Birla Institute of Technology and Science, Pilani.

Comprehensive Examination: EEE F243/ INSTR F243: Signals and Systems

Marks: 90 **AY: 2016-17, Semester: II** **Date: 11-May-2017, Thursday**

Time: 180 minutes **CLOSE BOOK** **Pages: 02**

Note: Neat and legible figures must be drawn wherever mentioned with all credentials.

Q 1 **15**

a. Sketch the following signal 1. $x[n] = \delta\left[\cos\frac{\pi}{6}n\right]$ 2. $x(t) = u\left(\sin\frac{\pi}{T}t\right) - u\left(-\sin\frac{\pi}{T}t\right)$

b. Consider the system shown in figure 1a with $x(t)$ as input and $y(t)$ as output. Determine whether it is (1) memoryless, (2) causal, (3) linear, (4) time-invariant or (5) stable. Justify your answer.

c. Consider the feedback system shown in figure 1b. Assume that $y[n] = 0$ for $n < 0$. Sketch the output $y[n]$, when $x[n] = \delta[n]$ and $x[n] = u[n]$ **[04+05+06]**

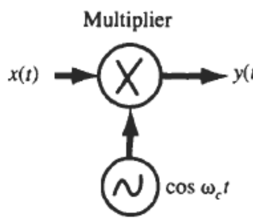

Figure 1a

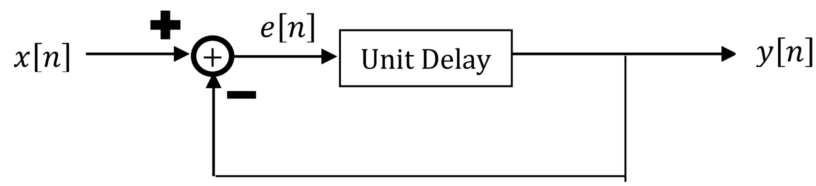

Figure 1b

Q 2 **15**

a. Consider the signal $x[n] = \alpha^n u[n]$. Determine the signal $g[n] = x[n] - \alpha x[n-1]$. Use this result in conjunction with the properties of convolution to determine a sequence $h[n]$ such that $x[n] * h[n] = \left(\frac{1}{2}\right)^n \left[u[n+2] - u[n-2]\right]$. Where * denote convolution. Perform all operations in time domain only.

b. Using graphical convolution method, compute and sketch the output $y(t)$ for a continuous-time LTI system whose impulse response is $h(t) = e^{-3t}u(t)$ and the input is $x(t) = u(t-3) - u(t-5)$. **[08+07]**

Q 3 Figure 3a shows the frequency response $H(j\omega)$ of a continuous-time system (filter). For each of the input signals $x(t)$ below, determine the system output $y(t)$. **15**

a. $x(t) = \cos(2\pi t + \theta)$

b. $x(t) = \cos(4\pi t + \theta)$

c. $x(t) = \begin{cases} \sin 2\pi t, & m \le t \le \left(m + \frac{1}{2}\right) \\ 0, & \left(m + \frac{1}{2}\right) \le t \le m \end{cases}$

For any integer m

See figure 3b for $x(t)$ **[05+03+07]**

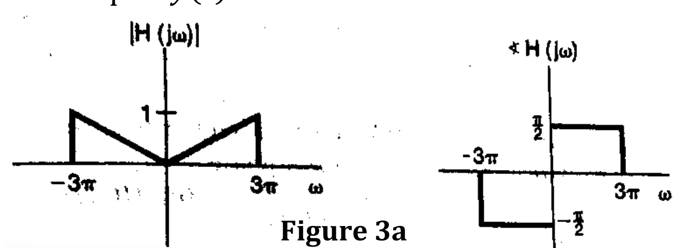

Figure 3a

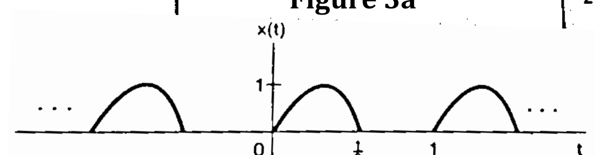

Figure 3b

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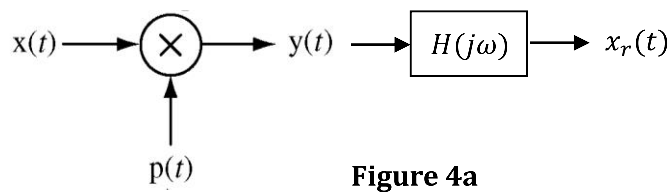
Q 4 Figure 4a show the sampling and reconstruction process. **15**

$x(t) = 10\cos(600\pi t)\cos^2(1600\pi t)$ is an input signal, $p(t) = \sum_{n=-\infty}^{\infty}\delta(t - nT_s)$ is an impulse train, $f_s = 4000\ Hz$ is sampling frequency, n is an integer, $H(j\omega)$ is the frequency response of a low-pass filter with cut-off frequency $f_c\ Hz$. Precisely mention values of frequencies (f) in Hz, and amplitude/magnitude on the sketch.

a. Find the range of cut-off frequencies f_c in Hz of low-pass filter such that $x_r(t) = x(t)$.

b. Sketch magnitude response of $X(j\omega)$, $Y(j\omega)$, $H(j\omega)$, $X_r(j\omega)$ and find $x_r(t)$, what should be the minimum sampling frequency f_s for $x_r(t) = x(t)$.

c. Sketch magnitude response of $Y(j\omega)$, $H(j\omega)$, $X_r(j\omega)$ and find $x_r(t)$ for $f_s = 2500\ Hz$ and $f_c = 1250\ Hz$



[02+08+05]

Figure 4a

Q 5 a) The signal $y(t) = e^{-2t}u(t)$ is the output of a causal all-pass system for which the system function is $H(s) = \frac{s-1}{s+1}$. Find at least two possible input $x(t)$ that could produce $y(t)$ and sketch the respective ROC. What is the input $x(t)$ if it is known that $\int_{-\infty}^{\infty} x(t)dt < \infty$. **15**

b) Using Laplace transform find the transfer function and frequency response of

1. Ideal delay of T sec, 2. Ideal differentiator, and 3. Ideal integrator

Plot the magnitude and phase responses **[09+06]**

Q 6 **A** causal LTI system is given by the difference equation $y[n] - 3y[n-1] + 2y[n-2] = x[n]$ **15**

a) Find $H(z)$. Plot the poles and zeros and sketch the ROC.

b) Realize the system function using Direct-I form.

c) Find the impulse response. Is the system stable? Justify your answer.

d) If the system is not causal, determine the all possible system functions, associated ROCs, and impulse responses which satisfy the preceding difference equation. Specify whether the corresponding systems are stable.

e) Find $y[n]$ if $x[n] = 3^n u[n]$, sketch ROC. **[03+02+03+04+03]**