DETAILED SOLUTIONS

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ESE 2026 : Prelims Exam
CLASSROOM TEST SERIES

E & T ENGINEERING

Test 20

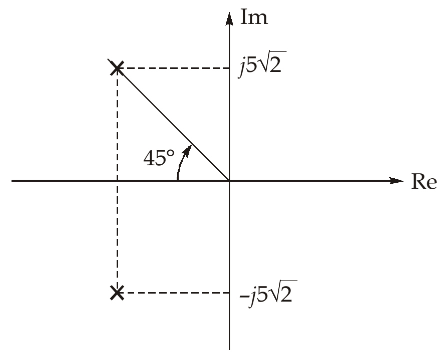
Full Syllabus Test 4 : Paper-II

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

DETAILED EXPLANATIONS

1. (d)

From the pole diagram:



$$\xi = \cos(45°) = \frac{1}{\sqrt{2}}$$

$$\omega_d = 5\sqrt{2} \text{ rad/s}$$

$$\omega_d = \omega_n\sqrt{1-\xi^2}$$

$$5\sqrt{2} = \omega_n\sqrt{1-\left(\frac{1}{\sqrt{2}}\right)^2}$$

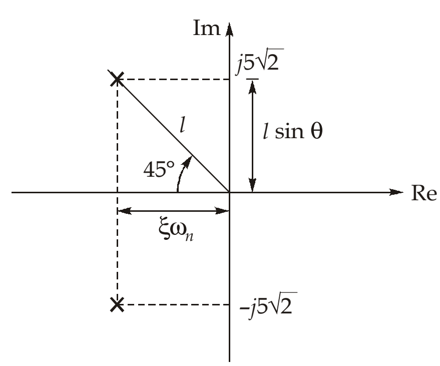
$$\omega_n = 10 \text{ rad/s}$$

Settling time for a 5% tolerance band is

$$t_s = \frac{3}{\xi\omega_n} = \frac{3}{\frac{1}{\sqrt{2}}\times 10} = 0.3\times\sqrt{2}$$

$$t_s = 0.424 \text{ s}$$

Alternate:



From the pole diagram:

$$l\cdot\sin\theta = 5\sqrt{2}$$

$$l\cdot\sin 45° = 5\sqrt{2}$$

$$l = 10$$

$$\xi\omega_n = l \cos 45°$$

$$\xi\omega_n = \frac{10}{\sqrt{2}}$$

Settling time for a 5% tolerance band is

$$t_s = \frac{3}{\xi\omega_n} = \frac{3\times\sqrt{2}}{10} = 0.424\,\text{s}$$

2. (c)

Given:
$$A = \begin{bmatrix} 0 & 1 \\ -2 & 3 \end{bmatrix}, B = \begin{bmatrix} 1 \\ 1 \end{bmatrix}, x(0) = \begin{bmatrix} 1 \\ 0 \end{bmatrix}$$

$$[sI - A] = \begin{bmatrix} s & -1 \\ 2 & s-3 \end{bmatrix}$$

$$[sI - A]^{-1} = \frac{1}{s^2 - 3s + 2}\begin{bmatrix} s-3 & 1 \\ -2 & s \end{bmatrix}$$

$$= \begin{bmatrix} \frac{s-3}{(s-1)(s-2)} & \frac{1}{(s-1)(s-2)} \\ \frac{-2}{(s-1)(s-2)} & \frac{s}{(s-1)(s-2)} \end{bmatrix}$$

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

$$\phi(t) = L^{-1}\{(sI - A)\}^{-1} = \begin{bmatrix} 2e^t - e^{2t} & -e^t + e^{2t} \\ 2e^t - 2e^{2t} & -e^t + 2e^{2t} \end{bmatrix}$$

$$\text{ZIR} = \phi(t) \times x(0)$$

$$= \begin{bmatrix} 2e^t - e^{2t} & -e^t + e^{2t} \\ 2e^t - 2e^{2t} & -e^t + 2e^{2t} \end{bmatrix}\begin{bmatrix} 1 \\ 0 \end{bmatrix}$$

