DETAILED SOLUTIONS

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ESE 2026 : Prelims Exam
CLASSROOM TEST SERIES

ELECTRICAL ENGINEERING

Test 18

Full Syllabus Test 2 : Paper-II

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

DETAILED EXPLANATIONS

1. (c)

From transmission line parameters,

$$V_1 = AV_2 - BI_2 \quad ...(i)$$

$$I_1 = CV_2 - DI_2 \quad ...(ii)$$

From y-parameters

$$I_1 = y_{11}V_1 + y_{12}V_2 \quad ...(iii)$$

$$I_2 = y_{21}V_1 + y_{22}V_2 \quad ...(iv)$$

From above two equations, we have,

$$y_{21} = \left.\frac{I_2}{V_1}\right|_{V_2=0}$$

and

$$y_{12} = \left.\frac{I_1}{V_2}\right|_{V_1=0}$$

From equations (i) and (ii),

Keeping $V_1 = 0$,

$$AV_2 = BI_2$$

and

$$I_1 = CV_2 - D\frac{A}{B}V_2$$

$\therefore$

$$y_{12} = -\left(\frac{AD - BC}{B}\right) = -\frac{\Delta T}{B}$$

and by keeping $V_2 = 0$, we have,

$$y_{21} = -\frac{1}{B}$$

2. (d)

$$P_{avg} = \frac{V_{rms}^2}{R}$$

$$V_{rms} = \sqrt{2^2 + \left(\frac{3}{\sqrt{2}}\right)^2 + \left(\frac{3\sqrt{2}}{\sqrt{2}}\right)^2}$$

$$= \sqrt{4 + \frac{9}{2} + 9}$$

$$= \sqrt{\frac{8 + 18 + 9}{2}} = \sqrt{\frac{35}{2}}$$

$\therefore$

$$P_{avg} = \frac{V_{rms}^2}{R} = \frac{17.5}{1} = 17.5\text{ W}$$

3. (c)

Using superposition theorem,

$$P = \left(\sqrt{P_1} \pm \sqrt{P_2}\right)^2 = \left(\sqrt{4} \pm \sqrt{1}\right)^2$$

$$= (2 \pm 1)^2$$

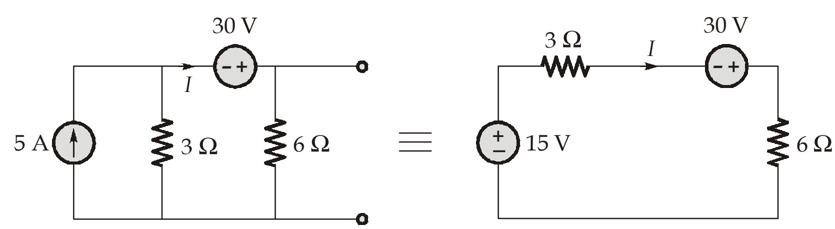
$$= 9 \text{ W or } 1 \text{ W}$$

4. (d)

$$P_{max} = \frac{V_{Th}^2}{4R_{Th}} = \frac{28 \times 28}{4 \times 20} = \frac{7 \times 14}{10} = 9.80 \text{ W}$$

5. (c)

At t = +3 sec, the circuit can be redrawn as



$$-15 - 30 + 9I = 0$$

$$9I = 45$$

$$I = 5 \text{ A}$$

6. (c)

We know that $i = \dfrac{dQ}{dt} \Rightarrow Q = \int i\,dt$

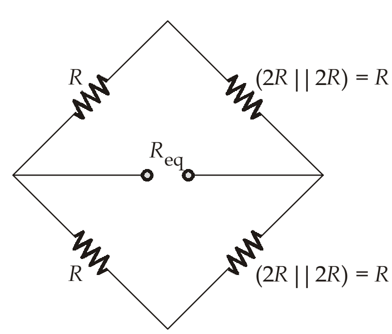
$Q_{4\text{ sec}}$ = Area under the curve from t = 0 to t = 4

$$= (10 \times 1) + \frac{1}{2}(10 - 5) \times 1 + (5 \times 1) + (5 \times 2) = 27.5 \text{ C}$$

7. (c)

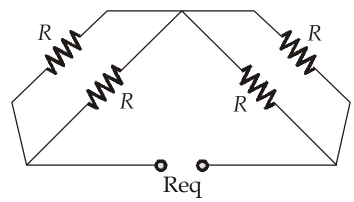
Redrawing the circuit

Case-I open switch



$$\Rightarrow \quad R_{eq} = (2R \,||\, 2R) = R$$

Case-II closed switch

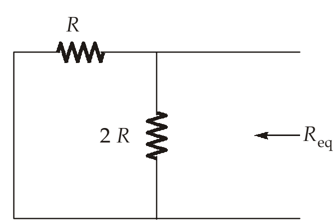


$$R_1 = (2R \,||\, 2R) = R$$
$$R_2 = (2R \,||\, 2R) = R$$
$$\Rightarrow \quad R_{eq} = (R \,||\, R) + (R \,||\, R) = R$$

⇒ equivalent resistance remains same.

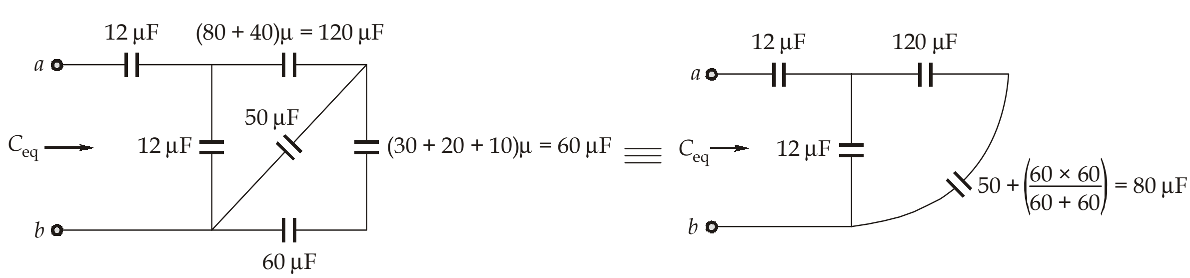
8. (d)

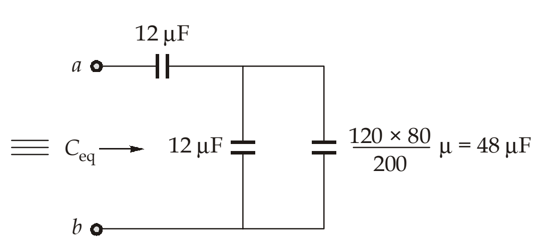
$$\tau = R_{eq} \cdot C_{eq}$$
$$= \frac{R \times 2R}{R + 2R} \times \frac{C \times 2C}{C + 2C}$$
$$= \frac{4}{9} RC$$



9. (a)

Simplifying the circuit

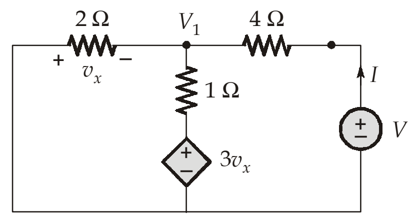




$$C_{eq} = \frac{12 \times (48 + 12)}{12 + 48 + 12} \mu = \frac{12 \times 60}{72} \mu = 10\, \mu F$$

10. (a)

When $R_L = R_{Th}$, power transferred is maximum. Calculating R_{Th},



Applying KCL

$$\frac{V_1}{2} + \frac{V_1 - 3v_x}{1} + \frac{V_1 - V}{4} = 0$$

We have, $V_1 = -v_x$

$$\frac{V_1}{2} + \frac{V_1 + 3V_1}{1} + \frac{V_1}{4} = \frac{V}{4}$$

$$\frac{2V_1 + 16V_1 + V_1}{4} = \frac{V}{4}$$

$$V = 19\ V_1$$

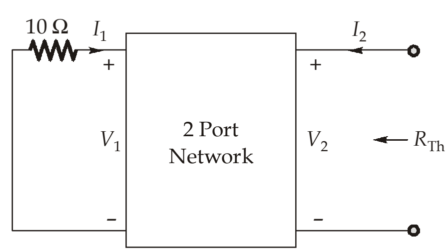
$$I = \frac{V - V_1}{4} = \frac{18V_1}{4}$$

$$R_{Th} = \frac{V}{I} = \frac{19 \times 4}{18}\frac{V_1}{V_1} = 4.22\ \Omega$$

11. (c)

Maximum power is transferred, if $R_L = R_{Th}$

Substituting the independent sources with their internal impedances to calculate Thevenin Resistance, we get



$$V_1 = 40I_1 + 60I_2$$

$$V_2 = 80I_1 + 120I_2$$

Here, $V_1 = -10I_1$

$$-10I_1 = 40I_1 + 60I_2$$

$$-5I_1 = 6I_2$$

$$V_2 = \frac{-6}{5} \times 80I_2 + 120I_2 = 24I_2$$

$$R_{Th} = R_L = \frac{V_2}{I_2} = 24\ \Omega$$

12. (d)

At half power frequencies, power is half of power at resonance.

