DETAILED SOLUTIONS

MADE EASY

India's Best Institute for IES, GATE & PSUs

Test Centres: Delhi, Hyderabad, Bhopal, Jaipur, Pune, Kolkata

ESE 2025 : Prelims Exam
CLASSROOM TEST SERIES

ELECTRICAL ENGINEERING

Test 16

Section A : Electromagnetic Theory + Computer Fundamentals + Electrical Materials [All Topics]

Section B : Systems & Signal Processing + Communication Systems [All Topics]

Section C : BEE-2 + Analog Electronics-2 + Elec. & Electro. Measurements-2 [Part Syllabus]

ANSWER KEY

1.	(a)	**16.**	(c)	**31.**	(d)	**46.**	(d)	**61.**	(a)
2.	(d)	**17.**	(c)	**32.**	(c)	**47.**	(a)	**62.**	(a)
3.	(c)	**18.**	(d)	**33.**	(b)	**48.**	(b)	**63.**	(b)
4.	(d)	**19.**	(c)	**34.**	(d)	**49.**	(d)	**64.**	(c)
5.	(c)	**20.**	(a)	**35.**	(a)	**50.**	(b)	**65.**	(d)
6.	(a)	**21.**	(c)	**36.**	(d)	**51.**	(c)	**66.**	(b)
7.	(b)	**22.**	(c)	**37.**	(d)	**52.**	(a)	**67.**	(d)
8.	(a)	**23.**	(b)	**38.**	(a)	**53.**	(a)	**68.**	(c)
9.	(b)	**24.**	(c)	**39.**	(b)	**54.**	(d)	**69.**	(d)
10.	(c)	**25.**	(c)	**40.**	(d)	**55.**	(b)	**70.**	(c)
11.	(c)	**26.**	(c)	**41.**	(d)	**56.**	(b)	**71.**	(c)
12.	(d)	**27.**	(a)	**42.**	(d)	**57.**	(b)	**72.**	(a)
13.	(b)	**28.**	(d)	**43.**	(a)	**58.**	(a)	**73.**	(c)
14.	(b)	**29.**	(b)	**44.**	(a)	**59.**	(c)	**74.**	(a)
15.	(c)	**30.**	(c)	**45.**	(b)	**60.**	(c)	**75.**	(d)

DETAILED EXPLANATIONS

Section A : Electromagnetic Theory + Computer Fundamentals + Electrical Materials

1. (a)

Divergence of curl of a vector

$$\nabla \cdot (\nabla \times \vec{A}) = 0$$

Curl of gradient of a scalar field

$$\nabla \times (\nabla \phi) = 0$$

2. (d)

Poisson's equation:

$$\nabla^2 V = -\frac{\rho}{\varepsilon}$$

This equation governs the behavior of the electric potential V in a region where charge (ρ) is present,

Laplace's equation, $\nabla^2 V = 0$

This equation applies in charge-free region ($\rho = 0$), describing the behavior of the electric potential where no free charge exists.

3. (c)

A medium behaves like a dielectric when it has very low or negligible free charge carriers, meaning it does not conduct electricity in the usual sense. Instead, when subject to an alternating electric field. It supports displacement current due to polarization of bound charges. In a perfect dielectric, the conduction current is almost zero, and the displacement current dominates.

Thus, for a medium to act as a dielectric, the displacement current much greater than the conduction current.

4. (d)

Magnetic field intensity at the centre of a circular coil

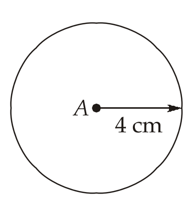
$$H = \frac{I}{2R} = \frac{2}{1} = 2 \text{ A/m}$$

5. (c)

The induced voltage is due to both the time varying magnetic field and the rotational motion of the loop, which changes the flux linkage.

6. (a)

$\because$ Sphere of 4 cm centered at A is a gaussian surface for point charge xC at A



$\therefore$ By Gauss theorem,

$$\oiint \vec{D}\cdot\vec{ds} = Q_{enclosed} = xC$$

$$D_r \times 4\pi r^2 = Q$$

$$D_r = \frac{Q}{4\pi r^2}$$

$$E = \frac{Q}{4\pi\varepsilon_0 r^2}$$

$$7200\ \text{V/m} = \frac{x\times 9\times 10^9}{(4\times 10^{-2})^2}$$

$$x = \frac{7200\times 16\times 10^{-4}}{9\times 10^9}$$

$$= 800 \times 16 \times 10^{-13} = 128 \times 10^{-11} = 1.28\ \text{nC}$$

7. (b)

