DETAILED SOLUTIONS

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ESE 2023 : Prelims Exam
CLASSROOM TEST SERIES

ELECTRICAL ENGINEERING

Test 20

Full Syllabus Test 4 : Paper-II

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

Note: In Q. no. 15 ('*' indicates) mark to all.

DETAILED EXPLANATIONS

1. (a)

Given,
$$H(s) = \frac{1}{(s+2)}$$
$$\updownarrow$$
$$h(t) = e^{-2t}\, u(t)$$

The system is stable because pole lies in the left side of s-plane

$$\frac{h(t+2)}{h(t)} = \frac{e^{-2(t+2)}u(t+2)}{e^{-2t}u(t)}$$

$$\frac{h(t+2)}{h(t)} = e^{-4}\ ;\ t > 0$$

The non-causal system with the same transfer function

$$h_1(t) = -e^{-t}\, u(-t)$$

The above system is unstable.

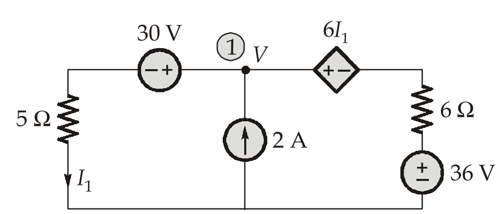
3. (a)

KCL at node-1,

$$\frac{V-30}{5} - 2 + \frac{V-36-6I_1}{6} = 0 \qquad \text{...(i)}$$

$$I_1 = \frac{V-30}{5} \qquad \text{...(ii)}$$

$$\left(\frac{V-30}{5}\right) - 2 + \frac{V - 36 - 6\left(\frac{V-30}{5}\right)}{6} = 0$$



$$\frac{6V - 180 - 60 + 5V - 180 - 6V + 180}{30} = 0$$

$$5\,V = 240$$

$$V = 48 \text{ V}$$

The current in 5 Ω resistor is

$$I_1 = \frac{V-30}{5} = \frac{48-30}{5} = 3.6 \text{ A}$$

4. (b)

8 k × 8 bit RAM = 0000 H to 1FFF H

last byte = 8800 H + 1FFF H

= A7FF H

5. (c)

$$E_{ind} = -N\frac{d\phi}{dt} = -200\frac{d}{dt}(t^3 - 2t)\times 10^{-3}$$

$$E_{ind}\big|_{t=8\,sec} = -200(3t^2 - 2)\big|_{t=8} \times 10^{-3}$$

$$= -200\ (3 \times 64 - 2) \times 10^{-3}$$

$$= -200 \times 190 \times 10^{-3}$$

$$= 38\ V$$

6. (c)

$$\Delta \times \vec{H} = \frac{\partial \vec{D}}{\partial t} + J$$

Where J is current density in A/m^2.

7. (b)

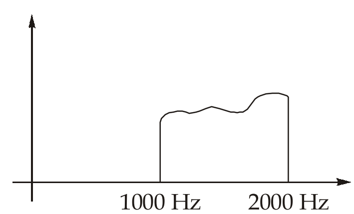
Coefficient of voltage reflection,

$$R_V = \frac{Z_L - Z_C}{Z_L + Z_C} = \frac{50-400}{50+400} = -\frac{350}{450} = -0.77$$

8. (a)

$$x(t) \xrightleftharpoons{\text{F.T.}} X(\omega)$$

$$x(0.5t) \xrightleftharpoons{\text{F.T.}} \frac{1}{0.5}X\left(\frac{\omega}{0.5}\right) = 2\ X(2\omega)$$



Time shifting will not change the bandwidth

$$X(\omega) = (1000,\ 2000)$$

Then $X(2\omega) = (500,\ 1000)$

Expansion in time domain leads to compression in frequency domain.

10. (b)

The eddy current,

$$P_{eddy} \propto (V)^2$$

and hysteresis loss, $P_{hys} \propto V^{1.6} f^{-0.6}$ $(\nu = 1.6)$

The magnetizing current,

$$I_m \propto \frac{V}{X_m} \propto \frac{V}{f}$$

Since voltage is held fixed and frequency is increased

So eddy current is constant and hysteresis loss will be increased.

If frequency is increased, then I_m will be decreased. The total core loss is decreased, then core loss current is also decreased.

11. (b)

$$\text{Expansion } e^x = 1 + x + \frac{x^2}{2!} + \frac{x^3}{3!} + \frac{x^4}{4!} + \ldots$$

$$\therefore \quad e^{\sin x} = 1 + \sin x + \frac{(\sin x)^2}{2!} + \frac{(\sin x)^3}{3!} + \ldots$$

$$= 1 + \left(x - \frac{x^3}{3!} + \ldots\right) + \frac{1}{2}\left(x - \frac{x^3}{3!} + \ldots\right)^2 + \frac{1}{6}\left(x - \frac{x^3}{3!} + \ldots\right)^3$$

$$+ \frac{1}{24}\left(x - \frac{x^3}{3!} + \ldots\right)^4 + \ldots$$

$$= 1 + \left(x - \frac{x^3}{6} + \ldots\right) + \frac{1}{2}\left(x^2 - \frac{x^4}{3} + \ldots\right) + \frac{1}{6}(x^3 \ldots) + \frac{1}{24}(x^4 + \ldots)$$

$$= 1 + x + \frac{x^2}{2} - \frac{x^4}{8} + \ldots.$$

12. (d)

All are correct.

13. (b)

The different equation of the system,

$x(n) - 8y(n-2) + 6y(n-1) = y(n)$

$y(n) - 6y(n-1) + 8y(n-2) = x(n)$

$$H(z) = \frac{1}{(1 - 6z^{-1} + 8z^{-2})}$$

$$H(z) = \frac{z^2}{z^2 - 6z + 8} = \frac{z^2}{(z-2)(z-4)}$$

The poles are, $z = 2, 4$

14. (b)

The primary line current, $I_1(L) = 10$ Amp

For star connected transformer,

$$I_{1\,(ph)} = I_1(L) = 10 \text{ Amp}$$

The secondary phase, current,

$$I_{2(ph)} = I_{1(ph)}\left(\frac{N_1}{N_2}\right) = 10(5) = 50 \text{ Amp}$$

The secondary line current, $I_2(L) = I_{2(ph)} \times \sqrt{3}$

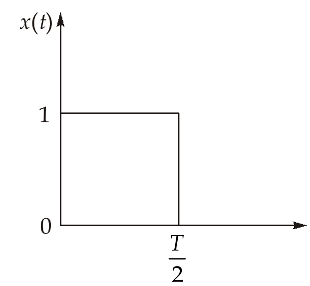
$$= \sqrt{3} \times 50 = 86.60 \text{ A}$$

15. (*)

$$x(t) = u(t) - u\left(t - \frac{T}{2}\right)$$

The $f(t)$ is periodic signal with repeating $x(t)$ in negative axis,

$$F(s) = \frac{-1}{(1-e^{-sT})}X(s)$$



$$X(s) = L\left[u(t) - u\left(t - \frac{T}{2}\right)\right]$$

$$X(s) = \frac{1}{s} - \frac{e^{-sT}}{s} = \frac{1-e^{-sT/2}}{s}$$

$$F(s) = \frac{-1}{(1-e^{-sT})} \times \frac{1-e^{-sT/2}}{s}$$

$$F(s) = \frac{-\left(1-e^{-sT/2}\right)}{s\left(1-e^{-sT}\right)}$$

$$F(s) = \frac{-\left(1-e^{-sT/2}\right)}{s\left(1-e^{-sT/2}\right)\left(1+e^{-sT/2}\right)}$$

$$F(s) = \frac{-1}{s\left(1+e^{-sT/2}\right)}$$

16. (d)

The applied voltage, $V_s = 0.4$ p.u.

The blocked rotor current,

$$(I_{st})_{\text{blocked}} = 2.40 \text{ p.u.}$$

The starting current for rated (1 p.u.) voltage

$$I_{st} = \frac{2.40}{0.40} = 6 \text{ p.u.}$$

Full load current, $I_{fl} = 1$ p.u.

Full load slip, $s = 0.05$ p.u.