13. (b)

For series circuit,

$$\xi = \frac{R}{2}\sqrt{\frac{C}{L}}$$

$$\xi = \frac{2}{2}\sqrt{\frac{2}{2}} = 1 \qquad \Rightarrow \text{Critically damped}$$

for parallel circuit,,

$$\xi = \frac{1}{2R}\sqrt{\frac{L}{C}}$$

$$= \frac{1}{2\times 2}\sqrt{\frac{2}{2}} = \frac{1}{4} < 1 \qquad \Rightarrow \text{underdamped}$$

14. (d)

Magnetic field due to a square loop current is given by,

$$H = \frac{2\sqrt{2}}{\pi \cdot d}\cdot I$$

Now magnetic field produced at the loop centre,

$$H_A = \frac{2\sqrt{2}}{\pi \cdot d}\cdot I\ ;$$

$$H_B = \frac{2\sqrt{2}\times I}{\pi(2d)}$$

Hence, $$H_A : H_B = \frac{1}{d} : \frac{1}{2d} = 2:1$$

15. (a)

Statement-1 and 2 are correct but statement-3 is wrong as static electric field is conservative, because, the line integral of E over a closed path is zero.

$$\oint E\cdot dl = 0$$

No work is done, or energy is conserved around a closed path.

16. (d)

As the voltage distribution across C_1, C_2 and C_3 is in the ratio 2 : 3 : 4, and the applied voltage is 135 V,

The voltages are 30 V, 45 V and 60 V respectively across C_1, C_2 and C_3

Capacitance = Charge divided by the potential difference.

Hence $$C_1 = \frac{4500}{30} = 150\ \mu\text{F}$$

$$C_2 = \frac{4500}{45} = 100\ \mu F$$

$$C_3 = \frac{4500}{60} = 75\ \mu F$$

If C is the resultant capacitance of the series combination,

$$\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$$

Solving, $C = 33.3\ \mu F$

17. (a)

We know that, $\vec{H} = -\nabla V_m$

$$= -\left(\frac{\partial}{\partial x}\hat{a}_x + \frac{\partial}{\partial y}\hat{a}_y + \frac{\partial}{\partial z}\hat{a}_z\right)(x^2y + y^2x + z)$$

$$= -(2xy + y^2)\hat{a}_x - (x^2 + 2xy)\hat{a}_y - \hat{a}_z$$

At (1, 0, 1), $\vec{H} = -\hat{a}_y - \hat{a}_z = -(\hat{a}_y + \hat{a}_z)$

Magnetic flux density, $B = \mu_0 \mu_r H$

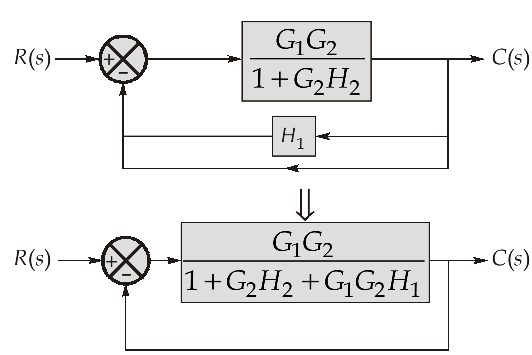
$$= 4\pi \times 10^{-7} \times 1 \times \sqrt{(1^2 + 1^2)}$$

$$= 4\pi \times 10^{-7} \times \sqrt{2}$$

$$= 0.56\pi\ \mu T$$

18. (d)

Reducing the given block diagram, we get,



Thus, closed loop transfer function is

$$T(s) = \frac{G_1 G_2}{1 + G_1G_2 + G_2H_2 + G_1G_2H_1}$$

$$= \frac{G_1 G_2}{1 + (G_1 + H_2 + G_1H_1)G_2}$$

19. (b)

Given, $$G(s) = \frac{K}{s(s^2+6s+12)}$$

$$1 + G(s) = 0$$

or, $$s(s^2 + 6s + 12) + K = 0$$

or, $$K = -(s^3 + 6s^2 + 12s)$$

For break away points, $$\frac{dK}{ds} = 0$$

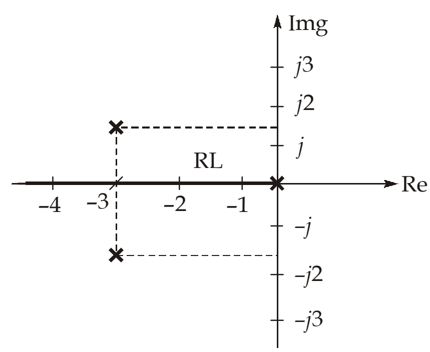
or $$3s^2 + 12s + 12 = 0$$

or, $$s^2 + 4s + 4 = 0$$

or, $$(s + 2)^2 = 0$$

or, $$s = -2, -2$$

For given O.L.T.F., $P = 3$, $Z = 0$, $P - Z = 3$



Poles are at $s = 0$ and $s = -3 \pm j\sqrt{3} = -3 \pm j1.732$

Since entire –ve real axis is a part of root locus, therefore $s = -2$ is a valid breakaway point.

20. (d)

Since positional error constant,

$$K_p = \lim_{s\to 0} G(s)$$

As $G(s)$ is a type-I system,

$$K_p = \lim_{s\to 0} G(s) = \infty$$

and acceleration error constant,

$$K_a = \lim_{s\to 0} s^2 G(s) = 0$$

Now e_{ss} for unit step input,

$$e_{ss} = \frac{1}{1+K_p} = \frac{1}{1+\infty} = 0$$

Therefore option (d) is the correct choice.

21. (b)

Number of decade change from first corner frequency 10 rad/sec to $\omega_1 = \frac{26-20}{20} = \frac{6}{20}$

Now, $$\log\frac{\omega_1}{10} = \frac{6}{20} \Rightarrow \omega_1 = 20\,\text{rad/sec}$$

Now, no. of decade change from corner frequency

$$\omega_1 \text{ to } \omega_2 = \frac{26}{20} = 1.3$$

$\therefore$ $$\log\frac{\omega_2}{\omega_1} = 1.3 \text{ or } \log\frac{\omega_2}{20} = 1.3$$

or, $$\omega_2 = 400\text{ rad/s}$$

22. (d)

$$G(j\omega) = \frac{1}{j\omega(1+j\omega)(1+j2\omega)} = \frac{1}{j\omega(1-2\omega^2+j3\omega)}$$

$$= \frac{1}{-3\omega^2 + j\omega(1-2\omega^2)}$$

At the phase crossover frequency ω_p, the imaginary part of the $G(j\omega)$ is zero.

Therefore, $$\omega_p\left(1-2\omega_p^2\right) = 0$$

Since, $$\omega_p \neq 0$$

$$1-2\omega_p^2 = 0$$

or, $$\omega_p^2 = \frac{1}{2},$$

or, $$\omega_p = 0.707\text{ rad/sec}$$

Now gain margin;

$$\text{G.M.} = \frac{1}{|G(j\omega)|_{\omega=\omega_p}} = \frac{1}{\left|\frac{1}{(-3\omega^2)}\right|_{\omega=\omega_p}}$$

$$= 3\omega_p^2 = 3\times(0.707)^2 = 1.5$$

23. (d)

Since, transfer function, $T(s) = C[sI - A]^{-1}\cdot B$

$$[sI - A] = \begin{bmatrix} s & -2 \\ 2 & s+1 \end{bmatrix}$$

$$[sI - A]^{-1} = \frac{1}{s^2+s+4}\begin{bmatrix} s+1 & 2 \\ -2 & s \end{bmatrix}$$

$$T(s) = [1 \quad 1] \times \frac{1}{s^2+s+4} \begin{bmatrix} s+1 & 2 \\ -2 & s \end{bmatrix} \times \begin{bmatrix} 0 \\ 1 \end{bmatrix}$$

$$= [1 \quad 1] \times \frac{1}{s^2+s+4} \begin{bmatrix} 2 \\ s \end{bmatrix}$$

$$T(s) = \frac{s+2}{s^2+s+4}$$

24. (c)

$$\text{Phase angle} = -\tan^{-1}\left(\frac{\omega}{1}\right) - 57.3° \times 0.1$$

$$= -\tan^{-1}(1) - 5.73° \qquad (\because r(t) = 0.5\cos t,\ \therefore \omega = 1 \text{ rad/sec})$$

$$= -45° - 5.73°$$

$$= -50.73°$$

25. (b)

Let system gain be K.

