OFFLINE TEST SERIES

MADE EASY

India's Best Institute for IES, GATE & PSUs

ESE-2017 : Prelims Exam

UPSC Engineering Services Examination

E & T ENGINEERING

Answer Key & Solutions

Test 20: Mock Test Technical

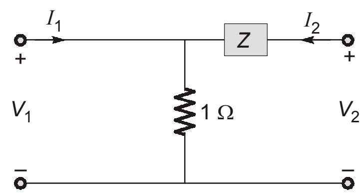
Engineering Discipline

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

DETAILED EXPLANATIONS

1. (b)

From the given diagram



$$V_1 = I_1 + I_2 \quad \text{...(i)}$$
$$V_2 = I_1 + (1 + Z)\, I_2 \quad \text{...(ii)}$$

The transmission parameters

$$V_1 = AV_2 - BI_2 \quad \text{...(iii)}$$
$$I_1 = CV_2 - DI_2 \quad \text{...(iv)}$$

from equations (i) and (ii)

$$A = \left.\frac{V_1}{V_2}\right|_{I_2 = 0} \Rightarrow 1$$

$$B = -\left.\frac{V_1}{I_2}\right|_{V_2 = 0} \Rightarrow Z$$

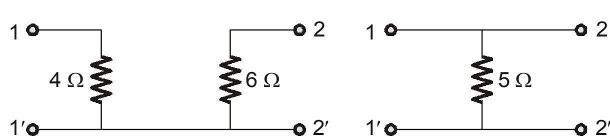
$$C = \left.\frac{I_1}{V_2}\right|_{I_2 = 0} \Rightarrow 1℧$$

$$D = -\left.\frac{I_1}{I_2}\right|_{V_2 = 0} \Rightarrow (1 + Z)$$

So, $Z = -j\,\Omega$

2. (a)

The given network is a series combination of two networks as



The z-parameters for network (i)

$$z_{11} = 4\ \Omega \quad \text{and} \quad z_{12} = z_{21} = 0$$
$$z_{22} = 6\ \Omega$$

The z-parameters for network (ii)

$$z_{11} = z_{12} = z_{21} = z_{22} = 5\ \Omega$$

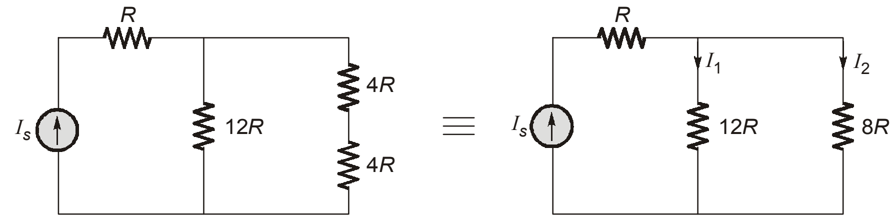
$\therefore$ overall z-parameter matrix $\Rightarrow [z] = [z_1] + [z_2]$

$z_{11} = 9\ \Omega$, $z_{22} = 11\ \Omega$, $z_{12} = 5\ \Omega$ and $z_{21} = 5\ \Omega$

$\because$

$$z_{12} = z_{21} = 5\ \Omega \quad \Rightarrow \text{Reciprocal}$$
$$z_{11} \neq z_{22} \quad \Rightarrow \text{Not Symmetrical}$$

3. (d)



Using current division rule

$$I_1 = \frac{8R}{12R+8R} \times I_s = \frac{2}{5} I_s$$

$$I_2 = \frac{12R}{8R+12R} \times I_s = \frac{3}{5} I_s$$

I_2 is divided into parallel combination of $6R$ and $12R$

$$\therefore \quad I_3 = \frac{6R}{6R+12R} I_2 = \frac{1}{3} I_2 = \frac{1}{3} \times \frac{3}{5} I_s = \frac{1}{5} I_s$$

$$I_1 : I_2 : I_3 = \frac{2}{5} I_s : \frac{3}{5} I_s : \frac{1}{5} I_s = 2:3:1$$

4. (d)

$$Q = \frac{\text{Resonant frequency}}{\text{Bandwidth}} = \frac{1500}{10} = 150$$

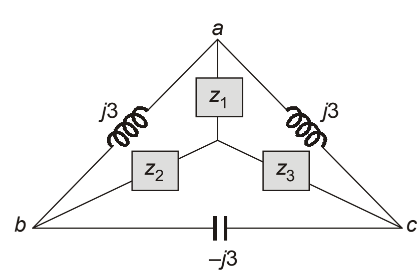
For series RLC circuit, the quality factor

$$Q = \frac{1}{\omega RC}$$

$$R = \frac{1}{\omega \times Q \times C}$$

$$= \frac{10^9}{2\pi \times 1500 \times 150 \times 150} = \frac{100}{2\pi}\left(\frac{8}{27}\right) = 4.7\ \Omega$$

5. (b)



$$z_1 = \frac{j3 \times j3}{j3 + j3 - j3} = j3$$

$$z_2 = \frac{-j3 \times j3}{j3 + j3 - j3} = -j3$$

$$z_3 = \frac{-j3 \times j3}{j3 + j3 - j3} = -j3$$

6. (b)