1. Motor with direct-on-stator:

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

$$\frac{T_{st}}{1} = \left(\frac{6}{1}\right)^2 \times 0.05 = 1.8$$

$$T_{st} = 1.8 \text{ p.u.}$$

2. Motor with 50% tapping (x = 0.5):

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

$$\frac{T_{st}}{1} = (0.5)^2\left(\frac{6}{1}\right)^2 \times (0.05)$$

$$T_{st} = 0.45 \text{ p.u.}$$

17. (d)

All are correct.

18. (b)

The system is all-pass filter,

For digital all-pass filter, condition,

$$\text{Zero} = \frac{1}{\text{Pole}^*}$$

$$\text{Zero} = -4$$

$$\text{Pole} = \alpha$$

So,

$$-4 = \frac{1}{\alpha}$$

$$\alpha = -0.25$$

19. (c)

For, RST 5.5

$$\text{Vector address} = (5.5 \times 8)_{10} = (44)_{10}$$

$$= (2C)_H$$

20. (d)

The primary current as 2 winging transformer

$$I_p = \frac{3}{0.10} = 30 \text{ Amp}$$

The maximum kVA rating,

$$S_{auto} = V_{auto} \times I_p$$

$\Rightarrow$

$$(100 + V_{sec}) \times 30 = 15 \times 10^3$$

$$V_{sec} + 100 = \frac{15 \times 10^3}{30}$$

$$V_{sec} = 500 - 100 = 400 \text{ V}$$

21. (a)

$$\text{Load factor} = \frac{\text{Average power}}{\text{Maximum demand}}$$

$$\text{Maximum demand} = \frac{500}{0.5} = 1000 \text{ kWh}$$

Now, $\text{Load factor} = 0.8$

$$0.8 = \frac{\text{Average power}}{\text{Maximum demand}}$$

$\Rightarrow$ $\text{Average power} = 0.8 \times 1000 \text{ kWh}$

$= 800 \text{ kWh}$

22. (b)

$$x(n) = \delta(n+2) + 3\,\delta(n+4)$$

$$X(z) = z^2 + 3z^4$$

$$X(-z) = (-z)^2 + 3(-z)^4$$

$$Y(z) = X(-z) = z^2 + 3z^4$$

$$Y(z) = X(z) = z^2 + 3z^4$$

So, $y(n) = x(n)$

23. (d)

The single-phase rating 250 kVA, 11 kV/231 V

The voltage required at load side,

$$V_L = 400 \text{ V}$$

$$V_L = 230\sqrt{3} \cong 398.37$$

$$V_L \approx 400 \text{ V}$$

So this bank will be connected in delta-star configuration. The effective kVA

$$S_{3\text{-}\phi} = 3S_{1\text{-}\phi}$$

$$= 3 \times 250 = 750 \text{ kVA}$$

24. (d)

Since the current in coil *ab* is entering at the dot marked terminal. Where as in coil *cd* the current is leaving, we can write the equations as,

$$V_1 = L_1\frac{di_1}{dt} - \frac{M\,di_2}{dt}$$

$$M = K\sqrt{L_1L_2} = 0.5\sqrt{36} = 3 \text{ H}$$

$$V_1 = 4\frac{d}{dt}[5\cos(50t - 30°)] - 3\frac{d}{dt}[2\cos(50t - 30°)]$$

$$V_1 = 20[-\sin(50t - 30°) \times 50] - 6[-\sin(50t - 30°) \times 50]$$

At $t = 0$, $V_1 = 500 - 150 = 350 \text{ V}$

25. (b)

In economizer, feed water is preheated by using flue.

26. (a)

For a parallel RLC circuit with $R = \infty$ or in series RLC circuit with $R = 0$, simple LC circuit provides an oscillatory response which can be maintained forever. Hence this is an undamped system.

Also, we can see for series resonance,

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

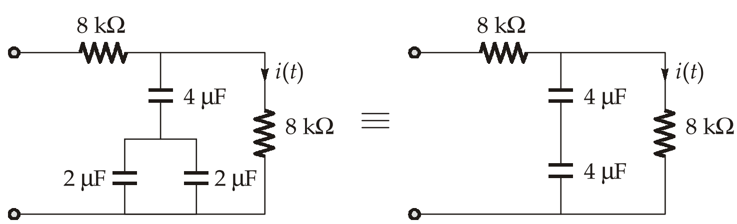
For $R = 0$, i.e. $\xi = 0$ (undamped)

27. (b)

All Arithmetic or logic instructions refer to memory via registers only.

29. (d)

For time constant calculation, the circuit can be redrawn as

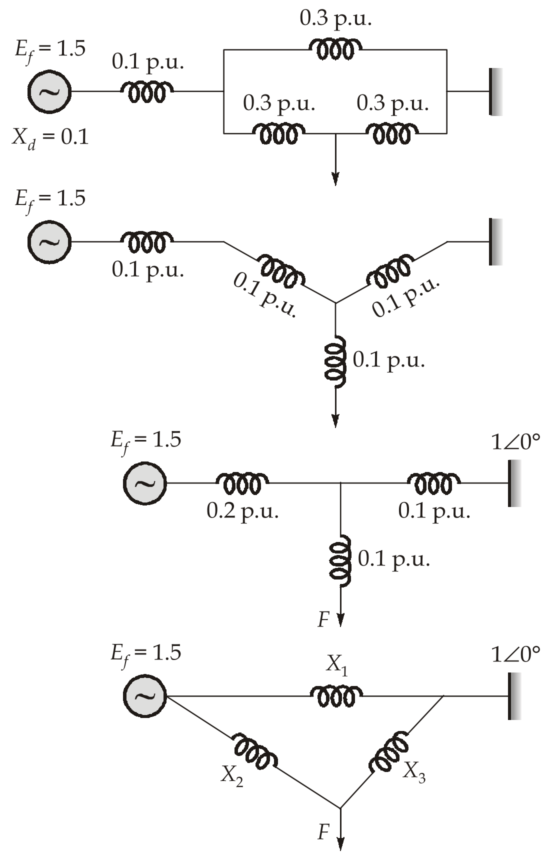


where, $R_{eq} = 8\ \text{k}\Omega$

and $C_{eq} = 2\ \mu\text{F}$

$\therefore$ $\tau = R_{eq}C_{eq} = 16$ ms

30. (b)



$$X_1 = 0.2 + 0.1 + \frac{0.2 \times 0.1}{0.1} = 0.5 \text{ p.u.}$$

$$\text{SSSL} = \frac{1.5 \times 1}{0.5} = 3 \text{ p.u.}$$

31. (a)

The load at the output port-2,

i.e.,
$$V_2 = -Z_L I_2$$
$$V_1 = Z_{11}I_1 + Z_{12}I_2$$
$$V_2 = Z_{21}I_1 + Z_{22}I_2$$
$$-Z_L I_2 = Z_{21}I_1 + Z_{22}I_2$$
$$I_2 = \frac{-I_1 Z_{21}}{Z_L + Z_{22}}$$

Substituting the value of I_2.

$$V_1 = Z_{11}I_1 - \frac{Z_{12}Z_{21}}{Z_L + Z_{22}} I_1$$

$$V_1 = I_1\left(Z_{11} - \frac{Z_{12}Z_{21}}{Z_L + Z_{22}}\right)$$

$$20 = I_1\left(10 - \frac{4\times 4}{30}\right) = I_1\frac{284}{30}$$

$$I_1 = 2.11 \text{ A}$$

32. (c)

The static synchronous compensator (STATCOM) is a shunt-connected FACTs device that is used primarily for reactive power control. STATCOM is a switched converter type shunt compensator.

33. (a)

Pitch factor, $$K_p = \cos\left(\frac{n\alpha}{2}\right)$$

Where n^{th} is the order or harmonics

To eliminate the 5^{th} order harmonics,

$$K_p = \cos\left(\frac{\alpha}{2}\times 5\right) = 0$$

$$\frac{\alpha}{2}\times 5 = 90$$

$$\alpha = 36°$$

So, $$\text{coil spain} = \frac{180-36}{180} = \frac{4}{5}$$

34. (d)

$$x(n) = \pi\cos(\pi^2 n)$$

Here, $$\omega_0 = \pi^2$$

$$2\pi K = \pi^2 N$$

$$N = \frac{2\pi}{\pi^2}K = \frac{2}{\pi}K$$

For any integer value of K, we can not have an integer value of N.