$\therefore$ $$\text{T.F.} = \frac{C(s)}{R(s)} = H(s) = \frac{K(s+2)}{s(s+1)(s+3)}$$

Given, $$H(2) = 4$$

So, $$\frac{K \times 4}{2 \times 3 \times 5} = 4 \text{ or } K = 30$$

$\therefore$ $$H(s) = \frac{30(s+2)}{s(s+1)(s+3)}$$

26. (c)

Order of a system is the number of effective energy storing elements.

27. (b)

$$s^2 + 2\xi\omega_n s + \omega_n^2 = s^2 + 2s + 4$$

On comparing, we get $2\xi\omega_n = 2$

$$\omega_n^2 = 4, \quad \omega_n = 2$$

$\therefore$ $$\xi = 0.5$$

$$M_p = e^{-\pi\xi/\sqrt{1-\xi^2}} = e^{-\pi 0.5/0.866} = e^{-0.57\pi}$$

28. (d)

$$|G(j\omega)|_{\omega=\omega_{pc}} = \frac{1}{2}$$

$$\text{Gain margin} = 20\log_{10}\frac{1}{|G(j\omega)|} = 20\log 2 = 6 \text{ dB}$$

30. (a)

Fermi level is that energy level at which the probability of finding an electron is 50%.

31. (d)

- The maximum value of residual flux density is known as retentivity.
- The maximum value which a coercive field can attain is known as coercivity.

32. (c)

The properties of carbon nanotubes:

- High stiffness
- High strength
- Low densities
- Very high conductivity
- Ductile

33. (b)

$$\text{Packing fraction of BCC} = \frac{\sqrt{3}\pi}{8} = 0.68$$

34. (a)

Oriental polarization is given by,

$$P = \frac{p_p^2}{3KT}E$$

where $\frac{p_p^2}{3KT} = \alpha_0$ is called orientation polarizability.

35. (b)

$$P = N\alpha E_i = N\alpha(E + \gamma P/\epsilon_0)$$

$$P = \frac{N\alpha E}{1 - N\alpha\gamma/\epsilon_0}$$

For spontaneous polarization $P \neq 0$ if $E = 0$ and for that,

$$N\alpha\gamma = \epsilon_0$$

36. (c)

A single crystal material has periodicity of atoms. Amorphous and noncrystalline solids lack an ordered internal structure and are randomly arranged.

37. (d)

We know, uniaxial stress, $p = Y\left(\frac{\Delta C}{C}\right)$

Also, $q = CV$

Polarization, $P = \frac{q}{A} = \frac{CV}{A}$

or $\Delta P = \frac{V}{A}(\Delta C)$

Hence by proportionality,

$$\frac{\Delta P}{P} = \frac{\Delta C}{C}$$

$\therefore$ $$p = Y\frac{\Delta P}{P} = 120 \times \left(\frac{500-480}{480}\right)$$

$$p = 5 \text{ GPa}$$

38. (a)

Void fraction = 1 – Packing fraction

= 1 – 0.74 (for FCC, APF = 0.74)

= 0.26

39. (c)

In Ward-Leonard method of speed control, the lower limit of speed is imposed by residual magnetism of the generator.

40. (d)

From the circle diagram all the above results are obtained.

41. (a)

By varying rotor resistance, the maximum torque can be achieved at any desired slip, but maximum torque remains constant.

42. (b)

Slip at full load, s_{fl} = 4% = 0.04

Slip at maximum torque,

$$s_{\max,T} = \frac{R_2}{X_{20}} = \frac{0.01}{0.04} = 0.25$$

We know that, $$\frac{T_{\max}}{T_{fl}} = \frac{s_{fl}^2 + s_{\max,T}^2}{2 \times s_{fl} \times s_{\max,T}} = \frac{(0.04)^2 + (0.25)^2}{2 \times 0.04 \times 0.25}$$

$$\frac{T_{\max}}{T_{fl}} = 3.2$$

43. (c)

Starting current with normal voltage = I_{sc}

Starting current with 75% of normal supply voltage

= 0.75 I_{sc}

Starting torque with normal supply voltage,

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

Starting torque with 75% normal supply voltage applied to the stator

$$\tau'_{st} = \tau_{fl}\left(\frac{0.75 I_{sc}}{I_{fl}}\right)^2 \times s_{fl} = 0.5625\,\tau_{st}$$

Percentage reduction in torque,

$$= \frac{\tau_{st} - \tau'_{st}}{\tau_{st}} \times 100 = \left(1 - \frac{\tau'_{st}}{\tau_{st}}\right) \times 100$$

$$= (1 - 0.5625) \times 100 = 43.75\%$$

44. (a)

Stepping frequency or pulse rate

= Pulse per second (PPS)

If α is step angle,

$$\text{Motor speed, } n = \frac{\alpha f}{360}\text{rps}$$

Given,

$$N = 750 \text{ rpm} = \frac{750}{60}\text{rps}$$

$$f = 250 \text{ step/sec}$$

So,

$$\frac{750}{60} = \frac{\alpha \times 250}{360}$$

$$\alpha = 18°$$

45. (b)

Supply voltage, V_s = 110 V

Primary winding current = 1 A at upf

Input power, $P_{in} = VI\cos\phi$ (For 1-ϕ transformer)

$= 110 \times 1 \times 1.0 = 110$ W

No load current, I_0 = 0.3 A (lagging)

Maximum efficiency, η_{max} = 85% (or) 0.85

For maximum efficiency, $P_{cu} = P_{iron}$

$$\eta_{max} = \frac{P_0}{P_{in}}$$

$$0.85 = \frac{P_{in} - 2P_{iron}}{P_{in}} = 1 - \frac{2P_{iron}}{P_{in}}$$

$$\frac{2P_{iron}}{P_{in}} = 1 - 0.85 = 0.15$$

$$P_{iron} = \frac{0.15 P_{in}}{2} = \frac{0.15 \times 110}{2}$$

Now Iron loss, $P_{iron} = V_0 I_0 \cos \phi_0$

$$\cos \phi_0 = \frac{P_i}{V_0 I_0} = \frac{\left(\frac{0.15 \times 110}{2}\right)}{(110 \times 0.3)}$$

No load power factor, $\cos \phi_0 = 0.25$ (lagging)

46. (c)

Magnetizing current, $I_m = \frac{V}{X_m} \propto \frac{V}{f}$

If V/f keeping constant then magnetizing current is also constant.

Stalling torque or breakdown torque or maximum torque

$$T_{max} = \frac{V^2}{2\omega_m \cdot X_2} \propto \frac{V^2}{f.f} \propto \left(\frac{V}{f}\right)^2$$

So V/f keeping constant then stalling torque is also constant.

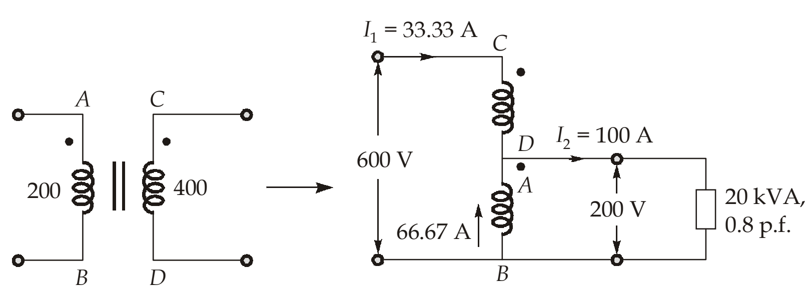
47. (c)

Two winding must be connected in series with the additive polarity so that 600 V can be applied across the total windings.

With 20 kVA load, load current, $I_2 = \frac{20 \times 1000}{200} = 100$ A

$$I_1 = \frac{20 \times 1000}{600} = 33.33 \text{ A}$$

current in common winding = (100 – 33.33) A = 66.67 A



48. (b)

Teaser Transformer has 86.6% of turns to that of main transformer.

