

Code No: A109210402

**R09****Set No. 2**

II B.Tech I Semester Examinations, MAY 2011

SIGNALS AND SYSTEMS

Common to BME, ICE, ETM, EIE, ECE

Time: 3 hours

Max Marks: 75

Answer any FIVE Questions  
All Questions carry equal marks

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1. (a) With the help of graphical example explain sampling theorem for Band limited signals.  
(b) Explain briefly Band pass sampling. [8+7]
2. (a) The network shown in figure 2a is excited by a voltage source  $e^{-t}$ . The switch is closed at  $t=0$ .

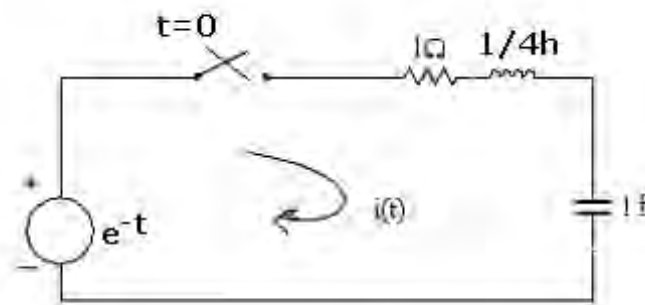


Figure 2a

Find:

- i. The transfer function
- ii. The current  $i(t)$
- (b) Is there any test which can distinguish the physically realizable characteristic from an unrealizable one? Discuss the test with necessary expressions and figures. [8+7]
3. (a) Explain how Fourier Transform is developed from Fourier series.  
(b) Power Signals will have Fourier Transforms and energy signals will have Fourier series in the frequency domain. Justify this statement. [10+5]
4. (a) Find the component of a waveform  $\sin \omega_2 t$  contained in another waveform  $\sin \omega_1 t$  over the interval  $(-T, T)$  for all real values of  $\omega_1$  and  $\omega_2$  ( $\omega_1 \neq \omega_2$ ). How does this component change with  $T$ .  
(b) Determine whether the following functions are periodic or non periodic
  - i.  $a \cos 2t + b \sin 7t + c \sin 13t$
  - ii.  $(a \sin t)^3$
  - iii.  $(a \sin 2t + b \sin 5t)^2$ .

Where  $a$ ,  $b$  and  $c$  are constants. [10+5]

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5. (a) A signal  $y(t)$  given by  $y(t) = C_0 + \sum_{n=1}^{\infty} C_n \cos(n\omega_0 t + \theta_n)$ . Find the auto-correlation and PSD of  $y(t)$ .
- (b) Explain the Graphical representation of convolution with an example. [8+7]
6. (a) A periodic waveform is formed by eliminating the alternate cycle of a Sinusoidal waveform as shown in figure 6a.