Reluctance, $$R = \frac{l}{\mu_0\mu_r A}$$

$$\text{MMF} = \text{Reluctance} \times \text{Flux}$$

$$1600 \times 5 = \frac{40\times 10^{-2}}{4\pi\times 10^{-7}\times \mu_r \times 40\times 10^{-4}} \times 4\times 10^{-3}$$

$$\mu_r \approx 40$$

8. (a)

We know,

$$\text{Biot Savart's law, } H = \int \frac{I\,\vec{dl}\times \hat{a}_r}{4\pi R^2} = \int_0^{2\pi} \frac{IR\,d\phi\,\hat{a}_\phi}{4\pi R^2}(-\hat{a}_\rho)$$

$$= \frac{I}{4\pi}\int_0^{2\pi} \frac{R d\phi}{R^2}(\hat{a}_z) = \frac{I}{2R}\hat{a}_z$$

9. (b)

Force acts in a direction from high flux concentrated area to low flux area when currents are in same direction then the force will be attractive.

10. (c)

$\nabla^2 A = -\mu_0 J$ is vector Poisson's equation, while rest of the expressions are part of Maxwell's equation for static electromagnetic field.

11. (c)

Given, $\vec{H} = 3y\,\hat{a}_x + (z^2 - x^2)\hat{a}_y + 4y\,\hat{a}_z$ A/m

So, $\nabla \times \vec{H} = \begin{vmatrix} \hat{a}_x & \hat{a}_y & \hat{a}_z \\ \frac{\partial}{\partial x} & \frac{\partial}{\partial y} & \frac{\partial}{\partial z} \\ 3y & z^2 - x^2 & 4y \end{vmatrix} = \hat{a}_x(4 - 2z) + \hat{a}_z(-2x - 3)$

At origin (0, 0, 0), $\nabla \times \vec{H} = 4\hat{a}_x - 3\hat{a}_z$

$|\nabla \times \vec{H}| = \sqrt{3^2 + 4^2} = 5$

12. (d)

We know, $\vec{F} = I(\vec{L} \times \vec{B})$

$= 8(2\hat{a}_z \times 3\hat{a}_x) = 48\hat{a}_y$N

$\vec{T} = \vec{r} \times \vec{F} = (0.3\hat{a}_x) \times (48\hat{a}_y)$

$= 14.4\,\hat{a}_z$ N-m

13. (b)

We know, $\nabla f = \frac{\partial f}{\partial x}\hat{a}_x + \frac{\partial f}{\partial y}\hat{a}_y + \frac{\partial f}{\partial z}\hat{a}_z$

$= 3x^2\hat{a}_x + 3\beta y^2\hat{a}_y + 3z^2\hat{a}_z$

$\nabla f_{(1,\,1,\,1)} = 3\hat{a}_x + 3\beta\hat{a}_y + 3\hat{a}_z$

$|\nabla f_{(1,1,1)}| = \sqrt{9 + 9\beta^2 + 9} = 11$

or, $18 + 9\beta^2 = 121$

or, $|\beta| = 3.38$

14. (b)

Given, $\vec{D} = \hat{a}_x \sin y + \hat{a}_y y$

$\nabla \cdot \vec{D} = \rho_v$

Hence, $\rho_v = \nabla \cdot \vec{D} = \frac{\partial D_x}{\partial x} + \frac{\partial D_y}{\partial y} + \frac{\partial Dz}{\partial z}$

$= 0 + 1 + 0 = 1$ C/m^3

15. (c)

For spherical coordinate systems,

$$\vec{dl} = r\sin\theta\, d\phi\, \hat{a}_\phi$$

$$\oint G\cdot dl = \int_0^{2\pi} (20r\,\hat{a}_\phi)\,(r\sin\theta\; d\phi\; \hat{a}_\phi)$$

$$= 20\cdot r^2\cdot \sin\theta(2\pi)$$

$$= 20\ (2)^2 \sin 30°\ (2\pi)$$

$$= 80\,\pi$$

16. (c)

$$\text{Memory size} = 8\text{ GB} = 2^{33}\text{ B}$$

So, $$\text{unique address} = \frac{2^{33}}{2^1} = 2^{32}$$

Hence, atleast 32 bits are required.

17. (c)

Instruction format is:

Opcode	Register Operand (R.O.)	Register Operand (R.O.)	Immediate Operand (I.O.)