49. (b)

$Z = 200$, A = Parallel paths = $P = 10$ (For lap winding)

$$\text{Conductors/Path} = \frac{Z}{A} = \frac{200}{10} = 20$$

$$\text{Average emf/Conductor} = 10 \text{ V} = e$$

$$\therefore \quad \text{Generated voltage} = 10 \times \frac{Z}{A} = 200 \text{ V}$$

$$\text{Armature current, } I_a = A \cdot I = 10 \times 10 = 100 \text{ A}$$

$$\therefore \quad \text{Power rating} = EI_a = 20 \text{ kW}$$

50. (c)

$$\text{Power} = \text{Torque} \times \text{Speed}$$

$$\text{Speed} = \frac{120 f}{P} = \frac{120 \times 50}{4} = 1500 \text{ (rpm)}$$

$$P = 2\pi \times 1500 \times \frac{100}{\pi} \times \frac{1}{60} = 5000 \text{ W}$$

51. (b)

Given, $V_1 = 440$ V ; $f_1 = 50$ Hz ; $P = 6$

$$N_{s_1} = \frac{120 \times 50}{6} = 1000 \text{ rpm}$$

$$N_{r_1} = 950$$

$$S_1 = \frac{N_{s_1} - N_{r_1}}{N_{s_1}} = \frac{1000 - 950}{1000} = 0.05$$

We have, $T \propto \dfrac{SV^2}{f}$;

$$S_2 = \frac{S_1 V_1^2}{V_2^2} = \frac{0.05 \times 440 \times 440}{550 \times 550} = 0.032$$

$$N_{r_2} = N_{s_2}(1 - s) = 1000 \times (1 - 0.032) = 968 \text{ rpm}$$

52. (c)

$$V_t = 220 \text{ V} ; \quad I_a = 20 ; \quad r_a = 1.0\ \Omega$$

$$E_b = V_t - I_a r_a = 220 - (20)(1) = 200 \text{ V}$$

$$200 = K_a \phi \omega$$

$$\omega = \frac{200}{K_a \phi} = \frac{200}{2} = 100 \text{ rad/sec}$$

$$N = \frac{60\omega}{2\pi} = \frac{60}{2\pi} \times 100 \approx \frac{3000}{\pi} \text{ rpm}$$

54. (b)

Horizontal microinstruction has longer control word as it uses 1 bit/control signal.

55. (c)

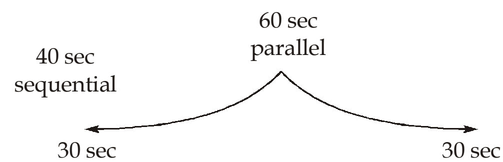
Compiler uses delayed load method to resolve data depending conflict by inserting no operand instructions.

56. (a)

Take a single processor which requires 100 sec for computation. Its 40 sec computation is done sequentially.

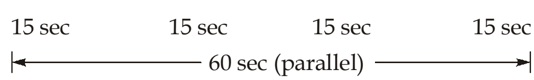
$\Rightarrow$ 60 sec computation is done parallel

If 2 processors are used



It leads to maximum i.e. 40 + 30 = 70 sec.

If 4 processors are used



Maximum elapsed time = 40 + 15 = 55 sec

57. (b)

$$\text{Revolution time} = \frac{60}{15000} = 4 \text{ ms}$$

$\therefore$ Average rotational latency $= \frac{1}{2}$ revolution time

$$= \frac{1}{2} \times 4 = 2 \text{ ms}$$

Transfer time = 1 revolution time = 4 ms/track

File shared in 5 adjacent track which doesn't require seek time for every track.

$\therefore$ Time required to access the file

= 4 ms + (2 ms + 4 ms) × 5 = 34 ms

58. (c)

Storage capacity = π × diameter tracks × storage density

= 3.14 × 4 × 100 × 500 = 628000 bits

60. (a)

Time required for non-pipelined process

= (2.5 + 1.5 + 2 + 1.5 + 2.5) = 10 nsec

Time required for pipelined processor,

$$T_p = t_p + \text{Buffer delay}$$
$$t_p = \max(2.5, 1.5, 2, 1.5, 2.5)$$
$$= 2.5 \text{ ns}$$
$$T_p = 2.5 + 0.5 = 3 \text{ nsec}$$

$$\text{speed up} = \frac{ET_{\text{non-pipeline}}}{ET_{\text{pipeline}}} = \frac{10}{3} = 3.33$$

61. (b)

The fault voltage at bus 2 if a three phase short circuit occurs at bus 3 is obtained by,

$$V_2^{(f)} = V_f\left(1 - \frac{Z_{23}}{Z_{33}}\right) = 1\left(1 - \frac{2}{2}\right) = 0 \text{ V}$$

62. (c)

Number of total bus in power system,

$$n = 500$$
$$\text{PV bus except slack bus} = m$$
$$= [\text{Gen. bus + Reactive power support bus except slack bus}]$$
$$m = 45 + 30 - 1 = 74$$
$$\text{Size of Jacobians matrix} = (2n - m - 2) \times (2n - m - 2)$$
$$= (2 \times 500 - 74 - 2) \times (2 \times 500 - 74 - 2)$$
$$= 924 \times 924$$

63. (b)

$$D_m = \sqrt[3]{(6.5 \times 6.5 \times 13)}$$
$$D_m = \sqrt[3]{549.25} \text{ m}$$

64. (d)

Given,
$$I_a = (500 + j150) \text{ A}$$
$$I_b = (100 - j600) \text{ A}$$
$$I_c = (-300 + j\,600) \text{ A}$$

The zero sequence current of phase a is,

$$I_{a0} = \frac{1}{3}(I_a + I_b + I_c)$$
$$= \frac{1}{3}(300 + j150)$$
$$I_{a0} = (100 + j50) \text{ A}$$

65. (d)

Given, $I_1 = (400 + j\,0)$ A

and $I_2 = (150 + j\,0)$ A

CT secondary current,

$$I_{1s} = \frac{(400 + j0)}{\left(\frac{500}{5}\right)} = (4 + j0)\,\text{A}$$

$$I_{2s} = \frac{(150 + j0)}{\left(\frac{500}{5}\right)} = (1.5 + j0)\,\text{A}$$

$$\text{Restraining current } (I_r) = \frac{I_{1s} + I_{2s}}{2} = \frac{4 + 1.5}{2} = 2.75\text{ A}$$

66. (b)

Transmission line equations for medium line, localized load end capacitance is

$$\begin{bmatrix} V_s \\ I_s \end{bmatrix} = \begin{bmatrix} 1 + YZ & Z \\ Y & 1 \end{bmatrix} \begin{bmatrix} V_R \\ I_R \end{bmatrix}$$

67. (d)

The maximum value of δ,

$$\delta_{\max} = \pi - \sin^{-1}\left(\frac{P_m}{P_{\max III}}\right) = \pi - \sin^{-1}\left(\frac{1}{2}\right)$$

$$= \pi - 30°$$

$$\delta_{\max} = 150°$$

68. (a)

Given, $Y_{23} = Y_{32} = j10$

$Y_{32} = -y_{23} = j10$

The impedance of line between bus 2 and 3 will be,

$$z_{23} = \frac{1}{y_{23}} = \frac{1}{-j10} = j\,0.1$$

69. (c)

Transmission line parameters,

$$V_s = A\,V_r + B\,I_r \quad \text{...(i)}$$

There is no load current but current flowing through the shunt inductor is I_L.

Now equation (i) becomes,

$$V_s = A\,V_r + B\,I_L$$

Dividing the above equation with I_L on both sides.

$$\frac{V_s}{I_L} = A\frac{V_r}{I_L} + B\frac{I_L}{I_L}$$

Since, $V_S = V_R$

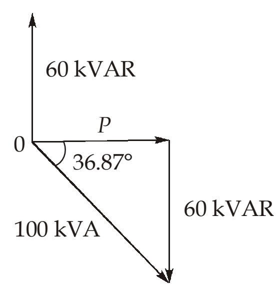
$$X_L = A\,X_L + B$$

$$X_L\,(1 - A) = B$$

$$X_L = \frac{B}{1-A} = \frac{160}{1-0.9} = 1600\ \Omega$$

70. (d)

According to power triangle,



Active power drawn from the supply = P

$$P\ \tan(36.87°) = 60\ \text{kVAR}$$

$$P = 80\ \text{kW}$$

Now, the power factor is unity,

Apparent power = 80 kVA

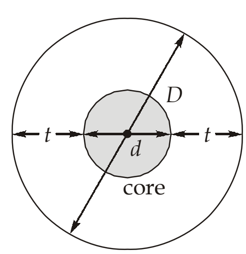
71. (b)

We know that,

$$\frac{g_{max}}{g_{min}} = \frac{D}{d}$$

$$\frac{40}{10} = \frac{D}{d}$$

$$D = 8\ \text{cm}$$



and $D = d + 2t$

$\therefore$ Insulation thickness, $t = \dfrac{D-d}{2} = \dfrac{8-2}{2} = 3$ cm

72. (a)

The first row of Y_{Bus} is $[Y_{11}\ Y_{12}\ Y_{13}]$

$$Y_{11} = y_{12} + y_{13} = 10 - j20 + 10 - j30$$

$$= (20 - j50)$$

$$Y_{12} = Y_{21} = -y_{12} = (-10 + j20)$$
$$Y_{13} = Y_{31} = -y_{13} = (-10 + j30)$$

The first row of Y_{Bus} is [(20 – j50) (–10 + j20) (–10 + j30)]

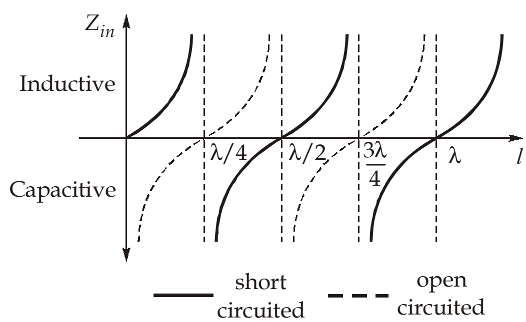
73. (c)

The frequency of restriking voltage

$$= \frac{1}{2\pi\sqrt{LC}} \text{Hz}$$

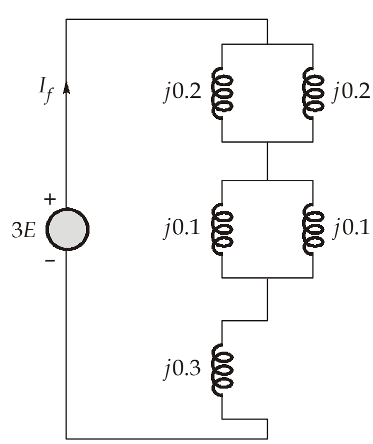
$$\omega_n = \frac{1}{\sqrt{LC}} \text{ radians/sec } = \frac{1}{\sqrt{10 \times 10^{-3} \times 400 \times 10^{-12}}}$$
$$= 500 \times 10^3 \text{ radians/sec}$$

74. (b)



From the graph it is clear that, length from $\frac{\lambda}{4} < l < \frac{\lambda}{2}$ can be represented as inductor if the line is lossless and open circuited.

