DETAILED SOLUTIONS

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ESE 2020 : Prelims Exam
CLASSROOM TEST SERIES

ELECTRICAL ENGINEERING

Test 18

Full Syllabus Test 2 : Paper-II

1. (d)	**26.** (a)	**51.** (c)	**76.** (b)	**101.** (b)	**126.** (b)
2. (c)	**27.** (c)	**52.** (b)	**77.** (a)	**102.** (b)	**127.** (b)
3. (b)	**28.** (b)	**53.** (d)	**78.** (a)	**103.** (a)	**128.** (c)
4. (a)	**29.** (a)	**54.** (b)	**79.** (d)	**104.** (a)	**129.** (d)
5. (c)	**30.** (c)	**55.** (b)	**80.** (b)	**105.** (b)	**130.** (a)
6. (c)	**31.** (d)	**56.** (d)	**81.** (c)	**106.** (b)	**131.** (a)
7. (a)	**32.** (b)	**57.** (c)	**82.** (d)	**107.** (c)	**132.** (a)
8. (b)	**33.** (c)	**58.** (b)	**83.** (c)	**108.** (a)	**133.** (b)
9. (b)	**34.** (a)	**59.** (b)	**84.** (b)	**109.** (c)	**134.** (a)
10. (a)	**35.** (b)	**60.** (b)	**85.** (c)	**110.** (d)	**135.** (c)
11. (b)	**36.** (b)	**61.** (a)	**86.** (c)	**111.** (b)	**136.** (c)
12. (d)	**37.** (b)	**62.** (a)	**87.** (d)	**112.** (b)	**137.** (a)
13. (d)	**38.** (a)	**63.** (c)	**88.** (b)	**113.** (a)	**138.** (c)
14. (c)	**39.** (d)	**64.** (a)	**89.** (a)	**114.** (a)	**139.** (b)
15. (c)	**40.** (c)	**65.** (c)	**90.** (c)	**115.** (b)	**140.** (c)
16. (c)	**41.** (c)	**66.** (c)	**91.** (c)	**116.** (a)	**141.** (b)
17. (b)	**42.** (b)	**67.** (a)	**92.** (d)	**117.** (c)	**142.** (c)
18. (b)	**43.** (b)	**68.** (b)	**93.** (a)	**118.** (a)	**143.** (a)
19. (b)	**44.** (a)	**69.** (c)	**94.** (b)	**119.** (a)	**144.** (c)
20. (a)	**45.** (d)	**70.** (c)	**95.** (a)	**120.** (b)	**145.** (c)
21. (b)	**46.** (d)	**71.** (c)	**96.** (c)	**121.** (b)	**146.** (b)
22. (b)	**47.** (d)	**72.** (b)	**97.** (b)	**122.** (c)	**147.** (c)
23. (c)	**48.** (c)	**73.** (d)	**98.** (d)	**123.** (a)	**148.** (d)
24. (d)	**49.** (b)	**74.** (c)	**99.** (a)	**124.** (d)	**149.** (c)
25. (d)	**50.** (d)	**75.** (a)	**100.** (c)	**125.** (c)	**150.** (a)

DETAILED EXPLANATIONS

2. **(c)**

The oscillating frequency of an under-damped RLC circuit is lower than the resonance frequency.

3. **(b)**

Using superposition, due to voltage source current through the circuit is zero so average power is zero.

4. **(a)**

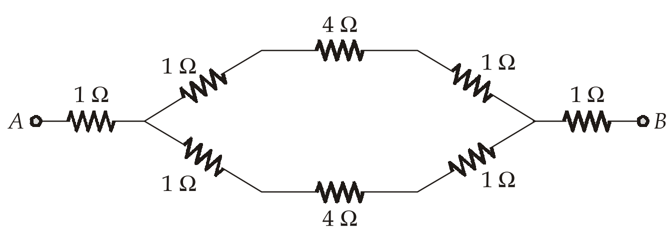
In RLC circuit, supply voltage and current are in phase means the circuit behaves like a resistive i.e. The circuit is at resonance.

At resonance, $|V_L| = |V_C|$

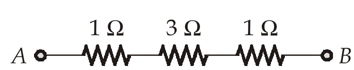
$$\frac{|V_L|}{|V_C|} = 1$$

5. **(c)**

Converting the two delta networks formed by resistors 3 Ω, 3 Ω and 3 Ω into equivalent star networks, we have,



The network can be simplified,



$R_{AB} = 5\ \Omega$

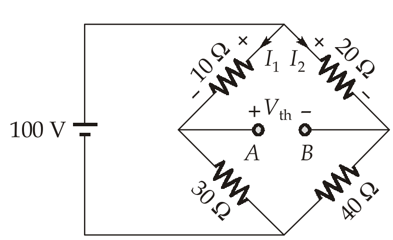
7. **(a)**

Step-I: Calculation of V_{th}

Removing the variable resistor R_L from the network,

$$I_1 = \frac{100}{10+30} = 2.5\text{ A}$$

$$I_2 = \frac{100}{20+40} = 1.66\text{ A}$$



Writing V_{th} equation,

$$V_{th} + 10I_1 - 20I_2 = 0$$

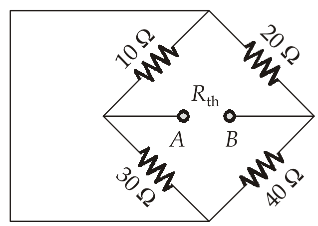
$$V_{th} = 20I_2 - 10I_1$$

$$= 20 \times 1.66 - 10 \times 2.5$$

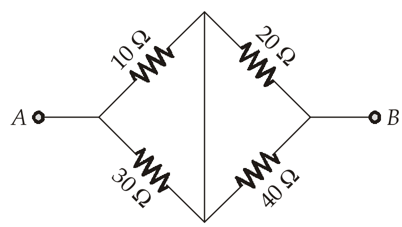
$$= 8.2 \text{ V}$$

Step-II: Calculation of R_{th}

Replacing the voltage source of 100 V with short circuit,



The above circuit can be redrawn as shown,



$$R_{th} = (10 \,||\, 30) + (20 \,||\, 40)$$

$$= \frac{300}{40} + \frac{800}{60} = 20.83 \ \Omega$$

Step-III: Calculation of P_{max}

$$P_{max} = \frac{V_{th}^2}{4R_{th}} = \frac{(8.2)^2}{4 \times 20.83} = 0.81 \text{ W}$$

8. **(b)**

$$V_{rms} = \sqrt{\frac{0^2 + (40)^2 + (60)^2 + (80)^2 + (100)^2 + (80)^2 + (60)^2 + (40)^2}{8}}$$

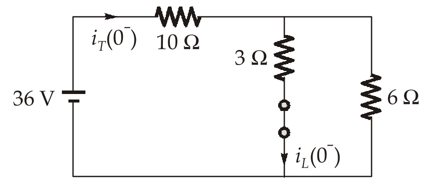
$$= \sqrt{\frac{33200}{8}} = 64.42 \text{ V}$$

9. **(b)**

At $t = 0^-$, the switch is closed and steady-state condition is reached. Hence, the inductor acts as a short circuit.

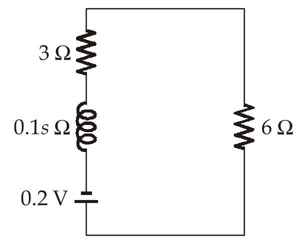
$$i_T(0^-) = \frac{36}{10 + (3 \,||\, 6)} = \frac{36}{10 + 2} = 3 \text{ A}$$

$$i_L(0^-) = 3 \times \frac{6}{6 + 3} = 2 \text{ A}$$



Since current through the inductor can not change instantaneously,

$$i_L(0^+) = 2\text{ A}$$



Applying KVL to mesh for $t > 0$,

$$-0.2 - 0.1sI(s) - 3I(s) - 6I(s) = 0$$

$$0.1\,sI(s) + 9I(s) = 0.2$$

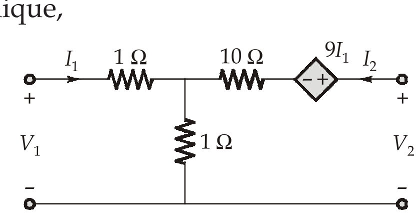
$$I(s) = \frac{0.2}{0.1s+9} = \frac{2}{s+90}$$

Taking inverse laplace transform,

$$i(t) = 2\,e^{-90t}$$

10. (a)

By source transformation technique,



Applying KVL to mesh-1,

$$V_1 = 2I_1 + I_2 \quad \text{...(i)}$$

Applying KVL to mesh-2,

$$V_2 = 9I_1 + 10I_2 + (I_1 + I_2)$$

$$= 10I_1 + 11I_2 \quad \text{...(ii)}$$

Comparing equation (i) and (ii) with Z-parameter equations, we get

$$\begin{bmatrix} Z_{11} & Z_{12} \\ Z_{21} & Z_{22} \end{bmatrix} = \begin{bmatrix} 2 & 1 \\ 10 & 11 \end{bmatrix}$$

11. (b)

For any vector $\vec{A}$ to be solenoidal,

$$\nabla \cdot \vec{A} = 0$$

Only option (b) satisfies above condition,

$$\nabla \cdot \left[2y^2\hat{i} + 3x^2z\hat{j} + 3xy\hat{k}\right] = 0$$

12. (d)

The electric field inside the sphere is zero, the potential at every point inside is constant,

For $r > R$

$$V = \int_0^r E \cdot dr \propto \frac{1}{r}$$

13. (d)

For an infinitely long wire with a line charge density of ρ_L,

$$\vec{E} = \frac{\rho_L}{2\pi\varepsilon_0 r}\hat{a}_r ,$$

$$V_B - V_A = -\int_A^B \vec{E} \cdot \vec{dr}$$

$$V_{B, A} = -\int_1^3 \frac{5 \times 10^{-6}}{2\pi\varepsilon_0 r} dr$$

$$V_B - V_A = \frac{-5 \times 10^{-6}}{2\pi\varepsilon_0} \ln 3 \text{ V}$$

Hence, potential is directly proportional to ln r.

