DETAILED SOLUTIONS

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ESE 2023 : Prelims Exam
CLASSROOM TEST SERIES

ELECTRICAL ENGINEERING

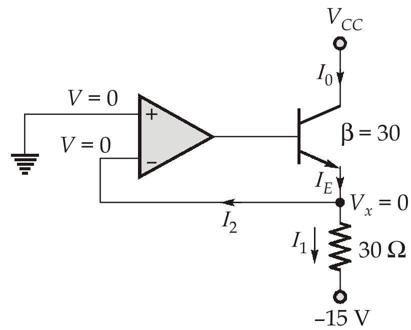
Test 22

Full Syllabus Test 6 : Paper-II

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

DETAILED EXPLANATIONS

1. (b)



Now, $$I_1 = \frac{0-(-15)}{30} = 0.5 \text{ A}$$

Applying KCL at node V_x,

$$I_E = I_1 + I_2$$

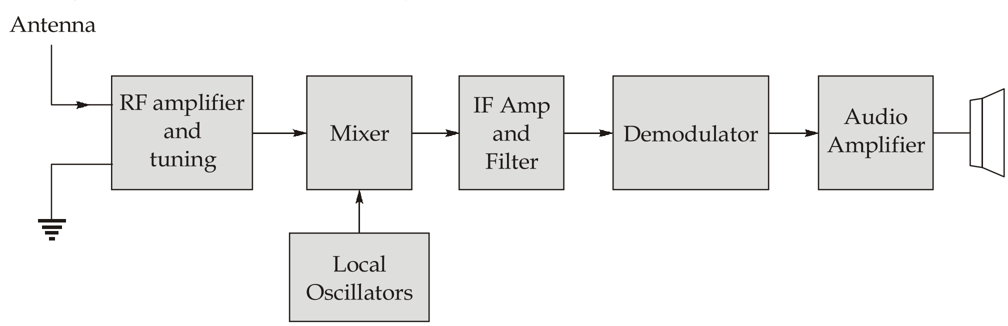
Since, $$I_2 = 0$$

$$I_E = I_1$$

$$I_0 = I_C = \frac{\beta}{\beta+1} I_E = \frac{30}{31} \times 0.5 = 0.483 \text{ A}$$

2. (b)

The block diagram of the super heterodyne receiver is represents:

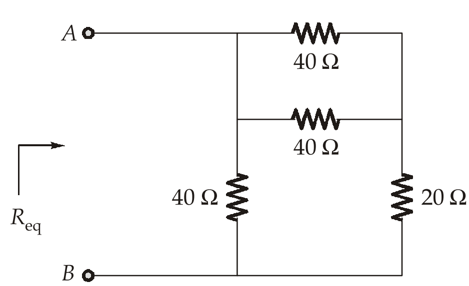


Arranging the components:

Antenna, RF amplifier, Mixer, IF amplifier, Audio amplifier.

3. (c)

Redrawing the circuit,



$$R_{eq} = 40 \,||\, (40 \,||\, 40 + 20)$$
$$= 40 \,||\, 40$$
$$= 20\ \Omega$$

5. (b)

Electric flux density, $D = \varepsilon E$

Electric field intensity, $E = \dfrac{D}{\varepsilon} = \dfrac{\dfrac{x}{4} \times 10^{-9}}{6 \times \dfrac{1}{36\pi} \times 10^{-9}}$

At $x = \dfrac{1}{2}$, $E = \dfrac{6\pi \times 10^{-9}}{4 \times 10^{-9}} \times \dfrac{1}{2}$

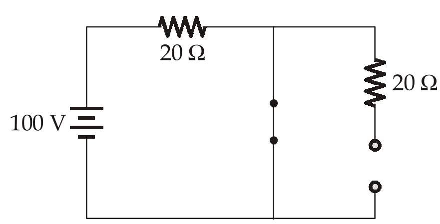
$$E = \frac{3\pi}{4}\ \text{V/m}$$

6. (b)

At $t = 0^+$

$V_C(0^-) = V_C(0^+) = 0 \quad \Rightarrow$ short circuited

$i_L(0^-) = i_L(0^+) = 0 \quad \Rightarrow$ open circuited

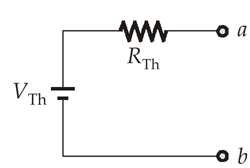


Applying KVL,

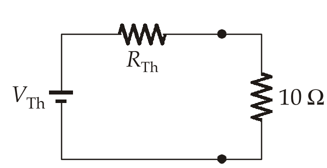
$$20I = 100$$
$$I = 5\ \text{A}$$

7. (b)

Drawing Thevenin equivalent circuit,



Case -I:

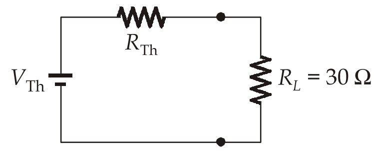


$$V_{Th} = (R_{Th} + 10)I_1$$

$$I_1 = \frac{24}{10} = 2.4 \text{ A}$$

$$V_{Th} = (R_{Th} + 10) \times 2.4 = 2.4R_{Th} + 24$$

Case -II:



$$V_{Th} = (R_{Th} + 30)I_2$$

$$I_2 = \frac{48}{30} = 1.6 \text{ A}$$

$$V_{Th} = (R_{Th} + 30) \times 1.6 = 1.6R_{Th} + 48$$

$$R_{Th} = 30\ \Omega$$

$$V_{Th} = 96 \text{ V}$$

8. (a)

Intermediate frequency, IF = 455 kHz

Signal frequency range 550 kHz to 1600 kHz

The local oscallator frequency,

$$f_l = f_s + IF$$

$$f_{l\text{, max}} = f_{s\text{ max}} + IF$$

$$= 1600 + 455$$

$$f_{l\text{, max}} = 2055$$

$$f_{l\text{, min}} = f_{s\text{ min}} + IF = 550 + 455$$

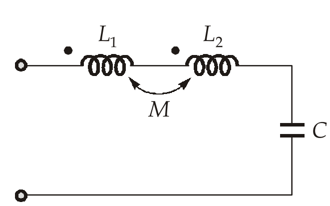
$$f_{l\text{, max}} = 1005$$

$$\text{Frequency tuning ratio} = \frac{f_{l,max}}{f_{l,min}} = \frac{2055}{1005} \approx 2.05$$

10. (b)

$$L_{eq} = L_1 + L_2 \pm 2M$$

$$f_0 = \frac{1}{2\pi\sqrt{(L_1 + L_2 \pm 2M)C}}$$



$L \propto N^2$

$$M \propto \sqrt{L_1 L_2}$$

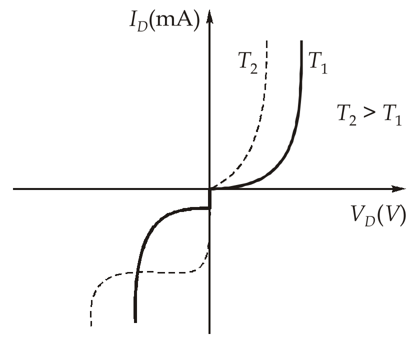
$$L_{eq} = 4L_1 + 4L_2 \pm 4 \times 2M$$

$$L_{eq} = 4(L_1 + L_2 \pm 2M)$$

$$f_0' = \frac{1}{2} f_0$$

11. (b)

Temperature dependence of characteristics of Si diode,



- In the forward bias region the characteristics of a Silicon diode shift to the left with increase in temperature.
- The reverse breakdown voltage of a semiconductor diode will increase or decrease with temperature depending on zener potential.
- For breakdown voltage less than 5 V, breakdown voltage will increase with temperature and vice-versa.
- In the reverse region the reverse saturation current of a Silicon diode increases with rise in temperature.