75. (d)



$$X_0 = j\,0.15 + 3\,X_n$$
$$= j\,0.15 + j\,0.15 = j\,0.3 \text{ p.u.}$$

For LG fault the fault current is,

$$I_f = \frac{3E}{j0.1 + j0.05 + j0.3} = \frac{3\times 1}{j0.45}$$

$$= \frac{20}{3}\angle -90° \text{ p.u.}$$

76. (c)

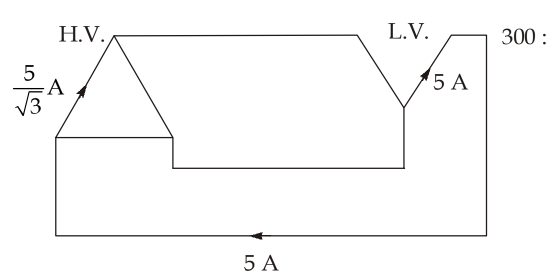
C.T. connection on L.V. side is ⅄ and H.V. side is Δ.

$$i_1 = \frac{5}{\sqrt{3}}\text{A}$$

and $i_2 = 5$ A

Now, $\frac{V_2}{V_1} = \frac{I_1}{I_2}$

$$I_1 = \frac{6.6}{33}\times 300 = 60\text{ A}$$



C.T. ratio on H.V. side $= \frac{I_1}{i_1} = \frac{60}{\left(5/\sqrt{3}\right)} = 12\sqrt{3} : 1$

77. (a)

Given, $I_{CEO} = 22$ μA

$I_{CBO} = 1.1$ μA

We know that, $I_{CEO} = (1 + \beta)I_{CBO}$

$22 \times 10^{-6} = (1 + \beta)\, 1.1 \times 10^{-6}$

$1 + \beta = 20$

∴ $\beta_{d.c} = 19$

78. (b)

From the given figure,

$$V_{CC} = (I_B + I_C)R_C + I_B R_B + V_{BE}$$

now, $\frac{\partial I_B}{\partial I_C} = -\frac{R_C}{R_B + R_C}$

∴ $$S = \frac{\partial I_C}{\partial I_{CO}} = \frac{1+\beta}{1-\beta\cdot\frac{\partial I_B}{\partial I_C}}$$

$$= \frac{1+\beta}{1+\frac{\beta R_C}{R_C + R_B}} = \frac{101}{1+\frac{100\times 0.5\times 10^3}{0.5\times 10^3 + 50\times 10^3}}$$

$$= \frac{101}{1+\frac{50}{50.5}} = \frac{101}{100.5} \times 50.5 = 50.751$$

79. (b)

$$V_{GS} = -2 \text{ V}$$

Thus, $$I_D = I_{DSS}\left[1-\frac{V_{GS}}{V_P}\right]^2$$

$$= 10\times10^{-3}\left[1-\left(\frac{-2}{-8}\right)\right]^2 = 10\times10^{-3}\left[1-\frac{1}{4}\right]^2 = 5.625 \text{ mA}$$

$$V_{DS} = V_{DD} - I_D R_D$$

$$= 10 - 5.625 \times 10^{-3} \times 1 \times 10^3 = 4.375 \text{ V}$$

81. (b)

$$\text{Ripple factor} = \sqrt{\left(\frac{V_{\text{rms}}}{V_{\text{dc}}}\right)^2 - 1}$$

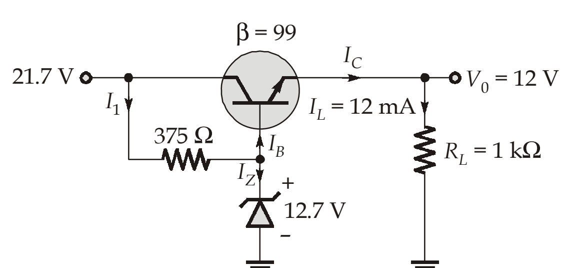
For a full-wave rectifier output,

$$V_{\text{rms}} = \frac{V_m}{\sqrt{2}}$$

$$V_{\text{dc}} = \frac{2V_m}{\pi}$$

So, $$\text{Ripple factor} = \sqrt{\left(\frac{\pi}{2\sqrt{2}}\right)^2 - 1} \approx 0.48$$

82. (c)



Since, we have to calculate maximum current through the zener diode, hence we will consider V_i = 21.7 V

Thus, $$V_0 = 12.7 - 0.7 = 12 \text{ V}$$

and $$I_L = \frac{12 \text{ V}}{R_L} = \frac{12}{1\times10^3} = 12 \text{ mA} = I_C$$

∴ $$I_B = \frac{12\text{ mA}}{100} = 0.12\text{ mA}$$

Now, $$I_1 = \frac{V_i - V_Z}{R} = \frac{21.7 - 12.7}{375\ \Omega} = \frac{3}{125}\text{ A} = 24\text{ mA}$$

$$I_{z(\max)} = (24 - 0.12)\text{ mA}$$
$$= 23.88\text{ mA}$$

83. (d)

$$P_D = \frac{T_J - T_A}{\theta_{JA}} = \frac{40-30}{10} = 1\text{ W}$$

84. (a)

$$I_C = \frac{I_{\text{reff}}}{\left(1+\frac{N}{\beta}\right)} \;;\quad \text{Here } N = 4$$

$$= \frac{21\times10^{-3}}{1+\left(\frac{4}{100}\right)} = \frac{25}{26}\times 21\text{ mA} = 20.19\text{ mA}$$

85. (c)

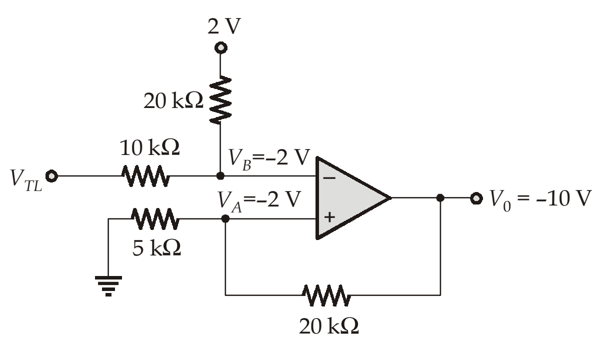
At V_{LT} the output must be

$$-V_{\text{sat}} = -10\text{ V},$$

Thus, the value of voltage

$$V_A = -10\times\frac{5}{25} = -2\text{ V}$$

Thus, the input voltage for which the transition occurs will be when $V_A = V_B = -2$ V



Thus applying KCL at node 'A', we get,

$$\frac{V_B - V_i}{10\text{ k}\Omega} + \frac{V_B - 2}{20\text{ k}\Omega} > 0$$

Thus, $$\frac{-2 - V_{LT}}{10\text{ k}\Omega} + \frac{-2-2}{20\text{ k}\Omega} = 0$$

$$\frac{-V_{LT}}{10\,\text{k}\Omega} = \frac{2}{10\,\text{k}\Omega} + \frac{4}{20\,\text{k}\Omega}$$