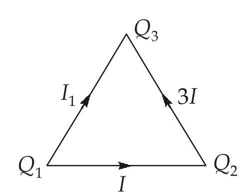
14. (c)

From the continuity equation,

$$-I_1 - 3I + \frac{dQ}{dt} = 0$$

$$-I_1 - 3I + 5I = 0$$

$$\Rightarrow \quad I_1 = 2I$$



15. (c)

Routh's tabulation of $s^3 + 3Ks^2 + (K + 2)s + 4 = 0$ is

s^3	1	$K+2$
s^2	$3K$	4
s^1	$\frac{3K(K+2)-4}{3K}$	0
s^0	4	

From the s^2 row, the condition of stability is $K > 0$ and from the s^1 row, the condition of stability is

$$3K^2 + 6K - 4 > 0$$

or, $K < -2.528$ or $K > 0.528$

When the conditions of $K > 0$ and $K > 0.528$ are compared

The closed-loop system to be stable, K must satisfy,

$$K > 0.528$$

16. (c)

Since, $r(t) = 1$

$\therefore$ $R(s) = \frac{1}{s}$

$\therefore$ $X(s) = \frac{1}{s}\frac{100}{(s^2+2s+50)}$

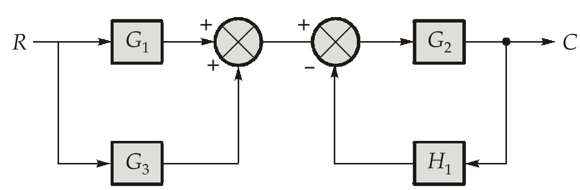
Applying final value theorem,

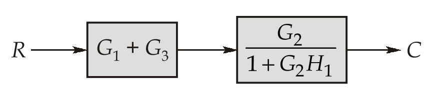
$$\underset{t\to\infty}{x(t)} = \lim_{s\to 0} sX(s)$$

$$= \lim_{s\to 0} s\frac{1}{s}\frac{100}{(s^2+2s+50)} = \frac{100}{50} = 2.0$$

17. (b)

The block diagram can be redrawn,





$$\frac{C}{R} = \frac{(G_1+G_3)G_2}{1+G_2H_1} = \frac{G_1G_2+G_2G_3}{1+G_2H_1}$$

18. (b)

The overall transfer function,

$$\frac{C(s)}{R(s)} = \frac{\frac{20}{[(s+1)(s+5)]}}{1+\frac{20}{(s+1)(s+5)}\cdot 1} = \frac{20}{s^2+6s+25}$$

$$= \frac{20}{25}\times\frac{25}{s^2+6s+25}$$

The characteristic equation is given by,

$$s^2 + 6s + 25 = 0$$

From the characteristic equation,

$$\omega_n = \sqrt{25} = 5 \text{ rad/sec}$$

$$2\xi\omega_n = 6$$

$$\xi = 0.6$$

The time at which the maximum overshoot occurs is

$$t_p = \frac{\pi}{\omega_n\left(\sqrt{1-\xi^2}\right)} = \frac{\pi}{5\sqrt{1-0.6^2}}$$

$$= \frac{\pi}{5\times 0.8} = \frac{\pi}{4} = 0.785 \text{ sec}$$

19. (b)

$$r(t) = 4t\,u(t), \text{ thus } A = 4$$

$$K_v = \lim_{s\to 0} sG(s)H(s) = \lim_{s\to 0}\frac{s\cdot 2(s^2+3s+20)}{s(s+2)(s^2+4s+10)} = 2$$

$$e_{ss} = \frac{A}{K_v} = \frac{1}{2}\times 4 = 2$$

20. (a)

$$B = \begin{bmatrix}1\\0\\1\end{bmatrix},$$

$$A = \begin{bmatrix}0 & 1 & 0\\0 & 0 & 1\\-6 & -11 & -6\end{bmatrix}$$

$$AB = \begin{bmatrix}0 & 1 & 0\\0 & 0 & 1\\-6 & -11 & -6\end{bmatrix}\begin{bmatrix}1\\0\\1\end{bmatrix} = \begin{bmatrix}0\\1\\-12\end{bmatrix}$$

$$A^2B = \begin{bmatrix}0 & 1 & 0\\0 & 0 & 1\\-6 & -11 & -6\end{bmatrix}\begin{bmatrix}0\\1\\-12\end{bmatrix} = \begin{bmatrix}1\\-12\\61\end{bmatrix}$$

Controllability test matrix is given by,

$$U = \left[B : AB : A^2B\right]$$

$\therefore$
$$U = \begin{bmatrix}1 & 0 & 1\\0 & 1 & -12\\1 & -12 & 61\end{bmatrix}$$

$\therefore$ $|U| \neq 0$ the system is controllable

$$C^T = \begin{bmatrix}10\\5\\1\end{bmatrix},$$

$$A = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -6 & -11 & -6 \end{bmatrix}$$

$$A^T = \begin{bmatrix} 0 & 0 & -6 \\ 1 & 0 & -11 \\ 0 & 1 & -6 \end{bmatrix}$$

$$A^TC^T = \begin{bmatrix} 0 & 0 & -6 \\ 1 & 0 & -11 \\ 0 & 1 & -6 \end{bmatrix}\begin{bmatrix} 10 \\ 5 \\ 1 \end{bmatrix} = \begin{bmatrix} -6 \\ -1 \\ -1 \end{bmatrix}$$

$$(A^T)^2C^T = \begin{bmatrix} 0 & 0 & -6 \\ 1 & 0 & -11 \\ 0 & 1 & -6 \end{bmatrix}\begin{bmatrix} -6 \\ -1 \\ -1 \end{bmatrix} = \begin{bmatrix} 6 \\ 5 \\ 5 \end{bmatrix}$$

Observability test matrix,

$$V = \left[C^T : A^TC^T : (A^T)^2C^T\right]$$

$$V = \begin{bmatrix} 10 & -6 & 6 \\ 5 & -1 & 5 \\ 1 & -1 & 5 \end{bmatrix}$$

$$|V| \neq 0$$

Therefore system is completely observable.

21. (b)

6 db/octave = 20 db/decade

The initial slope is –6 db/octave

∴ the type of system is 1.

1. The initial slope intersects 0 db axis at $\omega = 0.25$ rad/sec

$$K = 0.25$$

2. Beyond $\omega = 2.5$ rad/sec, the slope changes by +6 db/octave = +20 db/decade

$$(1 + j\omega T_1) = \left(1 + j\omega\frac{1}{2.5}\right) = (1 + j0.4\,\omega)$$

3. Beyond $\omega = 10$ rad/sec, the slope changes by +6 dB/octave (+20 db/decade) which corresponds to the term.

$$(j\omega T_2 + 1) = \left(1 + j\omega\frac{1}{10}\right) = (1 + j0.1\,\omega)$$

4. Beyond $\omega = 25$ rad/sec, the slope changes by –6 db/octave (–20 db/decade) which corresponds to the term

$$\frac{1}{(j\omega T_3 + 1)} = \frac{1}{1 + j\omega\frac{1}{25}} = \frac{1}{1 + j0.04\omega}$$

$$\therefore \qquad G(s)H(s) = \frac{0.25(1+0.4s)(1+0.1s)}{s(1+0.04s)}$$

22. (b)

$$A = \begin{bmatrix} 0 & 1 \\ 0 & -3 \end{bmatrix}$$

$$(sI - A) = \begin{bmatrix} s & -1 \\ 0 & s+3 \end{bmatrix}$$

$$(sI - A)^{-1} = \frac{\text{Adj}(sI-A)}{|sI-A|} = \frac{\begin{bmatrix} s+3 & 1 \\ 0 & s \end{bmatrix}}{s(s+3)} = \begin{bmatrix} \frac{1}{s} & \frac{1}{s(s+3)} \\ 0 & \frac{1}{s+3} \end{bmatrix}$$

Taking inverse Laplace transform

$$\phi(t) = \begin{bmatrix} 1 & \frac{1}{3}-\frac{1}{3}e^{-3t} \\ 0 & e^{-3t} \end{bmatrix}$$

23. (c)

Maximum phase shift occurs at,

$$\omega_{max} = \sqrt{\omega_1 \times \omega_2} = \sqrt{1 \times 2} = \sqrt{2} \text{ rad/sec}$$

24. (d)

At very high frequencies, the zero resistance of the superconductor is modified. But the transition temperature remain unaffected.