35. (a)

To find impedance Z, we first solve for X_C and X_L,

$$X_C = \frac{1}{2\pi fC} = \frac{1}{6.28\times 50\times 10\times 10^{-6}} = 318.5\ \Omega$$

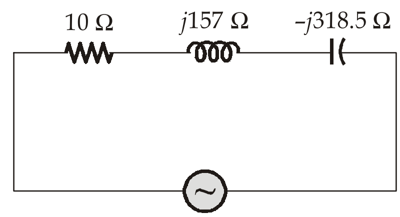
$$X_L = 2\pi f_L = 6.28 \times 0.5 \times 50 = 157\ \Omega$$

$$Z = 10 + j157 - j318.5$$

$$= 10 - j161.5\ \Omega$$

$$= 161.8\angle{-86.45}\ \Omega$$

$$I = \frac{50}{161.8} = 0.31 \text{ A}$$



50 V, 50 Hz

Voltage across the inductive reactance,

$$= IX_L = 0.31 \times 157$$
$$= 48.67 \text{ V}$$

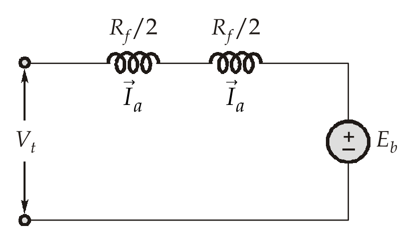
36. (c)

- Some materials get strained when an electric field is applied. This is known as electrostriction.
- Strain $\propto (E)^2$.

37. (d)

The torque is constant, $T \propto \phi I_a$

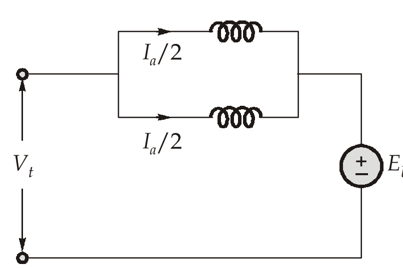
The coils are in series



$$\phi_{f1} \propto I_a$$

So, $$E_{b1} \propto \phi_{f1} N_1 \quad \text{...(i)}$$

The coils are in parallel,



$$\phi_{f2} \propto \frac{I_a}{2}$$

$$E_{b2} \propto \phi_{f2} N_2 \quad \text{...(ii)}$$

Assuming negligible drop

$$E_{b1} = E_{b2}$$

$$\phi_{f1}N_1 = \phi_{f2}N_2$$

$$N_2 = \frac{\phi_{f1}}{\phi_{f2}}N_1$$

$$N_2 = \frac{I_a}{I_a/2}\times 500 = 1000 \text{ rpm}$$

38. (c)

Capacitance of sphere,

$$C = 4\pi\varepsilon_0 a$$

Voltage at the centre of sphere,

$$V = \frac{Q}{4\pi\varepsilon_0 r}$$

Where, a = radius of sphere, r = distance between the centre of sphere and point charge

∴ Total induced charge on the conducting sphere,

$$q_{\text{ind}} = CV = 4\pi\varepsilon_0 a\times\frac{Q}{4\pi\varepsilon_0 r} = \frac{Qa}{r}$$

$$= \frac{20\times 4}{10} = 8\ \mu\text{C}$$

39. (b)

$$X(\omega) = \int_{-\infty}^{\infty} x(t)e^{-j\omega t}dt = \omega e^{-4\omega^2}$$

$$y(t) = 2\int_{-\infty}^{t} x(\tau)d\tau$$

$$y(t) = 2\,x(t) * u(t) \qquad [u(t)\to \text{step signal}]$$

$$\Rightarrow \quad y(\omega) = 2\,X(\omega)\times U(\omega)$$

$$y(\omega) = 2\omega e^{-4\omega^2}\left(\frac{1}{j\omega}+\pi\delta(\omega)\right)$$

$$y(\omega) = \frac{2e^{-4\omega^2}}{j}+(2\omega e^{-4\omega^2})\pi\delta(\omega)$$

$$y(\omega) = -2je^{-4\omega^2}+2(0)e^{-0}\pi\delta(\omega) = -j2e^{-4\omega^2}$$

$$\int_{-\infty}^{\infty} y(t)\,dt = y(0) = -2\,je^{-0} = -2j$$

40. **(c)**

Since cos(2π *t*) is time varying, so it is time variant

$$y(t) = x(t)\sin(2\pi t)$$

For $x(t) = x_1(t)$, the output $y_1(t) = x_1(t)\sin(2\pi t)$

For $x(t) = x_2(t)$, the output $y_2(t) = x_2(t)\sin(2\pi t)$

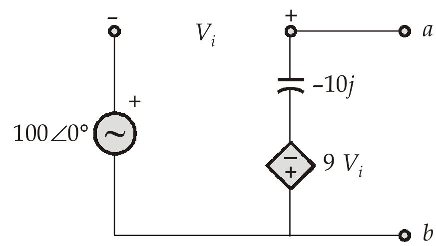
For $x(t) = x_1(t) + x_2(t)$, the output $y_3(t) = (x_1(t) + 2x(t))\sin(2\pi t)$

$$y_3(t) = y_1(t) + y_2(t)$$

41. **(a)**

From the circuit shown below,

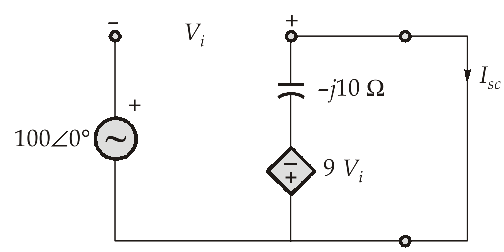
$$V_{OC} = -9\ V_i$$



$$V_i = -9\ V_i - 100\angle 0°$$

$$V_i = 10\angle 180°\ \text{V}$$

Thevenin's voltage, $V_{OC} = 90\angle 0°\ \text{V}$



$$V_i = -100\ \text{V}$$

$$9V_i - j10\ I_{sc} = 0$$

$$I_{sc} = 90\ j\ \text{A}$$

$$\therefore \qquad Z_{\text{th}} = Z_{ab} = \frac{V_{OC}}{I_{SC}} = \frac{90\angle 0°}{90j} = -j\,\Omega$$

$$Z_{\text{th}} = -1j\ \Omega$$

42. **(b)**

$H_1 = 6$ MJ/MVA, $H_2 = 4$ MJ/MVA

$f = 50$,

$P_1 = 1$ p.u. $P_2 = 0.5$ p.u.

then angular acceleration,

$$\frac{H_1 \times H_2}{H_1 + H_2} \times \frac{1}{180f} \frac{d^2\delta}{dt^2} = P_1 - P_2$$

$$\frac{6 \times 4}{6+4} \times \frac{1}{180 \times 50} \cdot \frac{d^2\delta}{dt^2} = 1 - 0.5$$

$$\frac{d^2\delta}{dt^2} = \frac{0.5 \times 180 \times 50}{2.4} = 1875 \text{ elec. degree/s}^2$$

43. (b)

The output of alternator,

$$P_{out} = 1500 \times 0.9 = 1350 \text{ kW}$$

The armature current, $I_a = \dfrac{1500}{\sqrt{3} \times 2.3} = 376.53$ Amp

The Cu loss, $P_{cu} = 3(I_a)^2 \times 0.06 = 3 \times (376.53)^2 \times 0.06$

$P_{cu} = 25.52$ kW

The total loss, $P_T = 25.52 + 25 + 18 + 125 \times 60 \times 10^{-3}$

$= 76.02$ kW

So, efficiency, $\eta = \dfrac{P_{out}}{P_{in}} = \dfrac{1350}{1350 + 76.02} \times 100$

$= 94.66\%$

44. (a)

Laplace equation in cylindrical co-ordinates

$$\nabla^2 V = \frac{1}{\rho}\frac{\partial}{\partial \rho}\left(\frac{\rho \partial V}{\partial \rho}\right) + \frac{1}{\rho^2}\left(\frac{\partial^2 V}{\partial \phi^2}\right) + \frac{\partial^2 V}{\partial z^2}$$

45. (d)

$$\text{KVA} = \frac{400}{0.8} = 500 \text{ kVA}$$

kW at 0.8 p.f. = 400 kW

kW at upf = 500 × 1 = 500 kW

Increase in power supplied by the alternator

= 500 – 400 = 100 kW

46. (b)

$x(t)$ is compressed by 4, the frequency will expand by same factor (4) but there won't any change in the values of a_K.