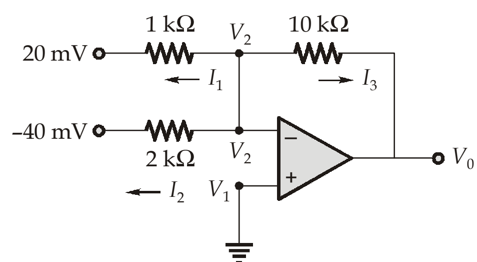
$$V_A = -4\text{ V}$$

86. (c)

$$A_v = \frac{-R_2/R_1}{1+\dfrac{(1+R_2/R_1)}{A_{OL}}} = \frac{-8/2}{1+\dfrac{(1+8/2)}{100}}$$

$$= \frac{-4}{1+\dfrac{5}{100}} = \frac{-4}{1.05} = -3.8095 \approx -3.81$$

87. (a)



$$I_1 + I_2 + I_3 = 0$$

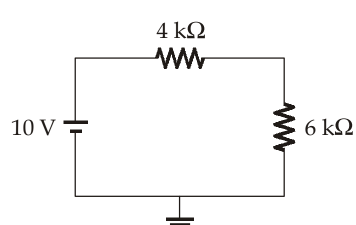
$$\frac{V_2 - 20\,\text{mV}}{1\text{k}} + \frac{V_2 + 40\,\text{mV}}{2\text{k}} + \frac{V_2 - V_0}{10\text{k}} = 0 \qquad [\because V_2 = 0\text{ V}]$$

$$\frac{-20\text{mV}}{1} + \frac{40\,\text{mV}}{2} = \frac{V_0}{10}$$

$\therefore$ $V_0 = 0\text{ V}$

88. (c)

Here, $D_1 \rightarrow$ F.B, $D_2 \rightarrow$ R.B



$$I = \frac{10\text{ V}}{10\text{K}} = 1\text{ mA}$$

90. (c)

$\because$ $f(A,B,C) = \overline{\Sigma m(1,2,4,6)} = \Sigma m(0, 3, 5, 7)$

91. (c)

$$f = 1$$
$$C = 1$$
$$B \odot C = 1 \Rightarrow B = 1$$
$$A \oplus B = 1 \Rightarrow A = 0$$

92. (c)

The minimum number of 2-input NOR gates required to implement the full subtractor is '9'.

94. (b)

Initial SP = 2099 H

PUSH H : SP decrements twice → 2097 H

POP B : SP increments twice → 2099 H

PUSH H → SP decrements twice → 2097 H

Final SP = 2097 H

95. (c)

Given that, $\mu = 0.8$

$A_c = 5$ V

Maximum value of the envelope of the AM signal,

$$E_{max} = A_c(1 + \mu) = 5 \times 1.8 = 9 \text{ V}$$

Minimum value of the envelope of the AM signal,

$$E_{min} = A_c(1 - \mu) = 5 \times 0.2 = 1 \text{ V}$$

96. (c)

When $m(t)$ is applied as message signal:

$$\Delta f_{max} = \frac{k_p}{2\pi}\left|\frac{dm(t)}{dt}\right|_{max}$$

$$\frac{k_p}{2\pi}\left|\frac{dm(t)}{dt}\right|_{max} = 10 \text{ kHz}$$

When $x(t) = m(2t)$ is applied as message signal:

$$\frac{dx(t)}{dt} = \frac{dm(2t)}{dt}$$

Let, $\tau = 2t \Rightarrow d\tau = 2dt$

So, $$\frac{dx(t)}{dt} = \frac{dm(\tau)}{d\tau}\times\frac{d\tau}{dt} = 2\frac{dm(\tau)}{d\tau}$$

$$\left|\frac{dx(t)}{dt}\right|_{max} = 2\left|\frac{dm(\tau)}{d\tau}\right|_{max} = 2\left|\frac{dm(t)}{dt}\right|_{max}$$

So, $$\Delta f_{max} = \frac{k_p}{2\pi}\left|\frac{dx(t)}{dt}\right|_{max} = 2\left[\frac{k_p}{2\pi}\left|\frac{dm(t)}{dt}\right|_{max}\right] = 20\text{ kHz}$$

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

98. (c)

$$f(t) = A_c \cos[2\pi f_c t + 5\sin(2\pi f_m t) + 2\sin(10\pi f_m t)]$$

General expression of angle modulated signal is,

$$S(t) = A_c \cos[2\pi f_c t + \phi(t)]$$

$$\phi(t) = 5\sin(2\pi f_m t) + 2\sin(10\pi f_m t)$$

Peak frequency deviation,

$$\Delta f = \left|\frac{1}{2\pi}\frac{d}{dt}\phi(t)\right|_{max}$$

$$= \left|\frac{1}{2\pi}[5\times 2\pi f_m \cos(2\pi f_m t) + 2\times 10\pi f_m \cos(10\pi f_m t)]\right|_{max}$$

$$= 5f_m + 10f_m$$

$$= 15f_m$$

99. (b)

$$\mu_1 = \frac{A_m}{A_c} = \frac{3}{4} = \mu_2$$

$$\mu_T = \sqrt{\mu_1^2 + \mu_2^2}$$

$$= \sqrt{\left(\frac{3}{4}\right)^2 + \left(\frac{3}{4}\right)^2} = \frac{3\sqrt{2}}{4}$$

$$\eta = \frac{\mu^2}{\mu^2 + 2} = \frac{\frac{9}{8}}{\frac{9}{8} + 2} = \frac{9}{25} = 36\%$$

100. (d)

$$\text{SNR} = \frac{P_s}{N_0 B} = \frac{10^{-3}}{10^{-20} \times 100 \times 10^6} = 10^9$$

$$(\text{SNR})_{\text{dB}} = 10 \log 10^9 = 90 \text{ dB}$$

Cable loss = 20 dB

SNR at receiver = (90 – 20) = 70 dB

101. (a)

No. of bits per symbol, $n = \log_2(M)$ where M = no. of symbols

For BPSK: $M = 2$

$n_1 = \log_2 2 = 1$ bits per symbol

For 64-QAM, $M = 64$

$n_2 = \log_2 64 = 6$ bits/symbol

$$\text{Avg. bits per symbol, } n_{avg} = \frac{n_1 + n_2}{2} = \frac{1+6}{2}$$

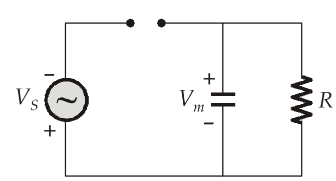
= 3.5 bits/symbol

Data rate $R_b = n_{avg} \times f_s$

= 3.5 × 2 = 7 Mega-bits/sec

102. (d)

During positive half cycle the capacitor charges upto $V_{max} = \sqrt{2} \times 230$ and during negative half cycle the circuit behaves as,



∴ $$\text{PIV} = 2 \times \sqrt{2} \times 230 = 650.5 \text{ V}$$

103. (c)

In forward blocking mode junction J_2 and in reverse blocking mode junction J_1 and J_3 acts as a capacitor hence leakage current present in both modes.

104. (d)

Given circuit turn off time of main thyristor is 110 µs

$$t_C = \frac{CV_s}{I_0}$$

$$I_0 = \frac{V_S}{R_L} = \frac{150}{10} = 15 \text{ A}$$

$$t_C = 110 \times 10^{-6} = \frac{C \times 150}{15}$$

$$C = 11\ \mu F$$

Peak value of current through main thyristor is,

$$I_p = I_0 + V_s\sqrt{\frac{C}{L}}$$

$$30 = 15 + 150\sqrt{\frac{11 \times 10^{-6}}{L}}$$

$$\frac{1}{10} = \sqrt{\frac{11 \times 10^{-6}}{L}}$$

$$L = 1.1\ \text{mH}$$

105. (c)

Triplen harmonics are always absent in 120° and 180° mode.

106. (d)

The energy (W) dissipated is,

$$W = \frac{1}{2}CV^2$$

$$= 0.5 \times 0.1 \times 10^{-6} \times (220)^2$$

$$W = 2.42\ \text{mJ}$$

107. (c)

The anode current at the end of 40 μs pulse

$$i = \frac{V_s}{L}t_p$$

$$= \frac{300}{2} \times 40 \times 10^{-6} \Rightarrow 6\ \text{mA}$$

Latching current 50 mA >> 6 mA. Therefore the thyristor never gets ON.

The shunt resistance for turning ON is

$$\text{Latching current} = i + i_R$$

$$50\ \text{mA} = 6\ \text{mA} + \frac{300}{R}$$

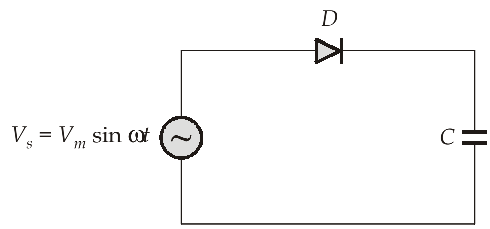
$$R = \frac{300}{44}\ \text{k}\Omega$$

$$= 6.81\ \text{k}\Omega$$

108. (b)

$$I_{sw,\ r} = I_s \times \sqrt{D} = 20 \times \sqrt{0.4} = 12.65\ \text{A}$$

109. (a)



During positive half cycle, capacitor start charging from 0° to 90° and it charges to maximum value of supply voltage (V_m). Further supply voltage cannot be more than V_m and diode is reverse biased.