Silsbee's rule:

When persistent current increased beyond a critical value, the superconductor becomes a normal conductor.

25. (d)

Parameters can be determined by using Hall effect:

1. Mobility of charge carriers.
2. Type of semiconductor.
3. Carrier concentration.

26. (a)

- In the radio frequency range (10^6 – 10^{11} Hz) the permanent dipoles will be unable to follow the field, the orientational polarization stops.
- In the infrared frequency range (10^{11} – 10^{14} Hz), the ions can not follow the field, and hence ionic polarization stops.
- Only electronic polarization contributes at very high frequencies ($f > 10^{14}$ Hz).

$\therefore$ The permittivity of dielectric decreases with increase in frequency (At higher frequencies)

27. **(c)**

The face-centred cubic has a coordination number of 12 and the body centred cubic has a coordination number of 8.

28. **(b)**

Properties of Nano-materials:

- They have very high magneto resistance.
- They have lower melting point.
- They have high solid state phase transition pressure.
- They have lower debye temperature.
- They have high self-diffusion coefficient.
- They have high catalytic activity.
- They have lower ferroelectric phase transition temperature.

29. **(a)**

$$\vec{P} = \varepsilon_0(k-1)\vec{E}$$

$$\vec{E} = \frac{V}{d} = \frac{110}{0.5\times10^{-3}} = 220 \times 10^3 \text{ V/m}$$

$$\vec{P} = 8.85 \times 10^{-12} \times (2-1) \times 220 \times 10^3$$

$$\vec{P} = 1.94 \times 10^{-6} \text{ C-m}$$

30. **(c)**

Ferrites have high permeability and low dielectric loss.

32. **(b)**

Loss tangent, $\tan\delta = \dfrac{\varepsilon_r''}{\varepsilon_r'}$

Complex permittivity, $\varepsilon_r^* = \varepsilon_r' - j\varepsilon_r''$

$$\varepsilon_r'' = 2 \times 0.004 = 0.008$$

$$\varepsilon_r^* = 2 - j\,0.008$$

33. **(c)**

Total polarizability,

$$\alpha = \alpha_e + \alpha_i + \alpha_0$$

$$\alpha_e = 4\pi\varepsilon_0 R^3 = \text{electronic polarizability}$$

$$\alpha_i = \text{ionic polarizability}$$

$$\alpha_0 = \frac{P_p^2}{3kT} = \text{orientational polarizability}$$

$$\alpha = f\left(R, \frac{1}{T}, E\right)$$

orientational polarizability depends the temperature.

E increases $\rightarrow$ radius R increases

R increases $\rightarrow$ α_e increases

34. (a)

3d shell | ↑↓ | ↑↓ | ↑↓ | ↑ | ↑ |

∴ Number of unpaired electrons in nickel atom = 2

∴ Magnetic moment = 2 Bohr magnetron.

35. (b)

Induced emf in a winding,

$$E = 4.44 \times f \times \phi_m \times T$$

$$500 = 4.44 \times 50 \times 500 \times \phi_m$$

$$\phi_m = \frac{500}{4.44 \times 50 \times 500} = 4.5 \times 10^{-3} \text{ Wb}$$

$$\text{Peak flux density, } B_m = \frac{\phi_m}{\text{core area}} = \frac{4.5 \times 10^{-3}}{90 \times 10^{-4}} = 0.5 \text{ Wb/m}^2$$

36. (b)

$$\text{Efficiency, } \eta = \frac{\text{Output}}{\text{Output} + \text{loss}} = \frac{(10 \times 1)}{(10 \times 1) + (0.2) + (0.2)} = 96.15\%$$

37. (b)

Power shared by transformers in parallel is inversely proportional to equivalent impedance.

Let, power shared by transformer-1,

$$P_{\text{shared } j4} \propto \frac{1}{j4}$$

and that by transformer-2 be,

$$P_{\text{shared } j8} \propto \frac{1}{j8}$$

$$\therefore \quad P_{\text{shared } j4} = \frac{j8}{j8 + j4} \times 240$$

$$\Rightarrow \quad \frac{j8}{j12} \times 240 = \frac{2}{3} \times 240 = 160 \text{ kW}$$

Similarly for second transformer,

$$P_{\text{shared j8}} = \frac{j4}{j8 + j4} \times 240 = \frac{4}{12} \times 240 = 80 \text{ kW}$$

Hence, transformer with impedance $j4$ shares more power.

38. (a)

Induction generators can work at leading power factor only.

39. (d)

The field flux axis is along direct axis and armature mmf axis is along interpolar region.

40. (c)

Since the torque is same the armature also remain same,

$$\text{The operating speed} = \frac{2}{3}\times\text{Initial speed}$$

$$= \frac{2}{3}\times 1500 = 1000 \text{ rpm}$$

We know, $E_b \propto N$

$$\frac{E_{b2}}{E_{b1}} = \frac{N_2}{N_1} = \frac{1000}{1500} = \frac{2}{3}$$

$$E_{b2} = \frac{2}{3}E_{b1} = \frac{2}{3}(V - I_aR_a)$$

$$= \frac{2}{3}(200 - 20\times 0.3) = 129.33 \text{ V}$$

Again using,

$$E = V - I_aR_T$$

$$R_T = \frac{V-E}{I_a} = \frac{200-129.33}{20} = 3.53\ \Omega$$

The resistance required in series, $R_T - R_a$

$3.53 - 0.3 = 3.23\ \Omega$

41. (c)

We know for proper armature reaction compensation.

Ampere turns by compensating winding = Armature reaction mmf

$$\frac{I_a\times T_{cw}}{\text{pole}} = \frac{I_aZ}{2AP}\left(\frac{\text{Pole arc}}{\text{Pole pitch}}\right)$$

$$\therefore \quad \text{Turns/pole} = \frac{Z}{2AP}\left(\frac{\text{Pole arc}}{\text{Pole pitch}}\right) = \frac{240}{2\times4\times4}\times 0.8 = 6$$

∴ Compensating conductors per pole,

$= 2 \times 6 = 12$

42. (b)

Rotating magnetic field speed,

$$N_S = \frac{120\times f}{P} = \frac{120\times 50}{4} = 1500 \text{ rpm}$$

$$\text{Slip, } s = \frac{f}{f_s} = \frac{2}{50} = 0.04$$

$$\text{Rotor speed, } N_r = N_s(1-s)$$

$= 1500\ (1 - 0.04)$

$= 1500 \times 0.96$

$= 15 \times 96 = 1440$ rpm

The output power, $P_0 = \tau \times \omega_r$

$$= 100 \times \frac{1440 \times 2\pi}{60} = 15.079 \text{ kW}$$

∴Rotor copper loss per phase

$$= \frac{1}{3}\frac{s}{(1-s)}P_0 = \frac{1}{3} \times \frac{0.04}{0.96} \times 15.079 = 209.43 \text{ W}$$

43. (b)

Characteristic-I represents dc series motor speed torque characteristics.

44. (a)

We know,

$$\frac{T_{st}}{T_{fl}} = \left(\frac{xI_{sc}}{I_{fl}}\right)^2 \times s_{fl}$$

$$= x^2\left(\frac{I_{sc}}{I_{fl}}\right)^2 \times s_{fl} = (0.5)^2 \times (6)^2 \times 0.04$$

$$\frac{T_{st}}{T_{fl}} = 0.25 \times 36 \times 0.04 = 0.36$$

$$T_{st} = 0.36\ T_{fl}$$

45. (d)

For given induction motor,

Stator frequency, $f_1 = 50$ Hz

Required rotor frequency,

$f_2 = 30$ Hz

No. of poles, $P = 4$

We know,

$$\text{Stator field speed, } N_s = \frac{120 \times f}{P} = \frac{120 \times 50}{4} = 1500 \text{ rpm}$$

Similarly, rotor field speed,

$$N_r = \frac{120 \times f}{P} = \frac{120 \times 30}{4} = 900 \text{ rpm}$$

When rotor is driven in direction of stator field

Speed $= n_s - n_r = 1500 - 900 = 600$ rpm

When rotor is driven in opposite direction of stator field

Speed $= N_s - (-N_r) = N_s + N_r$

$= 1500 + 900$

$= 2400$ rpm

46. (d)

- The ratio of gross power output to air gap power in induction motor with slip, *s* is (1 – *s*).
- If applied voltage to induction motor under no load becomes half of the rated value there is negligible change in speed but stator current decreases.

47. (d)

- The nature of armature mmf for zero power factor lagging in 3-ϕ alternator is demagnetizing.
- When a synchronous motor is over excited its back emf is greater than the supply voltage.