32 bits

For 40 distinction instructions/opcodes, minimum no. of bits required = 6 bits

For 24 general purpose register, minimum bits required for register operand = 5 bits

Thus for 2 register operand = (5 + 5) = 10 bits

32 bits

Opcode	R.O.	R.O.	I.O.
6 bits	5 bits	5 bits	x

Thus no. of bits for I.O. = x = 32 – 6 – 5 – 5 = 16 bits

18. (d)

Number of bits required for none or one of 6 micro-instructions of one kind (vertical μ-instruction)

$$= \log_2 6 \text{ bits} = 3 \text{ bits}$$

Atmost 6 μ-operation = 6 bits (Horizontal μ-instruction)

Total = 3 + 6 = 9 bits (minimum)

19. (c)

In pipelining, a number of functional units are employed in sequence to perform a single computation.

20. (a)

$1100 \rightarrow 1 \times 2^3 + 1 \times 2^2$

$= 8 + 4 = 12$

$110 \rightarrow 1\times\frac{1}{2}+1\times\frac{1}{2^2}$

$= \frac{1}{2}+\frac{1}{4} = 0.5 + 0.25 = 0.75$

21. (c)

The pipeline controller is responsible for detecting and handling data hazard (caused by instruction dependencies) and control hazard (caused by branch instruction).

22. (c)

Stack machines operate using Last In, Fist Out, so the most recent item is accessed first.

23. (b)

Control unit fetches, decodes and manages the execution of instructions.

24. (c)

$$\text{Hard disk transfer time} = \frac{300\text{ B}}{15\text{ kB}} = \frac{300}{15000} = 0.02\text{ sec}$$

$$\text{DMA time} = 750 + 950 = 1700\text{ cycles}$$

$$= 1700\times\frac{1}{800\text{ kHz}} = 2.125\text{ mill sec}$$

So, $$\%\text{ time consumed} = \frac{2.125\times10^{-3}}{0.02+2.125\times10^{-3}}\times100 = 0.096\times100 = 9.6\%$$

25. (c)

$$\text{Speedup }(S) = \frac{1}{(1-\text{Cache \% used})+\left[\frac{\text{Cache \% used}}{\text{Speedup using cache}}\right]}$$

$$= \frac{1}{(1-F)+\left(\frac{F}{S}\right)} = \frac{1}{(1-0.9)+\left(\frac{0.9}{30}\right)} = \frac{1}{(0.1)+\left(\frac{0.9}{30}\right)}$$

$$= \frac{30}{3.9} = 7.69$$

26. (c)

$$\text{Program execution time} = \frac{n\times[CPI]_{\text{avg}}}{f_{CLK(\text{CPU})}} = \frac{500\times5.5}{1\times10^6} = 2.75\text{ m sec.}$$

27. (a)

$$\text{Total disk size} = \text{No. of platter} \times \text{No. of sector} \times \text{No. of tracks} \times \text{Data on each sector}$$
$$= 5 \times 2^{10} \times 2 \times 2^{10} \times 2^9 \text{ bytes}$$
$$= 5 \times 2^{30} \text{ bytes} = 5 \text{ GB}$$

28. (d)

In a Mesh Topology, every device has a dedicated point-to-point link to every other device. i.e. the link carries traffic between only the two devices it connects. For this reason the communication between two links is reliable.

29. (b)

Ferrites have high resistivity and low eddy current losses.

Iron generally has higher specific gravity than ferrites.

30. (c)

By losing or gaining electrons → Ionic bond.

By sharing of electrons → Covalent bond.

31. (d)

Temperature: As temperature increases, the resistivity of a semiconductor decreases due to increased charge carriers giving it a negative temperature coefficient.

Illumination: Light exposure generates electron-hole pairs reducing resistivity.

Doping: The introduction of specific impurities alters the resistivity by increasing free charge carriers in the semiconductor materials.

32. (c)

Trivalent impurities like Boron, Gallium and Indium create holes by accepting electrons, forming a *p*-type semiconductor.

33. (b)

The mass action law states that under thermal equilibiring the product of electron concentration (n_e) and hole concentration (n_h) remains constant, regardless of the level of doping

$$n_e n_h = n_i^2$$

34. (d)

The hall effect is widely used to determine carrier concentration, calculate carrier mobility, measure magnetic field strength using a Gaussmeter and distinguish between *n*-type and *p*-type semiconductors based on the polarity of the hall voltage.