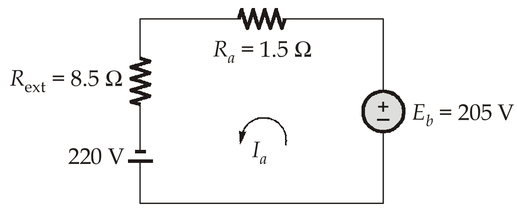
47. (b)

During normal operation,

Back emf, $E_b = V_s - I_a R_a = 220 - 10 \times 1.5$

$E_b = 205$ V

During plugging of the motor,



The armature current during plugging,

$$I_a = \frac{E_b + V_t}{R_a + R_{ext}} = \frac{220+205}{1.5+8.5} = 42.5 \text{ Amp}$$

48. (a)

The resonant frequency, $f_r = \frac{1}{2\pi}\sqrt{\frac{1}{LC} - \frac{R_L^2}{L^2}}$

$$= \frac{1}{2\pi}\sqrt{\frac{1}{0.1\times 10\times 10^{-6}} - \frac{(10)^2}{(0.1)^2}}$$

$$= \frac{1}{2\pi}\sqrt{10^6 - (100)^2} = \frac{994.98}{2\pi} = 158.35 \text{ Hz}$$

49. (c)

$P_m = 1$ p.u.

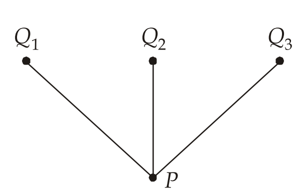
$P_{\text{max III}} = 1.25$ p.u.

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

$$= \pi - \sin^{-1}\left(\frac{1}{1.25}\right) = 180° - 53.13°$$

$= 126.86°$

50. (c)



Electric field at P due to Q_1 = $(\hat{a}_x + 2\hat{a}_y - \hat{a}_z)$

Electric field at P due to Q_2 = $\hat{a}_y + 3\hat{a}_z$

Electric field at P due to Q_3 = $2\hat{a}_x - \hat{a}_y$

So, total electric field at P due to all Q_1, Q_2 and Q_3 is

$$= (\hat{a}_x + 2\hat{a}_y - \hat{a}_z) + (\hat{a}_y + 3\hat{a}_z) + (2\hat{a}_x - \hat{a}_y)$$

$$= 3\hat{a}_x + 2\hat{a}_y + 2\hat{a}_z \text{ N/C}$$

51. (c)

For generator, $X_1 \approx X_2$

and $X_1 >> X_0$

52. (c)

$$\text{Average RRRV} = \frac{\text{Peak value of restriking voltage}}{\text{Time taken to reach the peak value}}$$

$$= \frac{1000}{\frac{\pi\sqrt{LC}}{2}} = \frac{2 \times 1000}{3.14 \times \sqrt{4 \times 10^{-3} \times 100 \times 10^{-6}}} \text{ V/sec}$$

$$= 10.07 \times 10^5 \text{ V/sec}$$

53. (d)

The best suitable material for the construction of armature of a dc machine is Silicon steel as it reduces hysteresis loss as well as eddy current loss if laminated.

54. (a)

$$V = \frac{8di}{dt} - \frac{4di}{dt} + \frac{10di}{dt} - \frac{4di}{dt} + \frac{5di}{dt} + \frac{6di}{dt} + \frac{5di}{dt} = \frac{26di}{dt}$$

$$V/(di/dt) = 26 \text{ H}$$

55. (b)

For minimum excitation, $\delta = 90°$

So the power taken by motor,

$$P_{on} = \frac{E_f V_t}{X_s} \sin\delta$$

$$1 = \frac{E_f \times 1}{0.9} \sin 90°$$

$$E_f = 0.9 \times 1 = 0.9 \text{ p.u.}$$

56. (a)

The polarisation is given as

$$\vec{P} = \chi_e \varepsilon_0 \vec{E}$$
$$= (\varepsilon_r - 1)\varepsilon_0 \vec{E}$$
$$= (\varepsilon_r - 1)\varepsilon_0 \frac{\vec{D}}{\varepsilon_0 \varepsilon_r} \qquad \{\because \varepsilon_r = (1+\chi_e)\}$$
$$= \left(1 - \frac{1}{\varepsilon_r}\right)\vec{D} = \left(1 - \frac{1}{2.4}\right) \times 4 \times 10^{-7}$$
$$= 2.33 \times 10^{-7} \text{ c/m}$$

57. (d)

The current at resonance is $I = V/R$.

$$10 = \frac{100}{R}$$
$$\therefore \quad R = 10\ \Omega$$
$$Q = \frac{\omega L}{R}$$

Since, $Q = 5, \quad R = 10$

$$\omega L = 50$$
$$\therefore \quad L = \frac{50}{\omega} = \frac{50}{50} = 1 \text{ H}$$

58. (a)

$$\log_2 (205) \approx 8$$
$$\log_2 (128) = 7$$

Opcode (8)	Destination (7)	Source (7)	Immediate (10)

← 32 →

$\therefore$ 10 bits required for immediate field.

59. (c)

- Electrical materials, which have large number of free electrons or loosely bound valence-band electrons that can easily be knocked out of their orbit and constitute a large current are known as conductors.
- Electrical materials, where no free electrons are available and the valence-band electrons are highly bound to the nucleus, are known as insulators.

60. (c)

For single precision floating point format

sign	exponent	mantissa
0	1 0 0 0 0 0 1 1	1 0 1 0 0 0 0
1 bit	8 bit	23 bit

$$\text{Bias} = (2^{n-1} - 1) = 2^7 - 1 = 127$$

$$\text{BE} = (10000011)_2 = (131)_{10}$$

$$\text{Value} = 1.\text{M} \times 2^{\text{BE}-\text{Bias}}$$

$$= 1.1010 \times 2^{131-127}$$

$$= (1.1010)_2 \times 2^4 = (11010)_2 = (32)_8$$

61. (b)

Characteristic equation of the system is given by,

$$1 + G(s)\,H(s) = 0$$

$$1 + \frac{K}{s(s+2)(s+5)} = 0$$

Solving this equation, we get

$$s^3 + 7s^2 + 10s + K = 0$$

Applying Routh-Harwitz criterion,

s^3	1	10
s^2	7	K
s	$\frac{70-K}{7}$	

System to be stable, first column should have same sign elements.

$$\therefore \quad \frac{70-K}{7} > 0$$

$$K < 70$$

$$K_{marginal} = 70$$

The desired value of gain K is 10. And the value of gain K for marginal stability is $K = 70$

$$\text{Gain margin} = \frac{K_{marginal}}{K_{desired}} = \frac{70}{10} = 7$$

$$\text{Gain Margin}\Big|_{dB} = 20 \log 7 = 16.9 \text{ dB}$$

62. (c)

Direction of induced current will be such that it opposes its own cause.

63. (a)

The field lines must begin on positive charges (or at infinity) and must terminate on negative charges (or at infinity).