48. (c)

For the synchronous motor neglecting losses,

$$\text{Power, } P_{i/p} = P_{o/p} = \sqrt{3}V_L I_L \cos\phi$$

$$P_{\text{in}} = \sqrt{3} \times 440 \times 100 \times 0.8$$

Torque developed is given by,

$$T = \frac{60}{2\pi N_s} \times P_{\text{out}} \text{N-m}$$

Using above relation, $$N_s = \frac{60}{2\pi T} \times P_{\text{out}}$$

$$= \frac{60}{2\pi \times \frac{2018}{\sqrt{3}}} \times \sqrt{3} \times 440 \times 100 \times 0.8$$

$$= \frac{60 \times 3}{2\pi \times 2018} \times 440 \times 100 \times 0.8 = 499.70 \approx 500 \text{ rpm}$$

Using relation of synchronous speed,

$$N_s = \frac{120 f}{P}$$

$$P = \frac{120 \times f}{N_s} = \frac{120 \times 50}{500} = 12$$

49. (b)

Effective access time = [(1 – p) × access time when no page fault + p × access time during page fault]

$$= \left[1 - \left(\frac{1}{10^6}\right)\right] \times 20\,\text{ns} + \left(\frac{1}{10^6}\right) \times 10\,\text{ms} = \left(\frac{10^6 - 1}{10^6}\right) \times 20\,\text{ns} + \left(\frac{1}{10^6}\right) \times 10 \times 10^6\,\text{ns}$$

$\approx$ 30 ns

50. (d)

$$T_{\text{readmiss}} = 50 \text{ nsec}$$
$$T_{\text{readhit}} = 5 \text{ nsec}$$
$$h = 0.8$$
$$T_{\text{avgread}} = h \times T_{\text{readhit}} + (1 - h) \times T_{\text{readmiss}} = 0.8 \times 5 + 0.2 \times 50$$
$$= 4 + 10 = 14 \text{ nsec}$$

51. (c)

Given,

Base-10 number = (7674)

By continued division by 2 converting in binary,

2	7674	0	A
	3837	1	
	1918	0	
	959	1	
	479	1	F
	239	1	
	119	1	
	59	1	
	29	1	D
	14	0	
	7	1	
	3	1	
	1	1	1

↑ reading order

The decimal number hexadecimal equivalent : $(1DFA)_{16}$

52. (b)

The ‘continue’ statement used in program is generally used with ‘if’ statement takes control to the beginning of the loop, bypassing the statements inside the loop which have not yet been executed.

53. (d)

Hazards are caused due to dependencies. Different Hazards in pipeline processor are:

1. **Structural Hazard:** arises when two different instructions in the pipeline wants to use same hardware.
2. **Control Hazard:** arises due to branch instructions.
3. **Data Hazard:** arises due to instruction dependency.

54. (b)

Given expression, $A = X\left(Y + Z(\overline{\overline{XY} + \overline{XZ}})\right)$

By Demorgan’s theorem,

$$A = X(Y + Z(\overline{\overline{XY}} \cdot \overline{\overline{XZ}})$$

$$= X\left[Y + Z\left(\bar{X} + \bar{Y}\right)\left(\bar{X} + \bar{Z}\right)\right]$$

$$= XY + XZ(\bar{X} + \bar{Y})(\bar{X} + \bar{Z})$$

$$= XY + \left(X\bar{X}Z + XZ\bar{Y}\right)\left(\bar{X} + \bar{Z}\right) \qquad \ldots \left[X\bar{X} = 0\right]$$

$$= XY + XZ\bar{Y}(\bar{X} + \bar{Z}) \qquad \ldots \left[Z\bar{Z} = 0\right]$$

$$= XY + 0 = XY$$

55. (b)

$$\text{Frequency rise} = \frac{50 \times 10}{100} = 5 \text{ Hz}$$

$$\text{Regulation} = \frac{5}{1500} \text{ Hz/MW} = \frac{1}{300} \text{Hz/MW}$$

56. (d)

- Towers depends upon the profile of land and right of way along which transmission lines are to be run, hence span lengths may or may not be equal.
- In Galloping conductors, to dampen the oscillations for stranded conductors, PVC tape is wrapped to make conductor circular.
- Lowest sag occurs when temperature is minimum and wind is maximum.

57. (c)

$$P_{\max} = \frac{|V_S||V_R|}{X}$$

To increase maximum power we need to reduce reactance or inductance.

$$L_{ph} = \frac{\mu_0}{2\pi} \ln\left(\frac{\text{GMD}}{\text{GMR}}\right)$$

∴ with low GMD and high GMR we can reduce inductance.

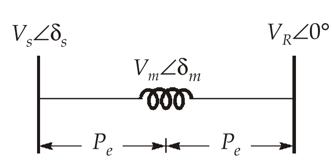
58. (b)

As the length of line increases the reactance increases and hence the maximum power transfer capability reduces.

$$P_{\max} = \frac{|V_S||V_R|}{X}$$

Maximum power is also called as steady state stability limit so as maximum power reduces, stability reduces.

59. (b)



The reactance of line upto midpoint is $\frac{X}{2}$

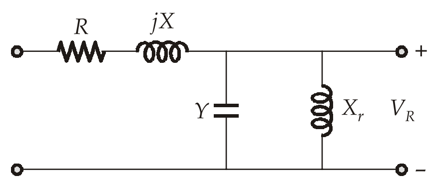
$$P_e = \frac{V_s V_m}{\frac{X}{2}} \sin(\delta_s - \delta_m) = \frac{V_m V_R}{\frac{X}{2}} \sin(\delta_m - 0)$$

$$\Rightarrow \quad \delta_s - \delta_m = \delta_m$$

$$\Rightarrow \quad \delta_m = \frac{\delta_s}{2} = \frac{60}{2} = 30°$$

$$\therefore \qquad P_e = \frac{V_s V_m}{\frac{X}{2}} \sin(\delta_s - \delta_m) = \frac{1.0 \times 0.95}{0.1} \sin 30° = 4.75 \text{ p.u.}$$

60. (b)



Equivalent *T*-matrix will be

$$\begin{bmatrix} A_1 & B_1 \\ C_1 & D_1 \end{bmatrix} = \begin{bmatrix} 1+YZ & Z \\ Y & 1 \end{bmatrix} \begin{bmatrix} 1 & 0 \\ \frac{1}{jX_r} & 1 \end{bmatrix}$$

For, $\qquad V_S = V_R \rightarrow A_1 = 1$

$$1 + YZ + \frac{Z}{jX_r} = 1$$

$$YZ = j\frac{Z}{X_r}$$

$$\Rightarrow \qquad |X_r| = \frac{Z}{YZ} = \frac{1}{Y} = 2000\ \Omega$$

61. (a)

The equivalent surge impedance of three transmission lines in parallel.

$$Z_{\text{line}} = \frac{400}{3}\Omega$$

$$V_2 = \frac{2\text{V} \times \frac{400}{3}}{100 + \frac{400}{3}} = \frac{8\text{V}}{7}$$

62. (a)

For the given values of sending end and receiving end voltages, the power transfer will be maximum when $\delta = \beta$.

$$A = A\angle\alpha = 0.96\angle 1.0°$$
$$B = B\angle\beta = 100\angle 80°$$

$$P_{R\ \max} = \frac{|V_S||V_R|}{|B|} - \frac{|A||V_R^2|}{|B|}\cos(\beta - \alpha)$$

$$= \frac{120 \times 110}{100} - \frac{0.96 \times 110^2}{100}\cos 79° = 109.83 \text{ MW}$$

63. (c)

Characteristic impedance,

$$Z_C = \sqrt{\frac{L}{C}}$$

$$\Rightarrow \quad Z_C \propto \frac{1}{\sqrt{C}}$$

So, addition of lumped capacitance in parallel does not increase the Z_C.

Propagation constant, $r = j\omega\sqrt{LC}$

$$\Rightarrow \quad r \propto \sqrt{C}$$

Increase in capacitance also increases propagation constant.

Charging current, $I_C = j\omega CV \Rightarrow I_C \propto C$

$\therefore$ Addition of lumped capacitance increases charging current.

$$Z_C\downarrow = SIL\uparrow$$

$$P_{\max} = \frac{V_1 V_2}{X_1}\uparrow\uparrow$$

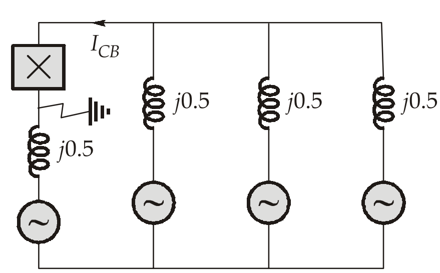
Hence steady state stability limit also increases.