35. (a)

A atom's total angular momentum consists of three components:

1. Orbital angular momentum of the electron.
2. Electron spin angular momentum.
3. Nuclear spin angular momentum.

36. (d)

All pyroelectric materials are Piezoelectric, but not all Piezoelectric materials are Pyroelectric materials can be ferroelectric, not all of them exhibit ferroelectricity.

37. (d)

- When equal no of anions and cations are missing from lattice, then it is but obvious that density will reduce.
- Schottky defect is found in highly ionic compound with high coordination numbers and where cations and anions are of similar size.
- Frenkel defect is found in ionic compounds with low coordination numbers and where anions are much-larger in size than cations.

38. (a)

Given parallel plate capacitor of area A and distance between plates is 6 mm,

$$\varepsilon_r = 2.4$$

and $$E = 4 \times 10^4 \text{ V/m}$$

Since, $$C = \frac{\varepsilon A}{d}$$

and $$Q = CV = CE\,d$$

$$\text{Charge density} = \frac{Q}{A} = \varepsilon E$$

$$= 2.4 \times 8.8 \times 10^{-12} \text{ F/m} \times 4 \times 10^4 \text{ V/m}$$

$$= 84.48 \times 10^{-8} \text{ C/m}^2$$

39. (b)

We have susceptibility, $$\chi_m = \frac{M}{H} = \mu_r - 1$$

So relative permeability, $$\mu_r = 1 + \frac{M}{H}$$

40. (d)

$$\text{Hysteresis loss} = \text{Area of hysteresis loop} \times \text{Frequency} \times \text{Volume of core}$$

$$= (50000) \times 10^{-4} \times 10^2 \times 60 \times 0.02$$

$$= 600 \text{ W}$$

41. (d)

Dielectric strength of solid dielectrics depends on many extraneous factors, such as

- Defects and inhomogeneity of the material.
- Thickness, area and volume of the specimen.
- The surface conditions and the method of placing the electrodes.
- The type and application of test voltage and test duration.
- Moisture and other contaminations.

42. (d)

Eddy current loss, $P_{eddy} = K_e f^2 B_{max}^2 C^2$

Also, $K_e = \frac{\pi^2}{\rho} = \pi^2\sigma$ ($\sigma \rightarrow$ conductivity)

$$P_{eddy} = \pi^2 \sigma f^2 B^2_{max} \times C^2$$

$\Rightarrow$ $P_{eddy} \propto \sigma$

$\therefore$ $$\frac{P_{eddy\,A}}{P_{eddy\,B}} = \frac{9}{16}$$

43. (a)

$$\text{Loss tangent, } \tan\delta = \frac{\text{Imaginary part of relative permittivity}}{\text{Real part of relative permittivity}} = \frac{\varepsilon_r''}{\varepsilon_r'}$$

$\Rightarrow$ $$0.005 = \frac{\varepsilon_r''}{2.4}$$

$\Rightarrow$ $$\varepsilon_r'' = \frac{24}{10} \times \frac{5}{1000} = \frac{120}{10000} = 0.012$$

45. (b)

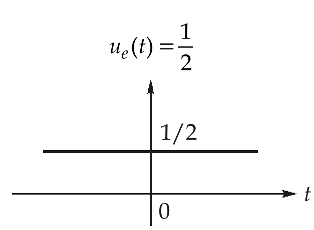
Both Statement (I) and Statement (II) are true but Statement (II) is **not** a correct explanation of Statement (I).

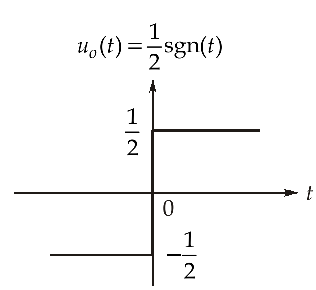
Section B : Systems & Signal Processing + Communication Systems

46. (d)

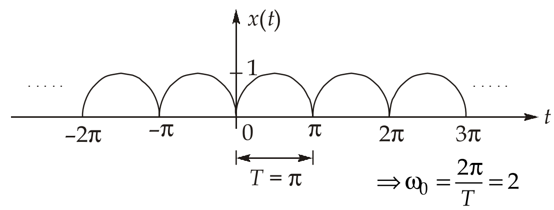
We know, $\text{sgn}(t) = 2\,u(t) - 1$

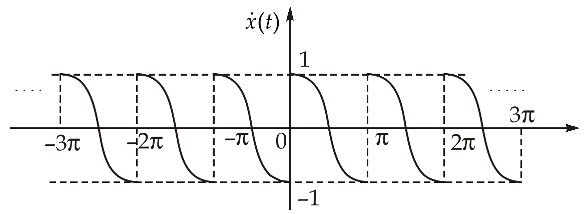
$\Rightarrow$ $$u(t) = \underbrace{\boxed{\frac{1}{2}}}_{\text{Even part}} + \underbrace{\boxed{\frac{1}{2}\text{sgn}(t)}}_{\text{Odd part}} = u_e(t) + u_o(t)$$