12. (a)

Width of the hysteresis curve 'W' can be given as,

$$W = V_{UT} - V_{LT}$$

$$V_{UT} \text{ (upper threshold voltage)} = 4\times\frac{2}{2+2} = 2\text{ V}$$

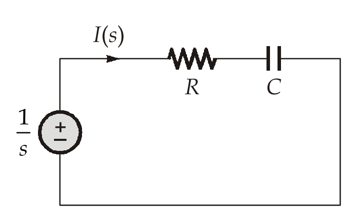
$$V_{LT} \text{ (lower threshold voltage)} = -2\times\frac{2}{2+2} = -1\text{ V}$$

∴ $$W = 2 - (-1) = 3\text{ V}$$

14. (d)

$$i(t) = \frac{1}{4}e^{-t/4}\text{ A}$$

$$I(s) = \frac{1}{4}\cdot\frac{1}{s+\frac{1}{4}} = \frac{1}{4s+1}$$



$$I(s) = \frac{\frac{1}{s}}{R+\frac{1}{Cs}} = \frac{C}{RCs+1}$$

From here, $C = 1$ F and $R = 4\ \Omega$

15. (d)

The electric potential is given by

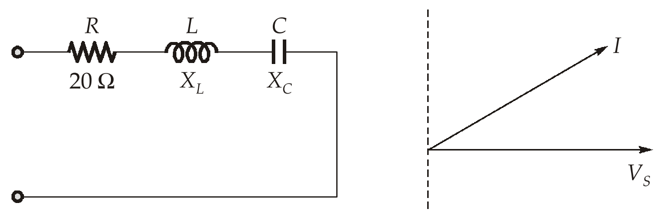
$$V = \frac{1}{4\pi\varepsilon_0}\sum_{m=1}^{n}\frac{Q_m}{R_m}$$

$$550 = \frac{Q}{4\pi\varepsilon_0}\left(\frac{1}{2}+\frac{1}{3}+\frac{1}{4}+\frac{1}{5}+\frac{1}{6}\right)$$

$$\frac{550\times 4\times\pi}{1.45}\times\frac{1}{36\pi}\times 10^{-9} = Q$$

$$Q = 42.14 \text{ nC}$$

16. (a)



$$V_C = 3\ V_L$$

$$IX_C = 3I\ X_L$$

$$X_C = 3X_L$$

Angle between applied voltage and current is 45° with current leading the voltage

$$V_R = V_C - V_L$$

$$20 \times I = (X_C - X_L)I$$

$$20 = X_C - X_L = X_C - \frac{X_C}{3} = \frac{2X_C}{3}$$

$$X_C = 30\ \Omega$$

17. (c)

$$\text{Percentage saving} = \frac{P_c\left(1+\frac{\mu^2}{4}\right)}{P_c\left(1+\frac{\mu^2}{2}\right)}\times 100$$

$$\text{Saving} = \frac{4+\mu^2}{2(2+\mu^2)}\times 100 = \frac{4+(1)^2}{2(2+(1)^2)}\times 100 = 83.33\%$$

18. (d)

All statements are correct.

20. (a)

We define two half-power frequencies, ω_1 and ω_2 as the frequencies at which the impedance magnitude $\sqrt{2}$ times the minimum impedance magnitude.

21. (c)

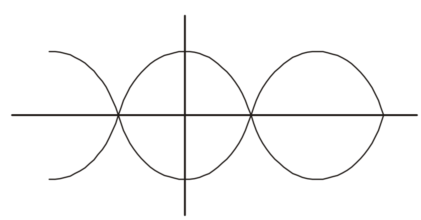
The induction machine will behave as induction generator. The induction generator supplies real power and draws reactive from the mains.

22. (a)

For maximum power, $Z_L = Z_S^*$

$$Z_S = \text{Internal impedance of source}$$
$$= 2 + j4\ \Omega$$
$$Z_L = 2 - j4\ \Omega$$
$$R_L = 2\ \Omega,\ V_{Th} = 10\ \text{V}$$
$$P_{max} = \frac{(V_{Th})^2}{4R_L} = \frac{10 \times 10}{4 \times 2} = 12.5\ \text{W}$$

24. (d)



$$\frac{f_y}{f_x} = \frac{\text{No. of intersections of the horizontal line with the curve}}{\text{No. of intersections of the vertical line with the curve}} = \frac{5}{2}$$

25. (c)

$$P_1 = \frac{1}{(s+4)},\ L_1 = \frac{1}{(s+2)},\ L_2 = \frac{-1}{(s+2)}$$

By Mason gain formula

$$\frac{C}{R} = \frac{\frac{1}{(s+2)}(1-0)}{1-\left[\frac{-1}{s+2}+\frac{1}{s+2}\right]+0}$$

$$\frac{C}{R} = \frac{1}{(s+2)}$$

26. (a)

Magnetic energy density,

$$W = \frac{1}{2}\mu|\vec{H}|^2 = \frac{1}{2}\times 4\times 4\pi\times 10^{-7}\left|\sqrt{2^2+4^2+8^2}\right|^2$$

$$= \frac{1}{2}\times 4\times 4\pi\times 10^{-7}\times[4+16+64]$$

$$= 672\pi\times 10^{-7}$$

$$\therefore \quad W \approx 211\ \mu\text{J/m}^3$$

27. (d)

Bandwidth,
$$\text{BW} = nf_m + (n-1)f_{\text{guard}}$$
$$= 16\times 10 + (16-1)\times 2$$
$$\text{BW} = 190\text{ kHz}$$

28. (b)

Full load current,
$$I_{fl} = \frac{15\text{K}}{2\text{K}} = 7.5\text{ Amp}$$

But short circuit test is conducted at $I = 5$ A,

So full load short circuit losses,

$$P_{\text{cu}} = \left(\frac{7.5}{5}\right)^2\times 80 = 180\text{ W}$$

So efficiency,
$$\eta = \frac{15000\times 1}{15000\times 1+100+180}\times 100 = 98.16\%$$

29. (c)

$$\oint\nabla\times\vec{A}\cdot dl = \iint\vec{V}\cdot d\vec{s} \rightarrow \text{Stoke's theorem}$$

$$\nabla\times\vec{E} = 0 \rightarrow \text{Static electric and magnetic field}$$
$$\nabla\cdot\vec{B} = 0$$

$$\nabla\times\vec{H} = \vec{J}+\frac{\partial\vec{D}}{dt} \rightarrow \text{Ampere's law}$$

$$\nabla\times\vec{H} = \vec{J} \rightarrow \text{Ampere's law}$$

30. (d)

Time for peak undershoot

$$t_p = \frac{n\pi}{\omega_n\sqrt{1-\xi^2}} \qquad n = 2, 4, 6, \ldots$$

For first undershoot

$$t_{p1} = \frac{2\pi}{\omega_n\sqrt{1-\xi^2}}$$

For 2nd undershoot

$$t_{p2} = \frac{4\pi}{\omega_n\sqrt{1-\xi^2}}$$

31. (c)

- Gain reduction takes place in low frequency band due to coupling and bypass capacitors selected while the reduction of gain in high frequency band is due to internal capacitance of amplifiers.
- At low frequency, internal capacitance have high value and therefore look like open and have no effect on transistor's performance.

