DETAILED SOLUTIONS

MADE EASY

India's Best Institute for IES, GATE & PSUs

Test Centres: Delhi, Hyderabad, Bhopal, Jaipur, Pune, Kolkata

ESE 2024 : Prelims Exam
CLASSROOM TEST SERIES

E & T ENGINEERING

Test 18

Full Syllabus Test 2 : Paper-II

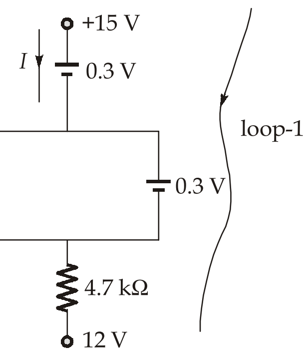
1. (b)	26. (b)	51. (c)	76. (a)	101. (a)	126. (b)
2. (b)	27. (c)	52. (a)	77. (b)	102. (d)	127. (b)
3. (c)	28. (c)	53. (d)	78. (d)	103. (b)	128. (c)
4. (a)	29. (c)	54. (b)	79. (d)	104. (c)	129. (c)
5. (d)	30. (b)	55. (b)	80. (d)	105. (d)	130. (c)
6. (b)	31. (c)	56. (c)	81. (a)	106. (d)	131. (a)
7. (b)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

DETAILED EXPLANATIONS

1. (b)

Initially, it would appear that the applied voltage will turn both diodes 'ON' (D_2 and D_3). But if both were "ON", the 0.7 V drop across the silicon diode would not match 0.3 V across the Ge diode as required by the parallel elements.

The Si diode will never have the opportunity to have 0.7 V across it and therefore remains in its open circuit state.



Applying KVL in loop-1, we get

$$15 - 0.3 - 0.3 - 4.7 \times I - 12 = 0$$

$$\frac{15 - 0.6 - 12}{4.7} = I$$

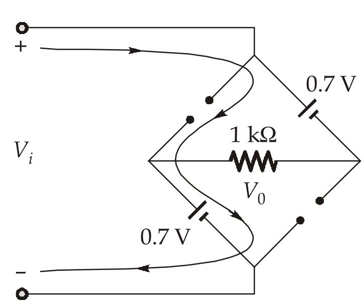
$$I = 0.5106 \text{ mA}$$

2. (b)

Given: $V_{rms} = 120$ V

$$V_{i\,max} = 120 \times \sqrt{2} \text{ V}$$

For positive value of voltage supply, diode D_2 and D_4 will be forward bias, D_1 and D_3 will be reverse biased. Thus, our equivalent circuit will be as below:



Applying KVL in the loop as shown by the arrow path direction;

$$V_i - 0.7 - V_0 - 0.7 = 0$$

$$V_0 = V_i - 14$$

$$(V_0)_{max} = 120\sqrt{2} - 1.4 = 168.30 \text{ V}$$

$$I_{D\,max} = \frac{V_{0\,max}}{R_L} = \frac{168.3}{1\text{ k}\Omega} = 168.3 \text{ mA}$$

Required power rating of each diode:

$$= V_T \times I_{D\,max}$$
$$= 0.7 \times 168.3 \times 10^{-3} = 117.81 \text{ mW}$$

3. (c)

For V_i > 25 V, zener diode is in breakdown region and ammeter reads full scale voltage. Hence,

$$V_z = V_0 = 20 \text{ V}$$
$$\frac{V_0}{R_2 + R_m} = 0.2 \times 10^{-3}$$
$$\frac{20}{0.2 \times 10^{-3}} = 560 + R_2$$
$$R_2 = 100 - 0.560$$
$$\therefore \quad R_2 = 99.44 \text{ k}\Omega$$

Since, for V_i > 25 V, some (overload) current is shunted by the zener diode, hence the current from the supply voltage is more than 0.2 mA. Hence, we have

$$R_1 \leq \frac{25 - 20}{0.2 \times 10^{-3}} = \frac{5}{0.2 \times 10^{-3}}$$
$$R_1 \leq 25 \text{ k}\Omega$$
$$\therefore \quad R_1 = 24 \text{ k}\Omega \text{ and } R_2 = 99.44 \text{ k}\Omega \text{ is the correct option.}$$

4. (a)

- In the emitter follower configuration, the feedback is the emitter voltage which is in series with the input voltage (base-emitter voltage). This feedback voltage is proportional to the output voltage and opposes the input voltage, resulting in voltage series feedback circuit.
- The emitter follower is a buffer stage with high input impedance, low output impedance, and a gain of approximately unity (slightly less than 1) used for impedance matching.

5. (d)

$$P_D = \frac{T_j - T_A}{\theta_{jA}}$$
$$\theta_{jA} = \theta_{jC} + \theta_{cS} + \theta_{sA} = 1 + 3 + 1 = 5°\text{C/W}$$
$$P_D = \frac{90 - 25}{5} = 13 \text{ W}$$

Considering the factor of safety as 2,

$$\text{Rating of transistor} = 13 \times 2 = 26 \text{ W}$$

6. (b)

Given: $A_V = -100$

Since nothing is said about r_0, so, we will neglect its effect.

Now, $$A_V = \frac{-R_C}{r_e} \quad \text{(for fixed bias configuration)}$$

$$-100 = \frac{-4.7 \times 10^3}{r_e}$$

$\therefore$ $$r_e = 4.7 \times 10 = 47\ \Omega$$

Since $$r_e = \frac{V_T}{I_E}$$

$$I_E = \frac{26\text{ mV}}{47} = 0.55\text{ mA}$$

Now, $$I_E = (1 + \beta)I_B$$

$$I_B = \frac{I_E}{(1+\beta)} = \frac{0.55}{91} = 6.04 \times 10^{-3}\text{ mA}$$

From dc analysis,

$$I_B = \frac{V_{CC} - V_{BE}}{R_B}$$

$$I_B = \frac{V_{CC} - 0.7}{1 \times 10^6}$$

$\therefore$ $$6.04 \times 10^{-6} \times 10^6 + 0.7 = V_{CC}$$

$$6.74\text{ V} = V_{CC}$$

$\therefore$ $$V_{CC} = 6.74\text{ V}$$

7. (b)

On applying KVL,

$$9 - 2 \times I_D - V_0 = 0 \quad \text{...(i)}$$

$$I_D = I_{DSS}\left(1 - \frac{V_{GS}}{|V_p|}\right)^2$$

$$I_D = 4 \times 10^{-3}\left(1 - \frac{1.6}{4}\right)^2$$

$$I_D = 4 \times 10^{-3} \times 0.36$$

$$I_D = 1.44\text{ mA} \quad \text{...(ii)}$$

Put the value of I_D from equation (ii) in equation (i), we get

$$9 - 2 \times 1.44 - V_0 = 0$$

$$V_0 = 6.12\text{ V}$$

8. (c)

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

$$V_d = V_{i1} - V_{i2} = 200 - 140 = 60\ \mu\text{V}$$

$$V_c = \frac{1}{2}(V_{i1} + V_{i2}) = \frac{1}{2}(200 + 140)$$

$$V_c = 170\ \mu\text{V}$$

$$V_0 = 6000 \times 60 \times 10^{-6}\left[1 + \frac{1}{200} \times \frac{170}{60}\right]$$

$$V_0 = 0.3651\text{ V}$$

9. (a)

1. For LC oscillator, $f_r = \dfrac{1}{2\pi\sqrt{(LC)}}$. Hence, frequency of oscillation is dependent on value of L and C.
2. Hartley, Colpitt's and Clapp oscillator are the example of LC oscillator whereas Miller oscillator and pierce oscillator are the examples of crystal oscillator.
3. Q for LC oscillators is less compared to the crystal oscillator.

10. (d)

Among the given static errors, only instrumental errors are 'Permanent, Repetitive and Constant' as they are inherent to the instrument and consistently affect measurements in the same way. Observational errors are typically random and unpredictable whereas Environmental errors are influenced by external factors. Hence, option (d) is correct.

11. (b)

For the sake of ease in calculations, the observations are tabulated and manipulated as under:

x	d	d^2
41.9	–0.1	0.01
42	0	0
41.7	–0.3	0.09
42.1	0.1	0.01
42.3	0.3	0.09
		0.2

$$\text{mean, } \overline{X} = \frac{\Sigma x}{n} = \frac{41.9+42+41.7+42.1+42.3}{5} = 42$$

$$\text{Standard deviation, } \sigma = \sqrt{\frac{|d_1^2|+|d_2^2|\ldots}{n-1}} = \sqrt{\frac{0.2}{(5-1)}} = 0.22$$

$$\text{Probable error for one reading, } r_1 = 0.6745\sigma$$

$$r_1 = 0.6745 \times 0.22$$

$$r_1 = 0.15 \text{ V}$$

$$\text{Probable error of mean, } r_m = \frac{r_1}{\sqrt{n-1}}$$

$$r_m = \frac{0.15}{\sqrt{(5-1)}} = \frac{0.15}{2} = 0.075 \text{ V}$$

$$\text{Range} = 42.3 - 41.7 = 0.6 \text{ V}$$

12. (a)

We have, $I_{fsd} = 1$ mA, $R_m = 200\ \Omega$

We know that, sensitivity, $S_{dc} = \dfrac{1}{I_{fsd}} = \dfrac{1}{1\text{ mA}}$

$$S_{dc} = 1000 \ \Omega/\text{volt}$$

For a half-wave rectifier, AC sensitivity $S_{ac} = 0.45 \times S_{dc}$. The series multipler resistance value is given by

$$R_s = S_{ac} \times \text{range} - R_m$$
$$= 1000 \times 0.45 \times 10 - 200$$
$$= 4.3 \text{ k}\Omega$$

Hence, option (a) is correct.

13. (c)

We have, $\% \text{ Error} = 0.8\%, \ X_{LP} = \frac{0.6R_P}{100}$

$$\%\text{Error} = \tan\phi \tan\beta \times 100$$

$$\frac{0.8}{100} = \tan\phi \tan\beta \quad \text{...(i)}$$

We know that, $\tan\beta = \frac{X_{LP}}{R_P} = \frac{0.6}{100}$

and Correction factor, $\text{C.F} = \frac{1}{(\tan\phi \tan\beta)+1} = \frac{1}{\frac{0.8}{100}+1} = 0.99 = \frac{\text{True reading}}{\text{Instrument reading}}$

After putting tan β in equation (i) we get,

$$\tan\phi = \frac{0.8 \times 100}{100 \times 0.6}$$

$$\tan\phi = \frac{4}{3}$$

For $\tan\phi = \frac{4}{3}$, Power factor, $\cos\phi = \frac{3}{5}$

When P.F. is lagging, the meter indicate more value and if P.F. is leading, the meter indicate less than the actual value. Since instrument reading is more than True reading, hence, power factor of load is 0.6 lagging.

Thus, we get correction factor, C.F = 0.99 and power factor of load as 0.6 lagging. Hence, option (c) is correct.

14. (b)

High value resistance are generally fabricated as three terminal device. Terminals 1 and 2 are input terminals, Terminal 3 is called Guard Terminal used to eliminate or bypass Leakage currents. Hence, option (b) is correct.