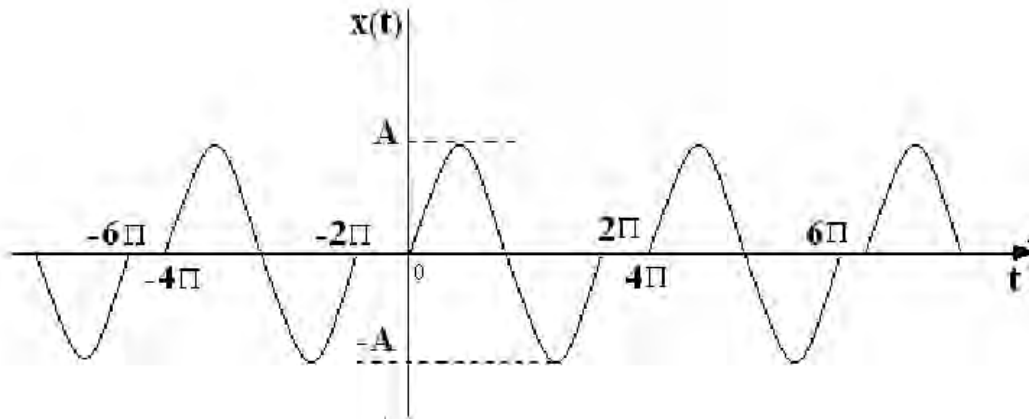


Figure 6a

- i. Find the Fourier series (exponential) by direct evaluation of the coefficients.
- ii. If the waveform is shifted to the left by  $\pi$  seconds, the new waveform  $f(t+\pi)$  is odd function of the time whose Fourier series contains only sine terms. Find the Fourier series of  $f(t+\pi)$ . From this series, write down the Fourier series for  $f(t)$ . [8+7]
7. Determine the constraint on  $r = |z|$  for each of the following sums to converge:
- (a)  $\sum_{n=-1}^{\infty} \left(\frac{1}{2}\right)^{n+1} z^{-n}$
- (b)  $\sum_{n=1}^{\infty} \left(\frac{1}{2}\right)^{-n+1} z^n$
- (c)  $\sum_{n=0}^{\infty} \left(\frac{1+(-1)^n}{2}\right) z^{-n}$
- (d)  $\sum_{n=-\infty}^{\infty} \left(\frac{1}{2}\right)^{|n|} \cos\left(\frac{\pi}{4}n\right) z^{-n}$  [3+4+4+4]
8. (a) Consider an LTI system with input  $x(t) = e^{-t}u(t)$  and impulse response  $h(t) = e^{-2t}u(t)$ . Determine the Laplace transforms of  $x(t)$  and  $h(t)$ . Using convolution property, determine the Laplace transform of the response,  $Y(s)$ .
- (b) Determine the Laplace transform and the associated ROC and pole-zero plot for the following functions
- i.  $x(t) = t e^{-2|t|}$
- ii.  $x(t) = e^{-4t}u(t) + e^{-5t}(\sin 5t)u(t)$  [6+9]

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1. (a) What is orthonormal vector and orthonormal set of vectors.
- (b) Consider the rectangular pulse  $x(t)$  as shown in figure 1b. Approximate the above function by  $A \sin 2\pi t$ , show that the mean square error is minimum. [7+8]

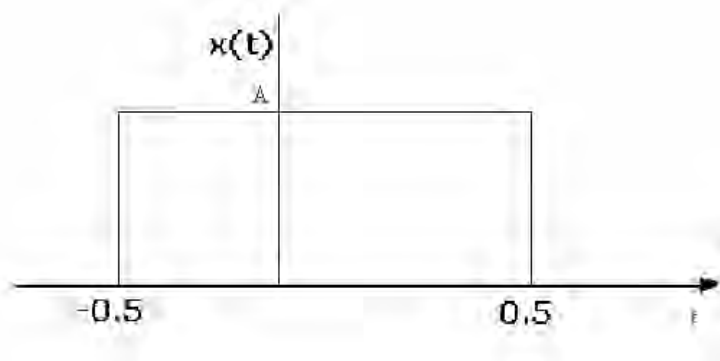


Figure 1b

2. (a) For the following signal, find the power, rms value and sketch the PSD.  
 $A \cos 40t + B \sin 60t$ .
- (b) If the waveform  $V(t)$  has the Fourier Transform  $V(f)$ , then show that the waveform delayed by time  $t_d$  i.e  $V(t-t_d)$  has the transform of  $V(f) \cdot e^{-j\omega t_d}$  [7+8]
3. (a) Define causality and stability with reference to a Linear system and its impulse response.
- (b) Consider an LTI system with the input and output related through the relation.  

$$y(t) = \int_{-\alpha}^{\infty} e^{-(t-\tau)} x(\tau - 2) d\tau$$
 What is the impulse response  $h(t)$  for this system. [8+7]
4. Find the power of periodic signal  $g(t)$  shown in figure4. Find also the powers of
  - (a)  $-g(t)$
  - (b)  $2g(t)$
  - (c)  $g(-t)$
  - (d)  $g(t)/2$ . [15]