At $t < 0$, the 8 mA source current is sum of the currents in the branches left of it

$$\therefore \quad i = -\left(\frac{8\times10^{-3}\times12\text{k}\Omega}{(4+12)\text{k}\Omega}\right) = -6 \text{ mA}$$

at $t = 0$

$$v_c(0^+) = v_c(0) = 8\times10^{-3}\times6\times10^{3} = 48 \text{ V}$$

$$v_c(t) = v_c(0)\, e^{-t/\tau} \quad ; \quad \text{for } t > 0$$

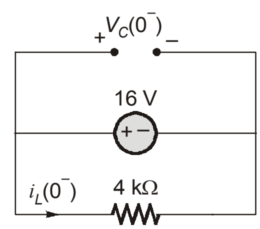
$$\because \quad \tau = R_{eq}\, C = (4\text{k}\Omega \,\|\, 12\text{k}\Omega \,\|\, 6\text{k}\Omega)\times5\times10^{-6} = 10 \text{ ms}$$

$$\therefore \quad i(t) = \frac{v_c(t)}{4\times10^{3}} = \frac{48\,e^{-t/10\times10^{-3}}}{4\times10^{3}} \text{ A}; \quad \text{for } t > 0$$

$$= 12\, e^{-100t} \text{ mA}; \quad \text{for } t > 0$$

7. (a)

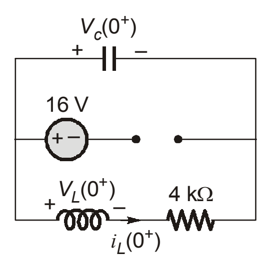
at $t = 0^-$,



$$i_L(0^-) = \frac{16}{4\text{ k}} = 4 \text{ mA} = i_L(0^+)$$

$$v_c(0^-) = 16 \text{ V} = v_c(0^+)$$

at $t = 0^+$,



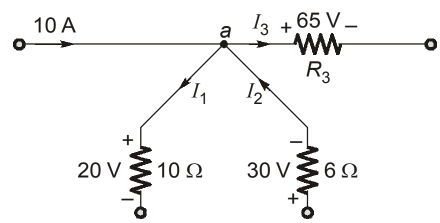
writing KVL in the loop

$$-v_L(0^+) - i_L(0^+)\times4\text{ k} + v_c(0^+) = 0$$

$$v_L(0^+) = -(4\times4)+16 = 0$$

$$L\frac{di_L(0^+)}{dt} = v_L(0^+) = 0$$

8. (a)



The value of current $$I_1 = \frac{20}{10} = 2\text{ A}$$

The value of current $$I_2 = \frac{30}{6} = 5\text{ A}$$

at node '*a*' by KCL $$10\text{ A} + I_2 = I_3 + I_1$$
$$10\text{ A} + 5\text{ A} = 2\text{ A} + I_3$$

or $$I_3 = 13\text{ A}$$

$\Rightarrow$ $$R_3 = \frac{65}{13} = 5\ \Omega$$

9. (b)

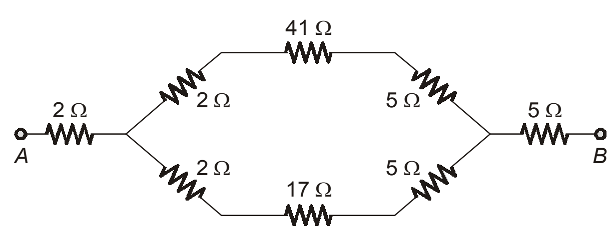
Using reciprocity theorem,

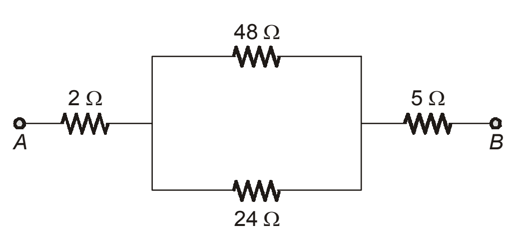
$$\frac{I_1}{10} = \frac{-I_2}{30}$$

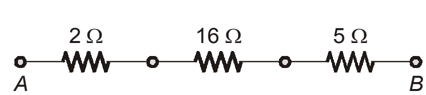
$$I_2 = -\frac{30}{10} I_1 = -6\text{ A}$$

10. (c)

Converting the two outer delta networks into equivalent star networks







$\therefore$ $$R_{AB} = 23\ \Omega$$

11. (b)

Total number of possible trees $= |A\,A^T|$

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

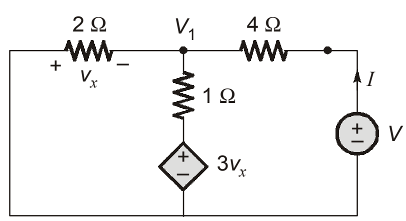
$$= \begin{bmatrix} 2 & -1 & 0 \\ -1 & 3 & -1 \\ 0 & -1 & 2 \end{bmatrix}$$

$$|A\,A^T| = \begin{vmatrix} 2 & -1 & 0 \\ -1 & 3 & -1 \\ 0 & -1 & 2 \end{vmatrix}$$

$$= 2(6-1) + 1(-2) = 8$$

12. (a)

