DETAILED SOLUTIONS

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ESE 2026 : Prelims Exam
CLASSROOM TEST SERIES

ELECTRICAL ENGINEERING

Test 20

Full Syllabus Test 4 : Paper-II

1. (a)	**26.** (c)	**51.** (a)	**76.** (d)	**101.** (c)	**126.** (a)
2. (c)	**27.** (d)	**52.** (c)	**77.** (b)	**102.** (c)	**127.** (b)
3. (b)	**28.** (b)	**53.** (b)	**78.** (c)	**103.** (c)	**128.** (c)
4. (b)	**29.** (d)	**54.** (a)	**79.** (a)	**104.** (b)	**129.** (c)
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10. (d)	**35.** (d)	**60.** (c)	**85.** (a)	**110.** (d)	**135.** (a)
11. (c)	**36.** (c)	**61.** (d)	**86.** (d)	**111.** (c)	**136.** (d)
12. (a)	**37.** (a)	**62.** (d)	**87.** (d)	**112.** (b)	**137.** (c)
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14. (c)	**39.** (b)	**64.** (d)	**89.** (a)	**114.** (b)	**139.** (a)
15. (d)	**40.** (a)	**65.** (b)	**90.** (a)	**115.** (d)	**140.** (c)
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17. (c)	**42.** (d)	**67.** (d)	**92.** (b)	**117.** (c)	**142.** (a)
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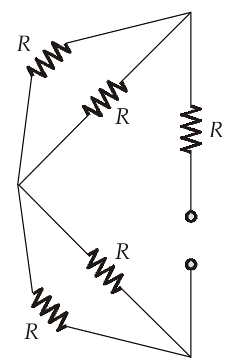
20. (d)	**45.** (a)	**70.** (c)	**95.** (c)	**120.** (b)	**145.** (c)
21. (b)	**46.** (b)	**71.** (a)	**96.** (b)	**121.** (c)	**146.** (a)
22. (d)	**47.** (a)	**72.** (c)	**97.** (a)	**122.** (d)	**147.** (d)
23. (d)	**48.** (b)	**73.** (c)	**98.** (d)	**123.** (a)	**148.** (c)
24. (b)	**49.** (a)	**74.** (a)	**99.** (c)	**124.** (d)	**149.** (d)
25. (b)	**50.** (b)	**75.** (d)	**100.** (b)	**125.** (b)	**150.** (c)

DETAILED EXPLANATIONS

1. (a)

Redrawing the circuit,



So, $R_{ab} = R + R = 2R$

2. (c)

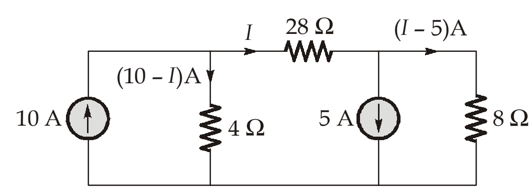
Based on loop analysis, $V = IZ$

$\therefore$ Z = Impedance matrix

The determinant of an impedance matrix cannot be zero and cannot be negative impedance matrix determinant is independent of network sources, but depends on values of the network passive elements.

3. (b)

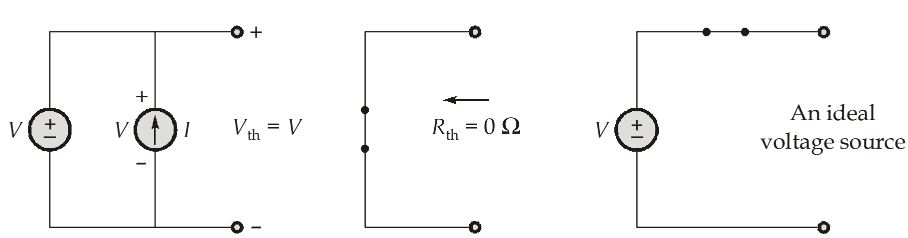
$$I_{8\Omega} = (I - 5)\text{A}$$
$$I_{4\Omega} = (10 - I)\text{A}$$



Apply KVL,

$$4(10 - I) - 28I - 8(I - 5) = 0$$
$$40 - 4I - 28I - 8I + 40 = 0$$
$$40I = 80$$
$$I = 2\text{ A}$$

4. (b)



It is impossible to convert an ideal voltage source into its equivalent current source and hence the Norton's equivalent does not exists.

Direct Norton's method:

By KCL,

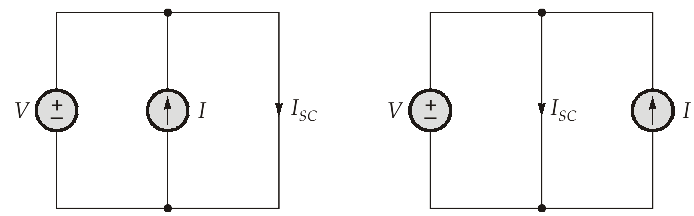
$$\Rightarrow \quad I_{SC} = I + \text{any value}$$

$$I_{SC} = \text{cannot be found}$$

By KVL,

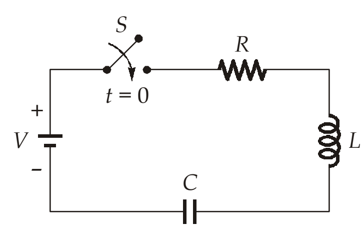
$$\Rightarrow \quad V - 0 = 0$$

$$V = 0$$

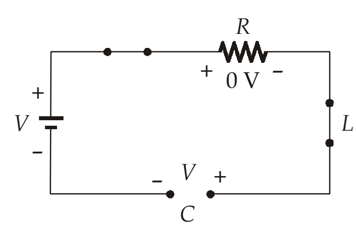


Since the violation of KVL in the circuit physical connection is not possible and hence it's impossible to evaluate I_{SC} , so the Norton's equivalent does not exist.

5. (d)



In steady state, the source voltage will be dropped across 'C' only.



6. (b)

When, $\omega = \omega_0 = \text{resonance}$

$$\text{Frequency} = \sqrt{\frac{1}{LC}}$$

$$Z = R + j\left(\omega L - \frac{1}{\omega C}\right) = R$$

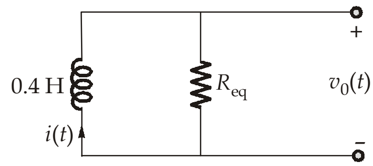
If $$LC < \frac{1}{\omega^2}$$

$$\omega < \sqrt{\frac{1}{LC}} (= \omega_0)$$

then the reactance of Z is negative and circuit is capacitive and current leads the applied voltage.

7. (d)

For $v_i(t) = 0$, the circuit can be redrawn as



Here, $$R_{eq} = \frac{2\times3}{2+3} = \frac{6}{5}\,\Omega$$

$$L_{eq} = 0.4\text{ H}$$

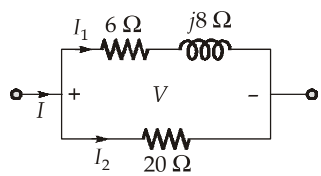
$\therefore$ $$\tau = \frac{L_{eq}}{R_{eq}} = \frac{0.4}{6/5} = \frac{2}{6} = \frac{1}{3}\text{ sec}$$

$\because$ $$i(t) = i(0)e^{-t/\tau} = 9e^{-3t}\text{ A} ; t > 0$$

$$v_0(t) = R_{eq}\, i(t) = 10.8e^{-3t}\text{ V} ; t > 0$$

8. (c)

Redrawing the given circuit, we get,



$\because$ $$V = Z \times I$$

$\Rightarrow$ $$I \propto \frac{1}{Z}$$

$\therefore$ $$\frac{I_{1\text{ effective}}}{I_{2\text{ effective}}} = \frac{Z_2}{Z_1} = \frac{20}{\sqrt{6^2+8^2}} = 2$$

$\therefore$ $$\frac{P_{6\,\Omega}}{P_{20\,\Omega}} = \frac{I_1^2(6)}{I_2^2(20)} = \left(\frac{I_1}{I_2}\right)^2 \times \frac{6}{20}$$

$$= (2)^2 \times \frac{6}{20} = \frac{6}{5} \quad \text{...(i)}$$

$\because$ $$P_{20\,\Omega} = \frac{5}{6}P_{6\,\Omega}$$

and $$P_{6\,\Omega} + P_{20\,\Omega} = 4400 \quad \text{...(ii)}$$

$$P_{6\,\Omega} + \frac{5}{6}P_{6\,\Omega} = 4400$$

$\Rightarrow$ $$P_{6\,\Omega} = \frac{4400}{11/6} = 400\times6 = 2400\text{ W}$$

10. (d)

- A "spanning subgraph" of a graph G has all the vertices, but retains only selective edges from graph G and may include a cycle whereas tree is a subgraph of a graph G, which contains all nodes from G with no cycle. Hence, every tree of a graph can be considered as spanning graph but all spanning graphs may or may not be a tree.
- Graph theory is only used for planar networks. In a graph, there is only one branch between any pair of vertices whereas the electric circuit may have multiple branches between nodes. Hence, the number of branches present in a graph will be less than or equal to the number of branches present in an electric circuit.