Note:

Value of Resistance	Fabricated as
• Low Value Resistance	four terminal
• Medium Value Resistance	two terminal
• High Value Resistance	three terminal

15. (b)

We have,
$$C.F = 1+\frac{C_d}{C_1} = 1.04$$
$$\frac{C_d}{C_1} = 0.04$$
$$C_d = 0.04\ C_1$$
$$C_d = 0.04 \times 500 \text{ pF}$$
$$C_d = 20 \text{ pF}$$

At $f_1 = 1$ MHz $\quad C_1 = 500$ pF

$f_2 = 2$ MHz $\quad C_2 = ?$

We know that,
$$\frac{f_2}{f_1} = n = 2$$
$$C_d = \frac{C_1 - n^2 C_2}{n^2 - 1}$$
$$20 = \frac{500 - 4C_2}{3}$$

$C_2 = 110$ pF $\Rightarrow$ Hence, statement 1 is correct.

Now, we know that resonant frequency is given by the formula
$$f_1 = \frac{1}{2\pi\sqrt{L(C_1 + C_d)}}$$
$$10^6 = \frac{1}{2\pi\sqrt{L(500+20)\times 10^{-12}}}$$
$$L = 48.712\ \mu\text{H}$$

Hence, statement (2) is incorrect.

∴ Statement (1) is correct and statement (2) is incorrect. Hence, option (b) is correct.

16. (d)

We have, $D = 5 \times 10^{-2}$ m; $E_a = 5000$ V; $d = 5 \times 10^{-3}$ m;

$L = 0.5$ m; $l_d = 2 \times 10^{-2}$ m

We know that,
$$D = \frac{L l_d E_d}{2 d E_a}$$
$$5 \times 10^{-2} = \frac{50\times 10^{-2} \times 2 \times 10^{-2} \times E_d}{2 \times 5 \times 10^{-3} \times 5000}$$
$$E_d = \frac{5 \times 5000 \times 2 \times 5 \times 10^{-5}}{50 \times 10^{-2} \times 2 \times 10^{-2}}$$
$$E_d = 250 \text{ V}$$

∴ input voltage required for a deflection of 5 cm
$$= \frac{E_d}{\text{gain}} = \frac{250}{50} = 5 \text{ Volt}$$

Hence, option (d) is correct.

17. (b)

We have, Gauge factor, G.F = 6

$$\Delta R = 10\ \Omega$$

$$R = 500\ \Omega$$

We know that

$$\text{G.F} = 1 + 2\gamma$$

$$6 = 1 + 2\gamma$$

$$\text{Poisson's ratio, } \gamma = 2.5$$

Now we have,

$$\text{G.F} = \frac{(\Delta R / R)}{(\Delta l / l)}$$

$$\frac{\Delta l}{l} = \frac{10}{500 \times 6}$$

$$\text{longitudinal strain, } \frac{\Delta l}{l} = \frac{1}{300}$$

$$\text{Poisson's ratio, } \gamma = \frac{(\Delta D / D)}{(\Delta l / l)} = \frac{\text{lateral strain}}{\text{longitudinal strain}}$$

$$\text{lateral strain, } \frac{\Delta D}{D} = \gamma \times \frac{\Delta l}{l}$$

$$\frac{\Delta D}{D} = 2.5 \times \frac{1}{300}$$

$$\frac{\Delta D}{D} = 0.0083$$

∴ lateral strain, $\frac{\Delta D}{D}$ = 0.0083. Hence, option (b) is correct.

Note:

- Gauge factor, G.F = $\frac{(\Delta R / R)}{(\Delta l / l)}$
- Longitudinal strain = $\frac{\Delta l}{l}$
- Poisson's ratio, $\gamma = \frac{(\Delta D / D)}{(\Delta l / l)}$
- Lateral strain = $\frac{\Delta D}{D}$
- Young's Modulus = $\frac{\text{Stress}}{\text{Strain}}$
- Stress = $\frac{\text{Force}}{\text{Area}}$

(where, D = Diameter; L = Length)

18. (d)

- Platinum, nickel and copper can be used for the fabrication of RTD. Hence, option (d) is correct.
- Platinum can be used for fabrication upto 630°C.
- Nickel can be used for fabrication upto 300°C.
- Copper can be used for fabrication upto 120°C.

19. (d)

$$\text{Material dispersion} = \frac{\text{Width of pulse spread}}{\text{Spectral width} \times \text{Length of optical fiber}}$$

$$= \frac{2\times10^{-9}\,\text{s/km}}{20\text{ nm}\times 28\text{ km}} = 3.57\text{ ps/(nm km}^2)$$

20. (c)

The single-mode operation only occurs above a cut-off wavelength λ_c given by

$$\lambda_c = \frac{2\pi a n_1}{V_c}(2\Delta)^{1/2}$$

- In multimode fiber, $\lambda < \lambda_c$.
  In single mode fiber, $\lambda > \lambda_c$.
- Multimode step index fiber suffers with modal dispersion.
  One of the ways to reduce modal dispersion is graded index fiber. With graded index fiber, the light follows a more curved path. The higher order modes spend most of the time travelling in lower index cladding layer near the outside of the fiber. These lower-index core layers allow the light to travel faster than in the higher-index center layers. Therefore, their higher velocity compensates for the longer paths of these high-order modes.
  Modal dispersion is completely eliminated by using single mode fiber.
- Numerical aperture is used to describe the light gathering ability and to measure the magnitude of acceptance angle of optical fiber.
- Pulse spreading occurs only in multimode fiber.

21. (b)

Given data: d = 60 km; f = 450 MHz, I = 0.05 A ; h_t = 120 m; h_r = 40 m

Received electric field,

$$|E_r| = \frac{240\pi I\, h_1 h_2}{\lambda d^2}$$

$$|E_r| = \frac{240\pi\times0.05\times120\times40\times450\times10^6}{3\times10^8\times(60\times10^3)^2}$$

$$= 75.3\times10^{-6}\text{ V/m}$$

22. (a)

A satellite link uses different frequencies for receiving and transmitting in order to avoid interference between its powerful transmitted signal and weak incoming signal.

23. (d)

$$T_s = 490\text{ K}$$

Gain of parabolic reflector,

$$G_r = 6\left(\frac{D}{\lambda}\right)^2 = 6\left(\frac{Df}{c}\right)^2$$

For C-band, downlink frequency f = 4 GHz

$$G_r = 6\left(\frac{50\times4\times10^9}{3\times10^8}\right)^2$$

$$= 6\times\frac{25\times16\times10^{20}}{9\times10^{16}}$$

$$= \frac{50\times16}{3}\times10^4 = \frac{8}{3}\times10^6$$

$$\text{Figure of merit, } M = \frac{G_r}{T_s} = \frac{8\times10^6}{3\times490}$$

$$M(\text{dB}) = 10\log 8\times10^5 - 10\log(147)$$

$$= 3\times3+50-20-1.67$$

$$= 39-1.67$$

$$= 37.32 \text{ dB}$$

24. (a)

The Advanced Research Projects Agency Network (ARPANET) was the first wide-area packet-switched network with distributed control and one of the first computer networks to implement the TCP/IP protocol suite.

25. (c)

- SCTP is a new transport layer protocol designed to combine some features of UDP and TCP. SCTP provides reliability similar to TCP but maintains a separation between data transmissions (called "chunks") similar to datagrams in UDP.
- SCTP provides flow control, error control and congestion control.

26. (b)

$$n = 2$$

Let us assume seven-cell reuse ($i = 1$, $j = 2$) pattern, so frequency reuse factor,

$$Q = \sqrt{3N} = \sqrt{21} = 4.582 \qquad \because [N = i^2 + j^2 + ij]$$

Also, signal to interference ratio is given by

$$\frac{S}{I} = \frac{1}{6}\times(\sqrt{3N})^n = \frac{1}{6}\times(21)^{2/2} = \frac{21}{6} = 3.5$$

$$\frac{S}{I}(\text{dB}) = 20\log(3.5) = 10.88 \text{ dB}$$

Since, this is greater than the minimum required $\frac{S}{I}$, $N = 7$ can be used.

27. (c)

The transmitter's window size = N.

The receiver's window size = M.

Since at any time number of unacknowledged frames are M at receiver and same time N packets are transmitted by sender. Therefore, for ARQ scheme, the minimum number of distinct sequence numbers (P) required to ensure correct operation will be sum of transmitter's and receiver's window size,

i.e., $P = N + M = 12 + 8 = 20$

28. (c)

The power density of EM wave, $\vec{P} = \frac{E_0^2}{2\eta}\hat{a}_x$ where $\eta = \frac{120\pi}{\sqrt{\varepsilon_r}}$

$$\vec{P} = \frac{4\times 3\hat{a}_x}{2\times 120\pi} = \frac{12\hat{a}_x}{2\times 120\pi} = \frac{1}{20\pi}\hat{a}_x$$

$$P_{avg} = \int \vec{P}.\vec{dS}$$

$$P_{avg} = \vec{P}\cdot S\hat{a}_n$$

where, $S = 80\text{ cm}^2$ and $\hat{a}_n$ an is a unit vector normal to the plane $x + 2y = 4$.

$$= \frac{80\times 10^{-4}}{20\pi}\left(\frac{\hat{a}_x + 2\hat{a}_y}{\sqrt{5}}\right)\hat{a}_x$$

$$P_{avg} = \frac{80\times 10^{-4}}{20\pi\sqrt{5}}$$

$$P_{avg} = 0.0569\text{ mW}$$

29. (c)

The load impedance Z_L is a parallel combination of $R = 1\text{ k}\Omega$ and $C = 0.5\text{ nF}$.

$$\therefore \quad Z_L = R\,||\,\frac{1}{j\omega C} = \frac{R}{1 + j\omega RC}$$

$$Z_L = \frac{10^3}{1 + j\times 2\times 10^6\times 10^3\times 0.5\times 10^{-9}}$$

$$Z_L = \frac{10^3}{1 + j}$$

$$Z_L = 500(1 - j)$$

The reflection coefficient at the load end of the line is:

$$\Gamma_L = \frac{Z_L - Z_0}{Z_L + Z_0} = \frac{500(1-j) - 50}{500(1-j) + 50}$$

$$\Gamma_L = 0.90 - j0.09049$$

30. (b)

The tangential and normal component of the field in medium (1) (dielectric) are

$$E_{t1} = 10\cos 60° = 10\times\frac{1}{2} = 5\text{ V/m}$$

$$E_{n1} = 10\sin 60° = 10\times\frac{\sqrt{3}}{2} = 5\sqrt{3}\text{ V/m}$$

From the boundary condition:

$$E_{t1} = E_{t2} = 5 \text{ V/m}$$

and

$$D_{n1} = D_{n2}$$

$$\varepsilon_0 \, \varepsilon_{r1} \, E_{n1} = \varepsilon_0 \varepsilon_{r2} E_{n2}$$

$$E_{n2} = 4E_{n1}$$

$$E_{n2} = 4 \times 5\sqrt{3}$$

$$E_{n2} = 20\sqrt{3} \text{ V/m}$$

∴

$$E_2 = \sqrt{E_{t2}^2 + E_{n2}^2} = \sqrt{(5)^2 + (20\sqrt{3})^2}$$

$$= 35 \text{ V/m}$$

31. (c)

$$E = (4x^3 + y^2)\hat{a}_x + xy\,\hat{a}_y \text{ kV/m}$$

$$Q = -5 \ \mu\text{C}$$

$$W = -Q\int \vec{E} \cdot \vec{dl}$$

$-\int \overline{E} \cdot \overline{dl}$ is voltage between two points.