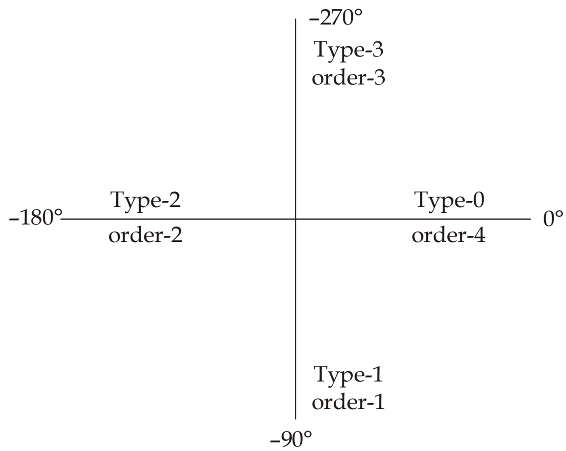
$$= \begin{bmatrix} 2e^t - e^{2t} \\ 2e^t - 2e^{2t} \end{bmatrix}$$

Alternate:
By option-wise substitution at $t = 0$, we obtain

$$x(0) = \begin{bmatrix} 1 \\ 0 \end{bmatrix} \text{ for only option (c)}$$

3. (d)

The given polar plot corresponds to a Type-III system,



For $G(s) = \dfrac{k(1+2s)}{s^3}$

The phase is given by, $\phi = -270° + \tan^{-1}(2\omega)$

At $\omega = 0$, Phase = –270°

At $\omega = \infty$, Phase = –180°

Alternate:

For a minimum phase system:

* At $\omega = 0$:

Polar plot angle = –90° × Type

* At $\omega = \infty$:

Polar plot angle = –90° × (Number of poles – Number of zeros)

Only option (d) satisfies these conditions.

4. (a)

From Figure (B), the closed loop transfer function is:

$$\frac{C(s)}{R(s)} = \left[\frac{G}{s+3}\right] + 1 = \frac{G}{s+3} + 1 \qquad \text{...(i)}$$

From Figure (A),

$$\frac{C(s)}{R(s)} = \frac{s+4}{s+3} \qquad \text{...(ii)}$$

On equating both equations, we get:

$$\frac{s+4}{s+3} = \frac{G}{s+3} + 1$$

$$\Rightarrow \quad \frac{s+4}{s+3} - 1 = \frac{G}{s+3}$$

$$\Rightarrow \quad \frac{1}{s+3} = \frac{G}{s+3}$$

$$\therefore \quad G = 1$$

5. (c)

A PI controller improves the steady-state performance of the system.

6. (c)

The open-loop transfer function is $G(s)H(s)$.

$$G(s)H(s) = \frac{5}{s^2}\cdot\frac{10}{s^4(s+5)} = \frac{50}{s^6(s+5)}$$

The type of a system is defined as the number of open-loop poles at origin.

$$\text{Type} = 6$$

Note: The order of the system is defined for both closed-loop and open-loop systems, whereas the type of the system is defined only for the open-loop system $G(s)\cdot H(s)$.

7. (a)

On adding a pole at the origin,

$$P - Z = 3 - 1 = 2$$

$\therefore$ Angle of asymptotes = 90°, 270°

8. (b)

We have,
$$G(s) = \frac{10}{s(1+0.2s)(1+0.05s)}$$

$$\angle G(j\omega) = -180°$$

$$-[90° + \tan^{-1}(0.2\omega) + \tan^{-1}(0.05\omega)] = -180°$$

$$\tan^{-1}\left[\frac{0.2\omega + 0.05\omega}{1-(0.2\omega)(0.05\omega)}\right] = 90°$$

$$1 - (0.2 \times 0.05)\omega^2 = 0$$

$$\omega^2 = \frac{1}{(0.2\times 0.05)} = 100$$

$$\omega = 10 \text{ rad/s}$$

9. (c)

The open-loop transfer function is:

$$G(s)H(s) = \frac{k}{\left(\frac{s}{1/3}+1\right)\left(\frac{s}{1/2}+1\right)\left(\frac{s}{1}+1\right)}$$

$$= \frac{k}{(3s+1)(2s+1)(s+1)}$$

From the Bode plot:

$$20 \log k = 0$$

$$k = 1$$

Hence,
$$G(s)H(s) = \frac{1}{(3s+1)(2s+1)(s+1)}$$

The closed-loop transfer function is,

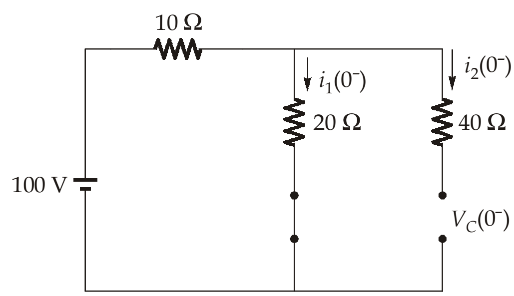
$$T(s) = \frac{G(s)}{1+G(s)H(s)}$$

For unity feedback, $H(s)$ =1. Hence,

$$T(s) = \frac{1}{6s^3+11s^2+6s+2}$$

10. (a)