64. (a)

The neutral current is

$$I_n = 3I_{a0}$$
$$= 3(5 - j15)$$
$$= (15 - j45)\text{ A}$$

65. (c)



Fault current, $I_f = \dfrac{1}{\dfrac{j0.5}{4}} = -j8\text{ p.u.}$

$$I_{CB} = -j8 \times \frac{j0.5}{j0.5 + j\dfrac{0.5}{3}} = -j6\text{ p.u.}$$

66. (c)

The current flowing in line is given by,

$$I = \frac{|V_S|\angle\delta - |V_R|\angle 0°}{-jX_C} = \frac{|V_S|\angle(\delta + 90°)}{X_C} - \frac{|V_R|\angle 90°}{X_C}$$

$$S_R = |V_R|\angle 0° \times I^* = \frac{|V_S||V_R|\angle -\delta - 90°}{X_C} - \frac{|V_R^2|}{X_C}\angle -90°$$

$$P_R = \frac{-|V_S||V_R|}{X_C}\sin\delta$$

For stable mode, $\frac{\partial P_R}{\partial \delta} > 0$

$$\therefore \quad \frac{-|V_S||V_R|}{X_C}\cos\delta > 0$$

$$\Rightarrow \quad -180° < \delta < -90°$$

67. (a)

$$y_{10} = \frac{1}{Z_{10}} = \frac{1}{0.2} = 5$$

$$y_{12} = \frac{1}{Z_{12}} = \frac{1}{0.4} = 2.5$$

$$y_{20} = \frac{1}{Z_{20}} = \frac{1}{0.4} = 2.5$$

$$Y_{bus} = \begin{bmatrix} 7.5 & -2.5 \\ -2.5 & 5.0 \end{bmatrix}$$

$$Z_{bus} = [Y_{bus}]^{-1} = \frac{1}{7.5 \times 5 - (2.5)^2}\begin{bmatrix} 5.0 & 2.5 \\ 2.5 & 7.5 \end{bmatrix}$$

$$Z_{bus} = \begin{bmatrix} 0.16 & 0.08 \\ 0.08 & 0.24 \end{bmatrix}$$

68. (b)

$$I_{0\ new} = I_{0old} \cdot 2^{\frac{T_2 - T_1}{10}}$$

$$\Rightarrow \quad 2^{\frac{T_2 - T_1}{10}} = 32 = 2^5$$

$$\Rightarrow \quad \frac{T_2 - T_1}{10} = 5$$

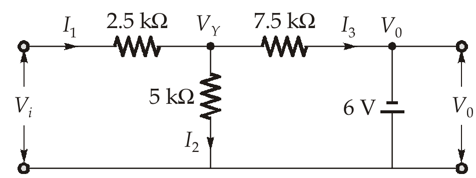
$$\Rightarrow \quad T_2 - 40 = 50$$

$$\Rightarrow \quad T_2 = 90° \text{ C}$$

69. **(c)**

During the positive half cycle, diode D_1 conducts through 10 Ω, and diode D_2 is blocked. During negative half cycle D_2 conducts through 10 Ω and D_1 is blocked, hence in both cases impedance offered by the circuit across terminals AB is 10 Ω.

70. **(c)**



$$V_Y = V_i\left(\frac{5}{7.5}\right) = \frac{2V_i}{3}$$

$$I_1 = I_2 + I_3$$

$$\frac{V_i - V_Y}{2.5} = \frac{V_Y}{5} + \frac{V_Y - V_0}{7.5}$$

$$\Rightarrow \quad 3V_i - 3V_Y = 2.5\ V_Y - V_0$$

$$\Rightarrow \quad V_0 = 5.5\ V_Y - 3V_i$$

$$-6 = 5.5 \times \frac{2V_i}{3} - 3V_i$$

$$\Rightarrow \quad V_i = -9\text{ V}$$

71. **(c)**

Here both diode and Zener diode are forward biased hence zener acts as simple diode.

$$\therefore \quad I = \frac{10 - 0.7}{50} = 186\text{ mA}$$

72. **(b)**

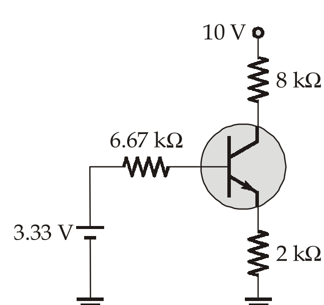
Given, $I_C = 1$ mA

$$r_e = \frac{V_T}{I_C} = 26\ \Omega$$

$$Z_i \approx \beta r_e = 120 \times 26 = 3.12\text{ k}\Omega$$

73. **(d)**

The Thevenin equivalent circuit is



$$V_{th} = 10 \times \frac{10}{30} = 3.33 \text{ V}$$

$$R_{th} = \frac{10 \times 20}{30} = 6.67 \text{ k}\Omega$$

$$\beta = 100$$

Applying KVL to i/p loop

$$I_B = \frac{V_{th} - 0.7}{R_{th} + (1+\beta)R_e} = \frac{2.63}{(6.67 + 202) \times 10^3} = 12.6 \ \mu\text{A}$$

$$I_c = 1.26 \text{ mA}$$

$$I_E = (1 + \beta)I_B = 1.273 \text{ mA}$$

$$V_{CE} = 10 - 8I_C - 2I_E = -2.626 \text{ V}$$

As V_{CE} is negative, so transistor is operating in saturation region.

74. (c)

$$I_C = 3 \text{ mA},$$

$$I_B = \frac{1}{30} \text{mA}$$

$$V_C - I_B R - 0.7 - I_E(1) = 0$$

$$4.5 - \frac{1}{30} \times R - 0.7 - 3 = 0$$

$$\Rightarrow \quad R = 24 \text{ k}\Omega$$

75. (a)

$$11 - I_C \,.\, 1\,K - V_{BE} = 0 \qquad (\text{Assuming } I_B \approx 0)$$

$$I_C = I = \frac{11 - 0.7}{1K} = 10.3 \text{ mA}$$

76. (b)

$$V_{th} = 16 \times \left[\frac{42\text{k}}{R + 42\text{k}}\right]$$

$$V_G \approx V_{th}$$

$$V_S = 4kI_D$$

$$V_{GS} = V_{th} - 4kI_D$$

$$I_D = \frac{16 - 12}{2\text{k}} = 2 \text{ mA}$$

Since it is a PMOS, V_{GS} should be negative i.e. $V_{GS} = -2$ V

$$\Rightarrow \quad -2 = 16\left(\frac{42\text{k}}{R + 42\text{k}}\right) - 8$$

$$R = 70 \text{ k}\Omega$$

77. (a)

Given,
$$\text{S.R.} = 5\ \text{V}/\mu\text{sec}$$
$$f = 1\ \text{MHz},$$
$$\text{S.R.} = \omega V_m = 2\pi f_m V_m$$
$$\Rightarrow \quad 5 \times 10^6 = 2\pi \times 1 \times 10^6 \times V_m$$
$$\Rightarrow \quad V_m = \frac{5}{2\pi}\text{Volts}$$

78. (a)

Figure shown is having +ve feedback. First assume $V_i = 0$, V_0 will be $+V_{sat} = +12$ V and voltage at +ve terminal will be 0 V. Now if V_i will make a transition from 0 to some positive voltage, C_2 will be short circuited and this will cause $V_- > V_+$. Hence op-amp output will make transition to $-V_{sat} = -12$ V. System will again return to previous state as voltage at –ve terminal of op Amp at steady state will become –2 i.e. < 0.

79. (d)

Apply KCL for 1st op amp
$$\frac{V_1}{10\text{k}} + \frac{V_2}{20\text{k}} = \frac{-V_{01}}{20\text{k}}$$
$$\Rightarrow \quad V_{01} = -(2V_1 + V_2)$$
KCL for 2nd op-amp:
$$\frac{V_{01}}{10\text{k}} + \frac{V_3}{5\text{k}} = \frac{-V_0}{10\text{k}}$$
$$\Rightarrow \quad V_0 = -(V_{01} + 2V_3) = 2V_1 + V_2 - 2V_3$$

80. (b)

Apply superposition theorem,
$$V_0 = V_1\left(1+\frac{2R}{R}\right)\left(\frac{R}{2R}\right) + V_2\left(1+\frac{2R}{R}\right)\left(\frac{R}{2R}\right)$$
Here,
$$V_1 = -3\ \text{V},$$
$$V_2 = (3 + \cos 200t)\ \text{V}$$
$$\therefore \quad V_0 = -3(1+2)\left(\frac{1}{2}\right) + (3+\cos 200t)(1+2)\left(\frac{1}{2}\right)$$
$$= \frac{-9}{2} + \frac{9}{2} + \frac{3}{2}\cos 200t = (1.5\cos 200t)\ \text{V}$$

81. (c)

Assuming base of number system be x,
The expression can be written as,
$$(16)_x + (45)_x = (63)_x$$
$$1 \cdot x^1 + 6x^0 + 4 \cdot x^1 + 5x^0 = 6x^1 + 3x^0$$
$$x + 6 + 4x + 5 = 6x + 3$$
$$x = 8$$

82. (d)

K-map,

$$\text{for } Y = A\bar{B} + B\bar{C}$$

	$\bar{B}\bar{C}$	$\bar{B}C$	BC	$B\bar{C}$
$\bar{A}$	0	1	3	1 (2)
A	1 (4)	1 (5)	7	1 (6)

$\Sigma(2, 4, 5, 6)$ = SOP

$\pi(0, 1, 3, 7)$ = POS

83. (c)

Input to *D*-flip flop can be represented as,

$$D_n = Q_n \oplus Y$$

D-flip flop output, $Q_{n+1} = D_n = Q_n \oplus Y$

By drawing truth table,

Y	Q_n	Q_{n+1}
0	0	0
0	1	1
1	0	1
1	1	0

So, $Q_{n+1} = Q_n$ for $Y = 0$

$Q_{n+1} = \bar{Q}_n$ for $Y = 1$

This logic matches logic of *T*-flip flop

∴ Option (c) is correct.