110. (b)

$$\text{per phase secondary voltage} = \frac{1000}{2} = 500\text{ V, then}$$

$$\text{PIV} = 2V_{mp} = 1000\sqrt{2} = 1414\text{ V}$$

111. (c)

$$\text{Effective on period} = T_{\text{on}} + \frac{2V_s}{I_0}C$$

$$= 200\mu\text{sec} + \frac{2\times 230}{100}\times 90\times 10^{-6}$$

$$= 614\ \mu\text{sec}$$

$$\text{Peak current through the main thyristor} = 100 + V_s\sqrt{\frac{C}{L}}$$

$$= 100 + 230\times\sqrt{\frac{90}{30}}$$

$$= 498.37\text{ A}$$

112. (a)

For constant load current $I_{or} = I_0 = 15$ A $[\because I_{sr} = I_{or} = I_0 = 15\text{ A}]$

$$V_s I_{or}\cos\phi = EI_0 + I_{or}^2 R$$

$$\cos\phi = \frac{120(15) + (15)^2\times 0.9}{230\times 15}$$

$$= 0.5804\text{ lag}$$

113. (b)

We know, $$\text{Gauge factor} = 1 + 2\gamma + \frac{\Delta\rho/\rho}{\epsilon},$$

$$G_f = 3.6$$

If piezoresistive effect is neglected $G_f = 1 + 2\gamma$

$$\text{Poisson's ratio, } \gamma = \frac{G_f - 1}{2} = \frac{3.6 - 1}{2} = 1.3$$

114. (c)

Count range for 3½ digit DVM is from 0 to 1999 i.e. 2000 counts

and $$\text{Resolution} = \frac{200 \text{ mV}}{2000} = 0.1 \text{ mV}$$

115. (b)

Deflecting torque in PMMC ;

$$T_d \propto BI \qquad (T_d = \text{NBIA})$$

Given, $$B_2 = 2B_1$$

and $$I_2 = \frac{I_1}{2}$$

$$\therefore \quad T_{d_2} \propto B_2 I_2 \propto (2B_1)\left(\frac{I_1}{2}\right) \propto B_1 I_1$$

Thus, $$T_{d_2} = T_{d_1}$$

At balance, $$T_d = T_c = k\theta$$

⇒ as torque is proportional to deflection. So, same deflection (90°) is produced.

116. (b)

First watt meter reading = 3 kW

Second watt meter reading = 1 kW

with terminal reversed second wattmeter reading = –1 kW

Power factor using two wattmeter method,

$$\phi = \left[\tan^{-1}\left(\sqrt{3}\frac{P_1 - P_2}{P_2 + P_1}\right)\right]$$

$$= \left[\tan^{-1}\sqrt{3}\left(\frac{4}{2}\right)\right] = \left[\tan^{-1}\sqrt{3}(2)\right]$$

$$\tan\phi = 2\sqrt{3}$$

$$\cos\phi = \frac{1}{\sqrt{13}}$$

117. (c)

At balanced the value of unknown arm resistor R

$$R = \frac{P}{Q}\cdot S = \frac{500}{500}\times 800 = 800\ \Omega$$

∴ Percentage error in value of R

$$\frac{\delta R}{R} = \pm\frac{\delta P}{P} \pm \frac{\delta Q}{Q} \pm \frac{\delta S}{S}$$

$$= \pm 0.04 \pm 0.04 \pm 0.20 = \pm 0.28\%$$

∴ Limiting values,

$$R + \frac{0.28}{100} \times 800 = 800 + 2.24 = 802.24\ \Omega$$

and

$$R - \frac{0.28}{100} \times 800 = 800 - 2.24 = 797.76\ \Omega$$

118. (b)

When input to vertical plate= 20 V dc

The bright spot moves up by 1 cm

Rms value of ac voltage, $V_{rms} = 20$ V

$$V_m = 20\sqrt{2}\ \text{V}$$

For 20 V dc $\rightarrow$ 1 cm moves

$$\therefore \quad 20\sqrt{2}\ \text{V} = 1 \times \sqrt{2}\ \text{cm} = 1.41 \text{ cm (in +ve direction)}$$

Since it is ac input same length appear in negative direction

On screen line length = 2 × 1.41 cm = 2.82 cm

119. (b)

$$I_W \times 200 = 200 \text{ mV}$$

$$I_W = 1 \text{ mA}$$

$$\therefore \quad I_W = \frac{3.2}{R_h + 200 + 2800}$$

$$1 \text{ mA} = \frac{3.2}{R_h + 3000}$$

$$R_h + 3000 = 3200$$

$$R_h = 200\ \Omega$$

120. (b)

Resolution on 10 V range: $R = \frac{1}{10^3} \times 10 = 00.01$

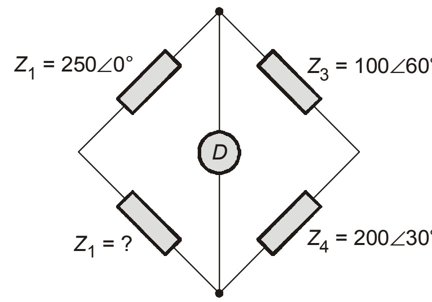
∴ The display is 11.25

121. (c)

$$\frac{f_y}{f_x} = \frac{\text{Horizontal tangencies}}{\text{Vertical tangencies}}$$

$$\therefore \quad \text{Vertical tangencies} = 8 \times \frac{6}{2} = 24$$

122. (d)



$$\omega = 1000 \text{ rad/sec}$$

Under balanced condition, $Z_1 Z_4 = Z_2 Z_3$ and $\angle Q_1 + \angle Q_4 = \angle Q_2 + \angle Q_3$

$$0° + 30° = \theta_2 + 60°$$

$$250 \times 200 = Z_2 \times 100$$

$$\therefore \quad Z_2 = 500\angle -30°$$

$$= 500\cos 30° - j500\sin 30°$$

$$= 500 \times \frac{\sqrt{3}}{2} - j500 \times \frac{1}{2} = 250\sqrt{3} - j250$$

$$X_C = 250$$

$$\frac{1}{\omega C} = 250$$

$$C = \frac{1}{1000 \times 250} = 4\,\mu\text{F}$$

$\therefore$ R in series with a capacitor of 4 μF.

123. (a)

$$E = \int_{-2}^{2} \left|3e^{j\omega_0 t}\right|^2 dt = \int_{-2}^{2} (3)^2 dt$$

$$= 9 \times 4 = 36$$

124. (c)

Both the statements are correct.

125. (d)

- Convolution of two rectangular pulses of equal duration will be a triangle.
- Convolution of two rectangular pulses of unequal duration will be a trapezoid.

126. (b)

Fourier series expansion is applicable only for periodic signals.

127. (a)

Fourier transform does not exist for neither energy nor power signals.

128. (a)

Given, $$X(s) = \frac{s+4}{s^2+3s+5}$$

Initial value: $$x(0) = \lim_{s\to\infty} sX(s) = \lim_{s\to\infty} \frac{s(s+4)}{(s^2+3s+5)} = \lim_{s\to\infty} \frac{s^2+4s}{s^2+3s+5} = 1$$

Final value: $$x(\infty) = \lim_{s\to 0} sX(s) = \lim_{s\to 0} \frac{s(s+4)}{s^2+3s+5} = 0$$

129. (c)

Both statements are correct.

130. (b)

Given, $$x(n) = n^2\, u(n)$$

We have, $$z\,[u(n)] = \frac{z}{z-1}$$

Using the multiplication by n-property, we have

$$z[n\ u(n)] = -z\frac{d}{dZ}[z\{u(n)\}] = -z\frac{d}{dz}\left(\frac{z}{z-1}\right)$$

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

Again using the multiplication by n property, we have

$$z[n^2\ u(n)] = -z\frac{d}{dz}\{z[nu(n)]\} = -z\frac{d}{dz}\left[\frac{z}{(z-1)^2}\right]$$

$$= -z\left[\frac{z-1-2z}{(z-1)^3}\right] = \frac{z(z+1)}{(z-1)^3}$$

131. (d)

Let, $$g(k) = u(k) * u(k)$$

$$= \sum_{r=-\infty}^{\infty} u(r)u(k-r) = \sum_{r=0}^{k} u(r)$$

$$= (k+1)\ u(k)$$

132. (c)

$$y(n) = x(n^2)$$

$y(-1) = x(1) \rightarrow$ present output depends on future input.

So, Non-causal system.

$$x(n) \rightarrow y(n),\ x_1(n) \rightarrow y_1(n) = x_1(n^2),$$

$$x_2(n) \rightarrow y_2(n) = x_2(n^2)$$

$$\alpha x_1(n) + \beta x_2(n) \rightarrow \alpha x_1(n^2) + \beta x_2(n^2) = \alpha y_1(n) + \beta y_2(n)$$

So, linear system

$$x_1(n) = x(n-1) \rightarrow y_1(n) = x_1(n^2) = x(n^2 - 1)$$

$$y(n-1) = x[(n-1)^2]$$

$$y_1(n) \neq y(n-1),$$

So, time variant.