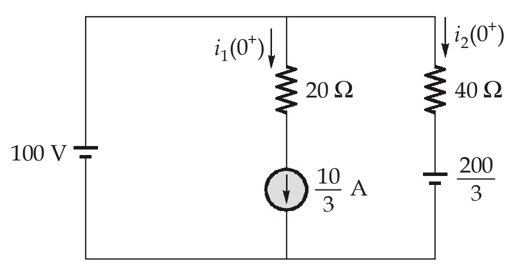
At $t = 0$,



$$i_1(0^-) = i_1(0^+) = \frac{100}{30} = \frac{10}{3}\,\text{A}$$

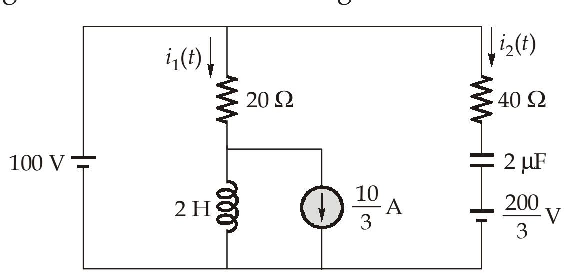
$$V_c(0^-) = V_c(0^+) = \frac{10}{3}\times 20 = \frac{200}{3}\,\text{V}$$

For $t = 0^+$:



$$i_2(0^+) = \frac{100-\frac{200}{3}}{40} = \frac{100}{3\times 40} = \frac{25}{30}\,\text{A}$$

For $t > 0$: The circuit configuration is shown in the figure.



Writing KVL equations for $t > 0$:

$$40i_2 + \frac{1}{2\times10^{-6}}\int_0^t i_2 dt = 100 - \frac{200}{3} = \frac{100}{3}$$

Differenciating both sides with respect to time:

$$40\frac{di_2}{dt} + \frac{1}{2}\times10^6 i_2 = 0$$

At $t = 0^+$:

$$\frac{di_2(0^+)}{dt} = \frac{-1}{2}\times10^6\left[i_2(0^+)\right]\times\frac{1}{40}$$

$$= \frac{-1}{2\times40}\times10^6\times\frac{25}{30} = \frac{-1\times10^6}{2\times8\times6}$$

$$= \frac{-1000\times10^3}{2\times8\times6} = \frac{-125}{12}\times10^3$$

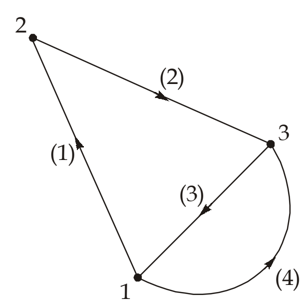
$$= -10.415 \times 10^3 \text{ A/s}$$

$$\frac{di_2(0^+)}{dt} = -10.415 \times 10^3 \text{ A/s}$$

11. (b)

To draw the graph:

1. Replace all resistors, inductors, and capacitors with line segments.
2. Replace the voltage source with a short circuit and the current source with an open circuit.
3. Assume the directions of branch currents arbitrarily.
4. Number all nodes and branches.



Complete incidence matrix (A_a):

$$A_a = \begin{array}{c} \\ 1 \\ 2 \\ 3 \end{array}\begin{array}{c} \begin{array}{cccc} 1 & 2 & 3 & 4 \end{array} \\ \begin{bmatrix} 1 & 0 & -1 & 1 \\ -1 & 1 & 0 & 0 \\ 0 & -1 & 1 & -1 \end{bmatrix} \end{array}$$

The reduced incidence matrix A is obtained by eliminating the last row from matrix A_a.

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

Number of possible trees = $|AA^T|$

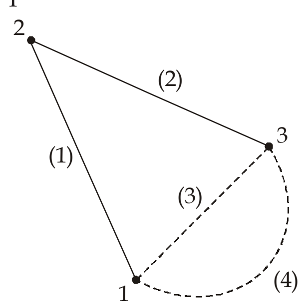
$$AA^T = \begin{bmatrix} 1 & 0 & -1 & 1 \\ -1 & 1 & 0 & 0 \end{bmatrix} \begin{bmatrix} 1 & -1 \\ 0 & 1 \\ -1 & 0 \\ 1 & 0 \end{bmatrix} = \begin{bmatrix} 3 & -1 \\ -1 & 2 \end{bmatrix}$$

$$|AA^T| = \begin{vmatrix} 3 & -1 \\ -1 & 2 \end{vmatrix} = 6 - 1 = 5$$

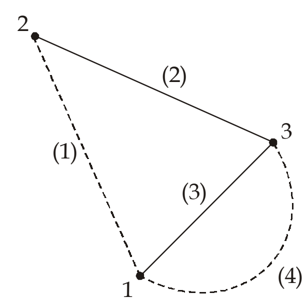
Alternate method:

