Electrical
Engineering
- Optional
For IAS (UPSC)

Signals & Systems - 2015-2021
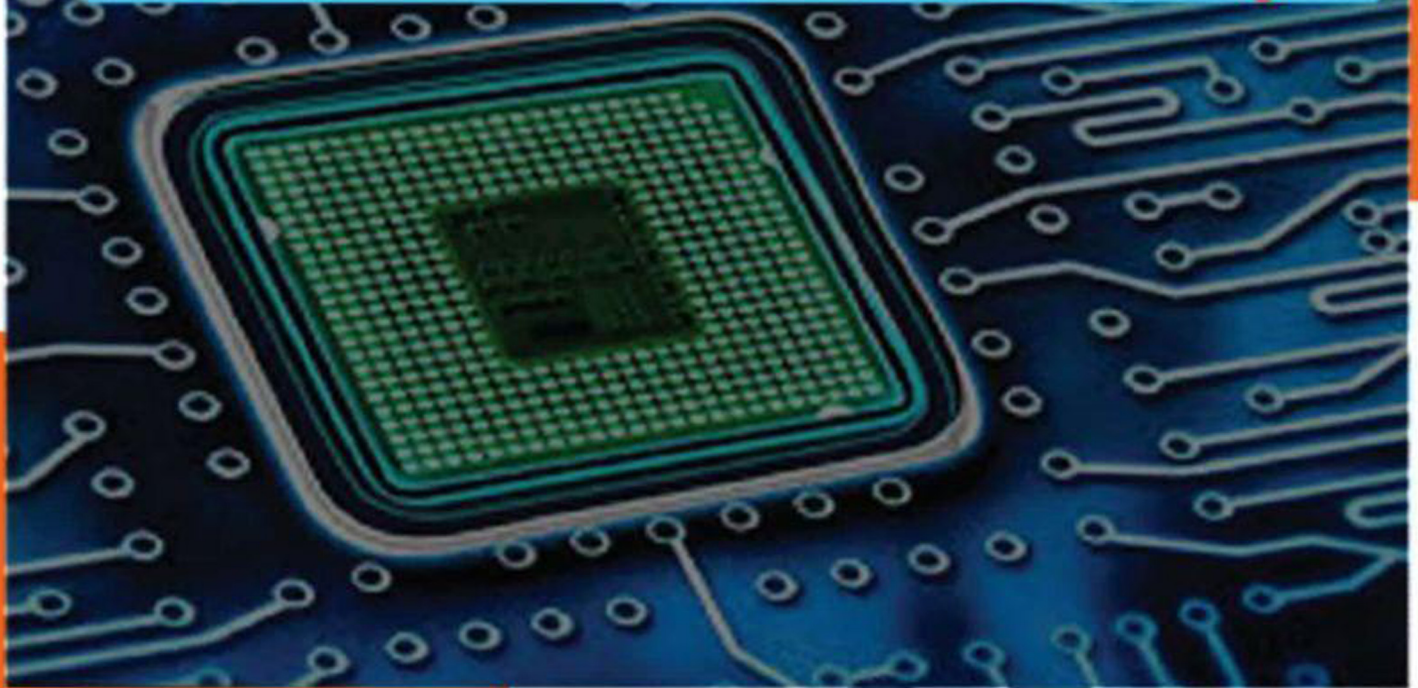
UPSC – ELECTRICAL Engineering optional – 2015 Questions

1. Find the z transform of:

$f(t) = \sin wt$ for t $\geq$ 0. **[10M]**

2. Find the Laplace transform of the function:

$f(t) = 2e^{-t}\cos 10t - t^4 + 6e^{-(t-10)}\ for\ t > 0.$ **[20M]**

3. The transfer function of a system is given as: $\frac{C(s)}{R(s)} = \frac{(s+3)}{s(s+1)(s+2)}$ .Find out the impulse response of the system. **[10M]**