32. (c)

At balance,

$$C_1 = \frac{R_4}{R_3}\cdot C_2 = \frac{2850}{2000}\times 0.5\ \mu\text{F} = 0.7125\ \mu\text{F}$$

$$R_1 = \frac{R_3}{R_4}(R_2 + r_2) = \frac{2000}{2850}\times(4.8+0.4)$$

$$= \frac{2000\times 5.2}{2850} = 3.6491\ \Omega$$

$$D = \omega C_1 R_1 = 2\times\pi\times 100\times 10^3\times 0.7125\times 10^{-6}\times 3.64912$$

$$= 1.6336 \approx 1.634$$

33. (a)

Net flux spreading out of any closed surface is equal to the total charge

$$\psi = Q_{enc}$$

$$\psi = \int \rho_v\, dV = \int_{r=0}^{1}\int_{\phi=0}^{2\pi}\int_{\theta=0}^{\pi}\frac{1}{r^2}r^2\sin\theta\, dr\, d\theta\, d\phi$$

$$= \int_{r=0}^{1} dr \int_{\phi=0}^{2\pi} d\phi \int_{\theta=0}^{\pi}\sin\theta\, d\theta$$

$$= \int_{r=0}^{1} dr \int_{\phi=0}^{2\pi} d\phi\,[-\cos\theta]\Big|_0^{\pi} = \int_{r=0}^{1} dr \int_{\phi=0}^{2\pi} d\phi\,(2)$$

$$= 2(2\pi)\,1 = 4\pi \text{ Coulombs}$$

34. (a)

Synchronous speed, $N = \frac{120 \times 60}{50} = 1200$ rpm

Slip, $s_1 = \frac{1200 - 1175}{1200} = \frac{1}{48}$

$$T \propto \frac{V^2 \delta}{\omega_s R_s}$$

Torque is constant

$$s_2 \frac{(0.9)^2}{0.94} = \frac{1}{48} \times \frac{1}{1}$$

$$s_2 = \frac{1}{48} \times \frac{0.94}{0.9^2} = 0.0242$$

New operating speed $= 1200(1 - s_2) \times 0.94 = 1200 \times 0.94(1 - 0.0242)$

$= 1100$ rpm

35. (a)

Given: $R(s) = \frac{6}{s}$

$$Y(s) = G(s)R(s)$$

$$= \frac{1}{(s^2 + 4s + 3)} \cdot \frac{6}{s} = \frac{6}{s} \frac{1}{(s^2 + 4s + 3)} = \frac{6}{s} \cdot \frac{1}{(s+1)(s+3)}$$

$$= \frac{A}{s} + \frac{B}{(s+1)} + \frac{C}{(s+3)}$$

$$A = \lim_{s \to 0} \frac{6}{(s^2 + 4s + 3)} = 2$$

$$B = \lim_{s \to -1} \frac{6}{s(s+3)} = -3$$

$$C = \lim_{s \to -3} \frac{6}{s(s+1)} = 1$$

So, $Y(s) = \frac{2}{s} - \frac{3}{(s+1)} + \frac{1}{(s+3)}$

$$y(t) = (2 - 3e^{-t} + e^{-3t})u(t)$$

36. (b)

$$\text{SNR}_1 = 40 \text{ dB}$$

$$\text{SNR}_1 = \frac{S}{N_0 B_1} \quad \text{...(i)}$$

$$B_2 = 2B_1$$

$$\text{SNR}_2 = \frac{S}{N_0 B_2} = \frac{S}{N_0(2B_1)}$$

$$\text{SNR}_2 = \frac{\text{SNR}_1}{2}$$

In dB $$\text{SNR}_2 = \text{SNR}_1 - 10\log(2)$$

$$= 40 - 10 \times 0.30$$

$$= 40 - 3 = 37 \text{ dB}$$

37. (b)

$$\text{The power factor} = \frac{I_{1\text{rms}}}{I_{\text{rms}}}\cos(\theta_1 - \phi_1)$$

$$I_{1\text{ rms}} = \frac{15}{\sqrt{2}}\text{Amp}$$

$$I_{\text{rms}} = \sqrt{8^2 + 0.5(15^2 + 6^2 + 2^2)} = \sqrt{196.5}$$

$$I_{\text{rms}} \approx 14 \text{ Amp}$$

So, $$\text{power factor} = \frac{15/\sqrt{2}}{14} \times \cos(0 - 30°) = \frac{15}{14\sqrt{2}}\cos 30°$$

$$= \frac{15}{14} \times 0.707 \times 0.87 = 0.66$$

38. (b)

Characteristics equation

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

$$CE = s(s^2 + s + 9) + K(1 - 2s)$$

$$CE = s^3 + s^2 + 9s - 2Ks + K$$

$$CE = s^3 + s^2 + (9 - 2K)s + K$$

By RH criterion,

s^3	1	$9-2K$
s^2	1	K
s^1	$\frac{-K+(9-2K)}{1}$	0
s^0	K	0

For stable $K > 0$ and $-K + (9 - 2K) > 0$

$$K > 0 \text{ and } K < 3$$

The maximum value of K is 3 for closed loop transfer to be stable.

39. (b)

Both input and output impedance decreases by voltage shunt feedback.

$$Z_{if} = \frac{Z_i}{(1+A\beta)}$$

$$Z_{0f} = \frac{Z_0}{(1+A\beta)}$$

40. (b)

By addition of zero, the system becomes more relative stable and less oscillatory.

41. (b)

Power factor, $$\cos\phi = \cos\left[\tan^{-1}\left(\sqrt{3}\cdot\frac{W_1 - W_2}{W_1 + W_2}\right)\right] \quad ...(i)$$

(a) $W_1 = W_2$, equation (i) becomes

$$\text{Power factor} = \cos\left[\tan^{-1}\left(\sqrt{3}\times 1\right)\right] = 1$$

(b) Let, $W_2 = 0$, equation (i) becomes

$$\text{Power factor} = \cos\left[\tan^{-1}\left(\sqrt{3}\times 1\right)\right] = \cos(60°) = 0.5$$

(c) Let, $W_1 = 2\,W_2$, equation (i) becomes

$$\text{Power factor} = \cos\left[\tan^{-1}\left(\sqrt{3}\times\frac{1}{3}\right)\right] = \cos(30°) = \frac{\sqrt{3}}{2}$$

42. (b)

Slip, $$s = \frac{1500-1425}{1500} = 0.05$$

The full load torque, $$T_{fl} = \frac{P_m}{\omega_s(1-s)} = \frac{10000\times 60}{2\pi\times 1500(1-0.05)} = 67 \text{ Nm}$$

Slip at which maximum torque occurs,

$$S_m = \frac{1500-1200}{1500} = 0.2$$

We konw, $$\frac{T_{st}}{T_{fl}} = \frac{\left(\frac{s}{s_m}+\frac{s_m}{s}\right)}{\left(s_m+\frac{1}{s_m}\right)} = \frac{s^2+s_m^2}{s\left(s_m^2+1\right)}$$

$$\frac{T_{st}}{T_{fl}} = \frac{0.05^2+0.2^2}{0.05(0.2^2+1)} = 0.82$$

$$T_{st} = 0.82\times 67 = 55 \text{ N-m}$$

43. (c)

The slope at high frequency

$$= -(P - Z) \times 20$$
$$= -(5 - 1) \times 20$$
$$= -80 \text{ dB/dec}$$

44. (d)

$$\text{Multiplying factor, } m = \frac{I}{I_m} = \frac{10}{1 \times 10^{-3}} = 10000$$

$$R_m = 100\ \Omega$$

$$R_{sh} = \frac{R_m}{m-1} = \frac{100}{10000-1} = \frac{100}{9999} = \frac{1}{99.99}$$

45. (c)

$$\xi = \frac{\sqrt{6}}{4}$$

If θ is the phase margin, $\xi = \frac{1}{2}\tan\theta\sqrt{\cos\theta}$

$$4\xi^2 = \tan^2\theta \cos\theta$$
$$(\sec^2\theta - 1)\cos\theta = 4\xi^2$$
$$\sec\theta - \cos\theta = 4\xi^2$$
$$\frac{1-\cos^2\theta}{\cos\theta} = 4\xi^2$$
$$1 - \cos^2\theta = 4\xi^2\cos\theta$$
$$1 - \cos^2\theta = 4 \times \left(\frac{\sqrt{6}}{4}\right)^2 \cos\theta$$
$$\cos^2\theta + \frac{3}{2}\cos\theta - 1 = 0$$
$$\cos\theta = -2, +0.5$$
$$\theta = \cos\theta\ \ -2, +0.5$$
$$\theta = \cos^{-1}(0.5) = 60°$$

Alternative solution:

$$\because \quad \xi < \frac{1}{\sqrt{2}}$$

The phase margin, $\text{PM} \approx 100\,\xi$

$$\text{PM} \approx 100 \times \frac{\sqrt{6}}{4} = 61.24°$$

46. (b)

$$V_0 = A_d\left[V_d + \frac{1}{\text{CMRR}} \times V_c\right]$$

$$V_c = \frac{100+120}{2} = \frac{220}{2} = 110\,\mu\text{V}$$

$$V_d = 120 - 100 = 20\ \mu\text{V}$$

$$\therefore \quad V_0 = 10000\left[20 + \frac{110}{110}\right] \times 10^{-6}$$

$$= 21 \times 10^{-2} = 210\ \text{mV}$$

47. (d)

$$\text{SNR} = (6n + 1.8)\ \text{dB}$$

Here each bit contribute to 6 dB.