11. (c)

- The coefficient of coupling is always less than unity and has a maximum value of 1. For an ideal circuit, $K = 1$.
- For parallel opposing inductors,

$$L_{eq} = \frac{L_1 L_2 - M^2}{L_1 + L_2 + 2M}$$

12. (a)

The maximum power transfer theorem maximizes the true power delivered to the load impedance. Hence, it is valid for only active power.

13. (a)

When no current is drawn form the cell i.e. when the cell is not connected to any external circuit, then the potential difference between its electrodes is called electromotive force.

14. (c)

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

is the Gauss's law for magnetostatic as divergence of magnetic field is zero.

15. (d)

Boundary conditions for electric fields are:

(i) $E_{t1} = E_{t2}$

(ii) $D_{n1} - D_{n2} = \rho_s$

or, $\epsilon_1 E_{n1} - \epsilon_2 E_{n2} = \rho_s$

16. (d)

Electric field density in dielectric, $\vec{D} = \epsilon_o \vec{E} + \vec{P}$

$$\vec{P} = \epsilon_o \chi_e \vec{E}$$

where, $\vec{P}$ = Polarizability, χ_e = Susceptibility

$$1 + \chi_e = \epsilon_r$$

$$\chi_e = \epsilon_r - 1 = 2$$

$$\vec{P} = \epsilon_o (2 \times 6)\hat{a}_x = 12 \epsilon_o \hat{a}_x$$

17. (c)

The step response of the first system

$$C_1(t) = 0.5\,(1 + e^{-2t})$$

or,

$$C_1(s) = \frac{1}{2}\left(\frac{1}{s} + \frac{1}{s+2}\right) = \frac{(s+1)}{s(s+2)}$$

Now transfer function;

Impulse response of first system,

$$H_1(s) = \frac{C_1(s)}{R_1(s)} = \frac{(s+1)}{s(s+2)} \times s = \frac{(s+1)}{(s+2)}$$

The impulse response of the another function,

$$H_2(s) = \frac{1}{(s+1)}$$

Now, the transfer function of the cascaded system,

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

18. (c)

For the root locus to be parallel to the imaginary axis, the angle of asymptotes should be ±90°.

Angle of asymptotes

$$\phi_A = \frac{(2q+1)\,180°}{P-Z};\ a = 0, 1, 2, \ldots P-Z-1$$

$$\phi_A \text{ for } G(s) = \frac{K}{(s+2)^2}$$

$$\phi_A = \frac{(2q+1)180°}{P-Z},\quad a = 0, 1$$

$$\phi_{A_1} = 90°,\quad \phi_{A_2} = 270° \text{ (or) } -90°$$

19. (a)

s^5	1	5	4
s^4	–3	–7	20
s^3	$\frac{8}{3}$	$\frac{32}{3}$	0
s^2	5	20	0
s^1	0(10)	0	0
s^0	20	0	0

$$A \cdot E = 5s^2 + 20$$

$$\frac{dA\cdot E}{ds} = 10s$$

$$A \cdot E \text{ roots} = s = \pm j2$$

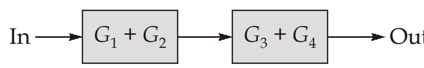
Two sign changes

$\therefore$ Number of $j\omega$-axis roots = 2

Number of left hand root = 1 (real)

20. (d)

Above system can be written as



$$\frac{\text{Out}}{\text{In}} = (G_1 + G_2)(G_3 + G_4)$$

21. (b)

$$\text{T.F.} = C[sI - A]^{-1} B$$

$$= \frac{[1 \;\; 2]\begin{bmatrix} s+1 & 1 \\ 5 & s \end{bmatrix}\begin{bmatrix} 1 \\ 2 \end{bmatrix}}{(s+1)\, s - 5} = \frac{5s+13}{s^2+s-5}$$

22. (d)

$$\sigma = \frac{0-4-4-(-8)}{4-1} = 0$$

$$\sigma = 0$$

23. (d)

$$\text{GM} = 40 \text{ dB}$$

$$40 = -20\log(K)$$

$$K = 0.01$$

$$\text{Gain doubled} = 0.02$$

$$\text{GM} = -20\log(0.02) = 34 \text{ dB}$$

24. (b)

$$\text{CLTF} = \frac{1}{s^2+1} = \frac{\omega_n^2}{s^2+2\xi\omega_n s+\omega_n^2}$$

$\therefore$ $\omega_n = 1 ;\quad \xi = 0$

$\therefore$ $M_p = e^{\frac{-\pi\xi}{\sqrt{1-\xi^2}}} \times 100 = 100\%$

25. (b)

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

$$\phi(t) = L^{-1}(sI - A)^{-1}$$

$$\phi(t) = \left[s\begin{bmatrix}1 & 0\\0 & 1\end{bmatrix} - \begin{bmatrix}0 & -1\\2 & 0\end{bmatrix}\right]^{-1} = \begin{bmatrix}s & 1\\-2 & s\end{bmatrix}^{-1}$$

$$\phi(t) = \begin{bmatrix}\frac{s}{s^2+2} & \frac{-1}{s^2+2}\\ \frac{2}{s^2+2} & \frac{s}{s^2+2}\end{bmatrix} = \begin{bmatrix}\cos\sqrt{2}t & -\frac{1}{\sqrt{2}}\sin\sqrt{2}t\\ \sqrt{2}\sin\sqrt{2}t & \cos\sqrt{2}t\end{bmatrix}$$

26. (c)

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

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

$|Q_C| = -1 + 2 = 1 \neq 0$ ∴ Controllable.

$$CA = [0 \quad 1]\begin{bmatrix}0 & -2\\1 & -2\end{bmatrix} = [1 \quad -2]$$

$$Q_0 = \begin{bmatrix}0 & 1\\1 & -2\end{bmatrix}$$

$$|Q_0| = -1 \neq 0$$

∴ Observable.

27. (d)

$$\text{T.F.} = \left(\frac{1+0.1s}{1+\alpha Ts}\right)$$

$$T = 0.1 \text{ sec}$$

$$\alpha T = 1$$

$$\alpha = 10$$

$$\omega_m = \frac{1}{T\sqrt{\alpha}} = \frac{1}{0.1\sqrt{10}} = \frac{10}{\sqrt{10}} = \sqrt{10} \text{ rad/sec}$$

28. (b)

$$\frac{Y(s)}{R(s)} = \frac{1}{12s^2+3s+24}$$

$$Y(s) = \frac{R(s)}{(12s^2+3s+24)}$$

$$Y(s) = \frac{1}{s(12s^2+3s+24)} \quad \left(\because R(s) = \frac{1}{s}\right)$$

Steady state value

$$y_{ss} = \lim_{s \to 0} sY(s) = \lim_{s \to 0} \frac{1 \times s}{s(12s^2 + 3s + 24)} = \frac{1}{24}$$

$$y_{ss} = \frac{1}{24}$$

29. (d)

The factors affecting the dielectric loss are:

1. Dielectric loss increases with the increase in frequency of applied voltage.
2. Dielectric loss increases with humidity.
3. Dielectric loss increases with temperature.
4. Dielectric loss increases with increase in voltage.

30. (a)

The primary function of a thermal insulator is to resist the flow of heat. Hence, low thermal conductivity is the most essential property.

Options (c) and (d) are desirable properties, but not defining ones, while (b) is incorrect because absorbing moisture reduces insulating ability.

31. (c)

The temperature dependence of H_c may be given by the following relation:

$$H_c(T) = H_c(0)\left[1 - \frac{T^2}{T_c^2}\right]$$

32. (b)

Critical value of the magnetic field,

$$H_c = 7900 \text{ A/m}$$

$$= \oint H \cdot dl = I_{\text{enc}}$$

$$I_c = 2\pi r H_c$$

$$= 2\pi \times 2 \times 10^{-3} \times 7900$$

$$I_c = 99.27 \text{ A}$$

33. (b)

Microphones convert sound vibrations into electrical signals. Piezoelectric materials generate an electric charge when mechanical pressure or vibration (sound waves) are applied. Hence, the transducers used in microphones are made of piezoelectric.

34. (c)

Orientational polarization occurs due to alignment of permanent dipoles. As temperature increases, thermal agitation increases and disturbs dipole alignment. Hence orientational polarization decreases with increase in temperature, i.e., it varies inversely with temperature.

