Code No: R059210403 **Set No. 1**

II B.Tech I Semester Regular Examinations, November 2007
SIGNALS AND SYSTEMS
(Common to Electronics & Communication Engineering, Electronics & Instrumentation Engineering, Bio-Medical Engineering, Electronics & Control Engineering and Electronics & Telematics)

Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions
All Questions carry equal marks
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1. (a) Write short notes on "Orthogonal Vector Space".
   (b) A rectangular function f(t) is defined by [6+10]
   $$f(t) = \begin{cases} 1 & (0 < t < \Pi) \\ -1 & (\Pi < t < 2\Pi) \end{cases}$$
   Approximate the above function by a finite series of Sinusoidal functions.

2. (a) Prove that Sinc(o)=1 and plot Sinc function.
   (b) Determine the Fourier series representation of that Signal x(t) = 3 Cos(Πt/2 + Π/4) using the method of inspection. [6+10]

3. (a) Find the Fourier Transform of the signal shown figure 3a.

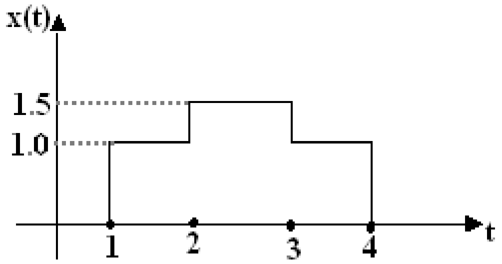

Figure 3a

   (b) Find the Fourier Transform of the signal given below [8+8]
   $$y(t) \begin{cases} \cos 10t, & -2 \le t \le 2 \\ 0, & otherwise \end{cases}$$

4. (a) Explain how input and output signals are related to impulse response of a LTI system.
   (b) Let the system function of a LTI system be $\frac{1}{jw+2}$. What is the output of the system for an input $(0.8)^t\, u(t)$. [8+8]

5. (a) State and Prove Properties of auto correlation function?
   (b) A filter has an impulse response h(t) as shown in figure 5b The input to the network is a pulse of unit amplitude extending from t=0 to t=2. By graphical means determine the output of the filter. [8+8]

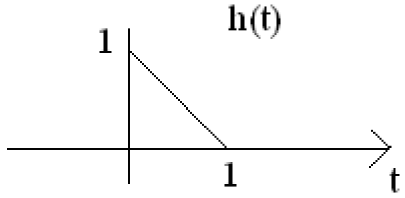

Figure 5b

6. (a) Consider the signal $x(t) = \left(\frac{\sin 50\Pi t}{\Pi t}\right)^2$ which to be sampled with a sampling frequency of $\omega_s = 150\Pi$ to obtain a signal g(t) with Fourier transform G(jω). Determine the maximum value of ω_0 for which it is guaranteed that $G(j\omega) = 75 \times (j\omega)\ for\ |\omega| \leq \omega_0$ where $X(j\omega)$ is the Fourier transform of x(t).

   (b) The signal $x(t) = u(t + T_0) - u(t - T_0)$ can undergo impulse train sampling without aliasing, provided that the sampling period T< $2T_0$. Justify.

   (c) The signal x(t) with Fourier transform $X(j\omega) = u(\omega + \omega_0) - u(\omega - \omega_0)$ can undergo impulse train sampling without aliasing, provided that the sampling period $T < \pi/\omega_0$. Justify. [6+5+5]

7. (a) Obtain the inverse laplace transform of F(s) = $\frac{1}{s^2(s+2)}$ by convolution integral.

   (b) Using convolution theorem find inverse laplace transform of $\frac{s}{(s^2+a^2)^2}$.

   (c) Define laplace transform of signal f(t) and its region of convergence. [6+6+4]

8. (a) A finite sequence x[n] is defined as x[n] = {5,3,-2,0,4,-3} Find X[Z] and its ROC.

   (b) Consider the sequence x[n] = $\begin{cases} a^n & 0 \leq n \leq N-1,\ a > 0 \\ 0 & otherwise \end{cases}$

   Find X[Z].