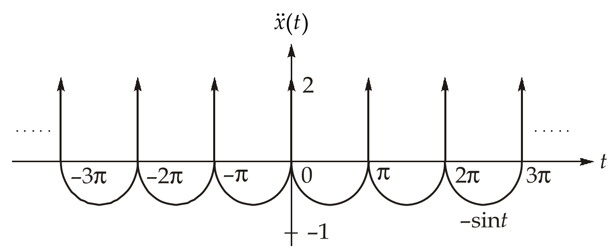


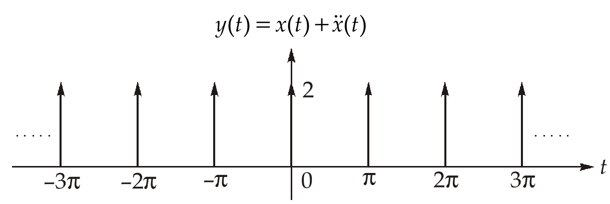


47. (a)









$\therefore$ $y(t)$ is train of impulses with Fourier series coefficients,

$$d_n = \frac{2}{T} = \frac{2}{\pi}$$

48. (b)

Convert the given $X(\omega)$ into strictly proper fraction

$$\begin{array}{r|l} & \quad 1 \\ \omega^2 + 25 & \omega^2 + 35 \\ & \omega^2 + 25 \\ & (-)\ (-) \\ \hline & \quad\ 10 \end{array}$$

$$\Rightarrow \qquad X(\omega) = \frac{\omega^2 + 35}{\omega^2 + 25} = 1 + \frac{10}{\omega^2 + 25}$$

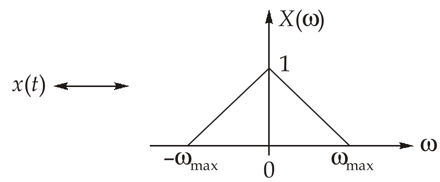
$$\Rightarrow \qquad X(\omega) = 1 + \left[\frac{2 \times 5}{\omega^2 + (5)^2}\right]$$

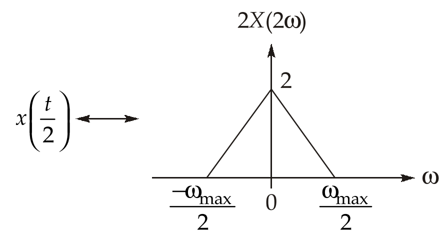
Taking inverse Fourier transform on both sides,

$$\Rightarrow \qquad x(t) = \delta(t) + e^{-5|t|}$$

49. (d)

If the signal $x(t)$ has a Nyquist rate $\omega_s = 2\omega_{max} = \omega_0$, then the maximum frequency present in the signal is $\omega_{max} = \frac{\omega_0}{2}$ and its Fourier transform $X(\omega) = 0$ for $|\omega| > \frac{\omega_0}{2}$.





$$x(t) * x\left(\frac{t}{2}\right) \leftrightarrow 2\, X(\omega) \cdot X\,(2\omega)$$

It will exist between $\frac{-\omega_{max}}{2}$ to $\frac{\omega_{max}}{2}$

$$\therefore \qquad \text{Nyquist rate} = 2\left[\frac{\omega_{max}}{2}\right] = \omega_{max} = \frac{\omega_0}{2}$$

50. (b)

$$X(s) = \log\left[\frac{s+10}{s+5}\right]$$

$$\left[\because x(t) \xleftrightarrow{\text{L.T.}} X(s) \quad -t\,x(t) \xleftrightarrow{\text{L.T.}} \frac{dX(s)}{ds}\right]$$

$$\Rightarrow \qquad X(s) = \log[s+10] - \log[s+5]$$

Differentiate with respect to 's' on both sides,

$$\frac{d}{ds}X(s) = \frac{1}{s+10} - \frac{1}{s+5}$$

Take inverse Laplace transform on both sides,

$$-t\;x(t) = e^{-10t}\,u(t) - e^{-5t}\,u(t)$$

$$\Rightarrow \qquad x(t) = \frac{1}{t}[e^{-5t} - e^{-10t}]u(t)$$

51. (c)