35. (d)

The various tests which are carried out on transformer oil are

1. Moisture test
2. Acidity test
3. Sludge resistance test
4. Electric strength test

36. (c)

Given, $\chi_{m1} = 0.0085;$

$T_1 = -80°C,\ T_1 = 193\text{ K},\ T_2 = -180°C = 93\text{ K}$

We know that, for paramagnetic materials,

$$\chi_m \propto \frac{1}{T}$$

$$\therefore \quad \frac{\chi_{m1}}{\chi_{m2}} = \frac{T_2}{T_1}$$

$$\therefore \quad \chi_{m2} = \frac{T_1}{T_2} \times \chi_{m1} = \frac{193}{93} \times 0.0085$$

$$\therefore \quad \chi_{m2} = 0.017$$

37. (a)

We know that,

$$\text{polarization, } P = \epsilon_0(\epsilon_r - 1)E$$

Where, $\epsilon_r = 2.5;\ E = \dfrac{V}{d} = \dfrac{220}{0.5 \times 10^{-3}}$

$$\therefore \quad E = 4.4 \times 10^5\text{ V/m}$$

$$\epsilon_0 = 8.85 \times 10^{-12}\text{ C/V-m}$$

$$\therefore \quad \text{polarization, } P = 8.85 \times 10^{-12}(2.5 - 1) \times 4.4 \times 10^5$$

$$\therefore \quad P = 5.84 \times 10^{-6}\text{ C/m}^2$$

38. (c)

We know that,

the maximum dipole moment, $M_{max} = N \times m$

$$M_{max} = 8.65 \times 10^{10} \times 9.27 \times 10^{-24}$$

$$M_{max'} = 8 \times 10^{-13}\text{ Am}^2$$

$$\text{Volume} = (10^{-6})^3 = 10^{-18}\text{ m}^3$$

∴ Maximum magnetization of the domain,

$$= \frac{M_{max'}}{\text{Volume}} = \frac{8 \times 10^{-13}}{10^{-18}} = 8 \times 10^5\text{ A/m}$$

39. (b)

For synchronous motor

$$V = E + I_a R_a + I_a (X_l \pm X_a)$$
$$E = 1.0 - (1.0)(0.5) = 0.5 \text{ p.u.}$$

40. (a)

$$\text{Electrical input} = P_{\text{mech} \cdot \text{output}} + \text{Friction loss} + \text{Core loss}$$
$$= 9 + 2 + 0.8 = 11.8 \text{ kW}$$
$$\sqrt{3} V_L I_L \cos\phi = 11800$$
$$\sqrt{3} \times 400 \times I_L \times 0.8 = 11800$$
$$I_L = 21.29 \text{ A}$$

41. (a)

When excitation fails, the motor rotates at synchronous speed in the same direction due to reluctance torque, the motor operate at lagging power factor.

42. (d)

For series motor, $I_L = I_f = I_a$

But $\phi \propto I_f \propto I_a$

Developed torque in series motor

$$T \propto \phi \cdot I_a \propto I_a^2$$

∴ % Increased torque,

$$\frac{T_2 - T_1}{T_1} = \frac{I_{a_2}^2 - I_{a_1}^2}{I_{a_1}^2} = \frac{144 - 100}{100} \times 10 = 44\%$$

43. (c)

All that a squirrel cage motor requires is that the shunt bars in the motor be an odd number if the number of stator poles is even.

44. (b)

$$\phi_1 = \phi_2$$
$$\phi \propto I_{\text{sh}}$$
$$\frac{N_2}{N_1} = \frac{E_{b_2}}{E_{b_1}} \times \frac{I_{sh_1}}{I_{sh_2}}$$

∴ $$\phi_1 I_{a_1} = \phi_2 I_{a_2}$$

$$I_{a_2} = I_{a_1} \times \frac{\phi_1}{\phi_2} = \frac{1}{\frac{250}{R_t}} \times 20 = \frac{2R_t}{25}$$

$$E_{b_1} = 250 - (20 \times 0.5) = 240 \text{ V}$$

$$E_{b_2} = 250 - \left(\frac{2R_t}{25} \times 0.5\right)$$

$$\frac{1000}{800} = \frac{250 - (R_t/25)}{240} \times \frac{R_t}{250}$$

$$R_t = 315.97\ \Omega$$

External shunt resistance = 315.97 – 250

= 65.97 Ω

45. (a)

To eliminate n^{th} harmonic,

$$\text{Short pitch angle, } \alpha = \frac{180}{n}$$

$$\text{The coil span, } \beta = 180 - \alpha$$

$$= 180 - \frac{180}{n} = 180\left(1 - \frac{1}{n}\right)$$

$$= \frac{n-1}{n} \times \text{Full pitch}$$

46. (b)

Short circuit ratio of a synchronous machine is defined as the ratio of field current required to produce rated voltage on open circuit and field current required to produce rated armature current on short circuit.

47. (a)

$$\text{Inductive kick} = \frac{L.\dfrac{2I_a}{A}}{T_c}$$

Where, Number of parallel paths,

$$A = P = 6$$

and T_c = Commutation time

$$\text{Inductive kick} = \frac{(2 \times 10^{-3}).\dfrac{2 \times 6}{6}}{2 \times 10^{-3}} = 2\text{ V}$$

48. (b)

Load shared by transformer is

$$P_{(\text{shared})} \propto \frac{1}{\text{Reactance}}$$

Leakage reactance, $X_A > X_B$

So, $P_A < P_B$

49. (a)

$$\text{Power converted, } P = \left(\frac{ZP}{2\pi}\right)\phi\omega_m I_c$$

$$\text{Torque developed, } T = \left(\frac{ZP}{2\pi}\right)\phi I_c$$

These quantities depend on number of conductors and permissible conductor current.

50. (b)

Given, Starting current, $I_{sc} = 5\ I_{fl}$

Full load slip, $s_{fl} = 5\% = 0.05$

We know that, $$\frac{T_{st}}{T_{fl}} = x^2\left(\frac{I_{sc}}{I_{fl}}\right)^2 \times s_{fl}$$

$$1 = x^2\left(\frac{5I_{fl}}{I_{fl}}\right)^2 \times 0.05$$

$$x^2 = \frac{1}{25\times 0.05} = \frac{1}{1.25} = 0.8$$

$$x = 89.44\%$$

51. (a)

Given, $L = 0.3$ m,

$I = 10$ A,

$N = 10$

and $B = 0.6\ T$

Force due to single slot is,

$$F = NIBL = 10 \times 10 \times 0.6 \times 0.3$$

$$= 18 \text{ Newton}$$

Torque is, $$T = \frac{B_{av}I_a L\cdot Z_a D}{2} = \frac{24\times 10\times 10\times 0.6\times 0.1\times 0.3}{2} = 21.6 \text{ N-m}$$

52. (c)

Given, $$\frac{Z_{\text{HV}(\Omega)}I_{\text{HV(rated)}}}{V_{\text{HV(rated)}}} = 0.08$$

$$Z_{HV(\Omega)}\cdot I_{HV\ (\text{rated})} = 0.08\ \text{V}_{\text{HV (rated)}}$$

$$V_{SC} = 0.08 \times 2000 = 160 \text{ V}$$

53. (b)

FCFS is non pre-emptive algorithm.

54. (a)

Using FCFS:

A	C	B	D	E

0 6 10 12 18 21

Process Name	Arrival Time	Execution Time	TAT
A	0	6	6
B	5	2	7
C	3	4	7
D	7	6	11
E	10	3	11
			42/5 = 8.4

55. (d)

34 bit

opcode	Reg	Reg	Reg	12 bit Immediate
4 bit	6	6	6	12

One instruction size = 34 bit = 5 bytes

56. (c)

Size of instruction 24 bits

Starting address of the program is 300. The size of instruction is 3 byte long So the address is always the multiple of 3 byte next address is 600 it is also the next instruction of the program.

57. (b)

Convert hexadecimal to binary

$$(1\ AF)_{16} = (0001\ 1010\ 1111)_2$$
$$= 000\ 110\ 101\ 111$$
$$= (657)_8$$

58. (c)

The control unit (CU) manages and directs the flow of data and instructions between different parts of the computer.

59. (d)

RAM is volatile memory, meaning it loses all stored data when power is turned off.

60. (c)

When time quantum used in round robin scheduling is more then maximum time required to execute any process, then it behave like first come first serve.

62. (d)

$$\text{Page size} = 8 \text{ kB} = 2^{13} = 13 \text{ bit offset}$$
$$\text{Number of frame bits} = 32 - 13 = 19 \text{ bits}$$
$$\text{Page table entry} = \text{Valid} + \text{dirty} + \text{permission bits} + \text{translation (frame bits)}$$
$$= 1 + 1 + 3 + 19$$
$$= 24 \text{ bits}$$

$$\text{Page table size} = 24 \text{ MB}$$

$$\text{Number of pages} = \frac{24\,\text{MB}}{24\,\text{bits}} = 8\text{ M} = 2^{23}\text{ pages}$$

∴ 23 bits needed for page and 13 bit offset

length of virtual address = 23 + 13 = 36 bits

63. (c)

The flux linkages due to internal flux is independent of the size of the conductor.