49. (a)

$$I_C = \beta I_B + (1 + \beta) I_{CBO}$$

$$\beta = \frac{I_C - I_{CBO}}{I_B + I_{CBO}} = \frac{(5 \times 10^{-3}) - (0.2 \times 10^{-6})}{(100 \times 10^{-6}) + (0.2 \times 10^{-6})} = 49.89 \approx 50$$

50. (c)

$$G(s) = \frac{s+1}{s+2}$$

$$G(j\omega) = \frac{(j\omega+1)}{(j\omega+2)}$$

The maximum phase will occur at

$$\omega_m = \sqrt{1 \times 2} = \sqrt{2}\ \text{rad/sec}$$

$$M = |G(j\omega_m)| = \sqrt{\frac{2+1}{2+4}} = \sqrt{\frac{3}{6}} = \frac{1}{\sqrt{2}}$$

So, attenuation $M = \dfrac{1}{\sqrt{2}}$

51. (b)

Unit of A is $\dfrac{\text{Wb}}{\text{m}}$

$\nabla \times A$ units will be $\dfrac{\text{Wb}}{\text{m}^2}$.

53. (a)

Machine cycles of CALL instruction are given below:

$$\underset{\text{6 T-states}}{\underline{\text{Fetch}}} + \underset{\text{3 T}}{\underline{\text{Read}}} + \underset{\text{3 T}}{\underline{\text{Read}}} + \underset{\text{3 T}}{\underline{\text{Write}}} + \underset{\text{3 T}}{\underline{\text{Write}}}$$

54. (c)

$$G(s)H(s) = \frac{K}{(s^3 + 9s^2 - 2s - 9)}$$

For root locus we use magnitude criteria to find gain

$$|\text{Gain}| = 1$$

$$\left|\frac{K}{0+0+0-9}\right| = 1 \quad \Rightarrow \quad K = 9$$

56. (c)

$$X_{\text{p.u. new}} = X_{\text{p.u. old}}\left(\frac{\text{MVA}_{b\text{new}}}{\text{MVA}_{b\text{old}}}\right)\left(\frac{\text{kV}_{b\text{old}}}{\text{kV}_{b\text{new}}}\right)^2$$

$$= 0.25 \times \left(\frac{100}{500}\right)\left(\frac{18}{20}\right)^2 = 0.0405 \text{ p.u.}$$

57. (b)

$$[sI - A] = \begin{bmatrix} s & -8 \\ 8 & s \end{bmatrix}$$

The characteristic equation $= s^2 + 8 \times 8 = 0$

$$s^2 + 64 = 0$$

$$s = \sqrt{-64} = \pm j8$$

58. (b)

Resonant converters have high conduction losses.

59. (a)

Size of MBR depends on the data pins MBR should able to hold data corresponding to capacity of one memory location.

61. (a)

$$\frac{f_1}{f_2} = \sqrt{\frac{C_2 + C_d}{C_1 + C_d}}$$

Where, C_d = self capacitance of the coil

$$\frac{2 \times 10^6}{1 \times 10^6} = \sqrt{\frac{250 + C_d}{40 + C_d}} = 2$$

$$\frac{250 + C_d}{40 + C_d} = 4$$

$$250 + C_d = 160 + 4C_d$$

$$90 = 3C_d$$

$$C_d = 30 \text{ pF}$$

62. (d)

Since horizontal microprogrammed required 1-bit control/signal

For 120 control signal, we need 120 bits

Total number of micro-operation instruction

$$= 220 \times 10 = 2200$$

$$\# \text{ bits} = \log_2 2200 \approx 12$$

$$\text{Control word size} = 120 + 12$$

$$= 132 \text{ bits}$$

63. (a)

In a Wein-bridge oscillator, for sustained oscillation,

$$A \geq 3$$

i.e., $$1 + \frac{R_2}{R_1} \geq 3$$

i.e., $$\frac{R_2}{R_1} \geq 2$$

$$R_2 \geq 2R_1$$

Thus, minimum value of $R_2 = 2R_1$

$\therefore$ $$R_2 = 2 \times 1 \times 10^3\ \Omega = 2\ \text{k}\Omega$$

64. (a)

In current commutated chopper, maximum output voltage across diode is V_s.

In voltage and load commutated chopper, maximum output voltage across diode is 2 V_s.

65. (c)

Throughput refers to total number of tasks executed per unit time. SJF scheduling algorithm will result in the maximum throughout because all the shortest jobs will be executed first hence many tasks will be completed.

66. (d)

All statements are correct.

67. (c)

The armature current, $I_a = 50$ A

During stalling of motor, $E_b = 0$

The armature current during stalling,

$$I_{a\,(\text{stall})} = \frac{V_s}{R_a + R_{\text{ext}}} = \frac{250}{1+1.5} = 100 \text{ A}$$

The torque, $T \propto I_a$ (ϕ - constant)

So, $$\frac{T_{(\text{stall})}}{T_{fl}} = \frac{I_{a(\text{stall})}}{I_a} = \frac{100}{50} = 2$$

69. (d)

$$\text{Average rotational latency} = \frac{1}{2} \times \text{rotational time}$$

$$= \frac{1}{2} \times \frac{1}{20} = 25 \text{ msec}$$

Average access time = Average rotational latency + seek time

= 25 msec + 50 msec

= 75 msec

70. (a)

Hard magnetic ferrite can be used for the manufacture of light weight permanent magnet.

71. (d)

For spring controlled PMMC instruments

$$T_C = K_C\theta$$

and for gravity controlled PMMC instruments

$$T_C = K_C \sin\theta$$

with the given data, no comparison is possible.

72. (a)

- Addressing modes, design of CPU, instructions set and data format are particular to specific CPU.
- Secondary memory and operating system can work with different computer with different architecture hence, they are not part of computer architecture.

73. (d)

The load impedance for lowest order harmonic,

$$Z_{\text{har}} = (10 - j5)\Omega$$

The lowest order harmonic is 5^{th}

$$n = 5 \qquad (\because n = mK \pm 1 = 6\text{ K} \pm 1 = 5, 7)$$

The load is capacitive,

So, $$X_c \propto \frac{1}{n}$$

$$\frac{X_{c1}}{X_{c5}} = \frac{n_5}{n_1} = \frac{5}{1}$$

For fundamental, $X_c = 5 \times 5 = 25\ \Omega$

$R = 10\ \Omega$ does not depend on frequency

So impedance at fundamental

$$Z = (10 - j25)\Omega$$

74. (a)

Stages in pipeline = 10

Without pipelining number of cycles required to execute 5 tasks

$$= 10 \times 5 = 50$$

When we have pipeline, for 1st task it requires 10 cycles and for next tasks (5 – 1) 1 cycle for each tasks,

So, total cycles required with pipelining

$$= 10 + (5 - 1) \times 1 = 14$$

∴ Speed gained by pipelines

$$= \frac{\text{Number of cycles without pipelining}}{\text{Number of cycles with pipeline}} = \frac{50}{14} = 3.57$$