   (c) Find the Z-transform of $x(n) = \cos(n\omega)u(n)$. [5+5+6]

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1. (a) Consider the pair of exponentially damped sinusoidal signals
$x_1(t) = A\,e^{\alpha t} Cos(\omega t) \quad t \geq 0$
$x_2(t) = A\,e^{\alpha t} \sin(\omega t) \quad t \geq 0$ Assume that A, a and w are all real numbers, the exponential damping factor α is negative and the frequency of oscillator ω is positive, the amplitude A can be positive or negative.
   i. Derive the complex valued signal x(t) whose real part is x_1(t) and imaginary part is x_2(t).
   ii. Determine a(t) for x(t) defined in part (i) where a(t) is envelope of the complex signal which is given by
   $a(t) = \sqrt{x_1^2(t) + x_2^2(t)}$
   iii. How does the envelope a(t) vary with time t.

   (b) Sketch the following signal x(t) = A[u(t+a) - u(t-a)] for a >0 Also determine whether the given signal is a power signal on an energy signal or neither.

   (c) State the properties of even and odd functions. [6+6+4]

2. (a) Write short notes on "Complex Fourier Spectrum".

   (b) Find the Exponential Fourier series for the rectified Sine wave as shown in figure 2. [6+10]

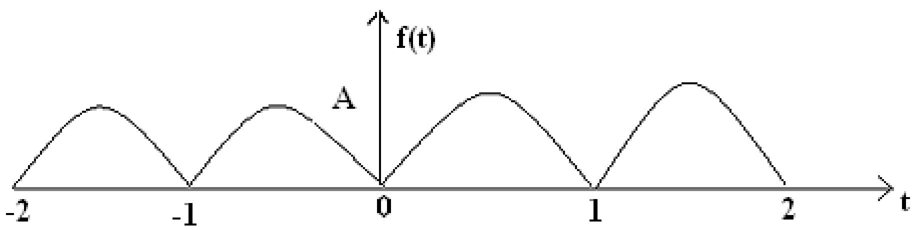

Figure 2

3. Find the Fourier Transform of the following function

   (a) A single symmetrical Triangular Pulse

   (b) A single symmetrical Gate Pulse

   (c) A single cosine wave at t=0 [8+4+4]

4. (a) Explain the characteristics of an ideal LPF. Explain why it can't be realized.
   (b) Differentiate between causal and non-causal systems. [12+4]

5. (a) If V(t) = Sin ω_ot.
      i. find R(Γ)
      ii. Find energy spectral density G_E(f) = Fourier transform of R(τ)
   (b) Applying the convolution theorem find Fourier Transform of $\left[A\ e^{-|at|} \sin c\, 2Wt\right]$.
   (c) Use the convolution theorem to find the spectrum of x(t) = A Cos^2 ω_ct
   [6+6+4]

6. (a) A low pass signal x(t) has a spectrum x(f) given by
   $x(f) = \begin{matrix} 1 - |f|/200 & |f| < 200 \\ 0 & elsewhere \end{matrix}$
   Assume that x(t) is ideally sampled at fs=300 Hz. Sketch the spectrum of $x_\delta(t) for\ |f| < 200$.
   (b) The uniform sampling theorem says that a band limited signal x(t) can be completely specified by its sampled values in the time domain. Now consider a time limited signal x(t) that is zero for $|t| \geq T$. Show that the spectrum x(f) of x(t) can be completely specified by the sampled values x(kf_o) where $f_0 \leq 1/2T$. [8+8]

7. (a) State the properties of the ROC of L.T.
   (b) Determine the function of time x(t) for each of the following laplace transforms and their associated regions of convergence. [8+8]
      i. $\frac{(s+1)^2}{s^2-s+1}$ Re$\{S\} > 1/2$
      ii. $\frac{s^2-s+1}{(s+1)^2}$ Re$\{S\} > -1$

8. (a) Find the Z-transform of $a^n \cos(n\omega)u(n)$
   (b) Find the inverse Z-transform of $X(Z) = \frac{2+Z^3+3Z^{-4}}{Z^2+4Z+3}$ $|Z| > 0$
   (c) Find the Z-transform of the following signal with the help of linearity and shifting properties.$x(n) = \begin{cases} 1 & for 0 \leq N-1 \\ 0 & elsewhere \end{cases}$. [5+5+6]