64. (d)

Surge impedance of a line is given by $\sqrt{\frac{L}{C}}$. Since by bundling, the self GMD is increased, the inductance is reduced and capacitance increased. As a result the surge impedance is reduced.

65. (b)

In practical power cables the loading is less than surge impedance loading.

66. (c)

$$\frac{\%\ V_{\text{REG}}\ (\text{lead})}{\%\ V_{\text{REG}}\ (\text{lag})} = \frac{R\cos\phi_R - X_L\sin\phi_R}{R\cos\phi_R + X_L\sin\phi_R}$$

$$\frac{\%\ V_{\text{REG}}\ (\text{lead})}{10} = \frac{(2\times 0.6)-(6\times 0.8)}{(2\times 0.8)+(6\times 0.6)}$$

$$\%\,V_{\text{REG (lead)}} = -6.92\%$$

67. (d)

The general size of Jacobian

$(2n - p) - m - 1 \times (2n - p - m - 1)$

Here, $n = 50$, $p = 5$,

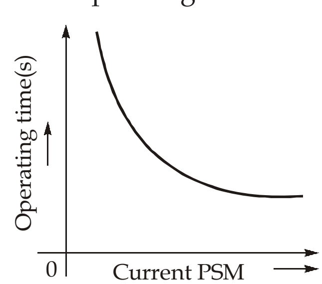
$m = 10 + 1 = 11$

$= (2 + 50 - 5) - (10 + 1) - 1 \times (2 + 50 - 5) - (10 + 1) - 1$

$= 83 \times 83$

68. (b)

IDMT relay gives an inverse time characteristic at lower value of operating current and definite time characteristic at higher value of the operating current.



69. (b)

For a fault at F_1, the voltage drop from A to F_1

$$= (500 \times 30) + (500 + 200)75 = 67500 \text{ V}$$

The impedance seen by the relay at A

$$= \frac{67500}{500} = 135\ \Omega$$

70. (c)

$$Z_{\text{pu new}} = Z_{\text{pu old}}\left(\frac{\text{MVA}_{\text{base new}}}{\text{MVA}_{\text{base old}}}\right)\left(\frac{\text{KV}_{\text{base old}}}{\text{KV}_{\text{base new}}}\right)^2$$

$$= 0.2\left(\frac{50}{30}\right)\left(\frac{13.2}{13.8}\right)^2 = 0.305 \text{ p.u.}$$

71. (a)

Complex power for the given three load are

$$S_1 = P_1 + jQ_1 = 10 + j0$$

$$S_2 = 10\angle\cos^{-1} 0.9 = 9 + j4.359$$

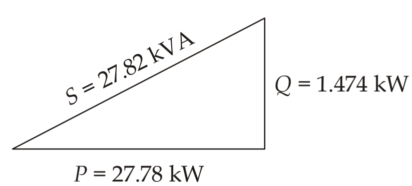
$$S_3 = \frac{10 \times 0.746}{0.85 \times 0.95}\angle -\cos^{-1} 0.95 = 8.776 - j2.885$$

Total power supplied by the source

$$S_T = S_1 + S_2 + S_3 = 27.78 + j1.474$$

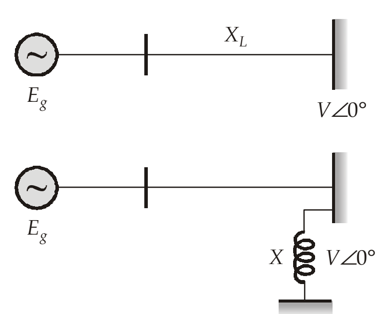
Real power, $P = \text{Re}(S_T) = 27.78$ kW

Reactive power, $Q = \text{Im}(S_T) = 1.474$ kVAR



Hence option (a) is correct.

72. (c)



As the line reactance connecting the infinite bus and the generator remains unaffected after connecting the shunt reactor at the infinite bus therefore, the stability limit $\left(\dfrac{V_{Eg}}{X_L}\right)$ remains constant.

73. (c)

In line to line fault

$$I_1 = -I_2$$

and $$I_0 = 0$$

$$|I_f| = \sqrt{3}\, I_1$$

$$|I_f| = \sqrt{3}\, I_2 = \sqrt{3}\times 2$$

$$= 3.464 \text{ p.u.} \approx 3.46 \text{ p.u.}$$

74. (a)

STATCOM has ability to maintain full capacitive output current at low system voltage. It is more effective than SVC in improving transient stability.

75. (d)

Wavelength, $$\lambda = \frac{2\pi}{\beta} \Rightarrow \lambda = \frac{2\pi}{0.00127}\text{ km}$$

$\Rightarrow$ $$\lambda = 4947.39 \text{ km}$$

$$\text{Ratio} = \frac{\text{Line length}}{\text{Wave length}}$$

$\Rightarrow$ $$\text{Ratio} = 0.12127 \text{ or } 12.127\%$$

76. (d)

$$y_{10} = Y_{11} - y_{12} - y_{13} - y_{14} = -0.5 \quad (\therefore \text{ Shunt element is present})$$

$$y_{20} = Y_{22} - y_{12} - y_{23} - y_{24} = -0.5 \quad (\therefore \text{ Shunt element is present})$$

$$y_{30} = Y_{33} - y_{13} - y_{23} - y_{43} = -2 \quad (\therefore \text{ Shunt element is present})$$

$$y_{40} = Y_{44} - y_{14} - y_{24} - y_{34} = 0$$

$\therefore$ Only bus 4 is not having shunt element.

77. (b)

Since relatively same amount of change occurs in I_C and I_E due to base width modulation. Thus the output curve of the transistor does not change much.

78. (c)

Given, $$I_{DSS} = 10 \text{ mA}$$

$$V_{GS(OFF)} = -5 \text{ V}$$

$$g_{mo} = 4 \text{ mS}$$

But, transconductance, $$g_m = g_{mo}\left[1 - \frac{V_{GS}}{V_{GS(OFF)}}\right]$$

$$1 \times 10^{-3} = 4\times10^{-3}\left[1-\frac{V_{GS}}{-5}\right]$$

$$1+\frac{V_{GS}}{5} = 0.25$$

$$\frac{V_{GS}}{5} = -0.75$$

$$V_{GS} = -3.75 \text{ V}$$

79. (a)

Given, drain current, $I_D = 5$ mA

Gate to source voltage, $V_{GS} = 5.5$ V

Threshold voltage, $V_T = 0.5$ V

Since, the MOSFET is operated in saturation region,

$$I_D = \frac{1}{2}\frac{\mu_n C_{ox} W}{L}(V_{GS}-V_T)^2$$

$$5 \times 10^{-3} = k_n(5.5-0.5)^2$$

$$\therefore \quad k_n = 2 \times 10^{-4} \text{ A/V}^2 = 0.2 \text{ mA/V}^2$$

80. (a)

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

$$= \beta I_B + I_{CEO}$$

now, $$\beta + 1 = \frac{I_{CEO}}{I_{CBO}} = \frac{0.6\times10^{-3}}{3\times10^{-6}} = 200$$

$$\therefore \quad \beta = 199$$

$$\therefore \quad I_C = 199(10\ \mu\text{A}) + 0.6 \text{ mA}$$

$$= (1.99 + 0.6) \text{ mA}$$

$$= 2.59 \text{ mA}$$

81. (a)

$$10.7 = 0.7 + I_B R_B$$

$$I_B = \frac{10}{100\text{k}} = 0.1 \text{ mA}$$

$$I_C = \beta I_B = 100 \times 0.1 \text{ mA} = 10 \text{ mA}$$

$$I_C R_C = V_0$$

$$R_C = \frac{V_0}{I_C} = \frac{5\times10^3}{10}$$

$$R_C = 500\ \Omega$$

82. (d)

$$x_{FM}(t) = A_c \sum_{n=-\infty}^{\infty} J_n(\beta)\cos(\omega_c + n\omega_m)t$$

$$\text{B.W.} = 2\,\omega_m$$

$$\Delta\omega = 3 \times \text{BW} = 6\,\omega_m$$

$$\beta = \frac{\Delta\omega}{\omega_m} = 6$$

$$\omega_c + n\omega_m = 2\pi \times 1008 \times 10^3 \text{ (given)}$$

$\therefore$ $$2\pi \times 10^6 + n \cdot 4\pi \times 10^3 = 2\pi \times 1008 \times 10^3$$

$\therefore$ $$n = 4$$

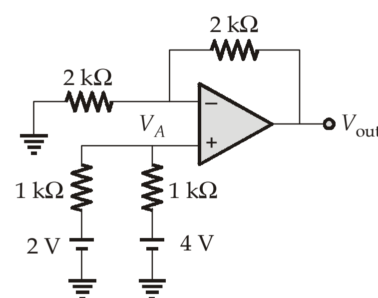
$\therefore$ Bessel coefficient $5J_4(6)$.