UPSC – ELECTRICAL Engineering optional – 2016 Questions

1. Determine the overall impulse response, $h(n)$, of the system shown in Fig. 1(b) below. Given that **[10M]**

$$h_1(n) = \delta(n) - \left(\frac{1}{5}\right)\delta(n-1)$$
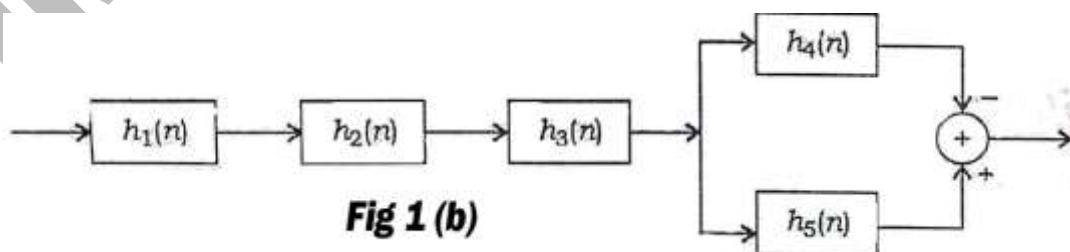
$$h_2(n) = \delta(n) - \delta(n-1)$$

$$h_3(n) = \left(\frac{1}{5}\right)^n u(n)$$

$$h_4(n) = (n-1)u(n)$$

$$h_4(n) = (n-1)u(n)$$

$h_5(n) = \delta(n) + nu(n-1) + \delta(n-2)$ where$\delta(n)$and $u(n)$ denote, respectively, the unit impulse and unit step signals:

Fig 1 (b)

2. Consider a continuous-time LTI system for which the input $x(t)$ and output $y(t)$ are related by the following differential equation: **[20M]**

$$\frac{d^2 y(t)}{dt^2} - \frac{dy(t)}{dt} - 2y(t) = x(t)$$

Determine the impulse response, $h(t)$, of the system for the following cases by plotting pole-zero pattern:

(i) The system is causal.

(ii) The system is stable.

(iii) The system is neither stable nor causal.

3. Determine the causal signal, $x(n)$, having its z-transform $X(z) = \frac{1}{(1+z^{-1})(1-z^{-1})^2}$ **[10M]**

UPSC – ELECTRICAL Engineering optional – 2017 Questions

1. A continuous time signal $x(t)$ is shown in Fig. 1(b). Sketch and label each of the following signals:

(i) $x(t)u(2-t)$ (ii) $x(t)\delta(t - \frac{7}{2})$ **[10M]**

चित्र 1(b)/Fig. 1(b)
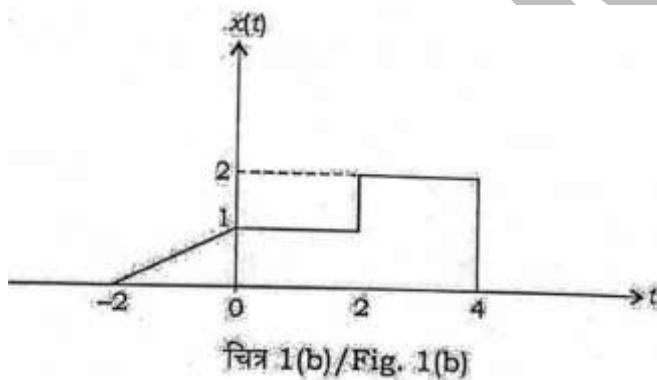
2. Discuss the properties of a probability density function. What additional features a normal distribution has? **[10M]**

3. Find the Laplace transform of the function $f(t) = u(\sin 2t)$. **[20M]**

4. Determine the transfer function and therefrom the impulse response of the causal linear time invariant system described by the difference equation

$$y(n) - \frac{1}{4}y(n-1) - \frac{3}{8}y(n-2) = -x[n] + 2x[n-1]$$ **[20M]**

UPSC – ELECTRICL Engineering optional – 2018 Questions

1. Find the Laplace transform of the periodic functions f(t) shown in Figure 1(b). **[10M]**
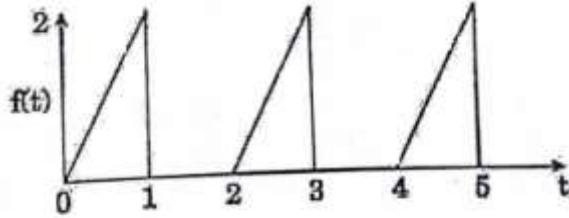

Figure 1(b)

UPSC – ELECTRICL Engineering optional – 2019 Questions

1. Determine and sketch the convolution of the two signals given below: **[10M]**

$$x(t) = \begin{cases} 2, & -1 \le t \le 1 \\ 1, & 1 < t \le 3 \\ 0, & \text{elsewhere} \end{cases}$$

and $h(t) = 2\delta(t+1) + \delta(t+2)$

2. Find the Laplace transform of the following signals: **[10M]**

(i) $x_1(t) = e^{-at} \cos(\omega_0 t)\, u(t)$

(i) $x_2(t) = e^{-at} \sin(\omega_0 t)\, u(t)$

3. An LTI system is characterized by the following difference equation:

$$y(n) - \frac{3}{4} y(n-1) + \frac{1}{8} y(n-2) = 2\, x(n)$$

(i) Find the impulse response of the system, if the input to the system is $x(n) = \left(\frac{1}{4}\right)^n u(n)$.