75. (b)

$$T_{avg} = HT_c + (1 - H)(T_m + T_c)$$

$$25 = (0.8 \times 20) + (1 - 0.8)(T_m + 20)$$

$$25 - 16 = 0.2\,(T_m + 20)$$

$$T_m + 20 = \frac{9}{0.2}$$

$$T_m = 45 - 20 = 25 \text{ nsec}$$

78. (a)

Real power, $P = \frac{E_f V_t}{X_s} \sin\delta$

$$1.2 = \frac{1.2 \times 1}{0.5} \sin\delta$$

$$\sin\delta = 0.5$$

$$\delta = \sin^{-1}(0.5) = 30^\circ$$

$$\frac{dP}{d\delta} = \frac{-E_f V_t}{X_s} \cos\delta \quad \text{...(i)}$$

The reactive power,

$$Q = \frac{E_f V_t}{X_s} \cos\delta - \frac{V_t^2}{X_s}$$

$$\frac{dQ}{d\delta} = \frac{-E_f V_t}{X_s}\sin\delta \quad ...(ii)$$

Equation (i) divide by equation (ii),

$$\frac{dQ}{dP} = -\tan\delta$$

$$dQ = -\tan\delta\ (dP)$$

2% increase in torque means 2% increase in real/power

So, $$dQ = -\tan(30)\ (2) = \frac{-1}{\sqrt{3}}\times 2$$

$$dQ = \frac{-2}{\sqrt{3}} = -1.154\%$$

This shows that with 2% increase in prime-torque mover, the reactive power Q is decreased by –1.154%.

79. (b)

I/O processor is part of I/O interface between the main memory and I/O devices. These interface is required because I/O is either too slow or too fast.

80. (c)

In a homogeneous medium, Poisson's equation is

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

If $\rho_v = 0$

$\therefore$ $\nabla^2 V = 0$

81. (a)

The magnitude of forward break over and reverse break down voltages are temperature dependent.

82. (d)

To create 5 bit parallel adder, we require 4-full adder plus 1 Half adder.

For 4 full adder, we require 8 Ex-OR gates, 8 AND gates and 4-OR gates.

and for 1 Half adder we require only 1 Ex-OR gate and one AND gate.

Thus finally for 5-bit adder we require 9 Ex-OR gates, 9 AND gates and 4 OR gates.

83. (b)

The burden of current transformers is expressed in VA rating of transformer.

84. (a)

Most frequently used block replacement algorithms in cache operation are:

Random and LRU. Other block replacement algorithms are FIFO, MRV, MFU etc.

LIFO is never used.

85. (b)

Given, $\chi_m = 1.4 \times 10^{-5}$

Magnetic flux density, $B = \mu_0 H$ ...(i)

When the free space is magnesium filled, then

$$B' = (1 + \chi_m)\mu_0 H$$

The percentage increase in magnetic induction

$$= \frac{B' - B}{B} \times 100 = \chi_m \times 100$$

$$= 1.4 \times 10^{-5} \times 100$$

$$= 1.4 \times 10^{-3} \%$$

87. (c)

$$\theta \propto I_1 I_2 \cos\phi$$

When deflection is 45°

$$45 = |i_1||i_2|\cos 45° \quad ...(i)$$

$$\theta = |i_1||i_2|\cos 60° \quad ...(ii)$$

Equation (i) divided by equation (ii),

$$\frac{45}{\theta} = \frac{\cos 45°}{\cos 60°}$$

$\Rightarrow$ $$\theta = \frac{45 \times 1}{2 \times \frac{1}{2\sqrt{2}}} = \frac{45}{\sqrt{2}} \approx 31.82°$$

88. (c)

The armature MMF waveform of a dc machine is triangular.

89. (b)

Directions of edge dislocation and burger vector are perpendicular to each other.

90. (d)

For maximum power output,

$$\delta = 0$$

$$Z_s = R_a + jX_s = 1 + j6 = \sqrt{31}\angle \tan^{-1}\left(\frac{6}{1}\right)$$

$$Z_s = 6.08\angle 80.54° \text{ ohm}$$

The generator will send maximum power to the load, if load angle $\delta = 80.54°$.

91. (b)

$$D = 1 - \frac{V_s}{V_0} = 1 - \frac{10}{20} = 0.5$$

The minimum value of inductor for continuous conduction

$$L_{\min} = \frac{D(1-D)^2 R}{2f} = \frac{0.5(1-0.5)^2 \times 20}{2 \times 50 \times 10^3}$$

$$L_{\min} = 25 \ \mu\text{H}$$

92. (b)

The dominant pole is the pole which is near to the imaginary axis, so it is at a lower frequency.

93. (a)

The rms thyristor current,

$$I_{T,\ \text{rms}} = \left(\frac{1}{\sqrt{3}}\right) I_L$$

$$\frac{150}{\sqrt{3}} = \frac{I_L}{\sqrt{3}}$$

$$I_L = 150 \text{ A}$$

94. (b)

$$\text{Energy supplied} = VI \cos \phi \times T \times 10^{-3}$$
$$= 230 \times 4 \times 1 \times 6 \times 10^{-3}$$
$$= 5.52 \text{ kWh}$$

$$\text{Meter constant} = \frac{\text{Revolutions}}{\text{kWh}} = \frac{2208}{5.52} = 400 \text{ rev/kWh}$$

95. (a)

In unipolar switching,

Harmonics order, $h = j(2mf) \pm K$

$h = j(2 \times 40) \pm K$

$h = j80 \pm K$

The harmonics frequency,

$f_H = (j80 \pm K) \times 50$

$j = 1, K = 1,$

$\Rightarrow$ $f_H = (80 + 1)50 = 4050$ Hz

97. (c)

Given, $R_a = 2\ \Omega$, $V_{s1} = 250$ V,

$I_a = 25$ A

The back emf, $E_{b1} = V_{s1} - I_a R_a = 250 - 25 \times 2 = 200$ A

Now supply voltage is changed to 200 V

$$V_{s2} = 200 \text{ V}$$

The current at that instant,

$$I_a = \frac{V_{s2} - E_{b1}}{R_a} = \frac{200 - 200}{2} = 0$$

here given torque, T is constant

$$T \propto \phi I_a$$

$$T \propto I_a \qquad \text{(for separately excited } \phi = \text{constant)}$$

$$T \propto I_a = \text{constant}$$

So I_a is constant for constant load torque. So speed reduces such that I_a becomes 25 A.

98. (c)

In cassette tapes, the sound is recorded in the form of magnetic field on the tape.

99. (b)

At maximum efficiency, $P_{cu} = P_i$

Maximum efficiency, $$\eta = \frac{\text{Output}}{\text{Output} + 2P_i} \times 100$$

$$0.98 = \frac{1 \times 1}{1 \times 1 + 2P_i}$$

$$1 + 2P_i = (0.98)^{-1} = 1.02$$

$$P_i = 0.010 \text{ p.u.} = R_{pu}$$

$$\text{Voltage regulation} = (R \cos \phi + X \sin \phi) \times 100$$

$$= (0.01 \times 0.6 + 0.2 \times 0.8) \times 100$$

$$= 16.6\%$$

100. (c)

The maximum dielectric stress, $$g_{max} = \frac{V}{r \ln(R/r)}$$

The minimum dielectric stress, $$g_{min} = \frac{V}{R \ln(R/r)}$$

$$\frac{g_{max}}{g_{min}} = \frac{\frac{V}{r}\ln\left(\frac{R}{r}\right)}{\frac{V}{R}\ln\left(\frac{R}{r}\right)} = \frac{R}{r} = \frac{2R}{2r} = \frac{D}{d}$$

Given, $D = 4$ cm, $$r = 2 \text{ cm}$$

$$\frac{g_{max}}{g_{min}} = \frac{4}{2} = 2$$

101. (b)

$$y = (\tan x)^{\tan 2x}$$

$$\log y = \tan 2x \log (\tan x)$$

$$\lim_{x \to \frac{\pi}{4}} \log y = \lim_{x \to \frac{\pi}{4}} \tan 2x \log(\tan x)$$

$$= \lim_{x \to \frac{\pi}{4}} \frac{\log \tan x}{\cot 2x} \qquad \left(\frac{0}{0} \text{ form}\right)$$

$$= \lim_{x \to \frac{\pi}{4}} \frac{\frac{1}{\tan x}\sec^2 x}{-2\operatorname{cosec}^2 2x} = \frac{\left(\sqrt{2}\right)^2}{-2} = -1$$

$$y = e^{-1}$$

102. (a)

In a differential amplifier the common mode signal is eliminated due to the use of two symmetric transistors thus the CMRR of a differential amplifier is very high. An operational amplifier employs this property of the differential amplifier at the input stage.