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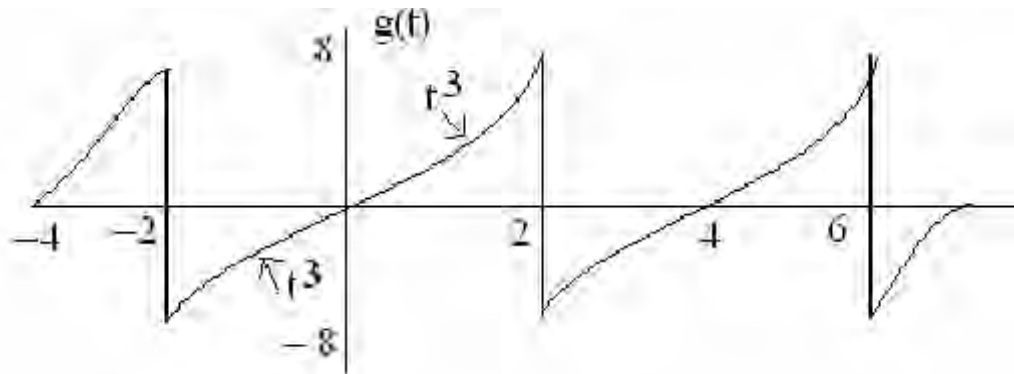


Figure 4

5. (a) Find the Fourier series of the wave shown in figure 5a.

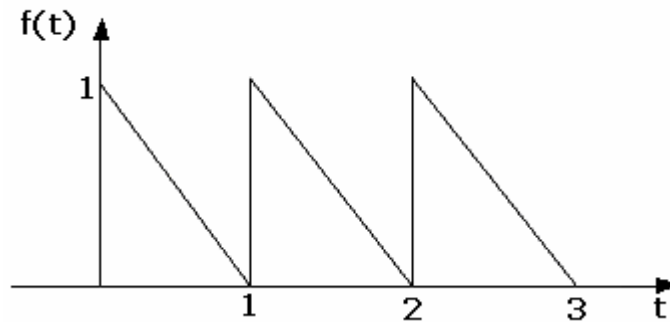


Figure 5a

- (b) Determine the Fourier series representation of  $x(t) = 2 \sin(2\pi t - 3) + \sin(6\pi t)$ . [8+7]
6. (a) How we can reconstruct the original signal from sampled signal.  
 (b) What is an aperture effect? Explain why flat top samples get the aperture effect. [7+8]
7. (a) Find the Z-transform of an  $\sin(\eta\omega_0).u(n)$   
 (b) Find the inverse Z-transform of  $X(Z) = (2+Z^3+3Z^4)/(Z^2+4Z+3)$ ,  $|Z| > 0$ .  
 (c) Find the Z-transform of the following signal  $x(n) = 1$  for  $0 \leq n < N - 1$   
 $= 0$  elsewhere. [6+5+4]
8. (a) Consider the signal  $x(t) = e^{-5t}u(t) + e^{-3t}u(t)$  and denote its Laplace transform by  $X(s)$ . What are the constraints placed on the real and imaginary parts of  $s$  if the ROC of  $X(s)$  is  $\text{Re}\{s\} > -3$ ?  
 (b) The system function of a causal LTI system is  $H(s) = \frac{(s+1)}{(s^2+2s+2)}$ . Determine and sketch the response  $y(t)$  when the input is  $x(t) = e^{-|t|}$ ,  $-\infty < t < \infty$ . [7+8]

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- When a function  $f(t)$  is said to be laplace transformable.
  - What do you mean by region of convergence?
  - List the advantages of Laplace transform.
  - If  $\delta(t)$  is a unit impulse function find the laplace transform of  $d^2/dt^2 [\delta(t)]$ .  
[4+4+3+4]
- Prove that the normalized power is given by  $P = \sum_{n=-\infty}^{\infty} |C_n|^2$  where  $|C_n|$  are complex Fourier coefficients for the periodic waveform.
  - Determine the exponential form of Fourier series for the waveform in below figure 2b.  
[8+7]