The path is (0, 6, 0) → (3, –2, 0)
Since, z is not changing, so $dz = 0$

$$\vec{dl} = dx\,\hat{a}_x + dy\,\hat{a}_y$$

$$W = -Q\int \vec{E} \cdot \vec{dl}$$

$$W = -Q\int \left\{(4x^3 + y^2)\hat{a}_x + xy\,\hat{a}_y\right\}\left\{dx\,\hat{a}_x + dy\,\hat{a}_y\right\}$$

$$W = -Q\int (4x^3 + y^2)dx + xy\,dy$$

for path: $(0, 6, 0) \rightarrow (3, 6, 0)$

$$y = 6 \quad \Rightarrow \quad dy = 0$$

Since y is not changing from (0, 6, 0) → (3, 6, 0); $x \rightarrow 0$ to 3, we have

$$W_1 = -Q\int_0^3 (4x^3 + 36)dx$$

$$W_1 = -Q\left[\frac{4x^4}{4} + 36x\right]_0^3$$

$$W_1 = -Q[189 \times 10^3]$$

$$W_1 = -[-5 \times 10^{-6}][189 \times 10^3] = 945 \text{ mJ}$$

for path : (3, 6, 0) to (3, –2, 0)

$$x = 3 \quad \Rightarrow \quad dx = 0$$

y varies from 6 to –2:

Now,

$$W_2 = -Q\int_{y=6}^{-2} xy\,dy$$

$$W_2 = -(-5\,\mu C)\times 3\times\left(\frac{y^2}{2}\right)_6^{-2}$$

$$W_2 = \frac{15}{2}\times[4-36]\times 10^{-3} = -240 \text{ mJ}$$

So, total work done $W = W_1 + W_2$

$$W = 705 \text{ mJ}$$

32. (c)

For $\frac{\lambda}{2}$ dipole;

$$|H_{\phi s}| = \frac{I_0 \cos\left(\frac{\pi}{2}\cos\theta\right)}{2\pi r \sin\theta}$$

$$6\times 10^{-6} = \frac{I_0 \cos\left(\frac{\pi}{2}\cos\frac{\pi}{2}\right)}{2\pi(3\times 10^3)\sin\frac{\pi}{2}}$$

$$6\times 10^{-6}\times 2\pi\times 3\times 10^3 = I_0$$

$$I_0 = 0.113 \text{ Amp}$$

$$P_{rad} = \frac{1}{2}I_0^2 R$$

$$P_{rad} = \frac{1}{2}(0.113)^2\times 73$$

$$P_{rad} = 0.466 \text{ Watt}$$

$$P_{rad} = 466 \text{ mWatt}$$

33. (c)

- Surface on which potential is constant are designated as equipotential surfaces. Equipotential surfaces are always perpendicular to the electric field, since no work is performed to move a charge perpendicular to electric field.
- Electric field due to infinite sheet is

$$\vec{E} = \frac{\rho_s}{2\varepsilon_0}(\pm\hat{a}_z) \quad \text{[independent of distance]}$$

- Points charges are assumed to have spherical shape and hence, possess spherical symmetry. Thus, the field lines emanates radially from the charge in all directions.

34. (a)

The two conductor transmission line behaves like a distributed circuit element with the resistance, inductance and capacitance distributed all along it's length.

35. (b)

$$\eta_{TM} = \eta\frac{\lambda}{\lambda_g}$$

$$\eta_{TM} = 120\pi\frac{\lambda}{\lambda_g}$$

Cutoff wavelength, $$\lambda_C = \frac{2}{\sqrt{\left(\frac{1}{4}\right)^2+\left(\frac{1}{2}\right)^2}} = 3.57 \text{ cm}$$

Guide wavelength $$\lambda_g = \frac{\lambda}{\sqrt{1-\left(\frac{\lambda}{\lambda_c}\right)^2}} = \frac{2}{\sqrt{1-\left(\frac{2}{3.57}\right)^2}} = 2.41 \text{ cm}$$

$$\eta_{TM} = 120\pi\frac{\lambda}{\lambda_g}$$

$$\eta_{TM} = 120\pi\frac{2}{2.41} = 99.58\ \pi\Omega \simeq 100\ \pi\Omega$$

36. (a)

Circular waveguides are easy to manufacture and easy to join. The main disadvantage is that it's cross-section is larger than that of a rectangular waveguide, thus occupying more space for carrying the same signal.

37. (b)

The overshoot of the step response can be decreased by reducing the positive correction torque and increasing the damping torque.

$$\xi \propto \frac{1}{\sqrt{K}} : K\downarrow\ \xi\uparrow\ M_p\downarrow$$

38. (d)

The block diagram has a transfer function

$$\frac{Y(s)}{X(s)} = \frac{3\times 12}{s^2+s(2+12\alpha)s+36}$$

Comparing with the standard second-order transfer function,

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

We get, $2\xi\omega_n = 2 + 12\alpha \quad \omega_n = \sqrt{36} = 6 \text{ rad/sec}$

Given, $\xi = 0.45$

Therefore, $2 \times 0.45 \times 6 = 2 + 12\alpha$

$$\alpha = \frac{5.40-2}{12} = \frac{3.4}{12} = 0.283$$

39. (a)

$$\frac{C(s)}{R(s)} = \frac{G(s)}{1+G(s)H(s)} = \frac{k}{s(s+6)(s+5)+k}$$

The characteristic equation is

$$s(s + 6)(s + 5) + k = 0$$
$$s^3 + 11s^2 + 30s + k = 0$$

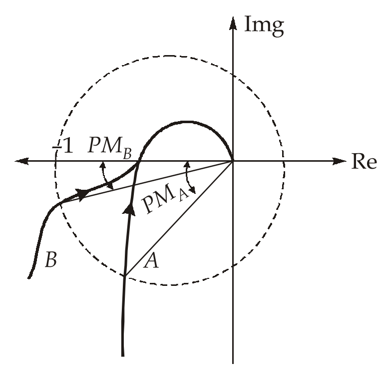
The Routh's array is

s^3	1	30
s^2	11	k
s^1	$\frac{330-k}{11}$	
s^0	k	

For the system to be stable, the conditions are $330 - k > 0$ or $k < 330$ and $k > 0$ which gives the condition $0 < k < 330$.

If $k = 4$; then the margin for stability $= \frac{330}{4} = 82.5 \Rightarrow$ the gain can be increased by a factor of 82 before instability arises.

40. (d)



Gain margin for both system is same. But phase margin of system A is more, thus A is relatively more stable.
So statement 2 is correct and statements 1 and 3 are incorrect.

41. (d)

PI controller is equivalent to a low-pass filter and thus, similar to phase lag compensator. So, statement 3 is incorrect.

42. (b)

The given system is a Type-1 system as one pole is present at origin resulting in an initial slope of -20 dB/decade. For a type-I system, the intersection of the initial slope of the Bode plot with 0 dB axis gives velocity error constant. Thus,

$$k_V = 8$$

$$\therefore \quad e_{ss} = \frac{1}{k_V} = \frac{1}{8} = 0.125$$

The corner frequency associated with poles causes the slope to change by –20 dB/decade and the corner frequency associated with zeros causes a slope change of 20 dB/decade. Thus,

Number of poles; $P = 1 + 1 + 1 + 1 = 4$

Number of zeroes: $Z = 2$

43. (d)

If the system matrix [A] is a diagonal matrix, then

- The system is observable if the output matrix [C] contain any non-zero elements.
- The system is controllable if the input matrix [B] contain an non-zero element.

44. (c)

- If there are two adjacent poles on the real axis and the segment of the real axis between the two poles is a part of the root locus, then at least one break away point exist between the poles as root locus branch originate from pole and terminate at zero or infinity.
- A system having three zeroes and four poles has branches/loci equal to 4.
- The number of asymptotes of the root locus plot that tend to infinity is $P - Z$ if $P > Z$ and $Z - P$ if $Z > P$.

  Here $P = 3$; $Z = 1$

  Number of asymptotes = $P - Z = 2$

45. (d)

Comparing the closed-loop transfer function to that of a standard second order system we have,

$$\omega_n^2 = 36$$

$$\omega_n = 6 \text{ rad/sec}$$

$$2\xi\omega_n = 8$$

$$\xi = \frac{8}{2\times 6} = \frac{2}{3} = 0.67$$

$$t_{max} = \frac{\pi}{\omega_d} = \frac{\pi}{6\times\sqrt{1-\left(\frac{2}{3}\right)^2}}$$

$$= \frac{\pi\times 3}{6\times\sqrt{9-4}} = \frac{\pi}{2\times\sqrt{5}}$$

$$= \frac{\pi}{2\sqrt{5}} \text{sec}$$

46. (c)

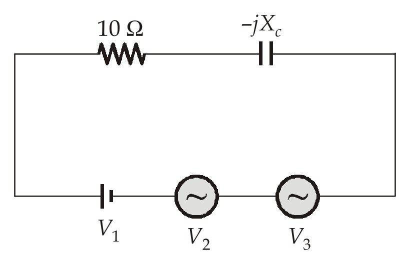
- Since voltage rating of the bulbs is equal, the low rating bulb has higher resistance than high rating bulb. In series, both bulbs have the same current flowing through them, therefore, the low rating bulb having higher resistance gives more brigtness whereas in parallel, the current through the high rating bulb would be large and therefore, high rating bulb gives more brightness.
- Field theory can be applied for both low and high frequency applications whereas, network theory is applied only for low frequency applications. At high frequency, the wavelength

becomes smaller and eventually becomes comparable to the size of the circuit elements due to which the phase of the voltage or current changes signifiantly over the physical extent of the device.

Therefore, statement (2) is incorrect. Hence, option (c) is correct.

47. (b)

We have,



$$V_1 = 10 \text{ V}; V_2 = 10 \sin 1000t \text{ V}; V_3 = 10\sqrt{2}\sin 2000t \text{ V}$$

Using superposition theorem,

For $V_1 = 10$ V,

$$\Rightarrow \quad X_C = \frac{1}{\omega C} = \infty; \text{ circuit become open circuit}$$

current due to 10 V, $i_1 = 0$ A

For $V_2 = 10 \sin 1000t$ V,

$$X_C = \frac{1}{\omega C} = \frac{1}{2\times 10^{-3}\times 10^{3}} = 0.5\ \Omega$$

$$Z_2 = (10 - j0.5)\Omega$$

$$|Z_2| = \sqrt{(10)^2 + (0.5)^2} = 10.01\ \Omega$$

then $$i_2 = \frac{V_2}{Z_2} = \frac{10}{\sqrt{2}\times 10.01} = 0.706 \text{ A (rms)}$$

For $V_3 = 10\sqrt{2}\sin 2000t$ V,

$$X_C = \frac{1}{\omega C} = \frac{1}{2000\times 2\times 10^{-3}}$$

$$X_C = 0.25\ \Omega$$

$$|Z_3| = \sqrt{(10)^2 + (0.25)^2} \approx 10\ \Omega$$

$$i_3 = \frac{V_3}{Z_3} = \frac{10\sqrt{2}}{\sqrt{2}\times 10} = 1 \text{ A (rms)}$$

The total current flowing in the circuit,

$$I_T = \sqrt{i_1^2 + i_2^2 + i_3^2} = \sqrt{0^2 + (0.706)^2 + (1)^2}$$

$$I_T = 1.22 \text{ A (rms)}$$

Power dissipated by 10 Ω, $P_{10\,\Omega} = I_T^2 R = (1.22)^2 \times 10$

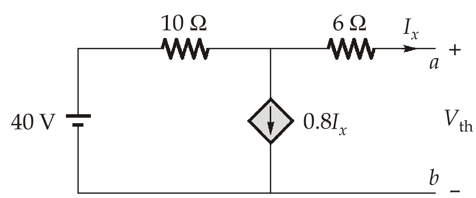
$$P_{10\,\Omega} = 14.9 \text{ Watt}$$

$$P_{10\,\Omega} \approx 15 \text{ Watt}$$

Hence, option (b) is correct.