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Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions
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1. (a) Explain orthogonality property between two complex functions f1(t) and f2(t) for a real variable t.
   (b) Discuss how an unknown function f(t) can be expressed using infinite mutually orthogonal functions. Hence, show the representation of a waveform f(t) using trigonometric fourier series. [6+10]

2. (a) Derive polar Fourier series from the exponential Fourier series representation and hence prove that $D_n = 2\,|C_n|$
   (b) Show that the magnitude spectrum of every periodic function is Symmetrical about the vertical axis passing through the origin. [8+8]

3. (a) Obtain the Fourier transform of the following functions:
      i. Impulse function δ(t)
      ii. DC Signal
      iii. Unit step function.
   (b) State and prove time differentiation property of Fourier Transform. [12+4]

4. (a) Explain how input and output signals are related to impulse response of a LTI system.
   (b) Let the system function of a LTI system be $\frac{1}{jw+2}$. What is the output of the system for an input $(0.8)^t\, u\,(t)$. [8+8]

5. (a) A signal y(t) given by $y(t) = C_0 + \sum_{n=1}^{\infty} C_n \cos(n\omega_o t + \theta_n)$. Find the auto correlation and PSD of y(t).
   (b) Find the mean square value (or power) of the output voltage y(t) of the system shown in figure 5b. If the input voltage PSD. $S_2(\omega) = rect(\omega/2)$. Calculate the power (mean square value) of input signal x(t). [8+8]

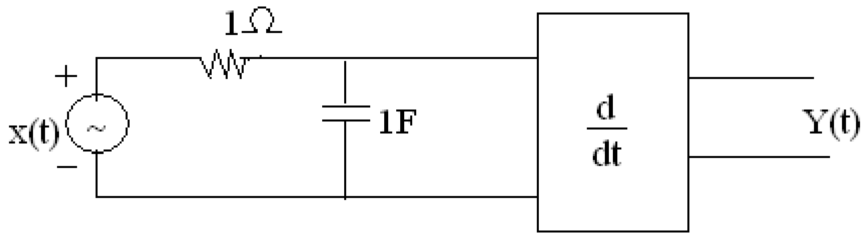

Figure 5b

6. (a) Consider the signal $x(t) = \left(\frac{\sin 50\Pi t}{\Pi t}\right)^2$ which to be sampled with a sampling frequency of $\omega_s = 150\Pi$ to obtain a signal g(t) with Fourier transform G(jω). Determine the maximum value of ω_0 for which it is guaranteed that $G(j\omega) = 75 \times (j\omega)\ for\ |\omega| \leq \omega_0$ where $X(j\omega)$ is the Fourier transform of x(t).
   (b) The signal $x(t) = u(t + T_0) - u(t - T_0)$ can undergo impulse train sampling without aliasing, provided that the sampling period T< $2T_0$. Justify.
   (c) The signal x(t) with Fourier transform $X(j\omega) = u(\omega + \omega_0) - u(\omega - \omega_0)$ can undergo impulse train sampling without aliasing, provided that the sampling period $T < \pi/\omega_0$. Justify. [6+5+5]

7. (a) Obtain the inverse laplace transform of F(s) = $\frac{1}{s^2(s+2)}$ by convolution integral.
   (b) Using convolution theorem find inverse laplace transform of $\frac{s}{(s^2+a^2)^2}$.
   (c) Define laplace transform of signal f(t) and its region of convergence. [6+6+4]

8. (a) Find the Z-transform X(n).
      i. $x[n] = \left(\frac{1}{2}\right)^n u[n] + \left(\frac{1}{3}\right)^n u[n]$
      ii. $x[n] = \left(\frac{1}{3}\right)^n u[n] + \left(\frac{1}{2}\right)^n u[-n-1]$
   (b) Find inverse z transform of x(z) using long division method [8+8]
   x(z) = $\frac{2 + 3z^{-1}}{\left(1 + z^{-1}\right)\left(1 + 0.25\,z^{-1} - \frac{z^{-2}}{8}\right)}$

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1. (a) Define
   i. Basis Functions
   ii. Norm.