64. (a)

State transition matrix $\phi(t)$ is given by

$$\phi(t) = e^{At}$$

(a) at $t = 0$

$$\phi(0) = e^{A.0} = I$$

(b) $\phi^{-1}(t) = (e^{At})^{-1}$

$\Rightarrow$ $\phi^{-1}(t) = e^{-At}$

$\Rightarrow$ But $-\phi(t) = -e^{At}$

$\Rightarrow$ $e^{-At} \neq -e^{At}$

(c) $\phi(t_1 + t_2) = e^{A(t_1+t_2)}$

$$= e^{At_1} \cdot e^{At_2}$$

$\Rightarrow$ $\phi(t_1 + t_2) = \phi(t_1) \cdot \phi(t_2)$

(d) $[\phi(t)]^n = [e^{At}]^n$

$$[\phi(t)]^n = e^{nAt}$$

$$n\phi(t) = ne^{At}$$

$$[\phi(t)]^n \neq n\phi(t)$$

65. (d)

1. If $(j + 1)^{th}$ instruction uses the result of j^{th} instruction as an operand then read-after-write hazard occurs. It is a part of data dependency.
2. The execution of a conditional jump instruction causes an flushing so conditional dependency occurs.
3. The j^{th} and $(j + 1)^{th}$ instruction require the ALU at same time causes write-after-read hazard.

67. (c)

Register operations

$R_1 \leftarrow a$

$R_2 \leftarrow b$

$R_3 \leftarrow c$

$R_1 \leftarrow R_1 + R_2$

$R_2 \leftarrow R_3 + R_1$

$R_1 \leftarrow R_2 + R_1$

$R_2 \leftarrow R_3 + R_2$

$R_2 \leftarrow R_3 + R_2$

$R_1 \leftarrow 5 + R_2$

return $(R_1 + R_2)$

Hence, 3 registers needed only.

70. (c)

$$\text{Loss factor} = \frac{\epsilon''}{\epsilon'}$$

71. (c)

In an insulating material connected to an a.c. signal, the dielectric constant and atomic polarisation decrease with frequency.

72. (b)

From nyquist plot, number of encirclements are two in clockwise direction,

$\therefore$ $N = -2$

From nyquist criteria, $N = P - Z$

$$-2 = 0 - Z$$

$$Z = 2$$

i.e. closed loop system has two poles in right hand s-plane. It means system is unstable for $K \geq 4$.

To make the system stable,

$$Z = 0$$

i.e. $N = 0$

$\therefore$ $K < 4$

74. (b)

Given system has

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

Roots of characteristic equation,

i.e. $|sI - A| = 0$

$$\begin{bmatrix} s & 0 \\ 0 & s \end{bmatrix} - \begin{bmatrix} 0 & -1 \\ 1 & -2 \end{bmatrix} = 0$$

$$\begin{vmatrix} s & 1 \\ -1 & s+2 \end{vmatrix} = 0$$

$$s(s + 2) + 1 = 0$$

$$(s + 1)^2 = 0$$

$\therefore$ The system is critically damped.

75. (d)

In the instruction PUSH B operands are present in BC pair.

76. (b)

Standard second order transfer function is given by

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

Comparing the given transfer function with standard transfer function, we get

$$2\,\xi\omega_n = 3$$

and $\omega_n = 2$ rad/sec

$$\therefore \quad \xi = \frac{3}{4}$$

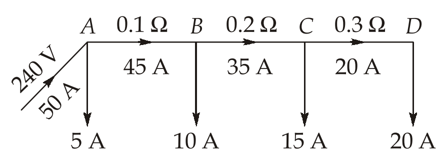
As ξ is greater than 0.707

therefore resonant peak $(M_r) = 1$

77. (a)

In a transformer, the core material should have low coercivity, retentivity and high permeability.

78. (d)



$$V_{AD} = 0.1 \times 45 + 0.2 \times 35 + 20 \times 0.3 = 17.5 \text{ V}$$

$$V_C = 240 - 45 \times 0.1 - 35 \times 0.2 = 228.5 \text{ V}$$

79. (b)

Given, plane = (2 2 1)

atomic radius (r) = 0.125 nm

atomic radius of FCC structure, $r = \frac{\sqrt{2}}{4}a$

$$a = \frac{4r}{\sqrt{2}}$$

The distance,

$$d_{221} = \frac{a}{\sqrt{h^2+k^2+l^2}} = \frac{4r}{\sqrt{2}\sqrt{h^2+k^2+l^2}}$$

$$d_{221} = \frac{4 \times 0.125 \times 10^{-9}}{\sqrt{2}\sqrt{2^2+2^2+1^2}} = \frac{4 \times 0.125 \times 10^{-9}}{\sqrt{2}\sqrt{9}} = 0.118 \text{ nm}$$

80. (a)

Given $\lambda = 2.0$ Å, $\theta = 60°$, $n = 1$

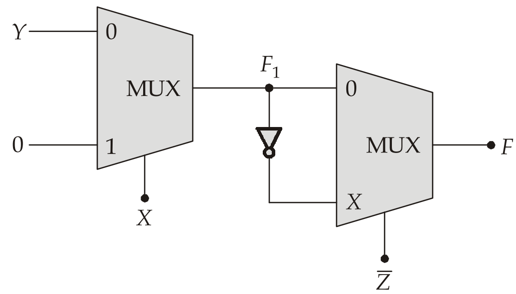
Formula given by Bragg's law

$$2d \sin\theta = n\lambda$$

where d = lattice constant

$$d = \frac{n\lambda}{2\sin\theta} = \frac{1\times 2.0\times 10^{-12}}{2\sin 60^\circ} = 1.1547\text{Å}$$

81. (b)



$$F_1 = \bar{X}Y$$

So,

$$F = ZF_1 + \bar{Z}\bar{F_1} = \bar{X}YZ + \bar{Z}(\overline{\bar{X}Y})$$

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

82. (b)

The characteristic equation:

$s^4 + 2s^3 + 4s^2 + 16s + 24 = 0$

Routh array:

s^4	1	4	24
s^3	2	16	
s^2	–4	24	
s^1	28		
s^0	24		

84. (b)

Transfer function of PID controller is given by,

$$T(s) = K_P\left(1 + \frac{1}{sT_i} + sT_d\right)$$

Where, K_P = gain of proportional controller

T_i = reset time

T_d = Rate time

Given, Proportional band = 60%

Reset time = 0.3 sec

Rate constant = 10

$$\text{Gain} = \frac{100}{\text{Proportional band}} = \frac{100}{60} = \frac{5}{3}$$

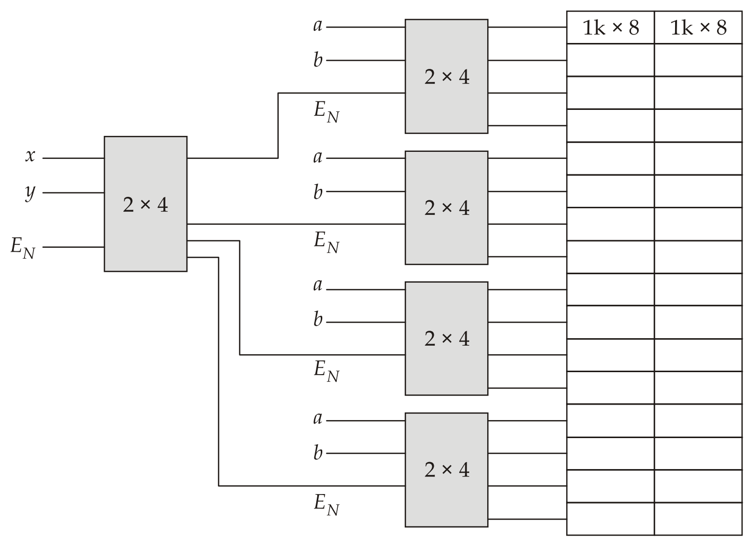
$$T(s) = \frac{5}{3}\left(1 + \frac{1}{0.3s} + 10s\right)$$

$$T(s) = \frac{5}{3}\left(\frac{3s^2 + 0.3s + 1}{0.3s}\right)$$

85. (b)

$$\text{Number of chips required} = \frac{16\text{ k} \times 16}{1\text{ k} \times 8} = 16 \times 2$$

Number of output lines needed are 16.



We need 5 decoders.