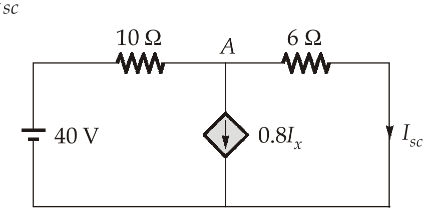
48. (a)

Step-I: Calculation of V_{th}



As $I_x = 0$ A $\Rightarrow$ $0.8I_x$ is also 0 A. Therefore, $V_{th} = 40$ V

Step II: Calculation of I_{sc}



$\because I_{sc} = I_x$

KCL at node A,

$$\frac{V_A - 40}{10} + 0.8I_x + I_x = 0$$

$$V_A - 40 + 18I_x = 0$$

As $I_x = \dfrac{V_A}{6}$

then, $V_A = 10$ V

Therefore, $I_x = I_{sc} = \dfrac{V_A}{6} = \dfrac{10}{6}$ A

Step III: Calculation of R_{th}:

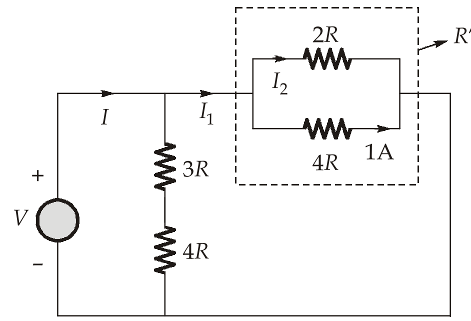
$$R_{th} = \frac{V_{th}}{I_{sc}} = \frac{40 \times 6}{10}$$

$$R_{th} = 24 \ \Omega$$

Hence, option (a) is correct.

49. (d)

For DC supply, capacitor is open circuited and inductor is short circuited. The modified circuit is

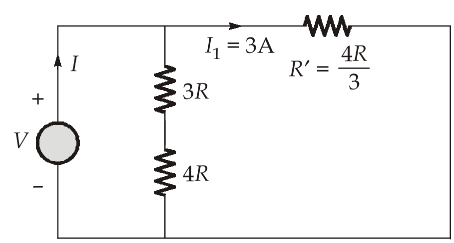


From current division, we know that

$$1\,A = \frac{I_1 \times 2R}{4R + 2R}$$

$$I_1 = 3\text{ A}$$

Now, $$R' = 2R \,||\, 4R = \frac{8R^2}{6R} \Rightarrow R' = \frac{4R}{3}$$



Again, applying current division, we get

$$I_1 = \frac{I \times 7R}{7R + \frac{4R}{3}} = \frac{I \times 21R}{25R}$$

$$I = \frac{I_1 \times 25}{21}, \quad \text{where, } I_1 = 3\text{A}$$

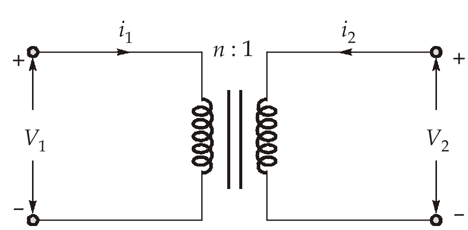
∴ $$I = \frac{25}{7}\text{A}$$

$$I \approx 3.6\text{A}$$

Hence, option (d) is correct.

50. (b)

We have,



We know that,

$$\frac{V_1}{V_2} = \frac{n}{1} = \frac{-i_2}{i_1}$$

$$V_1 = nV_2 \quad \text{...(i)}$$

$$i_1 = \frac{-i_2}{n} \quad \text{...(ii)}$$

Now compare (i) and (ii) with standard transmission parameters equation,

$$V_1 = AV_2 - BI_2$$
$$I_1 = CV_2 - DI_2$$

On comparison we get,

$$A = n \text{ and } D = \frac{1}{n}$$
$$B = C = 0$$

Therefore,

$$\text{transmission parameter matrix} = \begin{bmatrix} n & 0 \\ 0 & \frac{1}{n} \end{bmatrix}$$

Hence, option (b) is correct.

51. (c)

We know that,

For parallel RLC circuit,

$$\text{Quality factor, } Q = R\sqrt{\frac{C}{L}}$$

$$\because \quad Q = \frac{1}{2\xi}$$

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

Time constant, for parallel RLC circuit,

$$\tau_p = 2RC$$

and for series RLC circuit, $\tau_s = \frac{2L}{R}$

For no oscillation in parallel RLC circit, $\xi_{\text{parallel}} \geq 1$

$$\frac{1}{2R}\sqrt{\frac{L}{C}} \geq 1$$

$$\frac{1}{4R^2} \times \frac{L}{C} \geq 1$$

$$\frac{L}{R} \geq 4RC$$

Multiplying 2 on both sides,

$$\frac{2L}{R} \geq 8RC$$

$\because$ $\tau_p = 2RC$ and time constant of series RLC circuit, $\tau_s = \dfrac{2L}{R}$

We get, $\tau_s \geq 4\tau_p$

Hence, option (c) is correct.

52. (a)

We have,

Resonance frequency, $f_0 = 10$ kHz, $R = 2\ \Omega$, $C = 25$ nF, $V_{in} = 250\ \angle 0°$ V

We know that,

$$f_0 = \frac{1}{2\pi\sqrt{LC}}$$

$$10 \times 10^3 = \frac{1}{2\pi\sqrt{25 \times 10^{-9} \times L}}$$

$$L = \frac{1}{4\pi^2 \times 25 \times 10^{-9} \times 10^8}$$

$$L = \frac{1}{10\pi^2}\text{ Henry}$$

Maximum energy stored in inductor is given as

$$E_{inductor} = \frac{1}{2}LI_{max}^2 \quad \text{...(i)}$$

Now, $I_{rms} = \dfrac{V_{in}}{Z}$

At resonance, $Z = R$

$$I_{rms} = \frac{250}{2} = 125\text{ A}$$

$\because$ $I_{rms} = \dfrac{I_m}{\sqrt{2}} \Rightarrow I_m = \sqrt{2}\, I_{rms}$

Put all the values in equation (i), we get

$$E_{inductor} = \frac{1}{2} \times \frac{1}{10\pi^2} \times \left(\sqrt{2} \times 125\right)^2$$

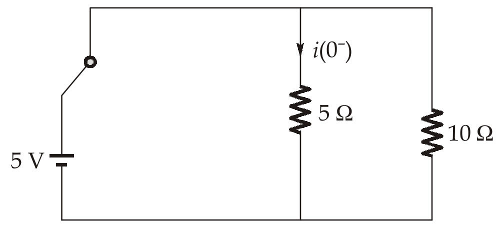
$$E_{inductor} = \frac{1}{2} \times \frac{2 \times 125 \times 125}{10\pi^2}$$

$$E_{inductor} \approx 158\text{ Joule}$$

Hence, option (a) is correct.

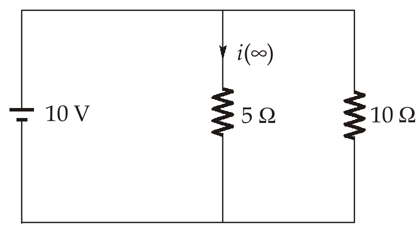
53. (d)

Case-I: For $t < 0$; at steady state, inductor acts as short circuit.



$$i(0^-) = \frac{5}{5} = 1\text{ A} = i(0^+)$$

Case-II: At $t = \infty$



$$i(\infty) = \frac{10}{5} = 2\text{ A}$$

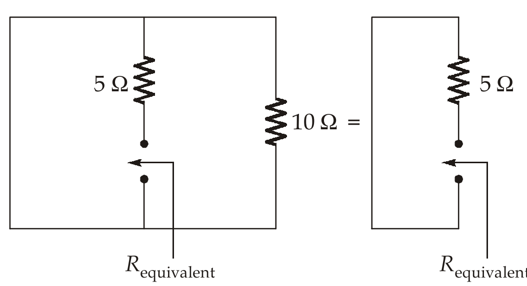
Now, we know that

$$i(t) = i(\infty) + (i(0^+) - i(\infty))e^{-t/\tau}$$

$$i(t) = 2 + (1 - 2)e^{-t/\tau} \quad \text{...(i)}$$

where, $$\tau = \frac{L}{R_{\text{equivalent}}}$$

$R_{\text{equivalent}}$:



$$R_{\text{equivalent}} = 5\ \Omega$$

Put all the values in equation (i) we get,

$$i(t) = 2 - e^{\frac{-t\,R_{equivalent}}{L}}$$

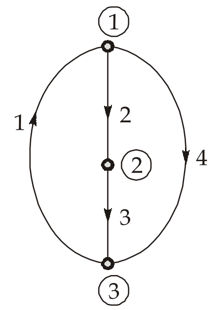
$$i(t) = 2 - e^{\frac{-t\times5}{0.1}}$$

$$i(t) = [2 - e^{-50t}]A$$

Hence, option (d) is correct.

54. (b)

The graph of the network is shown in figure:



From graph, We get number of nodes, $N = 3$ (①,② and ③)

number of branches, $B = 4$ (1, 2, 3 and 4)

Now, we know that,

$$\text{Number of links } (l) = B - (N - 1) = 4 - (3 - 1) = 2$$

$$\text{Number of Twigs} = N - 1 = 3 - 1 = 2$$

We get, number of links = 2 and number of Twigs = 2. Hence, option (b) is correct.

55. (b)

As the phase locked loop (PLL) will track the frequency of the incoming FM signal, it provides a high degree of noise immunity. Hence, there is no requirement of pre-emphasis and de-emphasis. Also, the PLL demodulators do not exhibit threshold in S/N performance.

56. (c)

Given $85.5\text{ MHz} < f_c < 105\text{ MHz}$

$$f_{LO} - f_c = 10.8\text{ MHz}$$

$$f_{LO} = 10.8\text{ MHz} + f_c$$

$$f_{LO\min} = 10.8 + 85.5 = 96.3\text{ MHz}$$

$$F_{LO\max} = 10.8 + 105 = 115.8\text{ MHz}$$

∴ Range of tuning of Local Oscillator = 96.3 MHz-115.8 MHz

57. (b)

$$m(t) = A\cos\omega_m t = A\cos(4\pi \times 10^3 t)$$

$$\left|\frac{dm(t)}{dt}\right|_{\max} = A(2\pi)(2\times 10^3)$$

Given: Nyquist Rate = 2.5 × 2 × 4 kHz = 20 kHz

The maximum allowable amplitude of the input sinusoidal is

$$A_{max} = \frac{\Delta}{\omega_m T_s} = \frac{\Delta}{\omega_m} f_s = \frac{200 \times 10^{-3}}{2\pi \times 2 \times 10^3} \times 20 \times 10^3$$

$$A_{max} = 318.309 \text{ mV}$$

Assuming that the cut off frequency of the low pass filter is f_m, we have

$$(SNR)_0 = \left(\frac{S}{N_q}\right)_0 = \frac{3}{8\pi^2}\left(\frac{f_s}{f_m}\right)^3$$

$$= \frac{3}{8\pi^2}\left(\frac{20}{2}\right)^3$$

$$= \frac{3}{8\pi^2} \times 10^3$$

$$= \frac{3 \times 0.101}{8} \times 10^3$$

$$(\text{SNR})_0(\text{dB}) = 10\log\left[\frac{(3 \times 0.101) \times 10^3}{8}\right]$$

