TECHNICAL UNIVERSITY OF MOMBASA

FACULTY OF ENGINEERING & TECHNOLOGY

DEPARTMENT OF ELECTRICAL & ELECTRONIC ENGINEERING

UNIVERSITY EXAMINATION FOR:

BACHELOR OF SCIENCE (ELECTRICAL & ELECTRONIC ENGINEERING)

EEE 2313 : SIGNALS & COMMUNICATION I

END OF SEMESTER EXAMINATION

SERIES : MAY 2016

TIME: 2 HOURS

DATE: Pick DateSelect MonthPick Year

Instructions to Candidates
You should have the following for this examination
-*Answer Booklet, examination pass and student ID*
This paper consists of FIVE questions. Attempt **Question ONE (Compulsory)** and any other **TWO Questions**
Do not write on the question paper.

Question ONE (Compulsory)

a. Define the following terms as used in signals and communication:
   i. Time convolution theorem
   ii. Time invariance
   iii. Superposition theorem (5 marks)

b. i. Let *x(t)* be the complex exponential signal

$$x(t) = e^{j\omega_0 t}$$

With radian frequency ω_0 and fundamental period $T_0 = 2\pi/\omega_0$. Consider the discrete-time sequence *x[n]* obtained by uniform sampling of *x(t)* with sampling interval T_s. That is,

$$x[n] = x(nT_s) = e^{j\omega_0 nT_s}$$

Find the condition on the value of T_s so that *x[n]* is periodic.

ii. Find the even and odd components of $x(t) = e^{jt}$

(6 marks)

c. Find and sketch the Fourier transform of the rectangular pulse signal x(t) (Figure Q1) defined by $x(t) = p_a(t) = \begin{cases} 1, & |t| < a \\ 0, & |t| > a \end{cases}$

(4 marks)

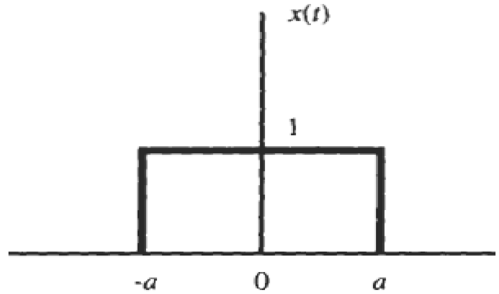

Figure Q1

d. Explain the following transmission effects using appropriate sketches:
   i. Amplitude distortion
   ii. Phase distortion

(5 marks)

e. i. State the sampling theorem

   ii. Distinguish between sampling and quantization (4 marks)

f. i. Pulse code modulation has emerged as the preferred method of modulation for the transmission of analogue message signals. Highlight three reasons to support this statement.

   ii. Describe **TWO** primary resources employed in communication systems and the major underlying design objective with regard to these resources.

(6 marks)

Question TWO

a. The system shown in **Figure Q2** is formed by connecting two systems in ***cascade.*** The impulse responses of the systems are given by $h_1(t)$ and $h_2(t)$ respectively, and

$$h_1(t) = e^{-2t}u(t) \qquad h_2(t) = 2e^{-t}u(t)$$

   i. Find the impulse response ***h(t)*** of the overall system.
   ii. Determine if the overall system is **BIBO** stable. (10 marks)

Figure Q2

b. Let H represent a discrete-time LTI system. Then show that

$$H\{z^n\} = \lambda z^n$$

where z is a complex variable and λ is a complex constant.

(8 marks)

c. Sketch the following CT signal:

$$x(t) = u(t) + 2u(t-3) - 2u(t-6) - u(t-9);$$ (2 marks)

Question THREE

a. Using the partial method, calculate the inverse CTFT of the following function:

$$X(\omega) = \frac{5(j\omega)+30}{(j\omega)^3 + 17(j\omega)^2 + 80(j\omega) + 100}$$

(10 marks)

b. State the Dirichlet conditions that a periodic signal x(t) must satisfy for it to have a Fourier series representation.

(3 marks)

c. For a distortionless transmission through an LTI system, show that the amplitude of H(ω) must be a constant over the entire frequency range and the phase of H(ω) must be linear with frequency. Use diagrams to illustrate your answer.