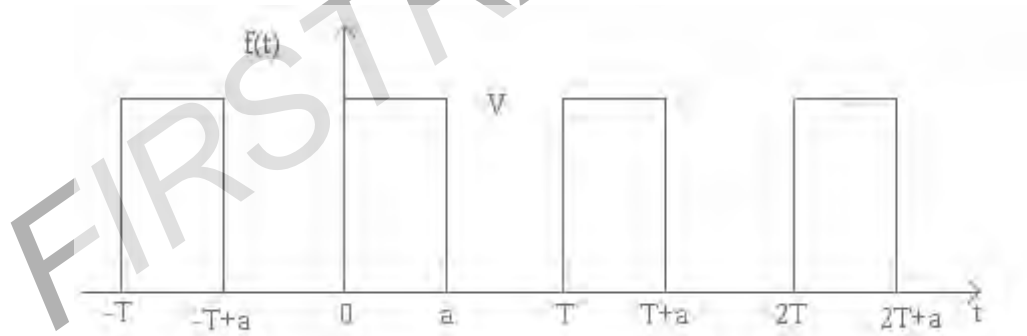


Figure 2b

- Explain how Fourier Transform is developed from Fourier series.
  - Find the Fourier Transform of  $\cos \omega_0 t$  and draw the spectral density function.  
[8+7]
- Find the Z transform of  $t^2 e^{-at}$ .
  - Find the final value and initial value of  $x(n)$  for  $X(z) = \frac{z^2}{(z-1)(z-0.2)}$ . [7+8]
- Let two signals be defined by
 
$$x_1(t) = \begin{cases} 1 & \cos(2\pi t) \geq 1 \\ 0 & \cos(2\pi t) < 1 \end{cases}$$

$$x_2(t) = \sin(2\pi t/10)$$
 Graph these products over the time range  $-5 < t < 5$ 
    - $x_1((t-2)/5) x_2(20t)$
    - $x_1(2t) x_2(-t)$

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- iii.  $x_1(t/5) x_2(20t)$   
 iv.  $x_1(t/5) x_2(20(t+1))$ .

(b) Find the signal energy of each of these signals:

i.  $x(t) = 2 \sin(200\pi t)$

ii.  $x(t) = 3 \operatorname{rect}(t/4)$ .

[8+7]

6. (a) Find the current  $i(t)$  in a series RLC circuit as shown in figure 6a when a voltage of 100 volts is switched on across the terminals a a<sup>1</sup> at  $t=0$ .

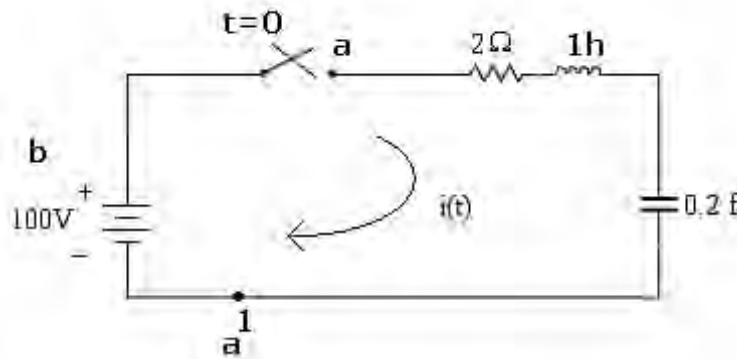


Figure 6a

- (b) A signal  $f(t) = \left(\frac{2\pi}{w}\right) \delta(t) - S_a\left(\frac{wt}{2}\right)$  is applied at the input terminals of the ideal low pass filter. The transfer function of such filter is given by  $H(j\omega) = K \operatorname{GW}(\omega) e^{-j\omega t_0}$ . Find the response.

[8+7]

7. (a) State and Prove Properties of cross correlation function.

- (b) If  $v(f) = AT \frac{\sin 2\pi fT}{2\pi fT}$  find the energy contained in  $V(t)$ .

[7+8]

8. (a) A low pass signal  $x(t)$  has a spectrum  $x(f)$  given by

$$x(f) = \begin{cases} 1 - |f|/200 & |f| < 200 \\ 0 & \text{else} \end{cases}$$

where

Assume that  $x(t)$  is ideally sampled at  $f_s = 300$  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  $x(kf_0)$  where  $f_0 \geq 1/2T$ . Where  $k$  is an integer.