$= 10 \log 303 - 10 \log 8$

$= 10 \log 3.03 \times 10^2 - 9$

$= 10[2 + 0.477] - 9$

$= 24.7 - 9 = 15.7$ dB

58. (b)

Let X be the random variable denoting the number of 1s generated in a five-digit sequence. Since, there are only two possible outcomes (1 or 0) and the probability of generating 1 is constant and there are five digits, it is clear that X has a binomial distribution with $n = 5$ and $k = 2$. Hence, the probability that two 1s and three 0s will occur in a five-digit sequence is

$$P(X = 2) = {}^5C_2(0.6)^2 \times (0.4)^3 = 0.23$$

59. (a)

$$P(z_2) = P(x_1) \times 0.8 \times 0.3 + P(x_2) \times 0.2 \times 0.3 + P(x_2) \times 0.8 \times 0.7 + P(x_1) \times 0.2 \times 0.7$$

$= 0.4 \times 0.8 \times 0.3 + 0.6 \times 0.2 \times 0.3 + 0.6 \times 0.8 \times 0.7 + 0.4 \times 0.2 \times 0.7$

$= 0.096 + 0.036 + 0.336 + 0.056$

$= 0.524$

$$I(z_2) = P(z_2)\log_2 \frac{1}{P(z_2)}$$

$$= 0.524 \log_2\left(\frac{1}{0.524}\right)$$

$= 0.488 \cong 0.5$ bits

60. (c)

$$\beta = \frac{\Delta f}{f_m}$$

$$\beta_{min} = \frac{80\times10^3}{20\times10^3} = 4$$

$$\beta_{max} = \frac{80\times10^3}{50} = 1600$$

If β_1 = 0.4, where β_1 is the input β, then the required frequency multiplication is

$$n = \frac{\beta_{max}}{\beta_1} = \frac{1600}{0.4} = 4000$$

The maximum allowed frequency deviation at the input denoted Δf_1 is

$$\Delta f_1 = \frac{\Delta f}{n} = \frac{80000}{4000} = 20 \text{ Hz}$$

61. (d)

- PSK is affected by QNE but not FSK.
- The waveform of MSK exhibits phase continuity, i.e, there are no abrupt phase changes as in QPSK. As a result, we avoid the inter symbol interference (ISI) caused by non linear amplifier.
- The distance between signalling points is inversely proportional to probability of error. More is the distance, less will be the probability of receiving one signal as another.
- In DPSK, the information is carried in the difference between adjacent received phases. Hence, it does not need a synchronous carrier at the receiver.

62. (a)

Given:
$$N = 20;\ L = 64$$
$$2^n = L$$
$$n = \log_2 64 = 6 \text{ bits/sample}$$
$$f_s = 10 \text{ kHz}$$

Total number of bits per sampling period,

$$= Nn + N + 1$$
$$R_b = (Nn + N + 1)f_s$$
$$= (20 \times 6 + 20 + 1)10 \times 10^3$$
$$= 141 \times 10 \times 10^3 = 1.41 \text{ M bits/sec}$$

$$\text{B.W} = \frac{R_b}{2} = \frac{1.41}{2}\times10^6 = 705 \text{ kHz}$$

63. (c)

For the envelope detector output to follow the envelope of AM signal,

$$RC \le \frac{1}{\omega_m}\frac{\sqrt{1-\mu^2}}{\mu}$$

For $m(t)$ = 15 cos 200t, ω_m = 200 rad/sec

$$\therefore \qquad RC \le \frac{1}{200} \times \frac{\sqrt{1-(0.8)^2}}{0.8}$$

$$RC \le \frac{1}{200} \times \frac{0.6}{0.8}$$

$$RC \le \frac{3}{800}$$

$$RC \le 3.75 \text{ ms}$$

64. (b)

Induced emf, $E = 4.44\ N\phi_m f$

$$\phi_m = \frac{2B_m Dl}{P},$$

where l = axial length of armature and D = diameter

We have, $D_1 = 3D$

$$l_1 = 3l$$

$$\phi_{m1} = \frac{2B_m D_1 l_1}{P} = \frac{2B_m(3D)(3l)}{P}$$

$$\phi_{m1} = 9\ \phi_m$$

Induced E.M.F

$$E_1 = 4.44\ f\ N_1 \phi_{m_1}$$

$$= 4.44 f(3N)\ (9\phi_m)$$

$$= 4.44\ f\ N\phi_m(27)$$

$$= 27\ E$$

$$\frac{E_1}{E} = 27$$

65. (c)

Magnetostriction is the phenomenon which causes changes in dimensions of the material when it is subjected to magnetic field. The contraction and expansion of the iron core due to the magnetic effect of the alternating current flowing through the transformer coils produces hums or noise in the transformer.

66. (d)

For maximum efficiency,

variable losses = constant losses

$$I_a^2 R_a = P_k$$

$$I_a = \sqrt{\frac{P_k}{R_a}} \qquad \text{...(1)}$$

Constant losses for dc machine is

$$P_k = \text{(core + mech)loss + field losses}$$

$$= 1200 \text{ W} + \frac{(240)^2}{120}$$

$$= 1200 + 480 = 1680 \text{ W}$$

Armature resistance (R_a): In wave wound armature, the number of parallel paths is always two. Hence,

$$\text{Conductors per path} = \frac{80 \times 10 \times 2}{2} = 800$$

$$\text{Resistance per path} = 800 \times 0.025\ \Omega$$

$$\text{Total armature resistance} = \frac{800 \times 0.025}{2}$$

$$= 10\ \Omega$$

From equation (i)

$$I_a = \sqrt{\frac{1680}{10}} = \sqrt{168}$$

$$= 2\sqrt{42} = 2 \times 6.48$$

$$= 12.96\ \text{A}$$

67. (c)

At starting, when the motor is stationary, there is no back emf. If the motor is directly switched on to the mains, the armature will draw a heavy current. The applied voltage is reduced by the starter, thereby reducing the starting torque and starting current both.

68. (a)

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

$$\text{Efficiency, } \eta = \frac{\text{Output}}{\text{Output} + P_{cu} + P_i}$$

$$0.95 = \frac{1}{1 + 2P_i}$$

$$1 + 2P_i = \frac{1}{0.95}$$

$$2P_i = \frac{20}{19} - 1 = \frac{1}{19}$$

$$P_i = \frac{1}{38}$$

$$P_i = 0.0263\ \text{pu}$$

$$(P_{\text{cu}})_{fl} = 0.0263\ \text{pu}$$

$$(P_{\text{cu}})_{fl} = R_{\text{pu}} = 0.0263\ \text{pu}$$

$$\text{Voltage regulation} = R_{\text{pu}} \cos\phi + X_{\text{pu}} \sin\phi$$

$$= 0.0263 \times 0.6 - 0.08 \times 0.8 \quad [\because \Phi \text{ is negative for leading p.f.}]$$

$$\%V_R = -4.822\%$$

$$\cong -5\%$$

69. (b)

$$N_s = \frac{120f}{P} = \frac{120 \times 50}{8} = 750 \text{ rpm}$$

$$f_2 = \frac{P(N_s \pm N_r)}{120}$$

(i)
$$f_2 = \frac{P(N_s + N_r)}{120} = \frac{8 \times (2500 + 750)}{120}$$

$$= \frac{8 \times 3250}{120} = \frac{650}{3} \text{Hz}$$

$$= 216.67 \text{ Hz}$$

(ii)
$$f_2 = \frac{P(N_s - N_r)}{120} = \frac{8 \times (2500 - 750)}{120}$$

$$= \frac{8 \times 1750}{120} = \frac{350}{3} = 116.67 \text{ Hz}$$

70. (c)

- In IM, rotor runs in the same direction as the rotating magnetic field. Therefore, the direction of rotation of a 3-phase induction motor can be reversed by interchanging any two of the three motor supply lines.
- DC motor requires brushes and it is difficult to design a DC motor exhibiting proper commutation. But IM doesn't require commutation and brushes and hence, are easy to design. So, IM is less costly and requires lesser maintenance.

71. (a)

- The synchronous motor operates at a lagging power factor when the excitation is under excited ($E_b < V$), at a unity power factor at normal excitation ($E_b = V$) and at a leading power factor when the excitation is over-excited ($E_b > V$).
- The oscillation of the rotor about its equilibrium position is known as hunting. The hunting (oscillations) can be prevented by providing damper winding on the rotor pole faces.

The armature reaction effect depends on load current and power factor of the load.

72. (c)

For a lead-acid cell, Lead peroxide (PbO_2) acts as the Positive active material, Sponge lead (Pb) acts as the Negative active material and Dilute sulfuric acid is the Electrolyte.

73. (c)

From the given plot, we observe that there is a deficit of minority carriers in the quasi-neutral region immediately adjacent to the depletion region. Hence, the diode is reverse biased.

- We have low level injection, so the p-side and n-side doping concentrations are given as

$$N_A = P_{P0} = P_P = 10^{16}/\text{cm}^3$$

$$N_D = n_{n0} = n_n = 10^{17}/\text{cm}^3$$

-
$$P_{n0} = 10^3/\text{cm}^3$$

$$n_{p0} = 10^4/\text{cm}^3$$

$$n_i^2 = n_{n0} \times P_{n0}$$
$$= P_{p0} \times n_{p0}$$
$$= 10^{20}/\text{cm}^6$$
$$n_i = 10^{10}/\text{cm}^3$$

Also, the intrinsic concentration can be obtained as

$$n_i = \sqrt{n(\infty)p(\infty)} = \sqrt{n(-\infty)p(-\infty)}$$
$$= \sqrt{10^{20}} = 10^{10}/\text{cm}^3$$

From the figure, the p-side doping concentration is $10^{16}/\text{cm}^3$ and n-side doping concentration is $10^{17}/\text{cm}^3$. Hence, statements 2 and 3 are incorrect.

74. (c)

$$E_F = E_V + kT\ln\frac{N_V}{N_A}$$
$$E_F - E_V = kT\ln\frac{N_V}{N_A}$$

At T = 300 K, $$0.25 = k(300)\ln\frac{N_V}{N_A} \quad ...(i)$$

At T = 380 K, $$(E_F - E_V) = k(380)\ln\frac{N_V}{N_A} \quad ...(ii)$$

Divide (ii)/(i),

$$\frac{E_F - E_V}{0.25} = \frac{380}{300}$$
$$E_F - E_V = \frac{19}{15}\times 0.25$$
$$= 0.3167 \text{ eV}$$
$$\cong 0.32 \text{ eV}$$

75. (d)

Given data

$$n = 10^{20}/\text{cm}^3$$
$$B = 0.5 \text{ Wb/cm}^2$$
$$J = 500 \text{ A/cm}^2$$
$$d = 6 \text{ mm}$$

$$V_H = \frac{R_H BI}{W} = \frac{B\times JWd}{n\times qW} = \frac{0.5\times 500\times 6\times 10^{-1}}{10^{20}\times 1.6\times 10^{-19}}$$
$$= \frac{250\times 6\times 10^{-1}}{1.6\times 10}$$
$$= 9.375 \text{ V}$$
$$V_H \cong 9.38 \text{ V}$$

76. (a)

- The built-in potential V_{bi} maintains equilibrium, so no current is produced by this voltage.
- The change in the amount of immobile charges with the reverse voltage is considered as the capacitance effect. Transition capacitance is the rate of change of immobile charges with reverse voltage.

77. (b)

There is no depletion region when MOS interface is in accumulation. As V_G increases from V_{FB}, ϕ_s increases from 0 towards $2\phi_B$. When Φ_s reaches $2\Phi_B$, the surface electron concentration becomes so large that the surface is considered inverted. The V_G at this point is called the threshold voltage, V_T.