   (b) Determine whether each of the following sequences are periodic or not. If periodic determine the fundamental period.
   i. x_1(n) = sin(6π n/7)
   ii. x_2(n) = Sin (n/8)

   (c) Consider the rectangular pulse x(t) of unit amplitude and a duration of 2 time units depicted in figure 1c. [8+4+4]

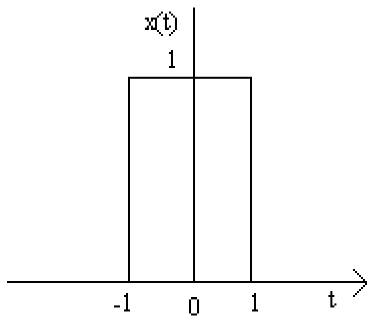

Figure 1c

   Sketch y(t) =x(2t+3).

2. (a) Derive polar Fourier series from the exponential Fourier series representation and hence prove that $D_n = 2\,|C_n|$

   (b) Show that the magnitude spectrum of every periodic function is Symmetrical about the vertical axis passing through the origin. [8+8]

3. (a) Obtain the Fourier transform of the following functions:
   i. Impulse function δ(t)
   ii. DC Signal
   iii. Unit step function.

   (b) State and prove time differentiation property of Fourier Transform. [12+4]

4. (a) Explain the difference between causal and non-causal systems.

(b) Consider a stable LTI system that is characterized by the differential equation $\frac{d^2y(t)}{dt^2} + 4\frac{dy(t)}{dt} + 3y(t) = \frac{dx(t)}{dt} + 2x(t)$
Find its response for input $x(t) = e^{-t}u(t)$. [4+12]

5. (a) A waveform m(t) has a Fourier transform M(f) whose magnitude is as shown in figure 5a. Find the normalized energy content of the waveform.

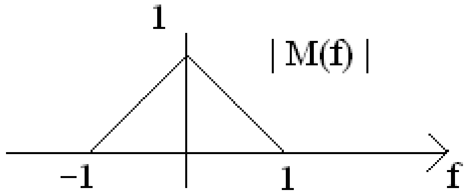

Figure 5a

(b) The signal V(t) = cos ω_0t + 2sin 3 ω_0t + 0.5 sin 4ω_0t is filtered by an RC low pass filter with a 3 dB frequency.
$f_c = 2f_0$. Find the output power S_o.

(c) State parseval's theorem for energy X power signals. [6+6+4]

6. (a) A signal x(t)= 2 cos 400 π t + 6 cos 640 π t. is ideally sampled at $f_s = 500Hz$. If the sampled signal is passed through an ideal low pass filter with a cut off frequency of 400 Hz, what frequency components will appear in the output.

(b) A rectangular pulse waveform shown in figure 6b is sampled once every T_S seconds and reconstructed using an ideal LPF with a cutoff frequency of $f_s/2$. Sketch the reconstructed waveform for $T_s = \frac{1}{6}$ sec $and T_s = \frac{1}{12}$ sec. [8+8]

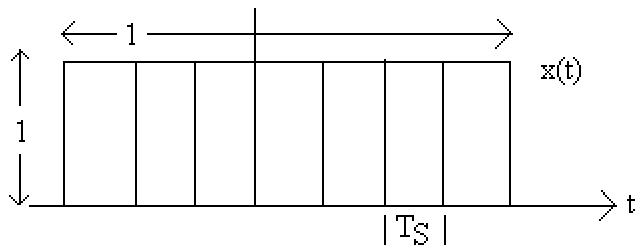

Figure 6b

7. (a) Find inverse Laplace transform of the following:
   i. $\frac{s^2+6s+7}{s^2+3s+2}$ Re$(s) > -1$
   ii. $\frac{s^3+2s^2+6}{s^2+3s}$ Re$(s) > 0$

(b) Find laplace transform of cos ωt. [8+8]

8. (a) Find the inverse Z-transform of the following X(z).
   i. $X(Z) = \log\left(\frac{1}{1-az^{-1}}\right), |z| > |a|$
   ii. $X(Z) = \log\left(\frac{1}{1-a^{-1}z}\right), |z| < |a|$

(b) Find the Z-transform X(n) $x[n] = \left(\frac{1}{2}\right)^n u[n] + \left(\frac{1}{3}\right)^n u[-n-1]$. [8+8]

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