Carrier peak voltage :

$$V_c = 10 \text{ V}$$
$$\mu = 0.5$$
$$P_c = \frac{V_c^2}{2R} = \frac{100}{2\times 1} = 50 \text{ watt}$$

Total sideband power is

$$P_{SB} = \frac{P_c\mu^2}{2} = \frac{50\times(0.5)^2}{2} = \frac{50\times 0.25}{2} = 6.25 \text{ watt}$$

52. (a)

- Some characteristics of a high-frequency sine wave (carrier) is varied in accordance with the instantaneous value of a low-frequency signal (message signal).
- The parameters of the carrier wave remain constant unless modulated.
- for proper and efficient radiation, the receiving antennas should have heights equal to the $\frac{1}{4}$th of the received signal wavelength.
- The signal is converted first within the frequency range 10 to 20 kHz (possibly as typical communication signals are much higher in frequency).

53. (a)

Total modulated power, $P_t = P_c\left[1+\frac{\mu_1^2+\mu_2^2}{2}\right]$

$$= 10\left[1+\frac{(0.3)^2+(0.4)^2}{2}\right]\text{kW}$$
$$P_t = 10 \times 1.125 = 11.25 \text{ kW}$$

54. (d)

$$f_s = \frac{2f_H}{K}$$

where, $K = \frac{f_H}{f_H - f_L} = \frac{5}{5-1} = 1.25 \text{ kHz}$

Greatest integer lower than 1.25 is 1.0

$\therefore$ $f_s = \frac{2\times 5}{1} = 10 \text{ K samples/s}$

55. (b)

Given data, $f_m = 3 \text{ kHz}$

$\Delta f = 6 \text{ kHz}$

For FM signal, $\Delta f = k_f A_m$

Given, $A'_m = 4\,A_m$

$\therefore$ $\Delta f' = 4k_f A_m = 4 \times 6 = 24$ kHz

Using Carson's rule, $\text{B.W (new)} = (\Delta f' + f'_m)2 = \left(24 + \frac{3}{2}\right)2 = 51\text{ kHz}$

56. (b)

$$(\text{BW})_{\min} \text{ minimum bandwidth} = \frac{R_b}{\log_2 M}$$

For *QPSK*, $\rightarrow$ $M = 4$

$$\therefore \quad (\text{BW})_{\min} = \frac{R_b}{\log_2 4} = \frac{R_b}{2} = \frac{10\text{ Mbps}}{2} = 5\text{ Mbps}$$

57. (b)

On comparing the given expression with the standard AM wave,

$$S_{AM(t)} = A_C(1 + \mu \cos \omega_m t) \cos \omega_c t$$

We get, $A_C = 10$, $\mu = 0.5$

$$\text{Maximum value} = A_C(1 + \mu)$$
$$= 10(1 + 0.5)$$
$$= 10(1.5) = 15\text{ V}$$
$$\text{Minimum value} = A_C(1 - \mu)$$
$$= 10(1 - 0.5)$$
$$= 5\text{ V}$$

58. (a)

Pre-emphasis circuit is used at transmitting end before modulation takes place.

59. (c)

We have,

$$m(t) = 2\cos[(4\pi \times 10^3 t)]$$
$$c(t) = 5\cos[2\pi \times 10^6 t]$$

Hence, $f_m = 2 \times 10^3$ Hz and $A_m = 2$

$f_c = 1 \times 10^6$ Hz and $A_c = 5$

It is given that $\Delta f = 4 \times (\text{BW})_{AM} = 4 \times 2f_m$

$\Delta f = 4 \times 2 \times 2 \times 10^3 = 16$ kHz

$$\therefore \quad \text{Modulation Index, } \beta = \frac{\Delta f}{f_m} = \frac{16\text{ kHz}}{2\text{ kHz}} = 8$$

The FM signal can be written as

$$S(t) = A_c \sum_{n=-\infty}^{\infty} J_n(\beta)\cos[2\pi(f_c + nf_m)t]$$

The value of n for the term $\cos[2\pi\,(1008 \times 10^3 t)]$ can be obtained as

$$f_c + nf_m = 1008 \times 10^3$$

$$(10^6) + (n \times 2 \times 10^3) = 1008 \times 10^3$$

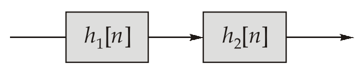
$$n = \frac{8}{2} = 4$$

Hence, the coefficient of the term.

$$\cos[2\pi\,(1008 \times 10^3 t)] = A_c J_n(\beta) = 5J_4(8)$$

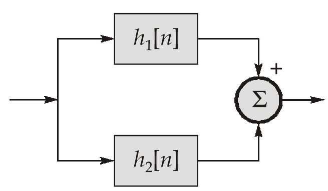
60. (c)

Connected in series:



$h[n] = h_1[n] * h_2[n]$ will be of linear phase.