84. (b)

For number of 8 : 1 multiplexers

$$\frac{1024}{8} = 128$$

$$\frac{128}{8} = 16$$

$$\frac{16}{8} = 2$$

$$\frac{2}{8} = 1$$

The total number of multiplexers :

$$128 + 16 + 2 + 1 = 147$$

85. (c)

The binary instructions are given abbreviated names i.e. mnemonics which form assembly language (not machine language) for microprocessor.

86. (c)

ADC M instruction adds memory with carry to accumulator, affecting all flags and requires-2 cycle. STAX Rp. has 7 states but is equivalent to 2 machine cycles: Fetch and memory write.

87. (d)

- LXI H, 2501 H instruction places 2501 in H-L pair which is address of data not the content or data.
- MOV A, M brings data stored at 2501 H memory location in accumulator.
- After execution of ADD M accumulator data becomes 9 FH which is stored in 2503 H in later instruction execution.

88. (b)

Vectored address corresponding to RST-7 is

$$8 \times 7 = (56)_{10} = 0038 \text{ H}$$

89. (a)

It does not provide the status of the TRAP and INTR interrupt.

90. (c)

$$s(t) = \cos[2\pi f_c t - 5\sin(3000\pi t)]$$

So, $\beta = 5$

$$f_m = \frac{3000\pi}{2\pi} = 1500 \text{ Hz} = 1.5 \text{ kHz}$$

Bandwidth, $BW = (1 + 5)(2 \times 1.5) \text{ kHz} = 18 \text{ kHz}$

91. (c)

Given that, $f_c = 640$ kHz

IF = 455 kHz

$f_{LO} > f_c$

So, the carrier frequency of the corresponding image signal can be given as,

$$f_i = f_c + 2(\text{IF}) = 640 + 2(455) = 1550 \text{ kHz}$$

92. (d)

Sampling rate does not affect the quantization noise power of a PCM system.

93. (a)

$$\text{sinc}(1000t) \xleftrightarrow{\text{CTFT}} \frac{1}{1000}\text{rect}\left(\frac{f}{1000}\right) \Rightarrow f_{max} = 500 \text{ Hz}$$

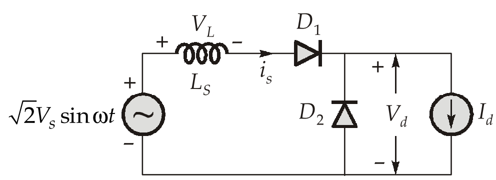
$$x_1(t) = \text{sinc}^2(1000t) \xleftrightarrow{\text{CTFT}} \frac{1}{10^6}\left[\text{rect}\left(\frac{f}{1000}\right) * \text{rect}\left(\frac{f}{1000}\right)\right] \Rightarrow f_{max} = 1000 \text{ Hz}$$

$$x_2(t) = \text{sinc}^3(2000t) \xleftrightarrow{\text{CTFT}} \frac{1}{(2000)^3}\left[\text{rect}\left(\frac{f}{2000}\right) * \text{rect}\left(\frac{f}{2000}\right) * \text{rect}\left(\frac{f}{2000}\right)\right] \Rightarrow f_{max} = 3000 \text{ Hz}$$

$$x(t) = x_1(t) * x_2(t) \xleftrightarrow{\text{CTFT}} X_1(f)X_2(f) \Rightarrow f_{max} = \min\{1000 \text{ Hz}, 3000 \text{ Hz}\} = 1000 \text{ Hz}$$

So, $$f_{s\,(min)} = 2f_{max} = 2000 \text{ Hz} = 2 \text{ kHz}$$

94. (b)



$$v_L = L_s \frac{di_s}{dt} \qquad 0 < \omega t < \mu$$

$$\sqrt{2}V_s \sin\omega t\, d(\omega t) = \omega L_s di_s$$

Area, $$A_\mu = \int_0^\mu \sqrt{2}V_S \sin\omega t\, d(\omega t) = \sqrt{2}V_S(1-\cos\mu)$$

95. (a)

$$\text{pf} = g\ DPF$$

$$g = \frac{I_{s1}}{I_{sr}} = \frac{\left(\frac{2\sqrt{2}I_d}{\pi} \times \frac{\sqrt{3}}{2}\right)}{\sqrt{\frac{2}{3}}I_d} = \frac{\sqrt{6}}{\pi} \times \sqrt{\frac{3}{2}} = \frac{3}{\pi}$$

$$\text{DPF} = 1$$

∴ $$\text{pf} = \frac{3}{\pi} = 0.955$$

97. (b)

Output of flyback converter is $V_s \frac{D}{(1-D)}\left(\frac{N_2}{N_1}\right)$ which is similar to buck-boost but includes additional term of turns ratio.

98. (d)

For ideal step up converter,

$$V_0 = \frac{V_s}{(1-D)}$$

$D = 1$; $\qquad V_0 = \infty$

$D = 0$; $\qquad V_0 = V_s$

99. (a)

In bipolar switching output is switched between high and low.

100. (c)

Fundamental voltage, $$V_{01,\text{ rms}} = \frac{2\sqrt{2}V_s}{\pi} = \frac{2\sqrt{2}\times 230}{\pi}$$

$$Z_{01} = \sqrt{R^2 + (X_L - X_C)^2} = \sqrt{1^2 + 1^2} = \sqrt{2}\,\Omega$$

Fundamental current, $$I_{01,\text{ rms}} = \frac{V_{01,\text{rms}}}{Z_{01}} = \frac{2\sqrt{2}\times 230}{\pi}\times\frac{1}{\sqrt{2}} = \frac{460}{\pi}\text{ A}$$

101. (b)

Resonant converters employs zero voltage and/or zero current switching and thus reduces switching losses.

102. (b)

By applying KVL during positive half cycle of source,

$$V_m \sin \omega t = L\frac{di}{dt}$$

$$i(t) = \frac{-V_m}{\omega L}\cos\omega t + A \quad \text{...(i)}$$

At $\omega t = 0$, $$i(t) = 0$$

$$0 = \frac{-V_m}{\omega L}\cos 0 + A$$

$$A = \frac{V_m}{\omega L}$$

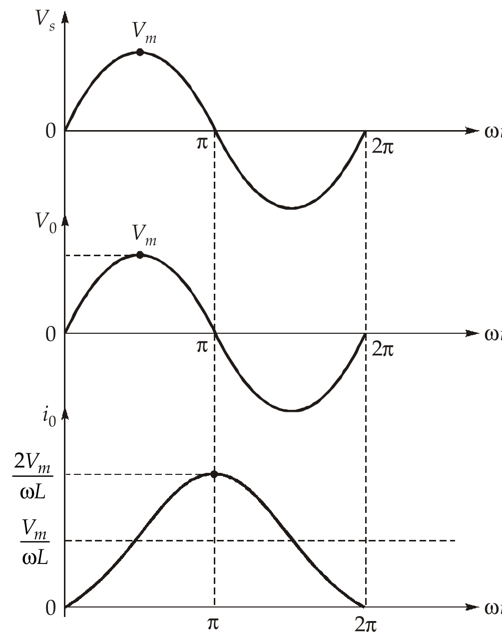
Substituting the value of A in equation (i),

$$i(t) = \frac{-V_m}{\omega L}\cos\omega t + \frac{V_m}{\omega L} = \frac{V_m}{\omega L}(1 - \cos\omega t)$$

$$I_{0\text{ avg}} = \frac{1}{2\pi}\int_0^{2\pi}\frac{V_m}{\omega L}(1 - \cos\omega t)d\omega t$$

$$I_{0\text{ avg}} = \frac{V_m}{\omega L}$$

$$I_{0\text{ rms}} = \sqrt{\left(\frac{V_m}{\omega L}\right)^2 + \left(\frac{\frac{V_m}{\omega L}}{\sqrt{2}}\right)^2} = \sqrt{\frac{3}{2}}\times\frac{V_m}{\omega L}$$



∴ The ratio rms value of output current to the average value of output current is,

$$\frac{I_{0\text{rms}}}{I_{0\text{avg}}} = \frac{\sqrt{\frac{3}{2}}\frac{V_m}{\omega L}}{\frac{V_m}{\omega L}} = \sqrt{\frac{3}{2}} = 1.22$$

103. (a)

$$V_{\text{line}} = V_s\sqrt{\frac{2}{3}}\text{ V}$$

$$V_{\text{phase}} = \frac{V_s\sqrt{2}}{3}\text{ V}$$

$$V_{\text{phase}} = \frac{450\sqrt{2}}{3} = 212.13\text{ V}$$

$$I_{\text{phase}} = \frac{V_{phase}}{R} = \frac{212.13}{10} = 21.21\text{ A}$$

$$P = 3I_{Phase}^2 \times R$$
$$= 3 \times (21.21)^2 \times 10 = 13.5\text{ kW}$$

104. (a)

True value of voltage across the 50 kΩ resistor

$$= 150 \times \frac{50}{150} = 50\text{ V}$$

Voltmeter-I (S = 1000 Ω/V) has a resistance of 50 V × 1000 Ω/V = 50 kΩ on its 50 V range.