$W_{dep} \propto \sqrt{\phi_s}$ in depletion mode of operation.

$$W_{d(\max)} = \sqrt{\frac{2 \in_s 2\phi_B}{qN_a}}$$

$W_{d(\max)}$ is constant in inversion region where ϕ_s saturates at $2\phi_B$.

78. (d)

Flat band is the condition where the energy band (E_C and E_V) of the substrate is flat at the Si-SiO_2 interface. Hence, Figure 2 represents the energy band diagram in flat band condition. Hence, option (d) is the correct answer.

79. (d)

- The value of dark current of a photo conductive cell is negligibly small.
- Photodiode is a type of semiconductor pn junction diode.
  We know that the current through a reverse biased *p-n* junction changes considerably if the device is exposed to illumination. The variation in the output current is linear with respect to the luminous flux. This characteristic of *p-n* junction has been utilized in fabricating semiconductor photodiode. It can operate in photovoltaic mode and photoconductive mode.
- In zener diode, doping concentration is high in *p* and *n* region of the diode, compared to normal *p-n* junction diode. Due to heavy doping, depletion region width is narrow. Hence, electric field intensity $E = V/d$ will be high near the junction which is responsible for zener breakdown.
- Avalanche breakdown occurs due to high energy electrons colliding with lattice atoms and generating free electrons for conduction. This cascading effect is called impact ionization leading to avalanche breakdown.

80. (d)

The emitter injection efficiency takes into account the injection of carriers from the base into emitter. For a p-n-p transistor, the common base current gain is given as

$$\alpha = \frac{I_C}{I_E} = \frac{I_{pC}}{I_{pE}} \times \frac{I_{pE}}{I_{pE} + I_{nE}}$$

$$\alpha = \beta^* \gamma$$

where α is the common-base current gain, β^* is the base transport factor and γ is the emitter injection efficiency.

81. (a)

Diffusion capacitance is

$$C_d = \frac{\tau_h}{r_d}$$

$$r_d = \frac{\eta V_T}{I_f}$$

$$C_d = \frac{\tau_h I_f}{\eta V_T}$$

$$\frac{C_d}{I_f} = \frac{\tau_h}{\eta V_T} = 2.5 \times 10^{-6}\ \text{F/A}$$

$$\tau_h = 2.5 \times 10^{-6} \times 2 \times 25 \times 10^{-3} \quad [\because \text{Ideality factor, } \eta = 2 \text{ for Si}]$$

$$= 125 \times 10^{-9}\text{s}$$

$$= 1.25 \times 10^{-7}\text{s}$$

82. (b)

A stack is the best data structure to check whether an arithmetic expression has balanced parenthesis or not. Traverse the arithmetic expression from left to right. For each opening parenthesis, push it onto the stack and for each closing parenthesis, pop an element from the stack. If the popped character is matching with the closing paranthesis, the expression has balanced paranthesis. If the closing parenthesis does not match the element popped or there are no more elements in the stack, the expression is considered unbalanced. Hence, option (b) is correct.

83. (d)

- For the given relational schema, the candidate key is *AB*. So, primary attributes are *A*, *B* and non-primary attributes are *C*, *D*, *E*, *P*, *G*.
- $B \rightarrow G$, it indicates that there is a partial dependency in the given relational schema (A partial dependency occur when a non-prime attribute depends functionally on a part of the given candidate key). Hence, it is not in 2NF.

84. (c)

- Structural hazards: Arise from resource conflict when the hardware can't support all possible combinations of instructions in simultaneous overlapped execution (eg. two instructions in the pipeline require the same resource).
- Data hazards: Arise when an instruction depends on the results of a previous instruction in a way that is exposed by overlapping of instructions in pipeline.
- Control Hazards: Arise from the pipelining of branches and other instructions that change the PC (Program Counter).

85. (d)

- Attributes are the properties that define the entity type.
  For example – Roll no. Name, DOB, etc....
- The different types of attributes in ER model include:
  - Key Attributes - uniquely identify the entity in the entity set.
  - Composite Attributes - can be split into components.
  - Multi-valued Attributes - takes up more than a single value for each entity instance.
  - Derived Attributes - can be derived from other attributes.
  - Simple Attributes - cannot be further subdivided into components.
  - Single-valued Attributes - takes up only a single value for each entity instance.

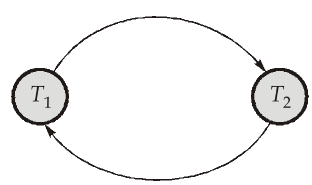
86. (c)

Consider the table for transaction,

For S_1

T_1	T_2
$r_1(X)$	
$r_1(Y)$	
	$r_2(X)$
	$r_2(Y)$
	$W_2(Y)$
$W_1(X)$	

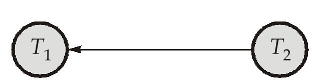
Precedence graph for S_1:



For S_2

T_1	T_2
$r_1(X)$	
	$r_2(X)$
	$r_2(Y)$
	$W_2(Y)$
$r_1(Y)$	
$W_1(X)$	

Precedence graph for S_2:



If a precedence graph contains cycle, then the schedule is not conflict serializable. So, S_1 is not conflict serializable and S_2 is conflict serializable.

87. (a)

Virtual Memory is a storage allocation scheme in which secondary memory can be addressed as though it were part of the main memory. It allows for execution of programs larger than the physical memory size loading only the segment of program into main memory required for execution.

88. (a)

- Double precision floating point format:

← 64 bits →

S	BE	M
1	11	52

- In normalized form, Range of Mantissa is given as [1 to $(2 - 2^{-x})$], where x is number of bits of Mantissa.

Hence, option (a) is correct.

89. (d)

- EMF induced in the conductor when it is being rotated in the steady magnetic field is called as Dynamically induced EMF and direction of dynamically induced EMF is given by Fleming's Right Hand rule.
- EMF induced in the conductor when it is subjected to time varying flux is called as statically induced EMF and direction of statically induced EMF is given by LENZ law.

Therefore, none of the statements are correct. Hence, option (d) is correct.

90. (b)

91. (a)

92. (b)

$$\text{XTHL requires} \Rightarrow 16 \text{ T-states}$$
$$\text{CALL 2018 H requires} \Rightarrow 18 \text{ T-states}$$
$$\text{STAX D requires} \Rightarrow 7 \text{ T-states}$$
$$\text{DAD H requires} \Rightarrow 10 \text{ T-states}$$

93. (d)

To generate a square wave, the required condition is,

$$T_{\text{clock}} \le T_{\text{square wave}}$$

To generate a squarewave with a time period of 100 ns,

$$T_{\text{clock}} \le 100 \text{ ns}$$

$$f_{\text{clock}} \ge \frac{10^9}{100} \text{Hz} = 10 \text{ MHz}$$

$$f_{\text{clock}} \ge 10 \text{ MHz} \qquad \text{...(i)}$$

To generate a square wave with a period of 10 ms,

$$T_{\text{clock}} \le 10 \text{ ms}$$

$$f_{\text{clock}} \ge \frac{1000}{10} = 100 \text{ Hz}$$

$$f_{clock} \geq 100 \text{ Hz} \quad ...(ii)$$

From equations (i) and (ii),

$$f_{clock} \geq 10 \text{ MHz}$$

$$f_{clock(min)} = 10 \text{ MHz}$$

94. (b)

95. (d)

"DAD D" requires one "opcode-fetch" machine cycle and two "bus idle" machine cycles.

So, Number of T-states = 4 + 2(3) = 10

96. (d)

- Idle mode can be terminated either with a hardware interrupt or with a hardware reset.
- Power down mode can be terminated only with a hardware reset.

97. (d)

All the given steps are necessary.

98. (b)

An embedded system must have processor and memory.

99. (b)

We have,

number of possible logic expressions = $2^{2^n} = 16 \Rightarrow n = 2$

For n = 2 variable inputs, (A and B) maximum number of possible inputs are

$$2^n = 2^2 = 4(\bar{A}\bar{B}, \bar{A}B, A\bar{B}, AB)$$

Hence, option (b) is correct.

100. (d)

We have, two inputs variables A, B and output Y.

Now, prepare truth table from given Venn diagram

A	B	Y
0	0	0
0	1	0
1	0	1
1	1	0

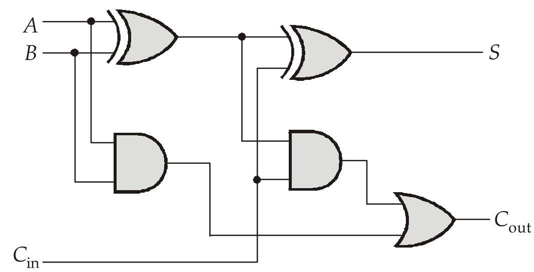
$$Y = A\bar{B} \quad \text{or} \quad Y = (A+B)(A+\bar{B})(\bar{A}+\bar{B})$$

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

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

Therefore, $Y = A\bar{B}$ or $Y = (A \oplus B)(A+\bar{B})$. Hence, option (d) is correct.

101. (a)



The full-adder is implemented using EX-OR, OR and AND gates as shown in the figure. Since, the propagation delay of each gate is same, say t_{pd}, we have

Total propagation delay for sum = $2t_{pd}$

Total propagation delay for carry = $3t_{pd}$

We have, $3t_{pd}$ = 20 nsec

t_{pd} = 6.67 nsec

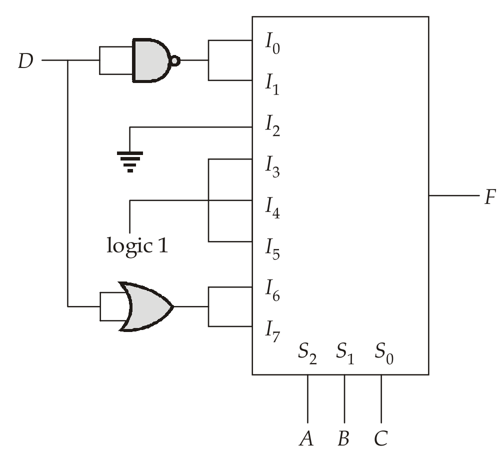
Propagation delay for sum = 6.67 × 2

= 13.34 nsec

Hence, option (a) is correct.

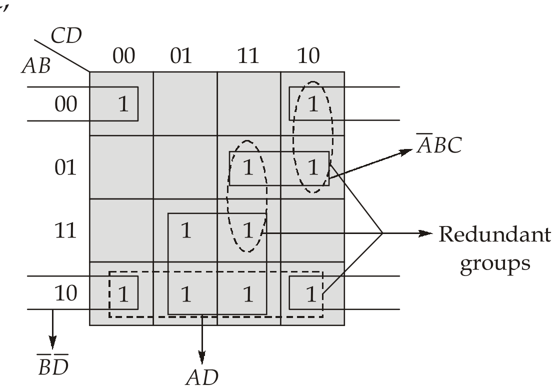
102. (d)

We have,



$$F = \bar{A}\bar{B}\bar{C}\bar{D} + \bar{A}\bar{B}C\bar{D} + \bar{A}BC + A\bar{B}\bar{C} + A\bar{B}C + AB\bar{C}D + ABCD$$

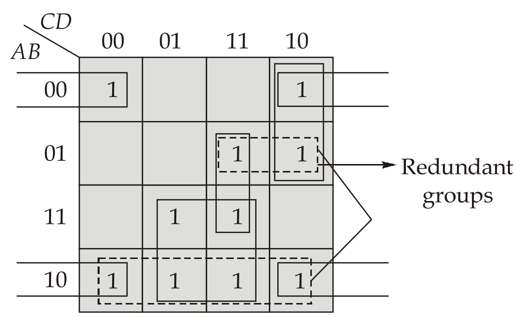
Now, from K-map we get,



$$F = \bar{A}BC + AD + \bar{B}\bar{D}$$
$$F = \Sigma m(0, 2, 6, 7, 8, 9, 10, 11, 13, 15)$$
$$F = \Pi M(1, 3, 4, 5, 12, 14)$$

Redundant groups are $A\bar{B}$, BCD and $\bar{A}C\bar{D}$

or $A\bar{B}$ and $\bar{A}BC$ as shown below:



For, $F = \bar{B}\bar{D} + AD + BCD + \bar{A}C\bar{D}$, $A\bar{B}$ and $\bar{A}BC$ are redundant groups.