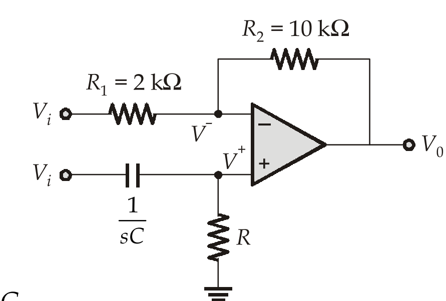
Connected in parallel:



$h[n] = h_1[n] + h_2[n]$ need not to be of linear phase.

Section C : BEE-2 + Analog Electronics-2 + Elec. & Electro. Measurements-2

61. (a)



$$R_2 = 10\text{ k}\Omega$$

$$R_1 = \frac{10}{5}\text{k}\Omega = 2\text{ k}\Omega$$

Op-amp is ideal by virtual short concept

$$V^- = V^+$$

where
$$V^+ = V_i \times \frac{R}{\left(R + \frac{1}{sC}\right)} = \frac{sRC}{(1+sRC)}V_i$$

∴
$$V^- = \frac{sRC}{(1+sRC)}V_i$$

$$V_0(s) = \left(1 + \frac{R_2}{R_1}\right)V^+ - \left(\frac{R_2}{R_1}\right)V_i(s)$$

$$= (1+5)\left(\frac{sRC}{1+sRC}\right)V_i(s) - 5V_i(s)$$

$$\frac{V_0(s)}{V_i(s)} = \frac{6sRC}{1+sRC} - 5$$

$$\frac{V_0(s)}{V_i(s)} = \frac{sRC-5}{1+sRC}$$

62. (a)

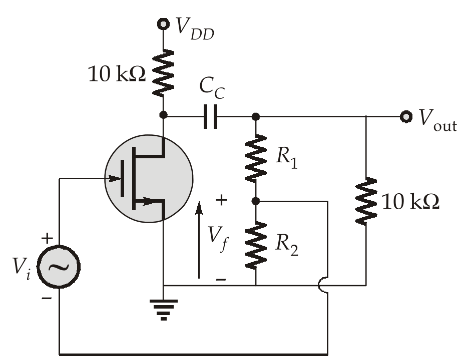
Slew rate, $S_R \geq \left|\frac{dV_0(t)}{dt}\right| \geq \left|\frac{d}{dt}(A_v V_i(t))\right| \geq \left|A_v \frac{dV_i(t)}{dt}\right|$

$$2 = A_v \frac{dV_i(t)}{dt}$$

$$\frac{2\text{V}}{\mu\text{sec}} = A_v \times \frac{0.8\text{ V}}{20\,\mu\text{sec}}$$

$\Rightarrow$ $A_v = 50$

63. (b)



$$A_f = \frac{A}{1+A\beta}$$

given $|A\beta| >> 1$ then, $A_f = \frac{A}{A\beta} = \frac{1}{\beta}$

$$\beta = \frac{V_f}{V_0} = \frac{V_0\left(\frac{-R_2}{R_1+R_2}\right)}{V_0} = \frac{-R_2}{R_1+R_2}$$

$$A_f = \frac{1}{\beta} = -\frac{(R_1+R_2)}{R_2} = \frac{-100\text{ k}\Omega}{20\text{ k}\Omega} = -5$$