83. (a)

The feedback element (R_F) is directly connected to both input and output. So, voltage-shunt type of feedback.

84. (a)

$\because$ The op-amp is ideal, then the voltage V_A is equal to



$$\frac{V_A - 2}{1\,\text{k}\Omega} + \frac{V_A - 4}{1\,\text{k}\Omega} = 0$$

$$V_A = 3\text{ V}$$

$\therefore$ $$V_{out} = \left(1 + \frac{R_f}{R}\right)V_A$$

$$= \left(1 + \frac{2}{2}\right) \times 3 = 2 \times 3 = 6\text{ V}$$

85. (a)

From the circuit, $$I_{BQ} = 10\ \mu\text{A}$$

$\therefore$ $$I_{CQ} = \beta_{dc}\, I_{BQ} = 100[10\ \mu]$$

$$= 1\text{ mA}$$

Hence by applying KVL at output,

$$V_{CE} = V_{CC} - I_C R_C$$

$$= 2.5 - 1 \times 10^{-3} \times 1\text{ K} = 1.5\text{ V}$$

$\therefore$ $$I_{CQ} = 1\text{ mA},$$

$$V_{CEQ} = 1.5\text{ V}$$

86. (d)

$$I_S = I_Z + I_L$$

$$I_{Z\,min} = I_S - I_{L\,max}$$

$$I_S = 200 \text{ mA}$$

$$16 \text{ V} - I_S R_S - 12 \text{ V} = 0$$

$$\therefore \quad R_S = \frac{4}{I_S} = \frac{4}{200 \text{ mA}} = 20\ \Omega$$

$$I_{Z\,max} = I_S - I_{L\,min} = 200 \text{ mA}$$

$$\therefore \quad P_{Z\,max} = 12 \times 200 \text{ mA} = 2.4 \text{ W}$$

87. (d)

- Since shunt or node sampling is implemented at the output section, the output signal in the circuit is voltage V_0.
- Since shunt or node mixing is implement at the section, the input signal in the circuit is current I_1.
- As input signal is current and output signal is voltage in the amplifiers it is a trans-resistance or trans-impedance amplifiers.

88. (a)

- Hartley oscillator uses two inductors and one capacitor in its feedback path and is suitable for oscillations in RF range.
- Wien-bridge oscillator produce oscillations in low frequency (or AF) range but is buffers frequency instability.
- Crystal oscillator that uses a good quality crystal with high quality factor (Q), produce RF oscillations with high frequency stability.

89. (a)

Given, Step size = 0.5 V

For a DAC, step size corresponds to the output pertaining to the LSB i.e., DCBA = 0001

Also for DAC, Step size = Resolution

∴ Output voltage, V_0 = Resolution × Decimal equivalent = 0.5 × 1 = 0.5 V

by nodal at non-inverting terminal,

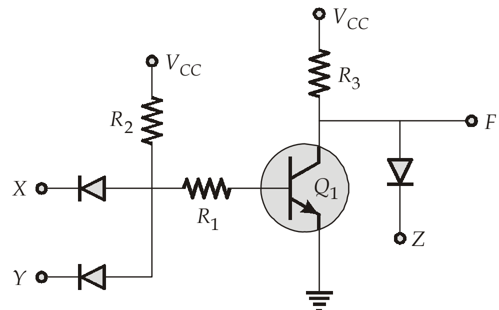
$$\frac{0-5}{8\text{ k}\Omega} + \frac{0-V_o}{R_F} = 0$$

$$-\frac{5}{8\text{ k}\Omega} = \frac{0.5}{R_F}$$

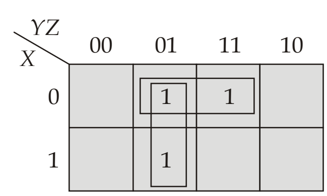
$$\therefore \quad |R_F| = 800\ \Omega$$

90. (a)

Transistor Q_1 will be ON when diodes D_1 and D_2 are OFF i.e., $X = 1$ and $Y = 1$. The truth table for the circuit can be written as below:



X	Y	Z	Transistor Q_1	F
0	0	0	OFF	0
0	0	1	OFF	1
0	1	0	OFF	0
0	1	1	OFF	1
1	0	0	OFF	0
1	0	1	OFF	1
1	1	0	ON	0
1	1	1	ON	0



$\therefore$ $$F = \bar{X}Z + \bar{Y}Z = Z(\bar{X} + \bar{Y}) = \overline{XY}\,Z$$

91. (a)

The output function, $F = \bar{S}_1\bar{S}_0\, I_0 + \bar{S}_1 S_0\, I_1 + S_1\bar{S}_0\, I_2 + S_1\, S_0\, I_3$

Given, $I_0 = I_3 = 1\ ;\quad I_2 = 0$

I_1 = Difference = $X \oplus Y$

S_1 = Barrow = $\bar{X}y$

$S_0 = 1$

$\therefore$ $$F = \overline{\bar{X}Y}\,(0)\,(1) + \overline{\bar{X}Y}\,(1)\,(X \oplus Y) + \bar{X}Y(0) + \bar{X}Y\,(1)\,(1)$$

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

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

$$F = X \oplus Y$$

93. (c)

Clock	Q_1	Q_0	$J_1 = Q_0$	$K_1 = Q_0$	$D_0 = \bar{Q}_1$
Initially →	0	1	1	1	1
1	1	1	1	1	0
2	0	0	0	0	1
3	0	1	1	1	1
4	1	1			

∵ The sequence produced is 101110 ....

94. (b)

Odd address word needs two cycles. Both banks are accessed only for even addressed word.

96. (b)

$$(\text{FOM})_{\text{AM}} = \frac{\mu^2}{2+\mu^2}$$

$$\text{For } \mu = 1, (\text{FOM})_{\text{AM}} = \frac{1}{3}$$

$$(\text{FOM})_{\text{DSB-SC}} = 1$$

$$(\text{FOM})_{\text{SSB-SC}} = 1$$

Since $(\text{FOM})_{\text{AM}} < 1$, therefore noise performance of AM receiver is always inferior to DSB-SC.

98. (d)

The transmission efficiency of a standard AM signal can be given as,

$$\eta = \frac{k_a^2 P_m}{1+k_a^2 P_m} \times 100$$

Where, k_a = amplitude sensitivity = 2 V^{-1}

P_m = average power of message signal = 6 W

So, $$\eta = \frac{24}{1+24} \times 100 = 96\%$$

99. (c)

From FM signal,

$$f_i = f_c + k_f m(t)$$

$$\theta_i = 2\pi f_c t + 2\pi k_f \int_{-\infty}^{t} m(t)\,dt$$

Maximum phase deviation,

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

$$\left|\int_{-\infty}^{t} m(t)\,dt\right|_{max} = \text{Area under } m(t)$$

$$= 5 \times 10^{-3} \times 2 \text{ V-sec} = 10 \times 10^{-3} \text{ V-sec}$$

So, $$\Delta\phi_{max} = 2\pi \times 2.5 \times 10^{3} \times 10 \times 10^{-3} \text{ rad}$$

$$= 50\pi \text{ rad}$$

101. (c)

The noise figure of any multistage circuit is mainly controlled by its first stage. RF amplifier is at the first stage in a superheterodyne receiver.

102. (c)

Expression for voltage across diode is,

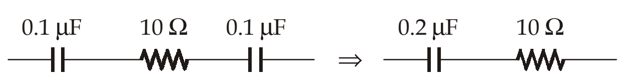
$$v_d = V_m(-1 + \sin \omega t)$$

Therefore, RMS value is $V_m\sqrt{\frac{3}{2}} = 230\sqrt{2} \times 1.225 = 398.45 \text{ V}$

103. (c)

In CSI, let T_3, T_4 are already conducting at $t = 0$.

At triggering of T_1, T_2 thyristor pair T_3, T_4 is forced commutated, again at $t = (T/2)$, T_1, T_2 are forced commutated, This completes a cycle.