Hence, option (d) is correct.

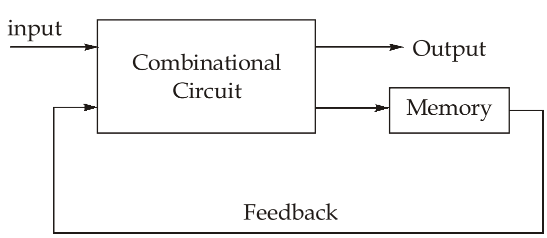
103. (b)

The minimum number of flip-flops, N, required to generate a sequence of length S is given by

$$S \leq 2^N - 1$$
$$7 \leq 2^N - 1$$
$$8 \leq 2^N$$
$$N \geq 3$$

Hence, option (b) is correct.

104. (c)

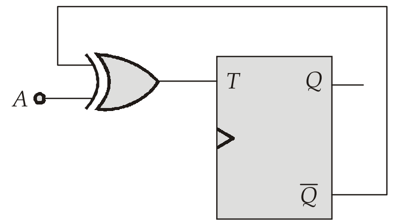


Basic block diagram of sequential circuit.

The output of a sequential circuit depends on both present and past inputs. The cyclic nature of a sequential circuit is due to the feedback loops within the machine. Hence, statement 2 is incorrect.

105. (d)

Considering EX-OR Gate,



$$Q_{n+1} = T \oplus Q \qquad \because T = \bar{Q} \oplus A$$

$$Q_{n+1} = (\bar{Q} \oplus A) \oplus Q$$

$$Q_{n+1} = (\bar{Q}\bar{A} + \bar{\bar{Q}}A) \oplus Q$$

$$Q_{n+1} = (\bar{Q}\bar{A} + QA)\bar{Q} + \overline{(\bar{Q}\bar{A} + QA)}Q$$

$$Q_{n+1} = \bar{Q}\bar{A} + (Q\bar{A} + \bar{Q}A)Q$$

$$Q_{n+1} = \bar{Q}\bar{A} + Q\bar{A}$$

$$Q_{n+1} = \bar{A}$$

Hence, option (d) is correct.

106. (d)

A Johnson ring counter, also called switch-tail ring counter, walking ring counter, Twisted ring counter, or Möbius counter, is a synchronous counter which connects the complement of the output of the last shift register to the input of the first register and circulates a stream of ones followed by zeros around the ring. Whereas Ripple counter is a cascaded arrangement of flip-flops where the output of one flip-flop drives the clock input of the following flip-flop.

107. (b)

Type of ADC	Resolution (max-bits)	Conversion rate (max.)
Dual slope	12-20	100 samples/s
Successive approximation	8-18	10 M samples/s
Flash	4-12	10 G samples/s
Pipeline	8-16	1 G samples/s
Delta-sigma	8-32	1 M samples/s

$$\text{Time taken} \propto \frac{1}{\text{Conversion rate}}$$

Hence, option (b) is correct.

108. (c)

The total number of implanted ions can be given by

$$Q = S \times (\text{surface area of wafer})$$

where; Dose of boron $S = 5 \times 10^{14}$ ions/cm^2

Diameter of wafer $d = 200$ mm $= 20$ cm

$$Q = S \times \pi \left(\frac{d^2}{4} \right)$$

$$Q = 5 \times 10^{14} \times \pi \times \frac{(20)^2}{4}$$

$$Q = 1.57 \times 10^{17} \text{ ions}$$

109. (b)

Verification : It is a predictive analysis to ensure that the synthesized design, when manufactured, will perform the given I/O function.

Test: It is a manufacturing step that ensure that the physical device manufactured from the synthesized design, has no manufacturing defects.

Yield: Yield is defined as the ratio of number of good chips to the total number of fabricated chips on a wafer.

110. (c)

The diffusion involves two steps. First step is the pre-deposition, also known as the constant source diffusion because the concentration of source dopant atoms is maintained constant during this process and second is the drive-in, also known as limited source diffusion because no extra dopant atoms are added during this process.

In the drive-in process:

1. No external source is required.
2. Doping profile is gaussian.
3. $N(x,t) = \frac{S}{\sqrt{\pi D t}} e^{-\frac{x^2}{4Dt}}$
4. Surface concentration is not constant. As drive-in progresses, surface concentration decreases.
5. Dose(s) is always constant.

111. (b)

$$\left(\frac{W}{L}\right)_{P,eq} = \frac{1}{\frac{1}{\left(\frac{W}{L}\right)_A} + \frac{1}{\left(\frac{W}{L}\right)_B} + \frac{1}{\left(\frac{W}{L}\right)_C}} + \frac{1}{\frac{1}{\left(\frac{W}{L}\right)_D} + \frac{1}{\left(\frac{W}{L}\right)_E}}$$

$$= \frac{1}{\frac{1}{5} + \frac{1}{5} + \frac{1}{5}} + \frac{1}{\frac{1}{5} + \frac{1}{5}}$$

$$= \frac{1}{\frac{3}{5}} + \frac{1}{\frac{2}{5}} = \frac{5}{3} + \frac{5}{2} = 4.16$$

112. (a)

The nominal etch time, $t_{nominal} = \frac{0.50}{0.30}$ minutes. The over etch is done to make sure all the oxide is etched for the worst case condition; that means for the thickest oxide and the slowest etch rate.

$$d_{ox(max)} = 0.5(1.05)\ \mu m = 0.525\ \mu m$$

$$r_{ox(min)} = 0.3(0.95)\ \mu m/\text{minute} = 0.285\ \mu m/\text{minute}$$

The time taken to etch the worst case;

$$t_{max} = \frac{d_{ox(max)}}{r_{ox(min)}} = \frac{0.525}{0.285} = \frac{35}{19}$$

The amount of over etch, in % time, can be given by

$$\text{overetch} = \frac{t_{max} - t_{nominal}}{t_{nominal}} \times 100$$

$$= \frac{\frac{35}{19} - \frac{5}{3}}{\frac{5}{3}} \times 100 = 0.1052 \times 100$$

$$= 10.52\%$$

113. (d)

- **Stuck-at fault model:** A signal, or gate output, is stuck at a 0 or 1 value, independent of the inputs to the circuit.
- **Open circuit fault model:** Here a wire is assumed broken, and one or more inputs are disconnected from the output that should drive them.
- **Short circuit fault model:** Also known as Bridging fault model, wherein two signals are connected together when they should not be.

114. (d)

In VLSI design flow, there are three design domains: Functional or Behavioral, structural, and geometric or physical domain. The relationship between the three domains is represented by Gajski's Y chart as shown below:

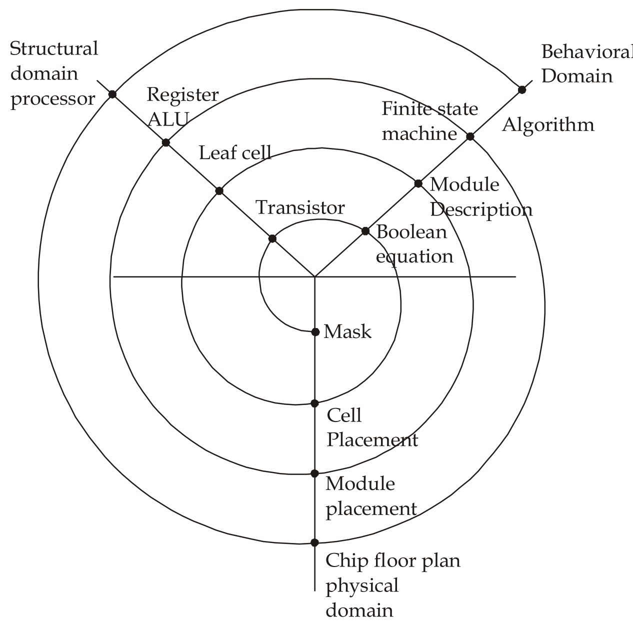


Fig: The Y chart

115. (d)

$$\text{Size of RAM} = 2^n \times M$$
$$n = \text{Width of Address bus}$$
$$2^n = \text{number of memory locations}$$
$$M = \text{bits stored in each memory location}$$
$$\text{size of RAM} = 2^n \times M = 2^4 \times 5$$
$$= 16 \times 5 = 80 \text{ bits}$$

116. (d)

117. (b)

- Anti ferromagnetic materials are characterized by the anti-parallel arrangement of dipoles with equal dipole moment values in the opposit directions. Above neel temperature, when external magnetic field is applied to Anti ferro magnetic material due to vibration, dipole does not align in one direction. Hence, magnetization is almost zero and material behaves as paramagnetic material.
- Above curie temperature, ferromagnetic material behaves as paramagnetic material.

118. (a)

- The phenomenon in which the value of a physical property lags behind changes in the effect causing it, is known as hysteresis. It is characterized as a lag of magnetic flux density (B) behind the magnetic field strength (H).
- Rentivity: The residual or remanent flux density inside the magnetic material when the magnetic field is reduced to zero is known as rentivity.
- Coercivity: Coercivity, is a measure of the ability of a ferromagnetic material to withstand an external magnetic field without becoming demagnetized.

119. (b)

120. (c)

Curie law for para magnetic material, $\chi_m = \frac{C}{T}$ and

for Anti ferro magnetic material, $\chi_m = \frac{C}{T+\theta}$

Hence, option (c) is correct.

121. (d)

- A nanoparticle is a small particle that ranges between 1 to 100 nanometres in size.
- If one dimension is reduced to the nano range while the other two dimensions remains large, then we obtain a structure known as a quantum well. If two dimensions are reduced and one remains large, the resulting structure is referred as a quantum wire.
- Carbon-60 which is known to have shape of truncated icosahedron is made of twenty hexagons and twelve pentagons, and resembles a football.
- CNTs can carry an electric current density which is more than 1000 times greater than that of metals.

All the above statements are correct.
Hence option, (d) is correct.

122. (c)

If any objects are made up of meta material, then objects are invisible to incoming electromagnetic wave, it is called as cloaking.

Material having $\mu_r > 0; \in_r > 0 \Rightarrow$ Right handed material

$\mu_r < 0; \in_r < 0 \Rightarrow$ Left handed material or meta material or stealth material

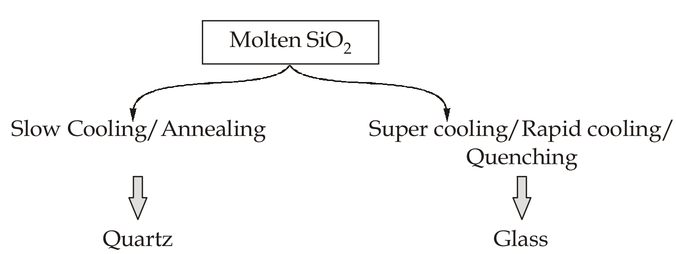
123. (a)

The detailed information regarding the mechanism of fracture is available from microscopic examination, normally using scanning electron microscopy, and its study is termed as Fractographic. Therefore, statement 3 is wrong. Hence, option (a) is correct.