64. (c)

$$V_0 = -\frac{R_4}{R_1}V_1 + \left(-\frac{R_4}{R_2}\right)V_2 + \left(-\frac{R_4}{R_3}\right)V_3$$

$$= -\left[\frac{R_4}{R_1}V_1 + \frac{R_4}{R_2}V_2 + \frac{R_4}{R_3}V_3\right]$$

$$|V_0| = \frac{R_4}{R_1}V_1 + \frac{R_4}{R_2}V_2 + \frac{R_4}{R_3}V_3$$

Given, $|V_0| = 3V_1 + 2V_2 + 7V_3$

$\therefore$ $\frac{R_4}{R_1} = 3, \frac{R_4}{R_2} = 2, \frac{R_4}{R_3} = 7$

$\therefore$ $R_1 : R_2 : R_3 : R_4$

$$\frac{1}{3} : \frac{1}{2} : \frac{1}{7} : 1$$

Multiplying by 12 we get,

$$\frac{12}{3} : \frac{12}{2} : \frac{12}{7} : 12$$

$$4\text{ k}\Omega : 6\text{ k}\Omega : \frac{12}{7}\text{ k}\Omega : 12\text{ k}\Omega$$

65. (d)

Power consumed, $P = I^2R$

Relative error in power, $\frac{\delta P}{P} = \left(\frac{2\delta I}{I} + \frac{\Delta R}{R}\right) = (2\times 0.75 + 0.2)$

$= 1.7\%$ Higher

66. (b)

$\cos\delta = 0.8, \sin\delta = 0.6$

Actual CT ratio, $R = n + \left(\frac{I_w \cos\delta \pm I_u \sin\delta}{I_s}\right)$ ($\because$ '+' for lagging PF load, '–' for leading PF load)

$$= \left[199 + \left(\frac{4\times 0.8 - 7\times 0.6}{5}\right)\right] = 198.8$$

$\therefore$ Ratio error $= \left(\frac{k_n - R}{R}\right)\times 100 = \left(\frac{200 - 198.8}{198.8}\right)\times 100 = 0.603\%$

67. (d)

Close generator frequency,

$$f_{\text{clk}} = 1.5\text{ MHz}$$

The meter can count upto 1999 ≈ 2000

Maximum counting time = Counts × $T_{\text{clk}} = \frac{2000}{1.5\times 10^6} = 1.33\text{ m sec}$

68. (c)

- Digital instrument should have input impedance of the order of mega ohm.
- Instrument must passes high input impedance to reduce loading effects.

69. **(d)**

The time base generator in a CRO gives an output is high frequency sawtooth waves.

70. **(c)**

For the current transformer,

Transformation ratio of CT is

$$R = n + \frac{I_\omega \cos\delta + I_m \sin\delta}{I_s}$$

Given the secondary winding is resistive

$\therefore$ $\cos\delta = 1$,

$\sin\delta = 0$

as $\delta = 0°$ voltage and current phasors are in phase at secondary side of C.T.

Now, $R = n + \frac{I_w}{I_s}$

$$20.6 = \frac{100}{x} + \frac{I_w}{I_s}$$

$$\Rightarrow \quad 20.6 = \frac{100}{x} + \frac{I_w}{x}$$

[$\because$ At rated condition, on primary side 100 A and on secondary side $I_S = x$ A will flow]

$$20.6 = \frac{100+3}{x}$$

$$\Rightarrow \quad x = 5$$

71. **(c)**

$$\frac{f_y}{f_x} = \frac{\text{No. of horizontal tangencies}}{\text{No. of vertical tangencies}}$$

$$\frac{9}{18} = \frac{4}{x}$$

No. of vertical tangencies,

$$x = \frac{4 \times 18}{9} = 8$$

72. **(a)**

$$\text{Power factor} = \frac{P}{VI}$$

$$\%\ \text{error} = \pm\left[\frac{\delta P}{P} + \frac{\delta V}{V} + \frac{\delta I}{I}\right]$$

$$= 2 + 2 + 1 = 5\%$$

73. (c)

$$\text{Sensitivity of LVDT} = \frac{\text{Output voltage}}{\text{Displacement}} = \frac{1.5\,\text{V}}{10\,\text{mm}} = 0.15\ \text{V/mm}$$

$$\begin{aligned}\text{Sensitivity of instrument} &= \text{Amplification factor} \times \text{Sensitivity of LVDT}\\ &= 300 \times 0.15\ \text{V/mm}\\ &= 45\ \text{V/mm}\end{aligned}$$

74. (a)

The Piezoelectric effect can be made to respond to (or cause) mechanical deformations of the material in many different modes. The modes can be thickness expansion, transverse expansion, thickness shear and face shear.

A Piezoelectric element used for converting mechanical motion to electrical signals may be thought as charge generator and a capacitor. Mechanical deformation generates a charge and this charge appears as a voltage across the electrodes. The voltage is $V = Q/C$.

75. (d)

Two sinusoidal waveforms of same frequency produces lissajous pattern which may be a straight line, a circle or an ellipse.

❍❍❍❍