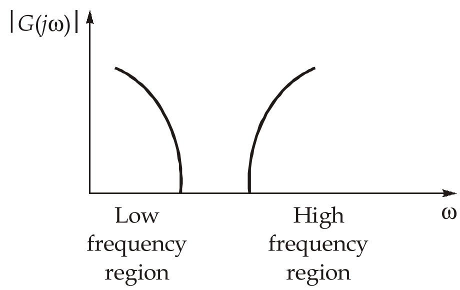
86. (d)

Penalty factor, $$L_i = \frac{1}{1 - \frac{\partial P_L}{\partial P_{gi}}}, \qquad i = 2, 3 \ldots \text{m}$$

Increamented loss, $$\frac{\partial P_L}{\partial P_g} = 0.6$$

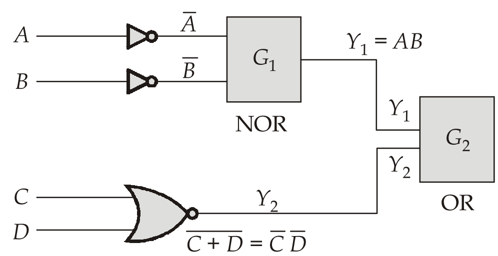
$$L = \frac{1}{1 - 0.6} = \frac{1}{0.4} = 2.5$$

87. (d)



Magnitude v/s ω curve of lag-lead compensator.

88. (a)



If $\quad G_1 = \text{NOR}$

$\Rightarrow \quad y_1 = \overline{\bar{A}+\bar{B}} = AB$

So, if $\quad G_2 = \text{OR},$

$\Rightarrow \quad y = y_1 + y_2 = AB + \bar{C}\bar{D}$

89. (d)

To eliminate n^{th} harmonics

$$\text{Pulse width } (2d) = \frac{2\pi}{n}$$

$$2d = \frac{2\pi}{3} = 120°$$

$$V_{01\text{ rms}} = \frac{4V_s}{\sqrt{2}\,\pi}\sin(nd) = \frac{2\sqrt{2}V_s}{\pi}\sin\left(\frac{\pi}{3}\right)$$

$$= \frac{2\sqrt{2}}{\pi}V_s \cdot \frac{\sqrt{3}}{2} = \frac{\sqrt{6}}{\pi}V_s$$

90. (a)

- Polarization of a pyroelectric material changes on heating.
- Every pyroelectric material is piezoelectric material but converse is not true.

91. (b)

R and RC firing scheme can not be used for feedback control systems.

94. (c)

H and L registers are known as "primary data pointers".

95. (c)

Closed loop transfer function of system is given by,

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

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

Desired characteristic equation from given closed loop poles is,

$$1 + G(s)\,H(s) = \left(s+1-j\sqrt{5}\right)\left(s+1+j\sqrt{5}\right)$$

$$= s^2 + 2s + 6$$

Comparing desired characteristic equation with given equation

$$K = 6$$

96. (c)

$$\text{Cache size} = 64 \text{ kilobytes} = 64 \times 2^{10} \text{ bytes}$$

$$\text{Block size} = 4 \text{ bytes}$$

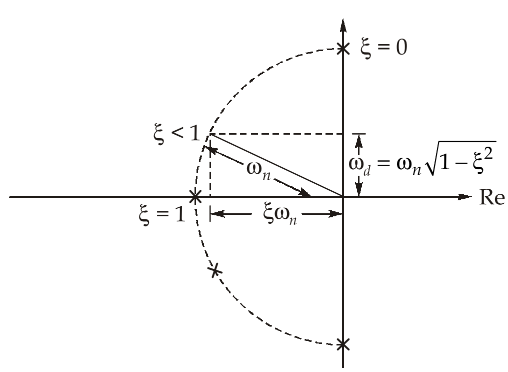
$$\text{Number of lines} = \frac{64 \times 2^{10}}{4} = 2^{14}$$

97. (d)

Inductor is charged during positive half cycle and it discharges during negative half cycle.

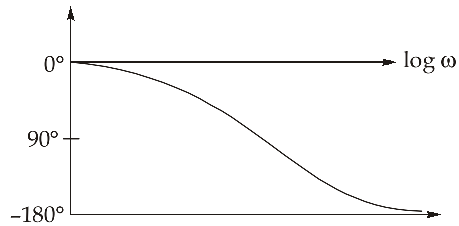
98. (c)

1. Locus of close loop poles of second order system by varying ξ is shown below



Radius of semi circle is ω_n

2. Phase angle curve of second order system is



As phase angle curve never crosses –180° line, therefore phase crossover frequency does not exist i.e. ω_{pc} is infinite and gain margin is also infinite.

99. (b)

Effective time = (Page fault rate × service time) + [(1 – page fault rate) × memory access time]

$$= \left[\frac{1}{5} \times (2+3)\right] + \left[\left(1 - \frac{1}{5}\right) \times 2\right]$$

$$= 1 + \frac{8}{5} = 2.6 \text{ msec}$$

100. (c)

Amplitude of the 50 Hz fundamental frequency is

$$V_1 = m_a V_{dr} = 0.6 \times 200 = 120 \text{ V}$$

101. (c)

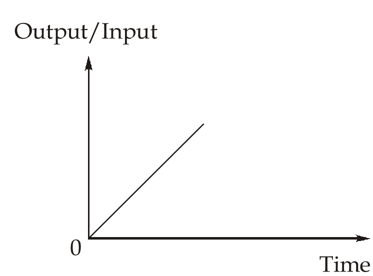
The expansion in the wire is proportional to the heating effect of current and to the square of the rms value of the current. Therefore, the meter may be calibrated to read the rms value of the current.

102. (c)

Compensating winding are connected in series with armature circuit.

104. (a)

For zero order control systems,



$$\frac{x_0(t)}{x_i(t)} = K$$

And, to study the behavior of any system using time domain approach, we need sufficient time lag between output and input.

105. (a)

Conductor surface is an equipotential surface as tangential component of electric field on conductor surface is zero and only normal component of electric field exists.

106. (a)

Associative memory is any device that associates a set of predefined output patterns with specific input patterns. Associative memory can also be called as content addressable memory (CAM) and is accessed simultaneously and in parallel on the basis of data rather than by specific address or location.

107. (b)

DC chopper involves one stage conversions while AC link chopper is two stage conversion link.

108. (b)

In parallel voltage is same

If R_1 is resistance of 1st ammeter and R_2 is resistance of 2nd ammeter,

Hence,
$$R_1 = \frac{V}{I_{fsd1}} = \frac{V}{5\text{ mA}}$$
$$R_2 = \frac{V}{I_{fsd2}} = \frac{V}{50\text{ mA}}$$
$$\therefore \quad \frac{R_1}{R_2} = \frac{50}{5} = 10 : 1$$

109. (a)

Here $h = 10$

Using trapezoidal rule

$$\text{Area, } A = \frac{h}{2}\left[y_0 + 2(y_1 + y_2 + ... + y_{n-1}) + y_n\right]$$
$$A = \frac{10}{2}\left[0 + 2\,(4 + 7 + 9 + 12 + 15 + 14 + 8) + 3\right]$$
$$= 5 \times (138 + 3) = 705\text{ m}^2$$

110. (b)

The given modulated signal is an AM signal.

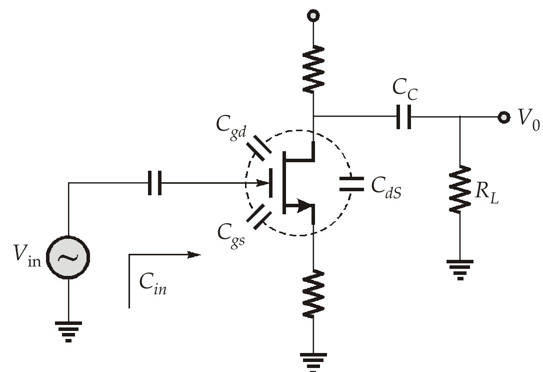
$$s(t) = (2.5 + 5\cos\omega_m t)\cos\omega_c t = 2.5(1 + 2\cos\omega_m t)\cos\omega_c t$$

So, the modulation index of the given AM signal is,

$$\mu = 2$$

As $\mu > 1$, synchronous detector is more suitable.