(7 marks)

Question FOUR

a. In the absence of an input signal, the carrier output from a distortionless frequency modulator has a frequency of 12 MHz and amplitude of 5.0 V peak. An input signal causes a frequency deviation of 25 kHz per volt. If the expression for the modulated wave at the output when the signal $v = 1.5 \sin 6280t$ volts is applied at the input, is given by $v_c = V_c\lfloor \omega_c t - m_f \cos\omega_m t \rfloor$, where $m_f = \frac{\Delta f_c}{f_m}$ is the modulation index, deduce:

i. the peak phase deviation of the modulated carrier

ii. the number of times in each second that this deviation occurs

iii. the peak frequency and phase deviations if the signal frequency is halved

iv. the peak frequency deviation if the signal amplitude is doubled.

(8 marks)

b. i. Describe with the aid of a block diagram, a TDM system using PCM to transmit four telephone signals along one physical circuit.

ii. Estimate the number of bits per second required if each signal contains frequencies between 0 and 3kHz and is quantized into 64 levels.

(12 marks)

Question FIVE

a. i. Explain why a single-sideband transmission is commonly used for multichannel line telephony and point-to-point radio circuits

ii. Outline **TWO** methods of producing a single-sideband signal

(10 marks)

b. i. Describe with the aid of a diagram, the envelope detector that employs a diode with an RC load.

ii. Discuss the merits in radio receivers of an envelope detector in (i) above.

(10 marks)

Table 1 CTFT pairs for elementary CT signals

CT signals	Time domain $x(t) = \frac{1}{2\pi}\int_{-\infty}^{\infty} X(\omega)e^{j\omega t}dt$	Frequency domain $X(\omega) = \int_{-\infty}^{\infty} x(t)e^{-j\omega t}dt$	Comments
(1) Constant	1	$2\pi\delta(\omega)$	
(2) Impulse function	$\delta(t)$	1	
(3) Unit step function	$u(t)$	$\pi\delta(\omega) + \frac{1}{j\omega}$	
(4) Causal decaying exponential function	$e^{-at}u(t)$	$\frac{1}{a + j\omega}$	$a > 0$
(5) Two-sided decaying exponential function	$e^{-a\|t\|}$	$\frac{2a}{a^2 + \omega^2}$	$a > 0$
(6) First-order time-rising causal decaying exponential function	$te^{-at}u(t)$	$\frac{1}{(a + j\omega)^2}$	$a > 0$
(7) Nth-order time-rising causal decaying exponential function	$t^n e^{-at}u(t)$	$\frac{n!}{(a + j\omega)^{n+1}}$	$a > 0$
(8) Sign function	$\text{sgn}(t) = \begin{cases} 1 & t > 0 \\ -1 & t < 0 \end{cases}$	$\frac{2}{j\omega}$	
(9) Complex exponential	$e^{j\omega_0 t}$	$2\pi\delta(\omega - \omega_0)$	
(10) Periodic cosine function	$\cos(\omega_0 t)$	$\pi[\delta(\omega - \omega_0) + \delta(\omega + \omega_0)]$	
(11) Periodic sine function	$\sin(\omega_0 t)$	$\frac{\pi}{j}[\delta(\omega - \omega_0) - \delta(\omega + \omega_0)]$	
(12) Causal cosine function	$\cos(\omega_0 t)u(t)$	$\frac{\pi}{2}[\delta(\omega - \omega_0) + \delta(\omega + \omega_0)] + \frac{j\omega}{\omega_0^2 - \omega^2}$	
(13) Causal sine function	$\sin(\omega_0 t)u(t)$	$\frac{\pi}{2j}[\delta(\omega - \omega_0) - \delta(\omega + \omega_0)] + \frac{\omega_0}{\omega_0^2 - \omega^2}$	
(14) Causal decaying exponential cosine function	$e^{-at}\cos(\omega_0 t)u(t)$	$\frac{a + j\omega}{(a + j\omega)^2 + \omega_0^2}$	$a > 0$
(15) Causal decaying exponential sine function	$e^{-at}\sin(\omega_0 t)u(t)$	$\frac{\omega_0}{(a + j\omega)^2 + \omega_0^2}$	$a > 0$
(16) Rectangular function	$\text{rect}\left(\frac{t}{\tau}\right) = \begin{cases} 1 & \|t\| \le \tau/2 \\ 0 & \|t\| > \tau/2 \end{cases}$	$\tau\,\text{sinc}\left(\frac{\omega\tau}{2\pi}\right)$	$\tau \neq 0$