(ii) Find the frequency response of the output $y(j\omega)$, and $y(n)$. **[20M]**

4. Find the Z-transform of the signal $g(n) = |n|a^{|n|}$. Also find the ROC. **[10M]**

UPSC – ELECTRICL Engineering optional – 2020 Questions

1. Sketch the continuous-time signal $x(t) = t[u(-t + 1) - u(-t - 1)]$ over a suitable range of t, where $u(t)$ is a unit step function. **[10M]**

2. The unit-impulse response of a linear time-invariant continuous-time system is given by $h(t) = [3e^{-3t} + 2te^{-3t}]u(t)$. Determine the system response $y(t)$ for an input $x(t) = 10e^{-3t}u(t)$, where $u(t)$ is a step function is **[20M]**

3. Find the Z transform of discrete sequence $x[n] = n[u[n] - u[n - 4]]$, where $u(n)$ is a unit step sequence. **[10M]**

4. A continuous-time signal $x(t) = \cos(2\pi\, 400t)$ is sampling frequency $f_s = 1600\, Hz$. Obtain the 4-point DFT of the sampled sequence and plot the magnitude and phase spectrum. **[20M]**

UPSC – ELECTRICL Engineering optional – 2021 Questions

1. For the signal shown in Figure 1(b), calculate the total energy of the signal $X(t)$. Also sketch $y(t) = X(10t - 5)$ **[10M]**
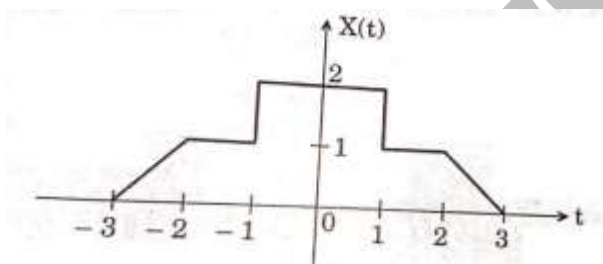

Figure 1(b)

2. Compute the convolution $X[n] * h[n]$, where

$$X[n] = \left(\frac{1}{2}\right)^{-n} u[-n - 2]$$

$$h[n] = u[n - 2]$$ **[10M]**

3. Consider the signal $X[t]$ shown in Figure 2(b) below. Represent the signal $X[t]$ in terms of rectangular pulse signal $V(t)$ shown in the same figure. **[10M]**
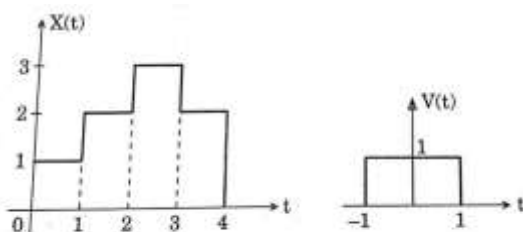

Figure 2(b)

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4. A mixer (analog multiplier) is used as a process in some analog communication systems. Two signals $X_1(t)$ and $X_2(t)$ are mixed to produce the output $y(t) = X_1(t)X_2(t)$.

If $X_1(t) = 10 \sin c\,(10t)$ and $X_2(t) = 2\cos(1000\,\pi t)$, then calculate and plot the magnitude of the Fourier transform of output signal. Further, specify and prove the property of Fourier transform used in calculations. **[10M]**

5. Consider a discrete time system with transfer function given by

$$H(z) = \frac{Y(z)}{R(z)} = \frac{z^{-1} - \frac{1}{2}z^{-2}}{\left(1 - z^{-1} + \frac{2}{9}z^{-2}\right)}$$ **[20M]**

Calculate the following:

(i)   The impulse response of the system
(ii)   The step response of the system with zero initial conditions
(iii) The step response of the system with initial conditions $y[-1] = 1$ and $y[-2] = 2$

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