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



Applying KCL

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

$$V_1 = -v_x$$

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

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

$$V = 19\,V_1$$

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

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

13. (b)

The standard form of compensator is

$$G(s) = \frac{s+z}{s+p}$$

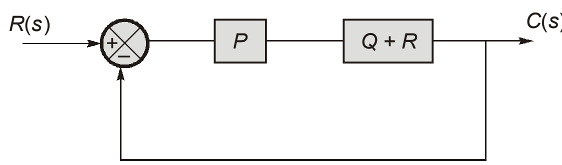
For first compensator

$$z = 0.1$$
$$p = 0.001$$
$$z > p \quad \Rightarrow \text{lag compensator}$$

For second compensator

$$z = 0.001$$
$$p = 0.1$$
$$z < p \quad \Rightarrow \text{lead compensator}$$

15. (c)



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

$$= \frac{PQ+PR}{1+PQ+PR}$$

16. (d)

$$\frac{C(s)}{R(s)} = \frac{(30)K_p}{3s+1+30K_p} = \frac{(30)K_p}{(30K_p+1)\left(1+\frac{3s}{30K_p+1}\right)}$$

Time constant of closed-loop system,

$$\tau_c = \frac{3}{30K_p+1}$$

Time constant of open-loop system,

$$\tau_o = 3 \text{ sec}$$

so,

$$\frac{3}{30K_p+1} = \frac{3}{6} = \frac{1}{2}$$

$$30K_p + 1 = 6$$

$$K_p = \frac{5}{30} = \frac{1}{6}$$

17. (a)

Writing the equations for state variables, we get

$$\dot{x}_1 = -x_1 + \frac{1}{2}x_2 + u$$

$$\dot{x}_2 = x_1 + \left(-1 - \frac{1}{2}\right)x_2 - u = x_1 - \frac{3}{2}x_2 - u$$

and $$y = \dot{x}_2 = x_1 - \frac{3}{2}x_2 - u$$

∴ The state space representation of the system is

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} -1 & 1/2 \\ 1 & -3/2 \end{bmatrix}\begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 1 \\ -1 \end{bmatrix}u$$

$$y = \begin{bmatrix} 1 & -3/2 \end{bmatrix}\begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + [-1]u$$

18. (d)

$$G(s) = \frac{K(2s+1)}{s(4s+1)\,(s+1)^2}$$

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

$$K_v = \lim_{s\to 0} sG(s) = K$$

∴ $$e_{ss} = \frac{1}{1+K_p} + \frac{3}{K_v} = \frac{3}{K}$$

∵ $$\frac{3}{K} \le 0.1$$

∴ $$K \ge 30$$

$$K_{min} = 30$$

19. (d)

The characteristic equation of the system is,

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

$$s(s+2)\,(s+4) + K = 0$$

$$s^3 + 6s^2 + 8s + K = 0$$

The Routh's tabular form

s^3	1	8
s^2	6	K
s^1	$48-K$	0
s^0	K	0

For system to cross the imaginary axis

$$48 - K = 0$$

or $$K = 48$$

20. (a)

- To produce non-oscillatory response, the roots or closed loop poles should be real.
- From the given root locus diagram, the closed loop poles are real for $0 < K \le 0.4$.

21. (a)

at $\omega = \omega_{pc}$

$$-180^\circ = -90^\circ - \tan^{-1}\frac{\omega_{pc}}{2} - \tan^{-1}\frac{\omega_{pc}}{5}$$

$$\tan 90^\circ = \frac{\frac{\omega_{pc}}{2} + \frac{\omega_{pc}}{5}}{1 - \frac{\omega_{pc}^2}{10}}$$

or $$1 - \frac{\omega_{pc}^2}{10} = 0$$

or $$\omega_{pc} = \sqrt{10} \text{ rad/sec}$$

$\therefore$ $$|G(j\omega)H(j\omega)|_{\omega = \omega_{pc}} = \frac{70}{\sqrt{10}\,\sqrt{10+4}\,\sqrt{10+25}}$$

$$= \frac{70}{\sqrt{10}\,\sqrt{14}\,\sqrt{35}} = \frac{70}{\sqrt{5\times2}\,\sqrt{7\times2}\,\sqrt{7\times5}}$$

$$= 1$$

$\therefore$ $$\text{gain margin} = -20\log_{10}|G(j\omega_{pc})H(j\omega_{pc})| = 0 \text{ dB}$$

22. (b)

$$\text{Setteling time for 5\% tolerance} = \frac{3}{\xi\omega_n}$$

$$9 = \frac{3}{\xi\omega_n}$$

or $$\xi\omega_n = \frac{1}{3}$$

Closed loop transfer function = $\dfrac{16}{s^2 + as + 16}$

$$\omega_n^2 = 16$$

$\Rightarrow$ $$\omega_n = 4 \text{ rad/sec}$$

and $$2\xi\omega_n = a$$

$$2 \times \frac{1}{3} = a$$

$$a = \frac{2}{3}$$

24. (b)