The system is Non-causal, Linear and Time varying

133. (a)

$$e^{-a|t|} \longleftrightarrow \frac{2a}{a^2 + \omega^2}$$

$$e^{-|t|} \xleftrightarrow{\text{F.T}} \frac{2}{\omega^2 + 1} = \frac{2}{4\pi^2 f^2 + 1}$$

$$y(t) = \frac{1}{2} e^{-|t|},$$

$$Y(f) = \frac{1}{1 + 4\pi^2 f^2}$$

Time shifting property of Fourier transform is

$$x(t - t_0) \longleftrightarrow e^{j2\pi f t_0} X(f)$$

$$X(f) = \frac{e^{-j4\pi f}}{1 + 4\pi^2 f^2} = e^{-j4\pi f} Y(f)$$

Taking I.F.T

$$x(t) = y(t-2) = \frac{1}{2} e^{-|t-2|}$$

134. (a)

Given, $$X(z) = \frac{1}{1 - \frac{z^{-1}}{3}}, \; x(n) = \left(\frac{1}{3}\right)^n u(n)$$

$$\therefore \quad \sum_{n=-\infty}^{\infty} |x(n)|^2 = \sum_{n=-\infty}^{\infty} \left(\frac{1}{3}\right)^n u(n) \left(\frac{1}{3}\right)^n u(n)$$

$$\therefore \quad \sum_{n=-\infty}^{\infty} |x(n)|^2 = \sum_{n=-\infty}^{\infty} \left(\frac{1}{3}\right)^{2n} u(n) = \sum_{n=0}^{\infty} \left(\frac{1}{9}\right)^n = \frac{1}{1 - \frac{1}{9}} = \frac{9}{8} = 1.125$$

135. (c)

$$f(t) = \int_{\tau=0}^{\infty} h(t-\tau)e(\tau)d\tau$$

$$= h(t) * e(t)$$

$$\therefore \quad F(s) = H(s)E(s)$$

$$10e^{-10t}u(t) \rightarrow \frac{10}{s+10} = H(s), \ \sin(10t)u(t) \rightarrow \frac{10}{s^2+100} = E(s)$$

$$F(s) = \frac{100}{(s+10)(s^2+100)}$$

136. (c)

Given, $AX = 0$

$$p(A_{n \times n}) = r \ (0 < r < n)$$

$$p = \text{number of independent solution} = \text{nullity}$$

We know that,rank + nullity $= n$

$$r + p = n$$

$$p = n - r$$

137. (a)

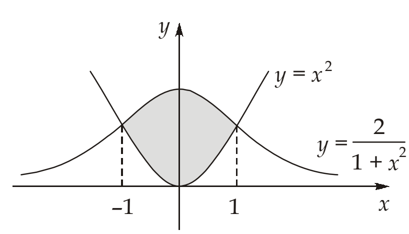
For intersection point,

$$x^2 = \frac{2}{1+x^2}$$

$$\Rightarrow \quad x^4 + x^2 - 2 = 0$$

$$\Rightarrow \quad (x^2 + 2)(x^2 - 1) = 0$$

$$\Rightarrow \quad x = \pm 1$$



Hence the required area;

$$= 2\int_0^1 \left(\frac{2}{1+x^2} - x^2\right)dx = 2\left[2\tan^{-1}x - \frac{x^3}{3}\right]_0^1$$

$$= 2\left(\frac{\pi}{2} - \frac{1}{3}\right) = \pi - \frac{2}{3}$$

138. (b)

$$(D^2 + 9)y = \sin 4x$$

Auxiliary equation is:

$$m^2 + 9 = 0$$

or, $$m = \pm 3i$$

Complementary function, CF $= A\cos 3x + B\sin 3x$

$$\text{P.I.} = \frac{1}{D^2+9}\cdot \sin 4x = \frac{\sin 4x}{-4^2+9}$$

$$= \frac{-\sin 4x}{7}$$

$\therefore$ Complete solution is, $y = A\cos 3x + B\sin 3x - \dfrac{\sin 4x}{7}$

139. (b)

Here,

$$\lim_{x\to 0^+} \log_{\sin x}\sin 2x = \lim_{x\to 0^+}\frac{\log\sin 2x}{\log\sin x} \qquad \left(\frac{-\infty}{-\infty}\text{ from}\right)$$

$$= \lim_{x\to 0^+}\frac{\frac{2\cos 2x}{\sin 2x}}{\frac{1}{\sin x}\cdot\cos x} \quad \text{(Applying L-hospitals' rule)}$$

$$= \lim_{x\to 0^+}\frac{\left(\frac{2x}{\sin 2x}\right)\cos 2x}{\left(\frac{x}{\sin x}\right)\cos x} \quad \text{(Multiply and divide by 'x')}$$

$$= \lim_{x\to 0^+}\frac{\cos 2x}{\cos x} = 1$$

140. (a)

$$\frac{dx}{dy} = \frac{1}{x(1+y^2)}$$

$$\int\frac{dy}{1+y^2} = \int x\,dx$$

$$\tan^{-1} y = \frac{x^2}{2} + K$$

$$y = \tan\left(\frac{x^2}{2}+K\right)$$

141. (a)

Given,
$$\phi_x = \psi_y = -2y - \frac{2xy}{(x^2+y^2)^2}$$

$$\phi_y = \psi_x = -2x - \frac{1}{x^2+y^2} - \frac{2x^2}{(x^2+y^2)^2}$$

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

We know that,
$$\phi = \int \underbrace{\phi_x \cdot dx}_{y-\text{constant}} + \underbrace{(-\phi_y)dy}_{x-\text{free terms}}$$

$$\phi = \int\left[-2y - \frac{2xy}{(x^2+y^2)^2}\right]dx$$

$$\phi = -2xy + \frac{y}{x^2+y^2} + C$$

142. (a)

Let s be the sample space,

then, $n(s)$ = Total number of determinants that can be made with 0 and 1
$= 2 \times 2 \times 2 \times 2 = 16$

$\{\because \begin{vmatrix} a & b \\ c & d \end{vmatrix}$; each element can be replaced by two types i.e. 0 and 1 only$\}$

and let E be the event that the determinant made is non negative also E' be the event that the determinant is negative.

$$\therefore \quad E' = \left\{\begin{vmatrix} 1 & 1 \\ 1 & 0 \end{vmatrix}, \begin{vmatrix} 0 & 1 \\ 1 & 1 \end{vmatrix}, \begin{vmatrix} 0 & 1 \\ 1 & 0 \end{vmatrix}\right\}$$

$$\therefore \quad n(E') = 3$$

then
$$P(E') = \frac{n(E')}{n(s)} = \frac{3}{16}$$

Hence, the required probability,
$$P(E) = 1 - P(E') = 1 - \frac{3}{16} = \frac{13}{16}$$

143. (c)

To calculate $\frac{1}{a}$ using NR method,

Set up the equation as;

$$x = \frac{1}{a}$$

i.e. $$\frac{1}{x} = a$$

$\Rightarrow$ $$\frac{1}{x} - a = 0$$

i.e. $$f(x) = \frac{1}{x} - a = 0$$

Now, $$f'(x) = \frac{-1}{x^2}$$

$$f(x_k) = \frac{1}{x_k} - a$$

$$f'(x_k) = -\frac{1}{x_k^2}$$

For N-R method,

$$x_{k+1} = x_k - \frac{f(x_k)}{f'(x_k)}$$

$$x_{k+1} = x_k - \frac{\left(\frac{1}{x_k} - a\right)}{\frac{-1}{x_k^2}}$$

Simplifying which we get,

$$x_{k+1} = 2x_k - a{x_k}^2$$

144. (b)

Given, $$I = \int_0^{\pi} |\cos x|\, dx$$

$$= \int_0^{\pi/2} \cos x dx - \int_{\pi/2}^{\pi} \cos x dx$$

$$= (\sin x)_0^{\pi/2} - (\sin x)_{\pi/2}^{\pi}$$

$$= (1 - 0) - (0 - 1) = 2$$

145. (d)

A capacitor has one pole at $s = 0$ and driving point impedance is

$$Z(s) = \frac{1}{sC}$$

146. (d)

Hard magnetic materials are used for making permanent magnets.

147. (a)

The reactance of bundle conductors is reduced because the self GMD of the conductors is increased and as we know reactance $= K \ln \frac{\text{GMD}}{\text{GMR}}$ and as GMR is increased the reactance is reduced.

Self GMD is also called as geometrical mean radius (GMR).

148. (d)

HLDA is only asserted after the completion of the entire instruction, not just a machine cycle or T-state (except in HALT state)

150. (d)

Nuclear power plants are used as a base load power plant.

Hence statement I is false.

■■■■