111. (a)



$$C_{in} = C_{gs} + C_{miller}$$

$$C_{in} = C_{gs} + (1 - A_v)C_{gd}$$

112. (c)

$$p = 0.2; \quad q = 0.8; \quad n = 400$$

$$\text{standard deviation} = \sqrt{npq} = \sqrt{400 \times 0.2 \times 0.8} = 8$$

113. (d)

$$\frac{\partial A_f}{A_f} = \frac{\partial A}{A}\left(\frac{1}{1 + A\beta}\right)$$

$$\frac{0.2}{100} = \frac{20}{1000}\left(\frac{1}{1 + 1000\beta}\right)$$

$$1 + 1000\beta = 10$$

$$\beta = \frac{9}{1000}$$

114. (a)

For 2 cm deflection 220 V

$$\text{For 3 cm deflection} = \frac{220}{2} \times 3 = 330 \text{ V}$$

115. (c)

$$V_{0n} = \frac{2V_s}{n\pi} \sin n\pi\alpha$$

$$V_{01} = \frac{2 \times V_s}{\pi} \sin\left(\frac{2\pi}{3}\right)$$

$$= \frac{2V_s}{\pi} \times \frac{\sqrt{3}}{2} = \frac{\sqrt{3}V_s}{\pi} \text{ V}$$

116. (b)

Mean value,

$$\bar{X} = \int_{-\infty}^{\infty} x \cdot \rho_x(x)\,dx = \frac{1}{4}\int_{-1}^{3} x\,dx = \frac{1}{4}\cdot\frac{x^2}{2}\Big|_{-1}^{3} = 1$$

Variance,

$$\overline{X^2} = \int_{-\infty}^{\infty} x^2 \rho_x(x)\,dx = \frac{1}{4}\int_{-1}^{3} x^2\,dx = \frac{1}{4\times 3}\cdot x^3\Big|_{-1}^{3} = \frac{1}{12}(27+1)$$

$$= \frac{28}{12} = \frac{7}{3}$$

$$\text{Variance, } \overline{X^2} - (\bar{X})^2 = \frac{7}{3} - 1 = \frac{4}{3}$$

117. (a)

$$\text{kWhr} = \frac{230\times 50}{1000}\times\frac{37}{3600} = 0.118 \text{ kWhr}$$

$$\text{Measured value} = \frac{61}{0.118} = 516$$

$$\text{True value} = 520$$

$$\therefore \quad \%\text{ error} = \frac{\text{Measured value} - \text{True value}}{\text{True value}}$$

$$= \frac{516-520}{520} = -0.769\%$$

118. (c)

$$x(t) = s(t)A\cos(\omega_c t + 30°)$$

$$= A^2[\cos(\omega_c t + 30°)\cos(\omega_c t)]m(t)$$

$$= \frac{A^2}{2}[\cos(2\omega_c t + 30°) + \cos 30°]m(t)$$

After passing through LPF, we get,

$$y(t) = \frac{A^2}{2}\cos(30°)\,m(t) = \frac{\sqrt{3}A^2}{4}m(t)$$

Average power of $y(t)$,

$$P_y = \left(\frac{\sqrt{3}}{4}A^2\right)^2 P_m = \frac{3A^4}{16}P_m$$

119. (b)

For natural turn-off, peak resonant current $\left(\frac{V_s}{Z_0} \text{ or } V_s\sqrt{\frac{C}{L}}\right)$ must be greater than load current I_0.

120. (d)

At input, there is series mixing i.e., voltages are mixed or compared.

At output, there is shunt connection i.e., voltage sampling.

Hence, in a series-shunt feedback amplifier topology, the voltages are compared and the output voltages are sampled.

121. (b)

The frequency is given by the equation,

$$f = \frac{1}{2\pi\sqrt{C_1 R_1 C_3 R_3}}$$

$$= \frac{1}{2\pi\sqrt{5\times10^{-9}\times4.7\times10^{3}\times10\times10^{-9}\times10\times10^{3}}}$$

$$= 3.283 \text{ kHz}$$

122. (b)

$$\text{Overall gain} = (A_0)^3 = A_0^3$$

$$\beta = 0.008$$

For the system to be oscillatory,

$$A\beta = -1$$

$$A_0^3(0.008) = -1$$

$$A_0^3 = -125$$

$$A_0 = -5$$

123. (a)

$\sin x \cos y\, dx + \cos x \sin y\, dy = 0$

Divide by $\cos x \cos y$, we get,

$$\tan x\, dx + \tan y\, dy = 0$$

Integrating the equation,

$$\log \sec x + \log \sec y = C_1$$

$$\log\frac{1}{\cos x \cos y} = C_1$$

$$\cos x \cos y = C$$

Since it passes through $(0, \pi/3)$

$$\cos(0)\cos(\pi/3) = C$$

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

The equation of curve is

$$\cos x \cos y = \frac{1}{2}$$

124. (b)

For forward converter,

$$V_0 = D\frac{N_2}{N_1}V_s = 0.4\times\frac{1}{2}\times 100 = 20\text{ V}$$

125. (a)

Here, wattmeter will read average active power

$\therefore$ $W = VI\cos\phi$

Given, $V = 200$ V, current through load = I

$\therefore$ $I = \frac{V}{|Z|} = \frac{200}{5} = 40$ A

Also, load power factor angle, $\phi = 30°$

$\therefore$ Wattmeter reading, $W = VI\cos\phi$

$= 400 \times 40 \times \cos 30° = 13.86$ kW

126. (c)

Characteristic equation is

$$\lambda^2 + 5\lambda + 6I = 0$$

$$A^2 + 5A + 6I = 0$$

$$A^2 = -(5A + 6I)$$

$$A^3 = -(5A^2 + 6A) = -5(-5A - 6I) - 6A = 19A + 30I$$

127. (c)

Both statements are correct.

128. (a)

$$40 = 10\log_{10}(\text{Ap})$$

$$A_p = 10^4$$

$$A_p = \frac{P_0}{P_{in}}$$

$$\Rightarrow \quad P_0 = A_p \cdot P_{in} = 10^4 \cdot 4\times 10^{-6}$$

$$= 40\text{ mW}$$

129. (b)

The standard form of an FM signal can be given as,

$$s(t) = A_c \cos\left[2\pi f_c t + 2\pi k_f \int_{-\infty}^{t} m(t)\,dt\right]$$

The maximum phase deviation of the FM signal can be given as,

$$\Delta\phi_{max} = 2\pi k_f \left|\int_{-\infty}^{t} m(t)\,dt\right|_{max}$$

Since $m(t)$ has only positive values,

$$\left|\int_{-\infty}^{t} m(t)\,dt\right|_{max} = \text{Area under } m(t) = 4 \times 2 = 8 \text{ V-sec}$$

$$\Delta\phi_{max} = 2\pi k_f \left|\int_{-\infty}^{t} m(t)\,dt\right|_{max}$$

$$= 2\pi(0.5 \text{ Hz/V})\ (8 \text{ V-sec}) \text{ rad} = 2\pi(0.5)\ (8) \text{ rad} = 8\pi \text{ rad}$$

130. (c)

Average armature terminal voltage,

$$V_t = (1 - \alpha)V_s$$

$$= (1 - 0.6) \times 500 = 200 \text{ V}$$

$$\text{Power returned to supply} = V_t I_a = 200 \times 80 = 16 \text{ kW}$$

131. (a)

$$\text{All Events} = {}^{11}C_2 = 55$$

Possible events = (0, 4), (0, 8), (2, 6), (2, 10), (4, 8) and (6, 10)

$$\text{Required probability} = \frac{6}{55}$$

132. (d)

In order to eliminate temperature errors, the working coil is wound with copper wire and is of comparatively less resistance. A high “swamping resistance” of material whose resistance temperature coefficient is small, is connected in series with the coil, so that although the resistance of the coil may change considerably the change in total resistance of circuit is small.

133. (d)

All the statements are correct.