Slope between ω = 10 rad/sec and ω = 100 rad/sec is,

$$\text{slope} = \frac{20-0}{\log 100 - \log 10}$$

$$= \frac{20}{2-1} = 20 \text{ dB/dec}$$

$$\therefore \qquad G(s) = \frac{\left(\frac{s}{10}+1\right)}{\left(\frac{s}{100}+1\right)} = \frac{10(s+10)}{(s+100)}$$

25. (a)

$$\text{Flux} = \int_s \vec{B}\cdot\vec{ds} \int_{\rho=2}^{4}\int_{z=0}^{2} 2\rho\hat{a}_\phi \cdot d\rho dz\hat{a}_\phi$$

$$= \rho^2\Big]_2^4 \times 2 = 24 \text{ Wb}$$

26. (b)

$$\frac{z_0^2}{z_{in}} = z_L \qquad \because \text{ length of the line is odd multiple of } \frac{\lambda}{4}$$

$$\Rightarrow \qquad z_L = 220 \times 2.2 = 484\ \Omega$$

27. (d)

$$\vec{E} = \frac{\rho_s}{2\epsilon_0}\hat{a}_x = \frac{20\times10^{-9}}{\frac{2\times10^{-9}}{36\pi}}(-\hat{a}_x)$$

$$= 360\pi\,(-\hat{a}_x) \text{ V/m} = -360\pi\,\hat{a}_x \text{ V/m}$$

29. (c)

$$\frac{E}{H} = 125.6\ \Omega = \frac{377}{\sqrt{\epsilon_r}}\ \Omega$$

$$\Rightarrow \qquad \sqrt{\epsilon_r} = \frac{377}{125.6} = 3$$

$$\Rightarrow \qquad \epsilon_r = 9$$

30. (b)

$$\Gamma_L = \frac{z_L - z_0}{z_L + z_0} = \frac{100-50}{100+50} = \frac{1}{3}$$

31. (c)

$$f_c = \frac{C}{2a} = 3\times10^9$$

$$\Rightarrow \quad a = \frac{3\times10^{10}}{2\times3\times10^9}\text{ cm} = 5\text{ cm}$$

33. (a)

$$\delta \propto \frac{1}{\sqrt{f}}$$

so, $$\frac{\delta_1}{\delta_2} = \sqrt{\frac{f_2}{f_1}}$$

$$\Rightarrow \quad \delta_2 = \sqrt{\frac{10}{40}}\cdot 20\text{ cm} = 10\text{ cm}$$

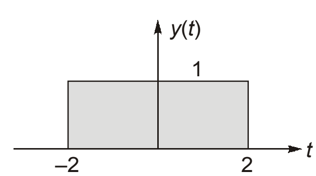
34. (b)

$$l < \frac{\lambda}{10}$$

$$\Rightarrow \quad R_{rad} = 80\pi^2\left(\frac{l}{\lambda}\right)^2 = 80\pi^2\times\frac{1}{400}$$

$$\approx 2\ \Omega$$

36. (b)



$$y(t) = \text{rect}\left(\frac{t}{4}\right)$$

$$\text{rect}(t) \xleftrightarrow{CTFT} \text{sinc}(f)$$

$$\text{rect}\left(\frac{t}{4}\right) \xleftrightarrow{CTFT} 4\,\text{sinc}(4f)$$

39. (b)

$|H(e^{j\omega})|$ (at $\omega = \pi$) > $|H(e^{j\omega})|$ at $\omega = 0$

$\Rightarrow$ High pass filter

40. (c)

$$x(n+2) \leftrightarrow z^2\,[X(z) - x(0) - x(1)z^{-1}]$$

$$= z^2\,X(z) - z^2x(0) - zx(1)$$

43. (b)

The circuit is divide by 2 frequency circuit

$$\therefore \quad f_{out} = \frac{f_{clk}}{2} = \frac{10\text{ kHz}}{2} = 5\text{ kHz}$$

44. (c)

A flip-flop has two stable states

45. (d)

For a ring counter

$$\text{MOD} = n; \qquad n = \text{number of flip-flops}$$

46. (c)

The number of comparators required for 12-bit flash type ADC = $2^n - 1$

$$= 2^{12} - 1$$
$$= 4095$$

48. (a)

$$f = (1)_2 + (2)_3 + (3)_4 + (4)_5 + (5)_6 + (6)_7 + \ldots\ldots + (9)_{10}$$
$$f = (1)_{10} + (2)_{10} + (3)_{10} + (4)_{10} + (5)_{10} + (6)_{10} + \ldots\ldots + (9)_{10}$$
$$\text{sum of first 9 natural numbers} = \frac{9(9+1)}{2} = (45)_{10} = (2D)_{16}$$

49. (a)

A \ BC	00	01	11	10
0	0 ^{0}	0 ^{1}	1 ^{3}	0 ^{2}
1	1 ^{4}	0 ^{5}	1 ^{7}	1 ^{6}

51. (b)

$$f(A, B, C) = \overline{\overline{AB} + \overline{A} + AB} + \overline{C}$$
$$= \overline{1 + \overline{A}} + \overline{C}$$
$$= 0 + \overline{C}$$
$$= \overline{C}$$

Hence, 1 NAND gate is required.