104. (c)

Hard magnetic materials have a high coercive field.

105. (a)

There is no voltage across an inductor if the current through it is not changing with time. An inductor is therefore a short circuit to dc.

106. (c)

Transportation lag commonly encountered in process control system is a non-minimum phase element.

108. (d)

When there is no charge in the interior of a conductor the electric field intensity is zero as per Gauss's law.

110. (c)

Power semiconductor devices used in chopper circuits are unidirectional devices.

111. (d)

The resultant magnetic field due to interaction of both fields shifts backwords in the case of motor not generator.

112. (d)

Mesh analysis is not applicable to non-planar circuits while nodal analysis is applicable to both planar and non-planar circuit.

Hence statement-I is wrong.

113. (a)

$$Z_S = \text{Surge impedance of line}$$

$$Z_S = \sqrt{\frac{L}{C}} = \sqrt{\frac{1\times10^{-3}}{1\times10^{-9}}} = 1000\,\Omega$$

$$P_{max} = \frac{(\text{kV})^2}{Z_S} = \frac{(400)^2}{1000} = 160 \text{ MW}$$

114. (b)

To eliminate slope-overload distortion,

$$\frac{\Delta}{T_s} \geq \left|\frac{dx(t)}{dt}\right|_{max}$$

$$\left|\frac{dx(t)}{dt}\right|_{max} = \left|\frac{10-0}{1-(1.5)}\right| = \frac{10}{0.5} = 20 \text{ V/sec}$$

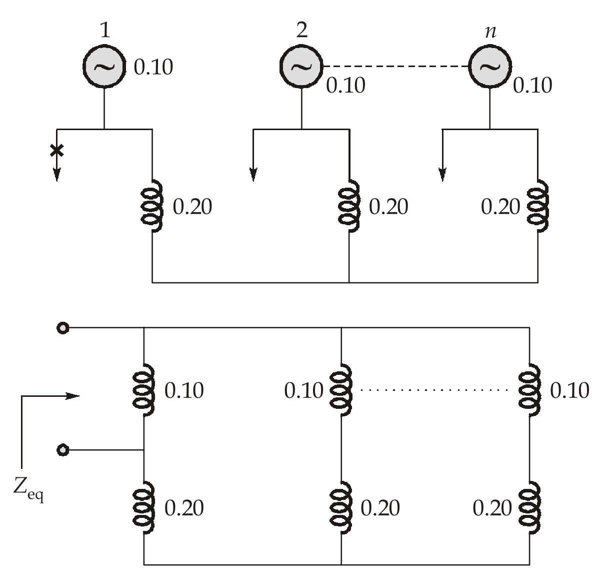
$$T_s = \frac{1}{f_s} = 10^{-4} \text{ sec} \qquad \because \text{Given that, } f_s = 10 \text{ kHz}$$

So,
$$\Delta \geq T_s\left|\frac{dx(t)}{dt}\right|_{max}$$

$$\Delta \geq (10^{-4})\ (20) \text{ V}$$

$$\Delta_{min} = 2 \text{ mV}$$

115. (d)



The Z_{eq} seen from the terminal of fault point

$$Z_{eq} = 0.10 \,||\, \left[0.20 + \frac{0.30}{n-1}\right]$$

n is very large, $Z_{eq} = 0.10 \,||\, 0.20 = \frac{0.10 \times 0.20}{0.30} = \frac{1}{15}$

So short circuit MVA, $(SC)_{MVA} = \frac{S_{base}}{Z_{eq(p.u.)}}$

$$(SC)_{MVA} = \frac{0.100}{1/15} = 1.5 \text{ MVA}$$

116. (c)

A combinational circuit does not have any storage elements.

117. (a)

With the increase in conductor radius, electric field intensity at the surface of conductor decreases resulting in reduced Corona loss.

118. (a)

$$\frac{d^2y}{dx^2} + \frac{\alpha dy}{dx} + \beta y = 0$$

$$D^2 + \alpha D + \beta = 0$$

Its solution is $y = C_1 e^{-2x} + C_2 e^{-4x}$

$$\text{Sum of roots} = -\alpha = -2 - 4$$

$$\alpha = 6$$

$$\text{Product of roots} = \beta = -2 \times -4 = 8$$

119. (c)

Gauss-Sedal method has linear convergence characteristics.

120. (b)

$$Y = A \oplus B = A\bar{B} + \bar{A}B$$

now, suppose terminal B is kept of logic '1', thus,

$$Y = A\bar{1} + \bar{A} \cdot 1$$

$$= A \cdot 0 + \bar{A} \cdot 1 = \bar{A}$$

Thus, if A is connected to input and B = 1, then the Ex-OR gate will work as an inverter.

121. (b)

$$\beta = \frac{2\pi fl}{v} = \frac{2\pi \times 50 \times 400}{3 \times 10^5} = 0.42$$

$$A = 1 - \frac{\beta^2}{2} = 1 - \frac{0.42^2}{2} = 0.91$$

$$V_{R\,(NL)} = \frac{V_S}{A} = \frac{400}{0.91} \approx 400 \times 1.10 \approx 440 \text{ kV}$$

122. (c)

Let $f(x) = xe^x - 1$

$f(0) = -1$

$f(1) = e - 1$

Since $f(0)$ is negative and $f(1)$ is positive, a root lies between 0 and 1, therefore we take

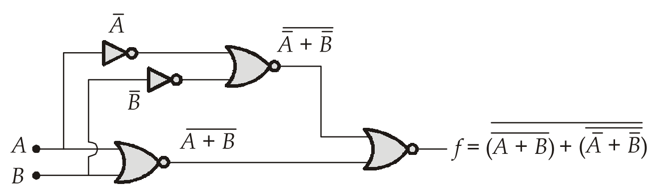
$$x_0 = \frac{0+1}{2} = \frac{1}{2}$$

$$f\left(\frac{1}{2}\right) = \frac{1}{2}e^{\frac{1}{2}} - 1 = -0.1756$$

Since, $f\left(\frac{1}{2}\right)$ is negative and f(1) is positive.

$$x_0' = \frac{\frac{1}{2}+1}{2} = \frac{3}{4} = 0.75$$

124. (b)



$$f = \overline{\overline{(A+B)} + \overline{(\bar{A}+\bar{B})}}$$

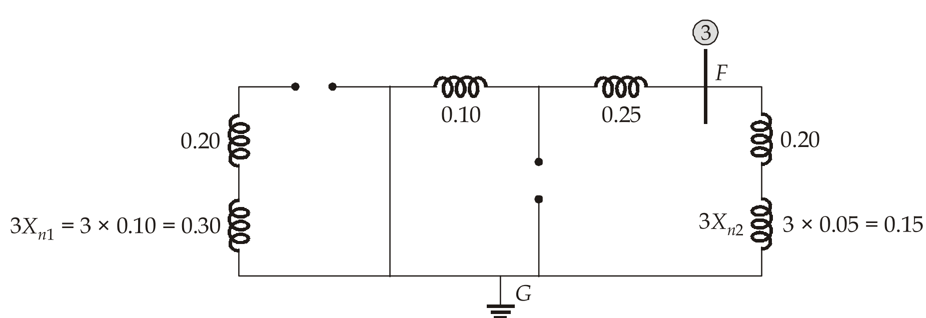
$$= \overline{\overline{(A+B)\,(\bar{A}+\bar{B})}} = (A+B)\,(\bar{A}+\bar{B})$$

$$= A\bar{B} + \bar{A}B$$

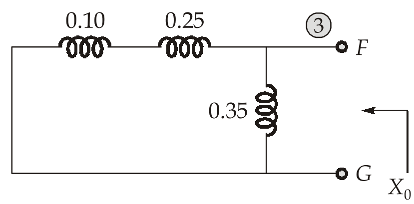
$$= A \oplus B$$

125. (c)