Connecting the meter across the 50 kΩ resistor causes the equivalent parallel resistance to be decreased to 25 kΩ and the total circuit resistance to 125 kΩ. The potential difference across the combination of meter and 50 kΩ resistor is

$$V_1 = \frac{25\,\text{k}\Omega}{125\,\text{k}\Omega} \times 150\text{ V} = 30\text{ V}$$

$$\%\text{ error} = \frac{\text{True voltage} - \text{Measured voltage}}{\text{True voltage}} \times 100\%$$

$$= \frac{50\text{V} - 30\text{V}}{50\text{V}} \times 100 = 40\%$$

Voltmeter-2 (S = 20 kΩ/V) has a resistance of 50 V × 20 kΩ/V = 1 MΩ

When this meter is connected across the 50 kΩ resistor the equivalent parallel resistance equals 47.6 kΩ.

The combination produces a voltage of

$$V_2 = \frac{47.6\,\text{k}\Omega}{147.6\,\text{k}\Omega} \times 150\text{V} = 48.36\text{ V}$$

The error in the reading of voltmeter-2 is

$$\%\text{ error} = \frac{50\text{V} - 48.36\text{V}}{50\text{V}} \times 100 = 3.28\%$$

105. (b)

$$\text{Form factors of the square wave} = \frac{E_{\text{rms}}}{E_{av}} = \frac{E_m}{E_m} = 1$$

The meter scale is calibrated in terms of the rms value of a sine-wave voltage, where

$$E_{\text{rms}} = 1.11\,E_{av}$$

For the square wave voltage, $E_{\text{rms}} = E_m$

Therefore the meter indication for the square-wave voltage is high by a factor 1.11

$$\text{The percentage error} = \frac{1.11 - 1}{1} \times 100\% = 11\%$$

106. (b)

$$\text{Power} = \text{Voltage} \times \text{current}$$

$$= 110.2 \times 5.3 = 584\text{ W}$$

Now, $P = VI$

$\therefore$ $$\frac{\partial P}{\partial V} = I = 5.3\text{ A}$$

and $$\frac{\partial P}{\partial I} = V = 110.2\text{ V}$$

$$w_v = \pm 0.2\text{ V}$$

$$w_I = \pm 0.06\text{ A}$$

$$\therefore \quad \text{uncertainty in power} = \sqrt{\left(\frac{\partial P}{\partial V}\right)^2 w_V^2 + \left(\frac{\partial P}{\partial I}\right) w_I^2}$$

$$= \sqrt{(5.3)^2 \times (0.2)^2 + (110.2)^2 \times (0.06)^2} = \pm 6.7 \text{ W}$$

$$\% \text{ uncertainty} = \pm\frac{6.7}{584} \times 100 = \pm 1.15\%$$

107. (c)

$$\text{Deflection, } \theta = 90° = \frac{\pi}{2} \text{rad}$$

At equilibrium,

$$T_d = T_c$$

$$K\theta = NBldI$$

$$\therefore \quad \text{Number of turns, } N = \frac{K\theta}{BldI}$$

$$= \frac{0.14 \times 10^{-6} \times \frac{\pi}{2}}{1.8 \times 10^{-3} \times 15 \times 10^{-3} \times 12 \times 10^{-3} \times 5 \times 10^{-3}} \approx 136$$

108. (a)

Correct multiplying power of shunt,

$$m = \frac{I}{I_m} = \frac{5 \times 10^{-3}}{100 \times 10^{-6}} = 50$$

$$\text{multiplying power of faulty shunt} = 50 \times \frac{4.1}{3.5} = 58.6$$

$$\text{Resistance value of faulty shunt} = \frac{1800}{(58.6 - 1)} = 31.25\ \Omega$$

$$\text{Correct value of shunt resistance} = \frac{1800}{(50 - 1)} = 36.73\ \Omega$$

109. (c)

$$\text{Deflection, } \theta = 90° = \frac{\pi}{2} \text{rad}$$

$$\text{Final steady deflection, } \theta = \frac{1}{2}\frac{V^2}{K}\frac{dc}{d\theta}$$

or rate of change of capacitance,

$$\frac{dc}{d\theta} = \frac{2\theta K}{V^2} = \frac{2 \times \frac{\pi}{2} \times 5 \times 10^{-6}}{(2000)^2}$$

$$= 3.93 \times 10^{-12} \text{ F/rad} = 3.93 \text{ pF/rad}$$

Change in capacitance when reading from 0 to 2000 V is

$$3.93 \times \frac{\pi}{2} = 6.17 \text{ pF}$$

∴ capacitance when reading 2000 V,

$$C = 15 + 6.17$$
$$= 21.17 \text{ pF}$$

110. (d)

Equal error for the two connections

$$I^2 R_c = \frac{V^2}{R_P}$$

$$I^2 = \frac{V^2}{R_c R_p} = \frac{(220)^2}{0.03 \times 6000}$$

$$I = 16.4 \text{ A}$$

111. (b)

At balance,

$$900 \times 10^3 \times \frac{1}{j\omega \times 45 \times 10^{-12}} = 100 \times 10^3 \times \frac{1}{j\omega C_1}$$

$$C_1 = \frac{100 \times 10^3 \times 45 \times 10^{-12}}{900 \times 10^3} = 5 \text{ pF}$$

112. (b)

- The CRO uses electrostatic method of focusing.
- The vertical amplifier is the principle factor in determining the sensitivity and bandwidth of an oscilloscope.

113. (a)

If time period of continuous time signal $x(t)$ is T. Then the time period of $x(\text{at})$ is $\frac{T}{a}$.

If time period of discrete time signal $x(n)$ is N. Then the time period of $x(2N) = \begin{cases} \frac{N}{2} \text{ if } N = \text{even} \\ N \text{ if } N = \text{odd} \end{cases}$

114. (a)

A discrete-time system is stable if all its eigen values are less than one in magnitude.

115. (b)

$$\text{tri}(t) \xleftrightarrow{F} \text{sin}\,c^2(f)$$

$$\text{sgn}(t) \xleftrightarrow{F} \frac{1}{j\pi f}$$

$$e^{-a|t|} \xleftrightarrow{F} \frac{2a}{a^2 + (2\pi f)^2}, \ \text{Re}(a) > 0.$$

116. (a)

$$x(n) = x(nT) = x\left(\frac{n}{f_s}\right)$$

$$= 5\cos\frac{2\pi}{5}n + 3\sin\frac{6\pi}{5}n + 2\cos\frac{12\pi}{5}n$$

$$= 5\cos\frac{2\pi}{5}n + 3\sin\frac{6\pi}{5}n + 2\cos\left(2\pi + \frac{2\pi}{5}n\right)$$

$$= 5\cos\frac{2\pi}{5}n + 3\sin 2\pi\left(\frac{-2}{5}n\right) + 2\cos\frac{2\pi}{5}n$$

$$x(n) = 7\cos\left(\frac{2\pi}{5}n\right) - 3\sin\left(\frac{4\pi}{5}n\right)$$

117. (c)

Given expression can be simplified as shown below,

$$Z^{-1}\left[\frac{1}{1-\frac{1}{2}z^{-1}} + \frac{1}{2}\frac{z^{-1}}{1-\frac{1}{2}z^{-1}}\right]$$

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

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

118. (a)

The N-point DFT is defined as

$$x(k) = \sum_{n=0}^{N-1} x(n)e^{-j2\pi nk/N}, \ K = 0, 1, \ldots N-1.$$

$$= \sum_{n=0}^{N-1} a^n e^{-j2\pi nk/N}$$

$$= \sum_{n=0}^{N-1}\left(a \cdot e^{-j2\pi nk/N}\right)^n = \frac{1-\left(a e^{-j2\pi k/N}\right)^N}{1-a e^{-j2\pi k/N}}$$

$$x(k) = \frac{1-a^N}{1-a e^{-j2\frac{\pi k}{N}}}, K = 0, 1, \ldots N-1$$

119. (a)

Magnitude of $X(f)$ has even symmetry while phase of $X(f)$ has odd symmetry.

120. (b)

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

Taking Laplace transform of both sides,

$$s^2Y(s) = e^{-2s}X(s) + s^2X(s)$$

$$\frac{Y(s)}{X(s)} = \frac{e^{-2s}+s^2}{s^2}$$

$$H(s) = 1+\frac{e^{-2s}}{s^2}$$

121. (b)

$$3 - \text{rank} = 1$$
$$\text{rank} = 2$$
$$\therefore \quad |A| = 0$$
$$1 \times [10x - 88] - 4[2x] + 8[8] = 0$$
$$10x - 88 - 8x + 64 = 0$$
$$2x = 24$$
$$x = 12$$

122. (c)

$$A = \begin{bmatrix} 1 & 2 & 3 & 4 \\ 2 & 1 & 4 & 5 \\ 1 & 5 & 5 & 7 \\ 8 & 1 & 14 & 17 \end{bmatrix}$$

Applying $R_2 \to R_2 - 2R_1$, $R_3 \to R_3 - R_1$ and $R_4 \to R_4 - 8R_1$

$$A = \begin{bmatrix} 1 & 2 & 3 & 4 \\ 0 & -3 & -2 & -3 \\ 0 & 3 & 2 & 3 \\ 0 & -15 & -10 & -15 \end{bmatrix}$$

Applying $R_3 \to R_3 + R_2$ and $R_4 \to R_4 - 5R_2$

$$A = \begin{bmatrix} 1 & 2 & 3 & 4 \\ 0 & -3 & -2 & -3 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix}$$

This is the row echelon form of A. Since the number of non-zero rows in the row echelon form is 2, we get rank $(A) = 2$.

