hz = 3,100 Hz. The telephone system is generally assumed to require a SNR of at least 3162 to operate without unacceptable bit errors. Calculate the maximum channel transmission capacity C as predicted by the Shannon equation. Also determine the required number of signal levels for the capacity obtained. (6 marks)

QUESTION FOUR (20 MARKS)

(a) Differentiate between a low-pass channel and a band-pass channel. Use sketches to back your explanation. (2 marks)

(b) Discuss the following digital modulation schemes. Explain the working principle, application and then their merits and demerits. (12 marks)
i) Amplitude shift keying (ASK)
ii) Frequency shift keying (FSK)
iii) Phase shift keying (PSK)

(c) In practice, the de-emphasis filter in an FM receiver is often a simple resistance capacitance (RC) circuit with transfer function:

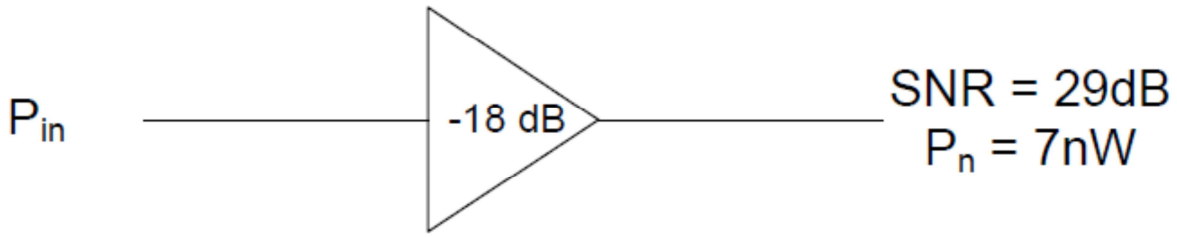
$$H_{de}(f) = \frac{1}{1 + j2\pi fRC}$$

i) Calculate the 3-dB bandwidth and equivalent bandwidth. (3 marks)

ii) Suppose the modulating signal has bandwidth W, the carrier amplitude is A, and the single-sided power spectral density of the white Gaussian noise is N_0. Compute the noise power at the output of the de-emphasis filter. (3 marks)

QUESTION FIVE (20 MARKS)

(a) For the system given below, what is the minimum required signal power (P_{in}) to achieve the desired Signal to Noise ratio. (5 marks)



(b) A single-sideband (SSB) signal is transmitted over a noisy channel, with the power spectral density of the noise given by:

$$\mathbb{S}(f) = \begin{cases} N_o\left(1 - \frac{|f|}{B}\right), & |f| < B \\ 0, & \text{otherwise} \end{cases}$$

where B = 200 kHz and No = 10^{-9} W/Hz. The message has bandwidth 10kHz and average power 10 W. The carrier amplitude at the transmitter is 1 V. Assume the channel attenuates the signal power by a factor of 1000, i.e., 30 decibel (dB). Assume the lower sideband (LSB) is transmitted and a suitable bandpass filter is used at the receiver to limit the out-of-band noise. Determine the predetection SNR at the receiver if

i) the carrier frequency is 100 kHz;

ii) the carrier frequency is 200 kHz. (10 marks)

(c) For the signal given by the formula:

$$\mathbf{v(t) = 10Vsin(2\,\pi\,450t) + 3Vsin(2\,\pi\,600t + 300^{o}) + 7Vsin(2\pi1100t)}$$

i) What is the minimum sampling rate that could be used to transmit this signal digitally such that a receiver could accurately reconstruct the signal?

ii) If the signal were mapped by a 5-bit quantizer with a resolution of 1V, what would this imply is the minimum voltage found in the waveform?

iii) Given your above answer, what bit stream would be generated by the sampled point (2.5s, -11.6V)? (5 marks)