134. (c)

Pole, z = 2 lies inside $|z|$ = 3

$$\text{Res } f(z) = \lim_{z\to 2}(z-2)\frac{z^2-2z+3}{z-2} = 4 - 4 + 3 = 3$$

By Cauchy residue theorem,

$$I = 2\pi i\,(3) = 6\,\pi\, i$$

135. (d)

For single phase full converter

$$V_{0\text{ avg}} = \frac{2V_m}{\pi}\cos\alpha = \frac{2\times 230\sqrt{2}}{3.14}\times\cos 60° = 103.58 \text{ V}$$

$$I_{0\text{ avg}} = \frac{103.58-40}{20} = 3.179 \text{ A}$$

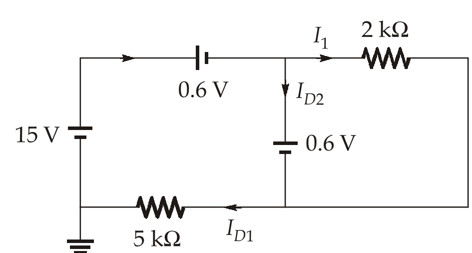
136. (c)

$$f_m = 100 \text{ Hz}$$

$$m_f = 15$$

$$\text{Bandwidth} = 2\,(m_f + 1)\,f_m = 2[15+1]\times 100 = 3.2 \text{ kHz}$$

137. (b)



Apply KVL,

$$15 - 0.6 - 0.6 = 5(I_{D1})$$

$$I_{D1} = I_{D2} + I_1$$

$$13.8 = 5\left(I_{D2} + \frac{0.6}{2}\right)$$

$$I_{D2} + 0.3 = 2.76$$

$$I_{D2} = 2.46 \text{ mA}$$

138. (b)

∵ Balance at 300 mm is corresponding to an emf of 1.18 V

∴ Balance at 340 mm is corresponding to an emf of $\frac{1.18}{300}\times 340 = 1.337 \approx 1.34$ V.

139. (b)

The given circuit is a astable multivibrator so the output is a square wave. Due to zener diodes the output will not be able to go beyond 4 V. Here $V_{UL} = V_{LL} = 2$ V, so it is a square wave of 50% duty cycle $\frac{T}{2} = RC\ln\left(\frac{1+\beta}{1-\beta}\right)$.

$$\beta = \frac{5}{5+5} = 0.5$$

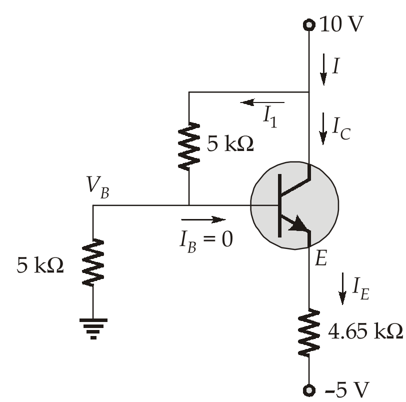
$$\tau = 2RC\ln\left(\frac{1+0.5}{1-0.5}\right)$$

$$= 2 \times 5 \times 10^3 \times 10 \times 10^{-6} \times \ln 3$$

$$\approx 110 \text{ msec}$$

140. (d)

As β is very large



$$I_B = 0$$

$$V_B = \frac{5}{5+5} \times 10 = 5 \text{ V}$$

$$I_1 = \frac{10-5}{5} = 1 \text{ mA}$$

$$V_E = 5 - 0.7 = 4.3 \text{ V}$$

$$I_E = \frac{4.3-(-5)}{4.65} = 2 \text{ mA}$$

$$I_E = I_C = 2 \text{ mA}$$

$$I = I_1 + I_C = 1 + 2 = 3 \text{ mA}$$

141. (c)

Redrawing the given bridge circuit, we have

$$Z_1 = \frac{1}{j\omega C_1}, \; Z_2 = 25 \text{ k}\Omega$$

$$Z_3 = \frac{10^6}{j0.2\,\omega}\Omega \text{ and } Z_4 = 75 \text{ k}\Omega$$

At balance, current through galvanometer

$$I_g = 0$$

and

$$|Z_1||Z_4| = |Z_2||Z_3|$$

∴

$$\left(\frac{1}{\omega C_1}\right) \times 75\text{k}\Omega = \left(\frac{10^6}{0.1\,\omega}\right) \times 25\text{k}\Omega$$

$$C_1 = \frac{75 \times 0.2}{25} = 0.6\ \mu F$$

$\therefore$ In μF, $C_1 = 0.6\ \mu F$

142. (c)

Clipper circuit is known as limiter circuit.

143. (a)

$$\text{Curl of vector} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ \frac{\partial}{\partial x} & \frac{\partial}{\partial y} & \frac{\partial}{\partial z} \\ 2x^2 & 3z^2 & y^3 \end{vmatrix}$$

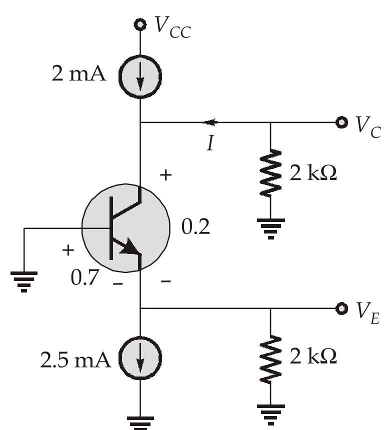
$$= \hat{i}\left[\frac{\partial}{\partial y}(y^3) - \frac{\partial}{\partial z}(3z^2)\right] - \hat{j}\left[\frac{\partial}{\partial x}(y^3) - \frac{\partial}{\partial z}(2x^2)\right] + \hat{k}\left[\frac{\partial}{\partial x}(3z^2) - \frac{\partial}{\partial y}(2x^2)\right]$$

$$= \hat{i}\left[3y^2 - 6z\right] - \hat{j}[0] + \hat{k}[0+0]$$

At, $x = 1$, $y = 1$ and $z = 1$.

$$\text{Curl} = i[3 \times 1^2 - 6 \times 1] = -3i$$

144. (c)



$$V_E = -0.7\ \text{V}$$

$$V_C = V_{CE} + V_E$$

$$= 0.2 - 0.7 = -0.5\ \text{V}$$

$$I = \frac{0-(-0.5)}{2}\text{mA} = 0.25\ \text{mA}$$

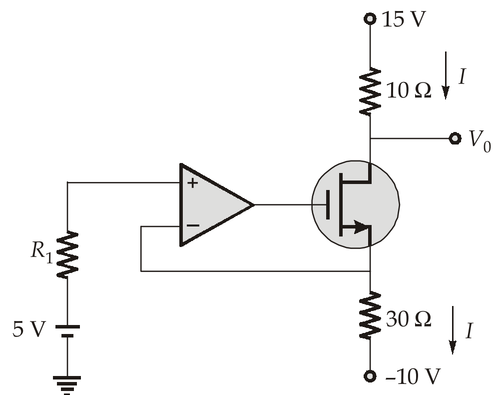
145. (d)

The sources of error in a dynamometer type of instruments are due to low torque/weight ratio, frequency, eddy currents, external magnetic field, temperature change.

146. (c)

In FM, the amplitude of higher frequency components reduces significantly. So the high frequency components are lost if not boosted before transmission which is called pre-emphasis.

147. (a)



As op-amp is ideal

$$V_- = V_+ = 5 \text{ V}$$

$$I = \frac{5-(-10)}{30} = \frac{15}{30} = 0.5 \text{ A}$$

$$V_0 = 15 - 10 \times 0.5 = 10 \text{ V}$$

149. (b)

Rate of change of inductance with deflection

$$\frac{dL}{d\theta} = \frac{d}{d\theta}(10 + 5\theta - \theta^2) = (5 - 2\theta) \ \mu\text{H/rad}$$

The deflection is, $$\theta = \frac{1}{2}\frac{I^2}{K}\frac{dL}{d\theta} = \frac{1}{2} \times \frac{(5)^2}{12 \times 10^{-6}} \times (5 - 2\theta) \times 10^{-6}$$

$$74\,\theta = 125$$

$$\theta = \frac{125}{74} = 1.689 \approx 1.69 \text{ rad}$$

150. (a)

$$f'(x) = 2x - 1$$

For minima/maxima, $f'(x) = 0$

$$2x - 1 = 0$$

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

$$f''(x) = 2 > 0 \text{ minima}$$

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