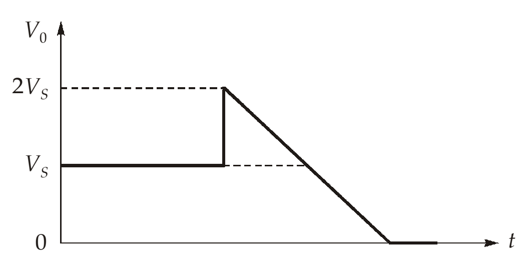


$$\text{Time constant } \tau = \text{RC} = 10 \times 0.2\,\mu = 2\,\mu\text{sec}$$

∴ Lowest possible operating frequency $= \frac{1}{\tau} = \frac{1}{2\mu} = 500 \text{ kHz}$

104. (b)

The load voltage waveform of voltage commutated chopper is



105. (b)

$$V_{Rn} = \frac{2Vs}{n\pi} \cdot \cos\left(\frac{n\pi}{6}\right) \cdot \sin\left[n\left(\omega t + \frac{\pi}{6}\right)\right]$$

$$V_{R1,\text{ rms}} = \frac{\sqrt{2}V_s}{\pi}\cos\left(\frac{\pi}{6}\right) = 312$$

$$Vs = 800.3 \text{ Volt}$$

$$V_{RY1,\ ms} = \frac{3Vs}{\sqrt{2}\pi} = 540.4 \text{ volt}$$

106. (b)

Reference wave

$\Rightarrow$ $V_r = 1$ V; $f = 50$ Hz (Inverter output-frequency)

Carrier wave

$\Rightarrow$ $V_c = 3$ V; $f_c = 1$ kHz

Number of pulses per half cycle

$$= N = \frac{f_c}{2f} = \frac{1\times10^3}{2\times50} = 10$$

$$\text{Modulation index} = \frac{V_r}{V_c} = \frac{1}{3}$$

$$\text{Total pulse width} = \pi\left(1-\frac{V_r}{V_c}\right) = \pi\left(1-\frac{1}{3}\right) = \frac{2\pi}{3} = 120°$$

$$\text{Each pulse width} = \frac{2d}{N} = \frac{120°}{10} = 12°$$

107. (d)

It takes 4 time constant to charge or discharge the capacitor. Therefore it limits the maximum frequency to

$$f_{max} = \frac{1}{4RC} = \frac{1}{4\times100\times25\times10^{-6}} = 100 \text{ Hz}$$

108. (c)

$$\text{Capacitor voltage, } v_c = \frac{1}{C}\int i_c dt$$

- When switch *CH* is on, i_c is constant current I_0, therefore v_c is linear function.
- When switch *CH* is off, i_c is changing linearly, therefore v_c is parabolic function.

109. (b)

Instantaneous peak power loss is given by,

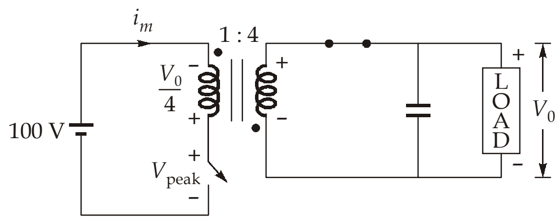
$$= v_c(t) \times i_c(t)$$

$$= \frac{V_{cs}I_{cs}}{4} = \frac{200\times90}{4}$$

Peak power loss = 4500 W

110. (d)

When switch S is in off state and diode D is in on state.



Applying KVL in input loop, we get

$$-100 - \frac{V_0}{4} + V_{peak} = 0$$

$$V_{peak} = \frac{V_0}{4} + 100 \quad \text{...(i)}$$

And, this converter is fly back converter

$$V_0 = \frac{N_2}{N_1} \times \left(\frac{\alpha}{1-\alpha}\right) V_s$$

$$= 4 \times \left(\frac{\frac{2}{3}}{1-\frac{2}{3}}\right) \times 100 = 4 \times \left(\frac{2}{3} \times \frac{3}{1} \times 100\right)$$

$$V_0 = 800 \text{ V}$$

From equation (i),

$$V_{peak} = \frac{800}{4} + 100 = 300 \text{ V}$$

111. (c)

Relationship between fundamental displacement factor and power factor is

$$PF = g \,.\, FDF$$

$$\frac{PF}{FDF} = g$$

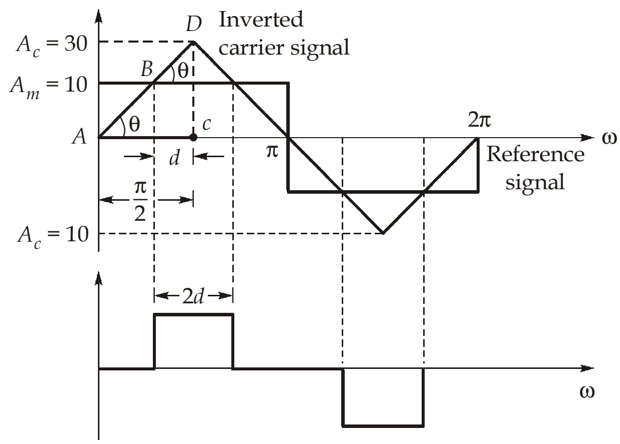
For distortion factor (g) < 1

$$\frac{PF}{FDF} < 1$$

$$\text{PF} < \text{FDF}$$

112. (b)

Reference signal is modulated with inverted carrier signal as



From similar triangle ΔADC and ΔBDE

$$\tan\theta = \frac{A_c}{\frac{\pi}{2}} = \frac{A_c - A_m}{d}$$

Pulse width,
$$2d = \left(1 - \frac{A_m}{A_c}\right)\pi$$

$$2d = \left(1 - \frac{10}{30}\right)\pi$$

$$2d = \frac{2\pi}{3}\text{rad} = 120°$$

113. (b)

$$C = \frac{0.41 \times L_P}{R_{se}^2} = \frac{0.41 \times 80 \times 10^{-3}}{(360)^2} = 0.253\ \mu\text{F}$$

114. (b)

Energy consumed by load (True value) $= \dfrac{250 \times 15 \times 1 \times 5}{1000} = 18.75\text{ kWh}$

Consumption shown by meter = 8253.1 – 8234.21 = 18.92 kWh

$$\text{Error} = \left(\frac{18.92 - 18.75}{18.75}\right) \times 100 = +0.906\% \approx +0.91\%$$

115. (d)

$$I_m = 120\text{ A}, \quad I_C = 30\text{ A}$$

Nominal ratio,
$$K_n = \frac{1000}{5} = 200\text{ a}$$

$\therefore$ % Ratio error $= \dfrac{K_n - R}{R} \times 100$

Transformation ratio, $R = n + \dfrac{I_o \sin(\alpha + \delta)}{I_s} = n + \dfrac{I_o \sin\alpha}{I_s} = n + \dfrac{I_c}{I_s}$

$= 200 + \dfrac{30}{5} = 206$

$\therefore$ % Ratio error $= \dfrac{200 - 206}{206} \times 100 = -2.9\%$

116. (b)

Given,deflecting torque, $T_d \propto \quad \theta \propto I^2$

$$T_d \propto \theta$$

$$\theta \propto I^2$$

$$\frac{\theta_1}{\theta_2} = \frac{I_1^2}{I_2^2}$$

$$\frac{60^\circ}{x^\circ} = \frac{(4)^2}{(6)^2}$$

$$x = \frac{60^\circ \times 36}{16} = 135^\circ$$

117. (c)

We know that deflecting torque,

$$T_d = \frac{1}{2} I^2 \frac{dL}{d\theta} \text{ N-m} \qquad \text{...(i)}$$

Control spring constant = 5×10^{-7} N-m/degree

Maximum deflection torque, = $K\theta = 5 \times 10^{-7} \times 120^\circ = 6 \times 10^{-5}$ N-m

$$\frac{dL}{d\theta} = 4 \ \mu\text{H/degree} = 4 \times 10^{-6} \text{ H/degree}$$

Using equation (i), we get

$$6 \times 10^{-5} = \frac{1}{2} I^2 \times (4 \times 10^{-6}) \text{ H/degree}$$

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

$\Rightarrow$ Current, $I = \sqrt{30} = 5.48$ A

118. (c)

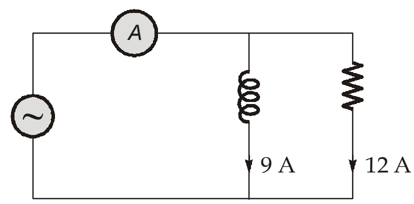
Total energy consumption = $220 \times 6 \times 1 \times 8$

$$E = (VI \cos\phi) \times t$$

$$\text{Energy meter constant} = \frac{\text{Total no. of revolution}}{\text{Total energy consumption}}$$

$$= \frac{3300 \times 1000}{220 \times 48 \times 1} = 312.5 \text{ rev/kWhr}$$

119. (c)



$$\bar{I}_R = \frac{V}{R}$$

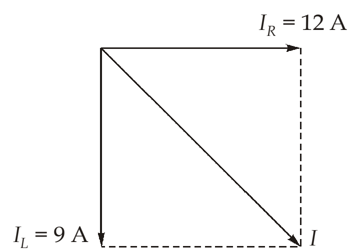
$$\bar{I}_L = \frac{V}{j\omega L}$$

$$\text{Total current, } \bar{I} = \bar{I}_R + \bar{I}_L$$

$$|I| = \sqrt{(9)^2 + (12)^2}$$

$$= \sqrt{81 + 144} = \sqrt{225}$$

$$= 15 \text{ A}$$



120. (b)