The zero sequence diagram shown below,



The zero equivalent circuit by assuming fault at node-3,



$$X_0 = 0.35 \,||\, 0.35 = \frac{0.35}{2} = 0.175 \text{ p.u.}$$

127. (b)

$$\lim_{x\to 0}\frac{1-\cos x}{x^2} = \lim_{x\to 0}\frac{2\sin^2\frac{x}{2}}{4\cdot\frac{x^2}{4}}$$

$$= \lim_{x\to 0}\frac{1}{2}\left(\frac{\sin\frac{x}{2}}{\frac{x}{2}}\right)^2 = \frac{1}{2}$$

128. (d)

$$f(A,B,C) = A\bar{B}\bar{C} + \bar{A}\bar{B}C + (1)B\bar{C} + (0)BC$$

$$= A\bar{B}\bar{C} + \bar{A}\bar{B}C + (A+\bar{A})B\bar{C}$$

$$= A\bar{B}\bar{C} + \bar{A}\bar{B}C + AB\bar{C} + \bar{A}B\bar{C}$$

$$\Rightarrow \quad f(A,B,C) = \Sigma m(1, 2, 4, 6)$$

129. (c)

The frequency is directly proportional to power input to the turbine.

130. (c)

$$f(t) = \sum_{n=-\infty}^{\infty} c_n e^{jn\omega_0 t} \qquad \text{where } \omega_0 = \frac{2\pi}{T}$$

The given signal $f(t)$ over the interval $(0, T)$ is

$$f(t) = \sum_{n=-\infty}^{\infty} \frac{3}{4+(n\pi)^2} e^{jn\pi t}$$

Comparing the above two equations, we get

$$C_n = \frac{3}{4+(n\pi)^2}$$

$$e^{jn\frac{2\pi}{T}t} = e^{jn\pi t}$$

Hence, $\dfrac{2\pi}{T} = \pi$, i.e. $T = 2$

When n = 3, the component of $f(t)$ will be

$$C_3 = \frac{3}{4+(3\pi)^2}e^{j3\pi t} = \frac{3}{4+(3\pi)^2}[\cos 3\pi t + j\sin 3\pi t]$$

Similarly, when n = –3, the component will be

$$C_{-3} = \frac{3}{4+(-3\pi)^2}e^{-j3\pi t} = \frac{3}{4+(3\pi)^2}[\cos 3\pi t - j\sin 3\pi t]$$

Therefore, $$C_3 + C_{-3} = \frac{6}{4+(3\pi)^2}\cos 3\pi t$$

Hence, when one of the component of $f(t)$ is $A \cos 3\pi t$, the value of A is

$$A = \frac{6}{4+(3\pi)^2}$$

131. (a)

$$M = \frac{GH}{\pi f} = \frac{100\times 4}{180\times 50} = \frac{2}{45} \text{ MJ-s/elec. degree}$$

$$M\alpha = P_a = P_m - P_e$$

$$\alpha = \frac{P_a}{M} = \frac{60-40}{2/45} = 450 \text{ elect. degree/s}^2$$

$$\alpha = 450\times\frac{2}{P}\times\frac{60}{360} \text{ rpm/sec}$$

The change in speed, $$\Delta N = 450\times\frac{2}{4}\times\frac{60}{360}t$$

$$\Delta N = 37.5t \quad (t = 10 \text{ cycles})$$

$$\Delta N = 37.5\times\frac{10}{50} = 7.5 \text{ rpm}$$

So, speed after 10 cycles $$= \frac{120\times 50}{4}+7.5 = 1507.5 \text{ rpm}$$

132. (d)

The given surfaces are

$$x^2 + y^2 = 9$$

and $$x^2 + z^2 = 9$$

The volume of the required solid is

$$V = \int_{x=-3}^{3}\int_{y=-\sqrt{9-x^2}}^{\sqrt{9-x^2}}\int_{z=-\sqrt{9-x^2}}^{\sqrt{9-x^2}} dz\,dy\,dx$$

$$= 8\int_0^3 \int_{y=0}^{\sqrt{9-x^2}} \int_{z=0}^{\sqrt{9-x^2}} dz\,dy\,dx$$

$$\left[\because \int_{-a}^{a} f(x)dx = 2\int_0^a f(x)dx \text{ if } f(-x) = f(x)\right]$$

$$= 8\int_{x=0}^{3} \int_{y=0}^{\sqrt{9-x^2}} \sqrt{9-x^2}\, dy\, dx$$

$$= 8\int_{x=0}^{3} \sqrt{9-x^2}\sqrt{9-x^2} = 8\int_{x=0}^{3} (9-x^2)dx$$

$$= 8\left(9x - \frac{x^3}{3}\right)_0^3$$

$$= 8(27 - 9) = 8 \times 18 = 144 \text{ Cubic units}$$

133. (d)

Following values are given,

P_r = VA burden of the relay at 3.75 A plug setting

P_r = 4 VA

I_s = Rated secondary current of CT = 5 A

I_r = Current setting of the relay = 3.75 A

Pe (the effective VA burden on the CT) is to be calculated,

$$P_e = P_r\left(\frac{I_s}{I_r}\right)^2 = 4 \times \left(\frac{5}{3.75}\right)^2 = 7.11 \text{ VA}$$

134. (c)

Let, $$A = \begin{bmatrix} 1 & 2 & 4 \\ 3 & 0 & 6 \\ 1 & 1 & P \end{bmatrix}$$

Let the eigen values of this matrix are λ_1 , λ_2 and λ_3

Here one values is given so let, $\lambda_1 = 3$

We know that,

Sum of eign values of matrix = Sum of the diagonal element of matrix A

$$\lambda_1 + \lambda_2 + \lambda_3 = 1 + 0 + P$$

$$\lambda_2 + \lambda_3 = 1 + P - \lambda_1$$

$$= 1 + P - 3$$

$$= P - 2$$

135. (c)

Given,
$$f(t) = e^{-a|t|}\,\text{sgn}(t)$$
$$= \begin{cases} -e^{at}, & \text{for } t < 0 \\ e^{-at}, & \text{for } t > 0 \end{cases}$$

Therefore,
$$F[f(t)] = \int_{-\infty}^{\infty} f(t)e^{-j\omega t}dt$$
$$= -\int_{-\infty}^{0} e^{at}e^{-j\omega t}dt + \int_{0}^{\infty} e^{-at}e^{-j\omega t}dt$$
$$= -\int_{-\infty}^{0} e^{(a-j\omega)t}dt + \int_{0}^{\infty} e^{-(a+j\omega)t}dt$$
$$= -\left[\frac{e^{(a-j\omega)t}}{(a-j\omega)}\right]_{-\infty}^{0} + \left[\frac{e^{-(a-j\omega)t}}{-(a+j\omega)}\right]_{0}^{\infty} = -\left[\frac{1}{a-j\omega}\right] + \left[0 + \frac{1}{a+j\omega}\right]$$
$$= \frac{1}{j\omega - a} + \frac{1}{j\omega + a} = \frac{j2\omega}{(j\omega)^2 - a^2} = \frac{-j2\omega}{(a^2+\omega^2)}$$

136. (c)

It is given that the function f is continuous at $x = 0$

Therefore,
$$\lim_{x\to 0} f(x) = f(0)$$
$$\lim_{x\to 0}\frac{1-\cos 4x}{8x^2} = K$$
$$\lim_{x\to 0}\frac{2\sin^2 2x}{8x^2} = K$$
$$\lim_{x\to 0}\left(\frac{\sin 2x}{2x}\right)^2 = K$$
$$K = 1$$

Thus, f is continuous at $x = 0$ if $K = 1$.