52. (d)

$$V_E = 11.7\text{ V}$$
$$V_C = -I_B R_B + V_{BE} + 11.7\text{ V}$$
$$V_{BE} = -0.7\text{ V}$$
$$V_C = 11.7 - 0.7 = 11\text{ V} \qquad \because I_B = 0, \text{ as } \beta \to \infty$$
$$\therefore \quad V_{CE} = 11 - 11.7 = -0.7\text{ V}$$

54. (a)

for $V_{in} < 10$ V $\Rightarrow D$ is in ON state and $V_{out} = 10$ V
for $V_{in} > 10$ V $\Rightarrow D$ is in OFF state and $V_{out} = V_{in}$

55. (c)

$$A_v \approx \frac{-R_C}{r_e}$$
$$= \frac{-2200}{100} = -22$$

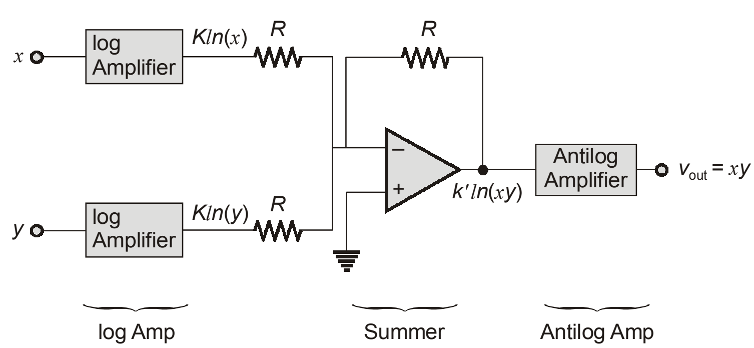
56. (c)

$$A_v = -g_m R_D$$
$$A_v = -\left(\sqrt{2\mu_n C_{ox}\frac{W}{L}\times I_D}\right)\times 1\times 10^3$$
$$= -\frac{1}{300}\times 1000$$
$$= -3.33$$

57. (c)

$$I_{out} = \frac{I_{reff}}{1+2/\beta} = \frac{11}{1+\frac{2}{20}}\text{mA}$$
$$= \frac{11}{1.1}\text{ mA} = 10\text{ mA}$$

58. (c)



60. (a)

$$N = i^2 + j^2 + ij$$

by trial and error if we put $i = 2$ and $j = 2$, we have

$$N = 4 + 4 + 4 = 12$$

61. (b)

$\because$ Co-channel reuse ratio $(Q) = \sqrt{3N}$

N = Cluster size

62. (b)

$\because$ Chromic dispersion $= D_{cd} \cdot L \cdot B \cdot \Delta\lambda$

D_{cd} = Chromatic dispersion constant

L = Length of fiber

B = bit rate

65. (d)

The hole-current density $$J_p(x) = -qD_p \frac{dP(x)}{dx}$$

$$J_p(x) = -qD_p \frac{d}{dx}\left[p_0 e^{-x/L_p}\right]$$

at $x = 0$ $$J_p(0) = q\frac{D_p}{L_p}p_0$$

$$= 1.6\times10^{-19}\times\frac{12}{10^{-4}}\times10^{16}$$

$$J_p(0) = 192 \text{ A/cm}^2$$

66. (a)

Given $N_A = 10^{18}/\text{cm}^3$; $N_D = 10^{16}/\text{cm}^3$

$W = 0.5\ \mu\text{m}$

$\therefore$ width of the depletion layer on the n-side is x_n

$$x_n = W\cdot\frac{N_A}{N_A+N_D}$$

$$= 0.5\times\frac{10^{18}}{10^{18}+10^{16}}$$

$$x_n = 0.495\ \mu\text{m}$$

69. (d)

Total capacitance between the gate and the channel of MOSFET

$$C = C_{ox}\times L\times W$$

$$= 8.6\times10^{-3}\times0.18\times10^{-6}\times0.72\times10^{-6}$$

$$C = 1.1\times10^{-15} = 1.1 \text{ fF}$$

70. (a)

Given $\alpha = 0.98$

$I_{CBO} = I_{CO} = 5\ \mu\text{A}$

Collector current $$I_C = \frac{\alpha\cdot I_B}{1-\alpha}+\frac{I_{CO}}{1-\alpha}$$

$$= \frac{0.98\times100\times10^{-6}}{1-0.98}+\frac{5\times10^{-6}}{1-0.98}$$

$$I_C = 5.15 \text{ mA}$$

72. (b)