Under balance condition,

$$\left(R_1 \parallel \frac{1}{j\omega C_1}\right)(R_4 + j\omega L_4) = R_2 R_3$$

$$\frac{R_1}{j\omega R_1 C_1 + 1}(R_4 + j\omega L_4) = R_2 R_3$$

$$R_1 R_4 + j\omega R_1 L_4 = R_2 R_3 + j\omega R_1 C_1 R_2 R_3$$

Comparing real and imaginary terms

$$R_1 R_4 = R_2 R_3$$

and $$R_1 L_4 = R_1 C_1 R_2 R_3$$

$$L_4 = C_1 R_2 R_3$$

So, $$L_4 = L$$

$$L = C_1 R_2 R_3$$

$$= 0.4 \times 10^{-6} \times 100 \times 200$$

$$= 8 \text{ mH}$$

121. (c)

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

$$\frac{f_y}{50} = \frac{3}{2}$$

$$f_y = \frac{3}{2} \times 50 = 75 \text{ Hz}$$

122. (d)

$$\text{Sensitivity of LVDT} = \frac{\text{Output}}{\text{Input}} = \frac{8 \text{ V}}{4 \text{ mm}} = 2 \text{ V/mm}$$

Minimum voltage that can be read by voltmeter

$$= 10 \times \frac{1}{100} \times \frac{2}{10} = 20 \text{ mV}$$

Minimum displacement that can be read by this voltmeter

$$= \frac{20 \text{ mV}}{2 \text{ V/mm}} = 10 \text{ µm}$$

123. (a)

$$y(t) = e^{x^2(t)}$$

If $x(t)$ is finite $x^2(t)$ is also finite.

$$y(t) = e^{\text{finite}} = \text{finite}$$

So, given system is generating finite output for finite input.

So, it is stable system.

Present output depends on present input so given system is causal.

124. (d)

$\omega_1 = 4, \omega_2 = 3\pi$

$$T_1 = \frac{2\pi}{\omega_2} = \frac{2\pi}{3\pi} = \frac{2}{3}$$

$$\frac{T_1}{T_2} = \frac{\pi/2}{2/3} = \frac{3\pi}{4}$$

It is a irrational number. So, the given signal is not a periodic signal.

125. (b)

Given $$X(\omega) = |X(\omega)| e^{j\angle X(\omega)}$$

$$= Ae^{-j\frac{\pi}{2}} \quad 0 < \omega < \omega_0$$

$$= Ae^{j\frac{\pi}{2}} \quad -\omega_0 < \omega < 0$$

$$x(t) = \frac{1}{2\pi}\int_{-\omega_0}^{\omega_0} X(\omega)e^{j\omega t}d\omega$$

$$= \frac{1}{2\pi}\left[\int_{-\omega_0}^{0} Ae^{j\frac{\pi}{2}}e^{j\omega t}d\omega + \int_{0}^{\omega_0} Ae^{-j\frac{\pi}{2}}e^{j\omega t}d\omega\right]$$

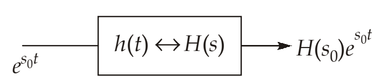
$$= \frac{A}{2\pi}\left[\int_{0}^{\omega_0} je^{-j\omega t}d\omega + \int_{0}^{\omega_0} -je^{j\omega t}d\omega\right] = \frac{A}{2\pi}j\left[\frac{e^{-j\omega t}}{-jt} - \frac{e^{j\omega t}}{jt}\right]\Bigg|_0^{\omega_0}$$

$$= -\frac{A}{2\pi t}\left[e^{-j\omega_0 t} - 1 + e^{j\omega_0 t} - 1\right] = -\frac{A}{2\pi t}\left[-2 + e^{j\omega_0 t} + e^{-j\omega_0 t}\right]$$

$$x(t) = \frac{A}{\pi t}[1 - \cos\omega_0 t]$$

126. (a)

For an LTI system



$$e^{2t} \longrightarrow \frac{1}{2}e^{2t} \quad \therefore \quad H(2) = \frac{1}{2}$$

From 2[nd] information taking Laplace transform on both sides

$$sH(s) + 2H(s) = \frac{1}{s+4} + \frac{k}{s}$$

$$H(s) = \frac{(1+k)s + 4k}{(s+2)(s+4)s}$$

$$H(2) = \frac{1}{2}$$

$$\therefore \quad \frac{1}{2} = \frac{(1+k)2 + 4k}{4.6.2}$$

$$24 = 2 + 2k + 4k$$

$$22 = 6k$$

$$k = \frac{11}{3}$$

127. (b)

Let $y(t) = [1 - e^{-t}]u(t)$

Then $x(t) = \frac{1}{t}y(t)$

$$\therefore \quad X(s) = \int_s^{\infty} Y(s)ds \quad \text{[frequency integration property]}$$

$$Y(s) = \frac{1}{s} - \frac{1}{s+1}$$

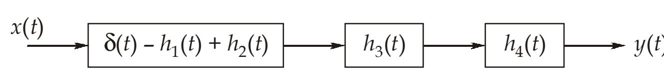
$$\therefore \quad X(s) = \int_s^{\infty} \frac{1}{s}ds - \int_s^{\infty} \frac{1}{s+1}ds$$

$$X(s) = \ln\left(\frac{s}{s+1}\right)\Bigg|_s^{\infty}$$

$$\therefore \quad X(s) = \ln(1) - \ln\left[\frac{s}{s+1}\right] = -\ln\left[\frac{s}{s+1}\right]$$

$$\therefore \quad X(1) = -\ln\left[\frac{1}{2}\right] = 0.693$$

128. **(c)**



$$h(t) = \{\delta(t) - h_1(t) + h_2(t)\} * h_3(t) * h_4(t)$$

129. **(c)**

$$\omega = 320\pi,\ T_s = \frac{1}{f_s} = \frac{1}{100}$$

$$\Omega = \omega T_s = \frac{320\pi}{100} = \frac{16\pi}{5}$$

$$N = \left(\frac{2\pi}{\Omega}\right)k = \left(\frac{2\pi}{\frac{16\pi}{5}}\right)k = \left(\frac{10}{16}\right)k = \frac{5}{8}k$$

$$\therefore \quad N = 5$$

130. **(c)**

$$y(t) = Ax(Bt + C)$$

where A, B, C are constants

If $x(t)$ energy is 'E' then $y(t)$ energy is $\frac{A^2}{|B|}E$

$$y(t) = 4x\left(\frac{-t}{3} - 2\right) A = 4;\ B = -\frac{1}{3}$$

$$E_{y(t)} = \frac{16}{\left|\frac{-1}{3}\right|}E = 48E$$

131. (a)

$$2t^2\,\delta(t-2) = 2 \times (2)^2\,\delta(t-2) = 8\,\delta(t-2)$$

132. (c)

Both statements are correct.

133. (a)

The wave form shown in figure has odd symmetry as well as half wave symmetry because

$$x(t) = -x(-t)$$

and also $$x(t) = -x\left[t \pm \frac{T}{2}\right]$$

∴ $$a_0 = 0,$$
$$a_n = 0$$

and $$b_n = \frac{8}{T}\int_0^{T/4} x(t)\sin n\,\omega_0 t\,dt$$

Now, $$b_n = \frac{8}{2\pi}\int_0^{T/4} A\sin nt\,dt = \frac{4A}{\pi}\left[\frac{-\cos nt}{n}\right]_0^{\pi/2}$$

$$= \frac{-4A}{n\pi}\left[\cos\left(\frac{n\pi}{2}\right) - \cos 0\right]$$

$$b_n = \begin{cases} \dfrac{4A}{n\pi} & \text{When } n \text{ is odd} \\ 0 & \text{When } n \text{ is even} \end{cases}$$

⇒ $$x(t) = \frac{4A}{\pi}\sin t + \frac{4A}{3\pi}\sin 3t + \frac{4A}{5\pi}\sin 5t + \ldots$$

134. (d)

Since the signal is a periodic signal thus the energy of the signal = ∞.