137. (a)

$$x(t) = 2\cos(t + 20°)$$

Here, $\omega = 1$ rad/sec

So,
$$H(j\omega) = \frac{1}{1-\omega^2 + j3\omega}$$

$$H(j1) = \frac{1}{1-1+j3} = \frac{1}{3}\angle -90°$$

So,
$$y(t) = 2|H(j1)|\cos(t+20° + \angle H(j1))$$
$$= 2\times\frac{1}{3}\cos(t+20°-90°)$$
$$y(t) = 0.667\cos(t - 70°)$$

138. (d)

As $\hat{a}+\hat{b}$ is a unit vector

$$(\hat{a}+\hat{b})\cdot(\hat{a}+\hat{b}) = 1$$
$$\hat{a}\cdot\hat{a}+\hat{b}\cdot\hat{b}+2\hat{a}\cdot\hat{b} = 1$$
$$1+1+2\hat{a}\cdot\hat{b} = 1$$
$$\hat{a}\cdot\hat{b} = \frac{-1}{2}$$
$$\cos\theta = \frac{-1}{2}$$
$$\theta = 120°$$

139. (c)

- The main reason for under-reach is the presence of arc resistance in the fault. Due to presence of arc resistance, the impedance seen by the relay is more than the actual impedance of the line upto fault point. Hence arc resistance causes under-reach.
- The important reason for overreach of the distance relay is the presence of dc offset in the fault current wave.

141. (a)

Let the line of regression of x and y be $2x - 9y + 6 = 0$

Then, the line of regression of y and x is $x - 2y + 1 = 0$

$\therefore$
$$2x - 9y + 6 = 0$$
$$x = \frac{9}{2}y - 3$$
$$b_{xy} = \frac{9}{2}$$

and
$$x - 2y + 1 = 0$$
$$y = \frac{1}{2}x + \frac{1}{2}$$
$$b_{yx} = \frac{1}{2}$$

$$r = \sqrt{b_{xy} \cdot b_{yx}} = \sqrt{\frac{9}{2} \times \frac{1}{2}} = \frac{3}{2} > 1 \text{ which is not possible}$$

∴ The regression line of y on x is $2x - 9y + 6 = 0$

$$x - 2y + 1 = 0$$

$$x = 2y - 1$$

$$b_{xy} = 2$$

and $$2x - 9y + 6 = 0$$

$$y = \frac{2}{9}x + \frac{6}{9}$$

$$b_{yx} = \frac{2}{9}$$

$$r = \sqrt{b_{xy} \cdot b_{yx}} = \sqrt{\frac{2}{9} \times 2} = \sqrt{\frac{4}{9}} = \frac{2}{3}$$

Hence the correlation coefficient between x and y is $\frac{2}{3}$.

142. (b)

$$x_1(n) = \{\underset{\uparrow}{2}, 1, 2, 1\}$$

$$x_2(n) = \{\underset{\uparrow}{1}, 2, 3, 4\}$$

The circular convolution,

$$x_1(n) * x_2(n) = \begin{bmatrix} 2 & 1 & 2 & 1 \\ 1 & 2 & 1 & 2 \\ 2 & 1 & 2 & 1 \\ 1 & 2 & 1 & 2 \end{bmatrix} \begin{bmatrix} 1 \\ 2 \\ 3 \\ 4 \end{bmatrix} = \begin{bmatrix} 2+2+6+4 \\ 1+4+3+8 \\ 2+2+6+4 \\ 1+4+3+8 \end{bmatrix} = \begin{bmatrix} 14 \\ 16 \\ 14 \\ 16 \end{bmatrix}$$

$$= \{\underset{\uparrow}{14}, 16, 14, 16\}$$

143. (a)

Impedance relay is used for the protection of medium transmission lines.

144. (c)

C-R equations in polar form

$$\frac{\partial u}{\partial r} = \frac{1}{r}\frac{\partial v}{\partial \theta}$$

$$\frac{\partial u}{\partial \theta} = -r\frac{\partial v}{\partial r}$$

145. (a)

$$X(z) = \frac{2z(9z-8)}{(7z^2-13z+6)} = \frac{2z(9z-8)}{(7z^2-7z-6z+6)}$$

$$= \frac{2z(9z-8)}{(7z-6)(z-1)}$$

By final value theorem, $$\lim_{x\to\infty} x(n) = \lim_{z\to 1}(z-1)X(z^+)$$

$$= \lim_{z\to 1}(z-1)\frac{2z(9z-8)}{(7z-6)(z-1)}$$

$$= \frac{2(1)(9-8)}{(7-6)} = 2$$

146. (d)

The system as 1-ϕ :

$$P = VI_1 \cos\phi$$

The line loss $$W_1 = 2I_1^2 P$$

The system as 3-ϕ ;

$$P_2 = \sqrt{3}VI_2\cos\phi$$

The line loss, $$W_2 = 3I_2^2 R$$

Since total line losses are same,

$$W_1 = W_2$$

$$2I_1^2 R = 3I_2^2 R$$

$$I_2 = \sqrt{\frac{2}{3}}I_1 \qquad \ldots(i)$$

The power transmitted as 3-ϕ

$$P_2 = \sqrt{3}V\,I_2\cos\phi = \sqrt{3}V\left(\sqrt{\frac{2}{3}}I_1\right)\cos\phi$$

$$P_2 = \sqrt{2}VI_1\cos\phi$$

∴ Percentage of additional load $$= \frac{P_2 - P_1}{P_1} = \frac{\sqrt{2}-1}{1}\times 100$$

$$= 41.40\%$$

148. (b)

$$(IC)_i\ L_i = \lambda$$

$$(2+0.05P_i)\times\frac{1}{1-\frac{\partial P_L}{\partial P_i}} = 30$$

$$(2+0.05P_i)\times\frac{1}{1-0.2} = 30$$

$$P_i = \frac{30\times 0.8-0.2}{0.05} = 440\text{ MW}$$

149. (b)

The current, $\bar{I}_B = -\left(\bar{I}_R+\bar{I}_Y\right)$

So, $I_B = \sqrt{I_R^2+I_Y^2+2I_RI_Y\cos\phi}$

$$V_{RY} = 1\angle 0°,\ V_{YB} = 1\angle -120°,\ V_{BR} = 1\angle 120°$$

$$\bar{I}_R = \frac{\bar{V}_{RB}}{R} = \frac{-1\angle 120°}{R} = \frac{1\angle -60°}{R} \quad \text{...(i)}$$

$$\bar{I}_Y = \frac{\bar{V}_{YB}}{2R} = \frac{1\angle -120°}{2R} \quad \text{...(ii)}$$

Here, $\left|\bar{I}_R\right| = 2\left|\bar{I}_Y\right|$

and phase difference between them is $\phi = 60°$

So, $I_B = \sqrt{I_R^2+(I_Y)^2+2I_RI_Y\cos 60°}$

$$I_B = \sqrt{\left(4I_Y^2\right)+(I_Y)^2+2\times 2I_Y^2\times\frac{1}{2}}$$

$$= \sqrt{(4+1+2)I_Y^2}$$

$$I_B = \sqrt{7}I_Y$$

So, $I_R : I_Y : I_B = 2:1:\sqrt{7}$

150. (b)

$$x(t) = \text{even}[e^{jt}+e^{j3t}]$$

$$= \text{even}\ [\cos t + j\sin t + \cos 3t + j\sin 3t]$$

$$= \cos t + \cos 3t$$

Since $\cos t$ and $\cos 3t$ are orthogonal, the power can be given as

$$P_{\text{avg}} = \frac{1^2}{2}+\frac{1^2}{2} = 1\text{W}$$

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