We know that the pinch-off voltage for p-channel silicon JFET,

$$V_P = \frac{qN_A}{2\varepsilon} \times a^2$$

Given $\rho = 20\ \Omega$-cm

$$\sigma = \frac{1}{\rho} = P \times \mu_p \times q = N_A\, q\, \mu_p$$

$$\therefore \quad qN_A = \frac{1}{\rho\mu_p} = \frac{1}{20 \times 500} = 10^{-4}\ \text{C/cm}^3$$

$$\therefore \quad V_p = \frac{qN_A}{2\varepsilon} \times a^2$$

$$qN_A = 100\ \text{C/m}^3$$

$$a = 2 \times 10^{-6}\ \text{m}$$

$$V_p = \frac{100 \times 4 \times 10^{-12}}{2 \times 12 \times \varepsilon_0} = \frac{2 \times 10^{-10}}{12 \times \frac{10^{-9}}{36\pi}}$$

$$= \frac{6\pi}{10} = \frac{3\pi}{5} \qquad \Rightarrow \text{closer to “2” } (< 2)$$

73. (d)

$$V_0 = \frac{kT}{q} ln\left[\frac{n_{no}p_{po}}{n_i^2}\right]$$

so, $$V_0 = \frac{kT}{q} ln\left[\frac{n_{no}}{n_{po}}\right]$$

74. (c)

Doping level $\Rightarrow D_E > D_C > D_B$

In PNP transistor $W_B << L_p$

76. (c)

Cubic crystal	Packing fraction
Simple cubic	0.52
Body centered cubic	0.68
Face centered cubic	0.74
Diamond cubic	0.34
Hexagonal closed packing	0.74

77. (a)

Spontaneous magnetization is not a result of cooperative effect among domains.

78. (b)

Type-I superconductor is a conductor with very large conductivity below a critical temperature so statement-1 and statement-2 are wrong.

79. (b)

$$\text{Strain} = \frac{560 - 550}{550} = \frac{10}{550}$$

$$\text{Stress} = \text{Young's modulus} \times \text{Strain}$$

$$= 130 \times \frac{10}{550} = 2.363 \text{ GPa}$$

81. (b)

$$\text{Dielectric loss is given by} = \frac{E^2 f \varepsilon_r \tan\delta}{1.8 \times 10^{12}} \text{ W/cm}^3$$

For this specimen the heat loss will be

$$= \frac{50^2 \times 10^6 \times 100 \times 4 \times 0.001}{1.8 \times 10^{12}} = 0.55 \text{ mW/cm}^3$$

82. (b)

$$D = 4P = 4\chi_e \varepsilon_0 E$$

but $$D = \varepsilon_r \varepsilon_0 E = (\chi_e + 1)\varepsilon_0 E$$

comparing above expression and taking $\chi_e = \varepsilon_r - 1$

$$4(\varepsilon_r - 1)\varepsilon_0 E = \varepsilon_0 \varepsilon_r E$$

$$4(\varepsilon_r - 1) = \varepsilon_r \Rightarrow 3\varepsilon_r = 4$$

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

83. (c)

$$P = VI$$

Limiting error in power, $$\frac{\delta P}{P}\% = \pm\left[\frac{\delta V}{V}\% + \frac{\delta I}{I}\%\right]$$

$$\frac{\delta P}{P}\% = \pm[2\% + 3\%] = \pm 5\%$$

85. (b)

$$R_{SH} = \frac{R_m}{(m-1)}$$

where, $R_m = 100\ \Omega$

$$m = \frac{I}{I_m} = \frac{250}{50} = 5$$

$$R_{SH} = \frac{100}{(5-1)} = 25\ \Omega$$

87. (d)

The dc sensitivity $s = \frac{1}{(I_{fsd})} = \frac{1}{50\ \mu A}$

$= 20\ k\Omega/V$

89. (d)

Resolution $(R) = \frac{V_{FS}}{10^N}$

Where N = number of full digits

$= \frac{10\ mV}{10^3} = 10\ \mu V$

90. (d)

$$R = 150\ \Omega$$
$$S_g = 4$$
$$\Delta l = 0.255 - 0.250 = 0.005\ m$$

Change is resistance $\Delta R = R \times S_g \times \frac{\Delta l}{l}$

$= 150 \times 4 \times \frac{0.005}{0.250} = 12\ \Omega$

Gauge resistance after application of strain

$= 150\ \Omega + 12\ \Omega = 162\ \Omega$

92. (b)

Some thermistors have also positive temperature coefficient.

Ex : Silistors.

93. (b)

Sensitivity of LVDT $= \frac{5\ V}{25\ mm} = 0.2\ V/mm$

Output of LVDT $= 0.2\ V/mm \times -18.75\ mm$

$= -3.75\ V$

94. (c)

The flux (alternating in nature) induces voltage in both windings.

95. (c)

Core losses are dependent on input voltage and copper loss on current flowing through winding. Hence (c) option correct.