135. (a)

Given, $$A = \begin{bmatrix} 0 & 2\beta & \gamma \\ \alpha & \beta & -\gamma \\ \alpha & -\beta & \gamma \end{bmatrix}$$

then, $$A^T = \begin{bmatrix} 0 & \alpha & \alpha \\ 2\beta & \beta & -\beta \\ \gamma & -\gamma & \gamma \end{bmatrix}$$

Given that A is orthogonal is:

$$A \cdot A^T = I$$

$$\Rightarrow \begin{bmatrix} 0 & 2\beta & \gamma \\ \alpha & \beta & -\gamma \\ \alpha & -\beta & \gamma \end{bmatrix}\begin{bmatrix} 0 & \alpha & \alpha \\ 2\beta & \beta & -\beta \\ \gamma & -\gamma & \gamma \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

$$\Rightarrow \begin{bmatrix} 4\beta^2+\gamma^2 & 2\beta^2-\gamma^2 & -2\beta^2+\gamma^2 \\ 2\beta^2-\gamma^2 & \alpha^2+\beta^2+\gamma^2 & \alpha^2-\beta^2-\gamma^2 \\ -2\beta^2+\gamma^2 & \alpha^2-\beta^2-\gamma^2 & \alpha^2+\beta^2+\gamma^2 \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

Equating the corresponding elements, we have

$$4\beta^2 + \gamma^2 = 1 \quad \text{...(i)}$$

$$2\beta^2 - \gamma^2 = 0 \quad \text{...(ii)}$$

$$\alpha^2 + \beta^2 + \gamma^2 = 1 \quad \text{...(iii)}$$

from (i) and (ii),

$$6\beta^2 = 1$$

$$\therefore \quad \beta^2 = \frac{1}{6}$$

$$\Rightarrow \quad \beta = \pm\frac{1}{\sqrt{6}}$$

$$\gamma^2 = 2\beta^2 = 2\times\frac{1}{6} = \frac{1}{3}$$

$$\gamma = \frac{1}{\sqrt{3}}$$

$$\alpha^2 = 1-\frac{1}{6}-\frac{1}{3} = \frac{1}{2}$$

$$\Rightarrow \quad \alpha = \pm\frac{1}{\sqrt{2}}$$

136. (d)

Let,
$$f(x) = \log\left(\frac{2-x}{2+x}\right)$$

$$f(-x) = \log\left(\frac{2+x}{2-x}\right) = \log\left(\frac{2-x}{2+x}\right)^{-1}$$

$$= -\log\left(\frac{2-x}{2+x}\right)$$

$$f(-x) = -\log\left(\frac{2-x}{2+x}\right) = -f(x)$$

i.e. $f(x)$ is odd function.

So,
$$\int_{-1}^{1} f(x)\,dx = \int_{-1}^{1} \log\left(\frac{2-x}{2+x}\right)dx = 0$$

$$\therefore \quad \int_{-a}^{a} f(x)\,dx = \begin{cases} 0, & \text{if } f(x) \text{ is odd} \\ 2\int_{0}^{a} f(x),dx & \text{if } f(x) \text{ is even} \end{cases}$$

137. (c)

$$x^2\frac{d^2y}{dx^2} + x\frac{dy}{dx} - y = 0$$

Let $x = e^z \leftrightarrow z = \log x$

$$x\frac{d}{dx} = xD = \theta = \frac{d}{dz}$$

$$x^2 D^2 = \theta(\theta - 1)$$

$$(x^2D^2 + xD - 1)y = 0$$

$$[\theta(\theta - 1) + \theta - 1]y = 0$$

$$(\theta^2 - \theta + \theta - 1)y = 0$$

$$(\theta^2 - 1)y = 0$$

Auxiliary equation is $m^2 - 1 = 0$

$$m = \pm 1$$

CF is $c_1e^{-z} + c_2e^z$

Solution is $y = c_1e^{-z} + c_2e^z$

$$= c_1x^{-1} + c_2x$$

$$= c_1\frac{1}{x} + c_2x$$

One independent solution is $\frac{1}{x}$.

Another independent solution is x.

138. (a)

$$\int_{-\infty}^{\infty} \frac{\sin x}{x^2 + 2x + 2}dx\,,\ I = \int_{-\infty}^{\infty} \frac{\sin z\,dz}{z^2 + 2z + 2}$$

$$\sin z = \text{imaginary part of } e^{iz}$$

$$= \int_{-\infty}^{\infty} \frac{\text{I.P of } e^{iz}}{z^2 + 2z + 2}dz$$

Poles are, $z^2 + 2z + 2 = 0$

$$z = \frac{-2 \pm \sqrt{4-8}}{2} = \frac{-2 \pm 2i}{2}$$

By Jordan's theorem, $z = -1 \pm i$

$z = -1 - i$
↓
Outside upper half
↓
Residue is 0
$-1 + i$
↓
Inside upper half

Res $\phi(z)$, $z = -1 + i$

$$= \lim_{z \to -1+i} (z-(-1+i)) \frac{e^{iz}}{(z-(-1+i1))(z-(-1-i))}$$

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

$$I = \text{I.P. of } 2\pi i\left(\frac{e^{-i-1}}{2i}\right) = \text{I.P. of } \pi(e^{-i} \cdot e^{-1})$$

$$= \text{I.P. of } \pi e^{-1} (\cos 1 - i \sin 1)$$

$$= \frac{-\pi \sin 1}{e}$$

139. (a)

Let the lengths of three parts of the wire be x, y and $l - (x + y)$. Then $x > 0$, $y > 0$ and $l - (x + y) > 0$.

i.e., $x + y < l$

or $y < l - x$

Since in a triangle, the sum of any two sides is greater than the third side, so

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

$$(x + l) - (x + y) > y = y < \frac{l}{2}$$

and $$y + l - (x + y) > x = x < \frac{l}{2}$$

So required probability,

$$= \frac{\int_0^{l/2} \int_{l/2-x}^{l/2} dy\, dx}{\int_0^{l} \int_0^{l-x} dy\, dx} = \frac{\int_0^{l/2} \left\{\frac{l}{2} - \left(\frac{l}{2} - x\right)\right\} dx}{\int_0^{l} (l-x) dx}$$

$$= \frac{\int_0^{l/2} x\,dx}{\int_0^{l} (l-x)\,dx} = \frac{\frac{l^2}{8}}{\frac{l^2}{2}} = \frac{1}{4}$$

140. (c)

Regression coefficient of y on x is –0.5

Regression coefficient of x on y is –0.87

$$r = \sqrt{(-0.5)(-0.87)} = \sqrt{0.43} = 0.66$$

141. (b)

There are infinite number of terms in the negative powers of $(z - 2)$, $z = 2$ is an essential singularity.

142. (a)

$$P_x(K) = \frac{e^{-4} 4^K}{K!}$$

$$P(X \le 2) = e^{-4}\left[1 + \frac{4^2}{2!} + \frac{4^1}{1!}\right] = 0.238$$

$$P(X > 2) = 1 - P(X \le 2)$$
$$= 1 - 0.238$$
$$= 0.762$$

144. (a)

$$K_1 = h\,f(x_0, y_0)$$
$$K_1 = 0.2\,[x_0 + y_0]$$
$$K_1 = 0$$
$$K_2 = h\,f\,(x_0 + h_1\, y_0 + k_1)$$
$$K_2 = 0.2[x_0 + h + y_0 + K_1]$$
$$= 0.2 \times 0.2 = 0.04$$
$$K = \frac{K_1 + K_2}{2} = 0.02$$
$$y_1 = y_0 + K = 0 + 0.02$$
$$y_1 = 0.02$$

145. (c)

Statement (I) is the statement of Tellegen's theoram.

Statement (II) is false because Tellegen's theoram validity the conservation of power in any electrical network.

146. (a)

The total emf induced is given by

$$e = -\frac{d\psi}{dt} \qquad \text{(where, } \psi = \text{total flux)}$$

The negative sign is due to Lenz's law i.e., the emf induced is equal to the time rate of decrease of the total magnetic flux linking the circuit.

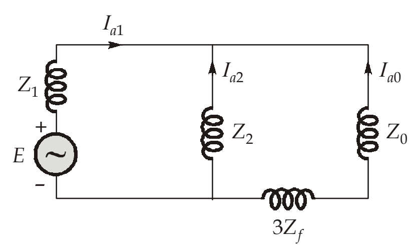
Hence, both statement (I) and statement (II) are individually true and statement (II) is the correct explanation of statement (I).

147. (d)

In double line to ground fault (LLG)

$$I_f = 3I_{a0}$$

And all sequence networks are connected in parallel. (if $Z_f = 0$)



148. (c)

Resonant switch converters is to reduce switching losses of the devices (MOSFETs, IGBTs etc) by operating them either in zero voltage or in zero current switching mode. Hence the current or voltage waveform becomes quasi-sinusoidal instead of square-wave in the dc to dc or dc to ac PWM converters.

149. (d)

A system is said to be stable if both phase margin and gain margin are positive only. Hence, statement (I) is false.

150. (c)

Above Curie temperature, spontaneous polarization in the material is reduced to zero because with the increase in temperature randomness in the orientation of dipoles increases so the size of domain decreases and at Curie temperature all the dipoles will be randomly oriented hence, statement-I is true.

Above Curie temperature material starts behaving like a piezoelectric material.

Hence, statement-II is false.

■■■■