123. (a)

We have, $M = 5x^3 + 12x^2 + 6y^2$ and $N = 6xy$

$$\frac{\partial M}{\partial y} = 12y,$$

$$\frac{\partial N}{\partial x} = 6y$$

The equation is not exact

Since, $$\frac{\left(\frac{\partial M}{\partial y}\right) - \left(\frac{\partial N}{\partial x}\right)}{N} = \frac{12y - 6y}{6xy} = \frac{1}{x} = f(x)$$

a function of x alone,

$$\text{Integrating factor} = e^{\int f(x)dx} = e^{\int \frac{1}{x}dx} = e^{\ln x} = x$$

124. (d)

The given equation is a Bernoulli equation with $n = 2$.

Set $V(x) = y^{1-2} = y^{-1}$

Therefore, $$\frac{dV}{dx} = \frac{-1}{y^2}\frac{dy}{dx}$$

$$= -\frac{1}{y^2}\left[y + y^2(\sin x + \cos x)\right]$$

$$= -\frac{1}{y} - (\sin x + \cos x)$$

$$\frac{dV}{dx} + V = -(\sin x + \cos x)$$

An integrating factor is

$$\text{I.F.} = e^{\int dx} = e^x$$

The solution is,

$$Ve^x = -\int e^x(\sin x + \cos x)dx = -\left[e^x \sin x\right] + c$$

$$V = \frac{1}{y} = -\sin x + ce^{-x}$$

$$y = \frac{1}{ce^{-x} - \sin x}$$

125. (c)

The integrand is not analytic at the points $z = \pm 2i$. The point $z = 2i$ lies inside C. we have

$$I = \oint_C \frac{dz}{(z^2+4)^2} = \oint_C \frac{\left(\frac{1}{(z+2i)^2}\right)}{(z-2i)^2}dz$$

Taking $f(z) = \frac{1}{(z+2i)^2}$ and using the Cauchy integral formula for derivatives ($n = 1$), we obtain

$$I = \left\{2\pi i\left[f'(z)\right]_{z=2i}\right\} = 2\pi i\left[\frac{-2}{(z+2i)^3}\right]_{z=2i}$$

$$= 2\pi i\left(\frac{-2}{(4i)^3}\right) = \frac{\pi}{16}$$

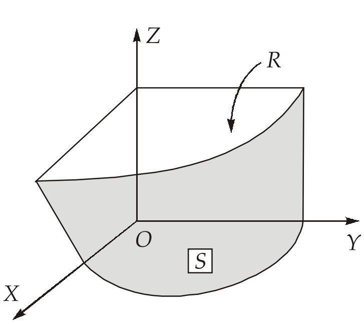
126. (b)

Let, $f(x, y, z) = x^2 + y^2 - 36 = 0$ be the surface, then grad $f = 2x\hat{i} + 2y\hat{j}$

$$n = \frac{\text{grad } f}{|\text{grad } f|} = \frac{2(x\hat{i} + y\hat{j})}{\sqrt{4(x^2+y^2)}} = \frac{1}{6}(x\hat{i} + y\hat{j})$$

The projection of S on x-y plane can not be considered. Project S on the y - z plane. The projection is a rectangle with sides of lengths 6 and 4. We have

$$dA = \frac{dy\,dz}{n \cdot i} = \frac{dy\,dz}{\frac{x}{6}}$$



Therefore, $$\iint_s F\cdot n\,dA = \iint_s \frac{1}{6}\left(z^2x + xy^2\right)dA$$

$$= \int_{z=0}^{4}\int_{y=0}^{6}\frac{1}{6}x(y^2+z^2)\frac{dy\,dz}{\frac{x}{6}}$$

$$= \int_0^4\left[\int_0^6 (y^2+z^2)dy\right]dz = \int_0^4\left(\frac{y^3}{3}+yz^2\right)_0^6 dz$$

$$= \int_0^4 (72+6z^2)dz = \left(72z+2z^3\right)_0^4 = 288 + 128 = 416$$

127. (b)

The given limit is of the form 0^0 which is an indeterminate form. Let $y = x^x$. Then, $\ln y = x \ln x$

Now, $$\lim_{x\to 0}[\ln y] = \lim_{x\to 0}[x\ln x]$$

$$= \lim_{x\to 0}\frac{\ln x}{\frac{1}{x}} = \lim_{x\to 0}\frac{\frac{1}{x}}{\frac{-1}{x^2}} \qquad \text{(Applying } L\text{'s hospital rule)}$$

$$= -\lim_{x\to 0} x = 0$$

Therefore, $$\lim_{x\to 0} y = e^0 = 1$$

128. (c)

There are 7 letters in the given word. The total permutations of the 7 letters in which there are 3 of first kind (S), 2 of second kind (A), one each of third and fourth kinds (I, N) is

$$= \frac{7!}{3!2!1!1!} = 420$$

There are 5 possible combinations of occurring of 3 S's consecutively

$S\ S\ S\ -\ -\ -\ -$

$-\ S\ S\ S\ -\ -\ -$

$-\ -\ S\ S\ S\ -\ -$

$-\ -\ -\ S\ S\ S\ -$

$-\ -\ -\ -\ S\ S\ S$

In each case, the total permutations of the 4 letters (2 of one kind), 1 each of third and fourth kinds is

$$= \frac{4!}{2!1!1!} = 12$$

$\therefore$ Required probability $= \dfrac{5\times 12}{420} = \dfrac{1}{7}$

129. (d)

We have, $$\frac{2(s+1)}{(s^2+2s+2)^2} = \frac{2(s+1)}{[(s+1)^2+1]^2}$$

$$= \frac{-d}{ds}\left[\frac{1}{(s+1)^2+1}\right] = -F'(s)$$

Hence, $$L^{-1}\left[-F'(s)\right] = t\, f(t)$$

and $$f(t) = L^{-1}\left[F(s)\right] = L^{-1}\left[\frac{1}{(s+1)^2+1}\right] = e^{-t}\sin t$$

Therefore,

$$L^{-1}\left[\frac{2(s+1)}{(s^2+2s+2)^2}\right] = t\, e^{-t}\sin t$$

130. (a)

By Newton-Raphson method,

$$x_{n+1} = x_n - \frac{f(x_n)}{f'(x_n)}$$

$$x_{n+1} = x_n - \frac{\left(x_n^3 - N\right)}{3x_n^2} = \frac{2x_n^3 + N}{3x_n^2}$$

133. (b)

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

134. (a)

A material in which the external magnetic field produces a resultant dipole moment in the opposite direction is called diamagnetic. i.e., induced moment is negative.

∴ The susceptibility is negative.

135. (c)

The relative stability of the system is improve by the addition of the zero to the loop transfer function of the system in LHS of s-plane.

136. (c)

Absolute and relative stability of only minimum-phase systems can be determined from the bode plot.

137. (a)

In the radio frequency range permanent dipoles will be unable to follow the field.

∴ The orientational polarization is not present.

138. (c)

On addition of lagging load on synchronous generator, the terminal voltage V_T decreases significantly.

139. (b)

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

140. (c)

HVDC system is costlier than HVAC as it requires costly terminal equipments like converters and DC switchgear.

141. (b)

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

142. (c)

Saturation current is directly proportional to the cross sectional area of the diode.

144. (c)

By programming interrupt can be raised again if instruction EI is written at being of the routine.

145. (c)

Any digital logic gate can be realized using either NAND or NOR gates individually and independently.

147. (c)

The wait states are added by forcing the ready signal low. When READY signal goes low, microprocessor waits for an integer no. of clock cycles until it goes HIGH.

149. (c)

A system is said to be invertible if unique excitations produce unique zero-state responses.
∴ statement-I is true.

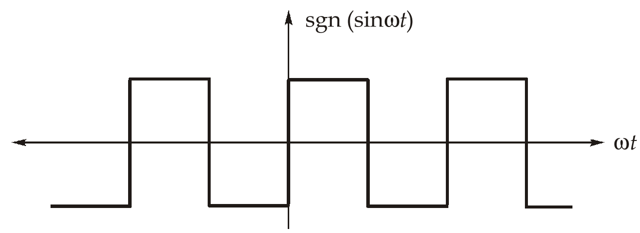
The output voltage signal $V_0(t)$ and input voltage signal $V_i(t)$ are related by $V_0(t) = |V_i(t)|$.

For, $V_i(t) = 1\text{ V};\quad V_0(t) = 1\text{ V}$

$V_i(t) = -1\text{ V};\quad V_0(t) = |-1| = 1\text{ V}$

∴ system producing same zero state responses for two difference inputs,
∴ system is not invertible.

150. (a)



This signal satisfies both

$$x(t \pm T) = x(t)$$

and $$x(t \pm T/2) = -x(t)$$

This signal contains only odd harmonics of sinusoidal.

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