96. (c)

Given V_i = 200 V, I_i = 0.32 A, P_i = 50 W

$$R_0 = \frac{V^2}{P} = \frac{(200)^2}{50} = 800\ \Omega$$

$$I_w = \frac{V_t}{R_0} = \frac{200}{800} = 0.25\ \text{A}$$

Hence I_μ (magnetizing current component) = $\sqrt{(0.32)^2-(0.25)^2}$ = 0.199 ≈ 0.20 A

$$\text{Hence magnetizing reactance} = \frac{V_t}{I_\mu} = \frac{200}{0.2} = 1000\ \Omega$$

97. (a)

Statement 1 and 2 are correct as no presence of zero sequence circulating current in star configuration as they are pass into ground via neutral.

98. (a)

MMF method is also called optimistic method as it gives lower value of regulation compared to other method.

99. (d)

Load in dc shunt motor is directly related to armature current and hence the losses which are affected the most are armature copper loss.

100. (d)

Given number of conductor (Z) = 240; (lap connected) i.e. $A = P = 4$

E = 480 V, speed of rotation (N) = 800 rpm

Emf equation of dc machine $E_b = k\phi\omega_m$ = 480 V

$$E_b = \frac{P\phi N}{60}\ Z/A$$

$$480 = \frac{\phi\times 800\times 240}{60}$$

$$\phi = \frac{120}{800} = \frac{6}{40} = \frac{3}{20} = 0.15\ \text{Wb}$$

101. (d)

Low frequency of emf induced is related to iron loss which are less in magnitude at low frequency.

102. (b)

The availability of continuous water flow is desirable but not necessary as the reservoir water is used when water is not available in river.

103. (d)

It acts as a regulating body by storing and releasing water similar to reservoir during light and peak load conditions respectively.

104. (b)

Airgap increase in between stator and rotor increases magnetizing current requirement and starting torque and power factor decreases.

105. (b)

Number of sets = 64/8 = 8 = 3 bits required

Number of blocks in main memory = 2

1 block = 512 words = 9 bits required

Tag	Set	Word
8	3	9

Tag = Total – (Set + Word)

Tag bits = 20 – (9 + 3) = 8 bits for Tag

106. (c)

From at

1 bit	8 bit	23 bit
Sign	Exponent	Mantissa
←	32	→
1	10000011	11110000 . . . 0

$$= (-1)^s (1.E) \times 2^{E-127}$$
$$= (-1)^1 (1.1111) \times 2^{131-127}$$
$$= -(1.1111) \times 2^4$$
$$= -[2^0 \times 1 + 2^{-1} \times 1 + 2^{-2} \times 1 + 2^{-3} \times 1 + 2^{-4} \times 1] \times 2^4$$
$$= [2^4 + 2^3 + 2^2 + 2^1 + 2^0]$$
$$= -(31)_{10}$$

107. (b)

Since operand forwarding not maintained. So wait until instruction finish.

	IF	ID	OF	PO	WO
ADD	1	1	1	1	1
MUL	1	1	1	2	1
SUB	1	1	1	1	1
DIV	1	1	1	4	1

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
I_0	IF	IO	OF	PO	WO											
I_1		IF	IO	OF	PO	PO	WO									
I_2			IF	ID	OF	OF	OF	OF	PO	WO						
I_3				IF	ID	–	–	–	OF	OF	OF	PO	PO	PO	PO	WO

108. (c)

Execution time for pipeline = $(k + n - 1) \times tp$

where k = Number of stages

n = Number of instruction

tp = Execution time = Max (all stages)

$P_1 = [8 + 500 - 1] \times 8 = 4056$

$P_2 = [5 + 500 - 1] \times 5 = 2520$

Time saved using P_2 = 4056 – 2520 = 1536 nsec = 1.536 μsec

109. (a)

$$CPI = \frac{\sum (J_i \times CP_i)}{I_C}$$

$$= \frac{[45000 \times 1 + 32000 \times 2 + 15000 \times 2 + 8000 \times 2]}{10^5}$$

$$= \frac{155000}{10^5} = \frac{155}{10^2} = 1.55$$

$$\text{Execution time} = \frac{I_C \times CPI}{f} = \frac{10^5 \times 1.55}{40 \times 10^6} = 3.87 \text{ msec.}$$

110. (d)

All the above statements are correct.

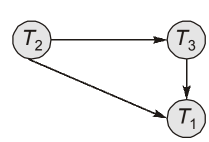
S1: Reference bit some times called access bit used in page table entry to show if page is replaced or not.

S2: In hierarchial memory access, CPU perform read and write operation only on level 1 memory. If miss occur then data is first transferred to level 1 then CPU access data.

S3: In simultaneous memory access, CPU perform read and write operation on any level of memory i.e. not necessary to take data first into level 1 memory than access it.

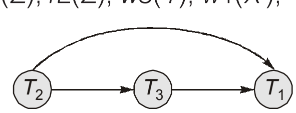
111. (c)

S_1: $r1(X); r3(Y); r3(X); r2(Y); r2(Z); w3(Y); w2(Z); r1(Z); w1(X); w1(Z)$



No cycle ⇒ S1 is conflict serializable.