124. (d)

- Non-crystalline solid has low density. Hence, statement (3) is incorrect.
- Crystalline solid has sharp melting points because all bonds are broken at particular temperature.

125. (d)



126. (b)

- Primitive unit cell has lattice point only at the corners of the cell and it is shared by eight adjacent unit cells. Example: Simple cubic cell.
- Non-primitive unit cell has not only one lattice point at the corner but also additional lattice points present. Example: BCC, FCC.

127. (b)

Given: $$F(e^{j\omega}) = 1 \cdot e^{-j\frac{3}{4}\omega}; \frac{-\pi}{3} \le \omega \le \frac{\pi}{3}$$

Using the synthesis equation;

$$f(n) = \frac{1}{2\pi}\int_{-\pi/3}^{\pi/3} e^{-j\frac{3}{4}\omega} e^{j\omega n} d\omega$$

$$f(n) = \frac{1}{2\pi}\int_{-\pi/3}^{\pi/3} e^{j\omega\left(n-\frac{3}{4}\right)} d\omega$$

$$f(n) = \frac{1}{2\pi j\left(n-\frac{3}{4}\right)}\left[e^{\frac{j\pi}{3}\left(n-\frac{3}{4}\right)} e^{-j\frac{\pi}{3}\left(n-\frac{3}{4}\right)}\right]$$

$$f(n) = \frac{1}{\pi\left(n-\frac{3}{4}\right)}\sin\frac{\pi}{3}\left(n-\frac{3}{4}\right)$$

$$f(n) = \frac{\sin\frac{\pi}{3}\left(n-\frac{3}{4}\right)}{\pi\left(n-\frac{3}{4}\right)}$$

For no integral value of n, $f(n)$, can be zero except for $n = \pm\infty$.

128. (c)

Given; $f_m = 500$ Hz

We choose, $f_s = 2f_m = 2 \times 500 = 1000$ Hz

The frequency resolution is Δf, given by

$$\Delta f = \frac{f_s}{N} = \frac{2f_m}{N}$$

i.e., $$10 = \frac{2f_m}{N}$$

$$N = \frac{1000}{10} = 100$$

$\therefore$ There are 100 number of points required in the DFT.

129. (c)

The mathematical expression for various window functions is described as

1. Hamming window

$$W(lT) = 0.54 + 0.46\cos\left(\frac{l\pi}{L}\right); |l| \le L = \frac{(N-1)}{2}$$

2. Blackman window

$$W(lT) = 0.42 + 0.5\cos\left(\frac{l\pi}{L}\right) + 0.08\cos\left(\frac{2\pi l}{L}\right)$$

for $|l| \le L = \frac{(N-1)}{2}$

3. Hanning window

$$W(lT) = 0.5 + 0.5\cos\left(\frac{l\pi}{L}\right); |l| \le L = \frac{(N-1)}{2}$$

4. Kaiser window

$$W(lT) = \begin{cases} \dfrac{I_0\left[\beta\left\{1-[(l-\alpha)/\alpha]^2\right\}^{1/2}\right]}{I_0\beta}; & 0 \le l \le N-1 \\ 0 \quad ; & \text{otherwise} \end{cases}$$

130. (c)

Given:

$$h(k) - 6h(k-1) + 9h(k-2) - \delta(k-1) - 8\delta(k-2) = 0$$

Rewriting in recursive form:

$$h(k) = \delta(k-1) + 8\delta(k-2) + 6h(k-1) - 9h(k-2)$$

For a causal system, $h(k) = 0$ for $k < 0$

Substituting for k in ascending order

$$k = 0;\ h(0) = 6h(-1) - 9h(-2) = 0$$
$$k = 1;\ h(1) = \delta(0) + 6h(0) - 9h(-1) = 1 + 6 \times 0 = 1$$
$$k = 2;\ h(2) = \delta(1) + 8\delta(0) + 6h(1) - 9h(0)$$
$$= 0 + 8 + 6 \times 1 - 9 \times 0 = 14$$
$$k = 3;\ h(3) = \delta(2) + 8\delta(1) + 6h(2) - 9h(1)$$
$$= 6 \times 14 - 9 \times 1 = 75$$

131. (a)

The discrete time Fourier series coefficient are periodic with period N, hence

$$A_k = A_{k+N} = A_{k+2N}$$

Therefore, by periodicity, we have,

$$A_{15} = A_{2\times7+1} = A_1 = j$$
$$A_{16} = A_{2\times7+2} = A_2 = 2j$$
$$A_{17} = A_{2\times7+3} = A_3 = 3j$$

As the signal is real and odd, the Fourier coefficients are pure imaginary and ODD.
By oddness property,

$$A_0 = 0,\ A_{-1} = -j,\ A_{-2} = -2j,\ A_{-3} = -3j$$

132. (b)

$$\omega_0 = \frac{2\pi}{8} = \frac{\pi}{4};\ \text{Fundamental frequency}$$

We have,
$$f(t) = \sum_{n=-\infty}^{\infty} F_n e^{jn\omega_0 t}$$

Only fundamental frequency and third harmonics are present in the signal, hence

$$f(t) = \left[2e^{\frac{j\pi t}{4}} + 2e^{\frac{-j\pi t}{4}}\right] + \left[4je^{\frac{j3\pi t}{4}} - 4je^{\frac{-j3\pi t}{4}}\right]$$

$$f(t) = 2\times 2\cos\frac{\pi t}{4} + 4j(2j)\sin\frac{3\pi t}{4}$$

$$f(t) = 4\cos\frac{\pi t}{4} - 8\sin\frac{3\pi t}{4}$$

$$f(t)\big|_{t=0} = 4\times 1 - 8\times 0$$

$$f(t)\big|_{t=0} = 4$$

133. (d)

$$y(n+1) - \alpha y(n) = \alpha r(n)$$

Taking the z transform,

$$zY(z) - \alpha Y(z) = \alpha R(z)$$

$$Y(z)[z-\alpha] = \alpha R(z)$$

$$H(z) = \frac{Y(z)}{R(z)} = \frac{\alpha}{[z-\alpha]}$$

$$H(z) = \frac{\alpha z^{-1}}{\left[1-\alpha z^{-1}\right]};\ \text{ROC: } |z| > |\alpha|$$

Pole is located at $z = \alpha$. The impulse response decays if $|\alpha| < 1$, which is then the condition for the system to be BIBO stable. Alternatively, for the system to be BIBO stable, ROC must include the unit circle i.e. $|\alpha| < 1$.

134. (a)

According to bilinear transformation,

$$z = \frac{1+r}{1-r}$$

substituting z in the given characteristic equation,

$$\left(\frac{1+r}{1-r}\right)^3 - 0.3\left(\frac{1+r}{1-r}\right)^2 + 0.1\left(\frac{1+r}{1-r}\right) - 0.1 = 0$$

$$(1 + r)^3 - 0.3(1 + r)^2(1 - r) + 0.1(1 + r)(1 - r)^2 - 0.1(1 - r)^3 = 0$$
$$1.5r^3 + 2.9r^2 + 2.9r + 0.7 = 0$$

Routh table

r^3	1.5	2.9
r^2	2.9	0.7
r^1	7.36 / 2.9	
r^0	0.7	

As there is no sign change in the first column terms, the system is stable.

135. (c)

The given differential equation is

$$\frac{dy}{dt} + 2y(t) = r(t)$$

On taking Fourier transform

$$j\omega Y(j\omega) + 2Y(j\omega) = R(j\omega)$$
$$Y(j\omega)[2 + j\omega] = R(j\omega)$$
$$Y(j\omega) = \frac{R(j\omega)}{(2 + j\omega)}$$
$$r(t) \longleftrightarrow R(j\omega)$$
$$F_n e^{jn\omega_0 t} \longleftrightarrow 2\pi F_n \delta(\omega - n\omega_0)$$
$$Y(j\omega) = \frac{2\pi F_n \delta(\omega - n\omega_0)}{(2 + j\omega)}$$

On taking inverse Fourier transform

$$y(t) = \frac{1}{2\pi}\int_{-\infty}^{\infty} \frac{2\pi F_n \delta(\omega - n\omega_0) e^{j\omega t} d\omega}{(2 + j\omega)}$$

$\therefore$
$$y(t) = \frac{F_n e^{jn\omega_0 t}}{(2 + jn\omega_0)}$$

136. (b)

Dirichlet conditions:

(i) The function has a finite number of finite discontinuities in each period.
(ii) The function has a finite number of maxima and minima in each period.
(iii) The function is absolutely integrable over a period.

137. (b)

ROM is a non-volatile computer memory that permanently stores data and firmware for booting electronic devices, ensuring data retention even when power is off. The BIOS is always the first program that executes when a computer is powered up. Hence, it is stored in ROM.

138. (b)

- In digital computers, an overflow occurs if the result from an operation is too large to fit in the allocated memory space. Therefore, an arithmetic overflow is a software problem and not a hardware problem.
  Hence, option (b) is correct.

139. (a)

140. (b)

- **Properties of Transaction:**
  Atomicity, Consistency, Isolation and Durability
  Atomicity is defined as a property of database transactions which are guaranteed to either completely occur or having no effect of transaction. It ensures that a transaction is treated as a single, indivisible unit of work and the transactions do not occur partially.
  Hence, statement (I) is correct.
- A schedule is called conflict serializable if it can be transformed into a serial schedule by swapping non-conflict operations.
  Hence, statement II is also correct.

141. (d)

- Associative memory is a fast operating memory because it can be accessed simultaneously and in parallel, on the basis of data content rather than by specific address or location.
- It is also called as content addressable memory (CAM).

142. (b)

The short circuit current is the current through the solar cell when the voltage across the solar cell is zero (i.e., when the solar cell is short circuited).
For an ideal solar cell, the short-circuit current and the light generated current are identical. Therefore, the short circuit current is the largest current which may be drawn from the solar cell. It depends on the number of photons being absorbed by the material, optical properties of the solar cell and it's size.

143. (b)

Auto transformer has higher efficiency than an equivalent two winding transformer because due to the reduction in conductor and core materials, the Ohmic losses in the conductor and the core losses are smaller.

144. (b)

145. (a)

Multiple poles at imaginary axis leads to terms like $t^n \cos \omega t$, $t^n \sin \omega t$, which leads to unbounded response.

146. (a)

Time constant of open loop system is larger due to which the transients takes large time to die-out. Hence, open loop system is slow.

147. (b)

All the lobes other then the main lobe are called the minor lobes representing the radiation in undesired directions. The side lobes are the minor lobes adjacent to the main lobe and are generally the largest among the minor lobes.

148. (a)

In RSA algorithm, for encryption, we use $C = P^e \pmod{n}$ where C is the cipher text, P is the plain text, e is the public key and for decryption, we use $P = C^d \pmod{n}$, where d is the private key.

149. (a)

150. (b)

A monostable multivibrator has one stable and one Quasi-stable stale. The circuit remains in its stable state till an external triggering pulse causes a transition to the Quasi-stable state. It generates a fixed-duration output pulse when triggered by an external input signal. Hence, it can be used to alter the pulse width of a repetitive pulse train.

❍❍❍❍