[8+7]

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1. (a) Explain the concept of Fourier Transform for periodic signals.
- (b) Find out the Fourier Transform of the periodic pulse train shown in figure 1b. [8+7]

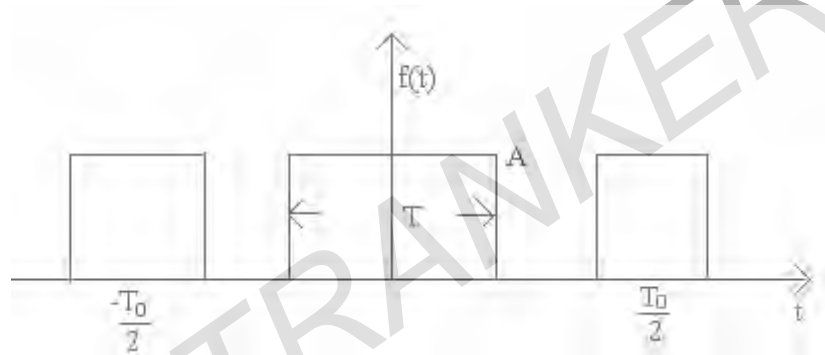


Figure 1b

2. Write about the following:
  - (a) Properties of LTI system
  - (b) Explain the following:
    - i. Causality
    - ii. Stability
    - iii. Invertability for an LTI system. [7+8]
3. (a) Show that the exponential Fourier series for the symmetric square wave shown in figure 3a.

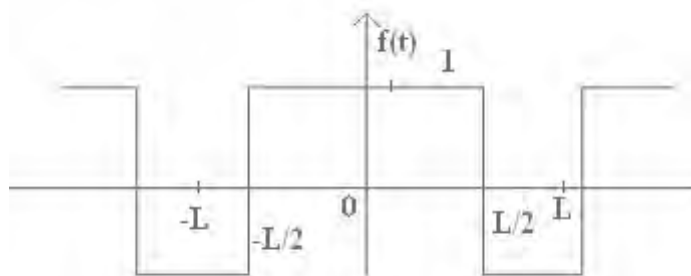


Figure 3a

$$f(t) = \frac{2}{\pi} \sum_{n=-\infty}^{\infty} \frac{(-1)^n}{2n+1} e^{j(2n+1)\frac{\pi}{2}t}$$

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- (b) Show that the Fourier series of a periodic signal with rotational symmetry contain only odd harmonics. [10+5]
4. (a) Derive Parseval's theorem from the frequency convolution property.  
 (b) Find the cross correlation between  $[u(t) + u(t-\tau)]$  and  $e^{-t} u(t)$ . [7+8]
5. (a) The signal  $g(t) = 10 \cos 20\pi t \cos 200\pi t$  is sampled at the rate of 250 samples per second.  
 i. Determine the spectrum of the resulting sampled signal.  
 ii. Specify the cut-off frequency of the ideal reconstruction filter so as to recover  $g(t)$  from its sampled version.  
 iii. What is the Nyquist rate of  $g(t)$ ?  
 (b) What is Natural sampling? [8+7]
6. (a) Obtain the inverse laplace transform of  $F(s) = 1/s^2(s+2)$  by convolution integral.  
 (b) Using convolution theorem find inverse laplace transform of  $s/(s^2+a^2)^2$ .  
 (c) Define laplace transform of signal  $f(t)$  and its region of convergence. [5+6+4]
7. (a) Find the inverse z - transform of  

$$X(z) = \frac{1}{1024} \left[ \frac{1024 - z^{-10}}{1 - \frac{1}{2}z^{-1}} \right], |z| > 0.$$
  
 (b) Distinction between Laplace, Fourier and Z transforms. [8+7]
8. (a) Which of the following signals or functions are periodic and if what is its fundamental period.  
 i.  $g(t) = e^{-j60\pi t}$   
 ii.  $g(t) = 10 \sin(12\pi t) + 4 \cos(18t)$   
 (b) Let two functions be defined by:  

$$x_1(t) = 1, \sin(20\pi t) \geq 0$$

$$-1, \sin(20\pi t) < 0$$

$$X_2(t) = t, \sin(2\pi t) \geq 0$$

$$-t \sin(2\pi t) < 0$$
  
 Graph the product of these two functions vs time over the time interval  $-2 < t < 2$ . [8+7]

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