S_2: $r1(X); r3(Y); r2(Y); r3(X); w2(Z); r1(Z); r2(Z); w3(Y); w1(X); w1(Z)$



No cycle ⇒ S_2 is conflict serializable.

112. (b)

By default x will be initialized to 0. Since its storage class is static, it preserves its exit value (and forbids reinitialization on re-entry). So, 123 will be printed.

113. (c)

$$R_{b\min} = nf_{s\min}$$

$$n = \text{number of bits/sample}$$

given $$2^n = 16 \Rightarrow n = 4$$

$$f_{s\min} = 2f_{m\max} = 8 \text{ kHz}$$

so, $$R_{b\min} = (4)(8000) = 32 \text{ kbps}$$

115. (c)

Double spotting does not occur in FM, as there is no image problem in FM receiver.

116. (d)

For a real stationary random process, $S_X(\omega) \geq 0$ always.

For some values of ω, $\cos(3\omega)$ is negative and for some values of ω, $\cos(3\omega)$ is positive.

So, for any choice of k (except zero), $S_X(\omega)$ is less than zero for some values of ω.

117. (d)

$$B_N = \frac{1}{4\tau}$$

$$\tau = RC = (10^3)(10 \times 10^{-6}) = 10 \text{ ms}$$

$$B_N = \frac{1000}{40} \text{ Hz} = 25 \text{ Hz}$$

118. (c)

NBFM is used in first generation mobile communication systems like AMPS.

120. (a)

To avoid slope overload distortion,

$$\delta f_s \geq \left|\frac{dm(t)}{dt}\right|_{\max}$$

$$\left|\frac{dm(t)}{dt}\right|_{\max} = 10 \text{ V/s}$$

$$R_b = nf_s = 10 \text{ kbps}$$

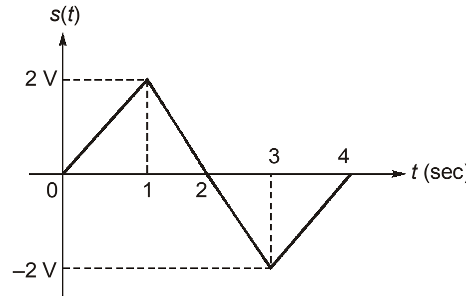
so, $$f_s = 10 \text{ kHz} \qquad \because n = 1 \text{ for delta modulation}$$

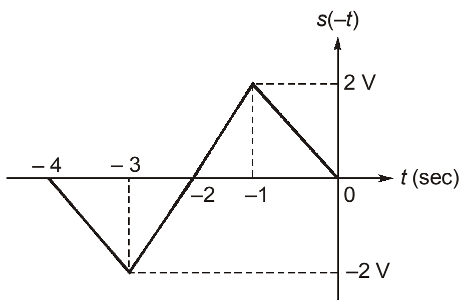
$$\delta_{\min} f_s = 10 \text{ V/s}$$

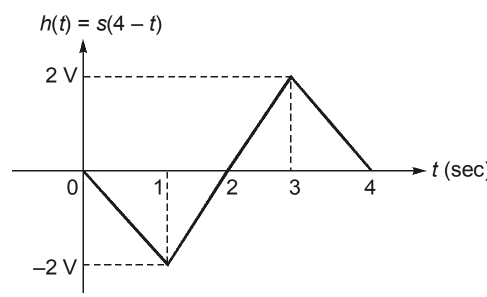
$$\delta_{\min} = \frac{10}{10} \text{ mV} = 1 \text{ mV}$$

121. (b)

$$h(t) = s(T - t) \quad ; \quad T = \text{signal duration}$$
$$= s(4 - t)$$

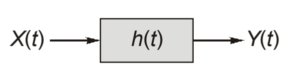






$$h(t) = s(4 - t) = -s(t)$$

123. (b)



Given
$$h(t) = e^{-2t}\,u(t) \text{ and } E[X(t)] = 2$$
$$E[Y(t)] = H(0)\,E[X(t)]$$
$$H(s) = L\{h(t)\} = \frac{1}{s+2}$$
$$H(0) = \frac{1}{2}$$
$$E[Y(t)] = \frac{1}{2}(2) = 1$$

130. (b)

As, P has high volatality. So, GaAs and InP require sealed tube during the process of diffusion.

133. (b)

$$CD = \sqrt{\lambda g} \qquad \text{for proximity printing}$$

$$= \sqrt{4000 \times 10^{-15}} \text{ m} = 2 \ \mu\text{m}$$

144. (a)

Reason is Faraday's first law of electrolysis which states electrochemical equivalent of a substance.

146. (d)

A system having zeros in the RHS of s-plane is called as non-minimum phase system.

147. (b)

For fixed bias,

$$S = \beta + 1$$

For self bias,

$$S = \frac{\beta + 1}{1 + \frac{\beta R_E}{R_B + R_E}}$$

where S is stabilization factor.

$$(S)_{\text{Self bias}} < (S)_{\text{Fixed bias}}$$

The closer the value of S to 1, the more stable the circuit.

❍❍❍❍