All possible trees are shown below:

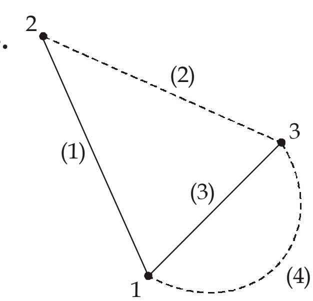
1.



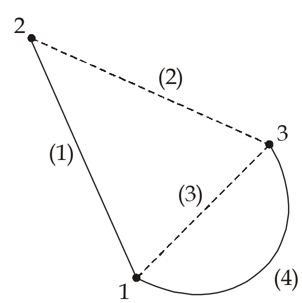
2.



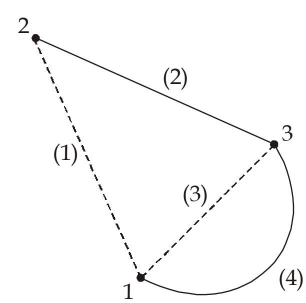
3.



4.



5.



12. (d)

We have:

$$f = 50 \text{ Hz}$$

$$V_{rms} = \frac{V_m}{\sqrt{2}}$$

$$50\sqrt{2} = \frac{V_m}{\sqrt{2}}$$

$$V_m = 100 \text{ V}$$

The voltage expression is:

$$v(t) = V_m \sin(2\pi f t)$$

$$v(t) = 100 \sin(314t) \text{ V}$$

13. (b)

We know that: $\quad \text{Quality factor } (Q) = \dfrac{\text{Resonant frequency } (\omega_0)}{\text{Bandwidth}}$

Here, $\quad \text{Resonant frequency } (\omega_0) = \sqrt{\omega_1 \cdot \omega_2} = 2\omega_1$

$$\text{Bandwidth (B.W)} = \omega_2 - \omega_1 = 3\omega_1$$

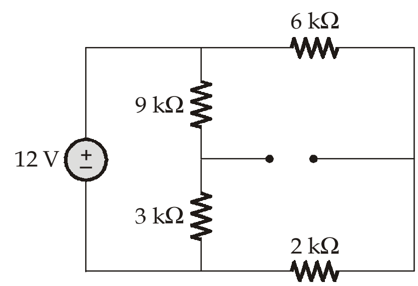
$$Q = \frac{2\omega_1}{3\omega_1} = \frac{2}{3}$$

14. (b)

From given network, we observe that the bridge is in a balanced condition,

i.e., $$z_1 z_4 = z_2 z_3$$

Therefore, the simplified circuit is as shown.



Since R = 1 kΩ acts as an open circuit, the current through it is zero.

Hence, $I_X = 0$ A

15. (c)

We know that:

$$Z_{11} = \left.\frac{V_1}{I_1}\right|_{I_2 = 0}$$

In terms of transmission parameters:

$$Z_{11} = \frac{A}{C}$$

Similarly, $$Y_{11} = \left.\frac{I_1}{V_1}\right|_{V_2 = 0} \quad \text{or} \quad Y_{11} = \frac{D}{B}$$

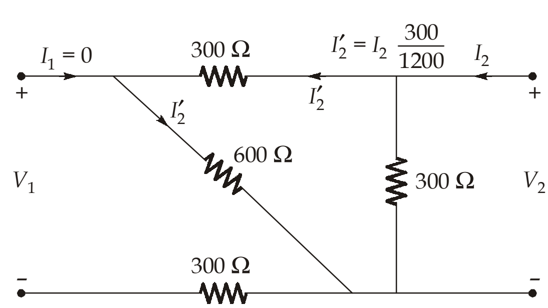
Now, since: $$Z_{11} = \frac{1}{Y_{11}}$$

$$\frac{A}{C} = \frac{B}{D}$$

or, $$AD - BC = 0$$

16. (b)

$$Z_{12} = \left.\frac{V_1}{I_2}\right|_{I_1 = 0}$$



From the given circuit, with $I_1 = 0$:

$$I_2' = I_2 \frac{300}{1200} = \frac{I_2}{4}$$

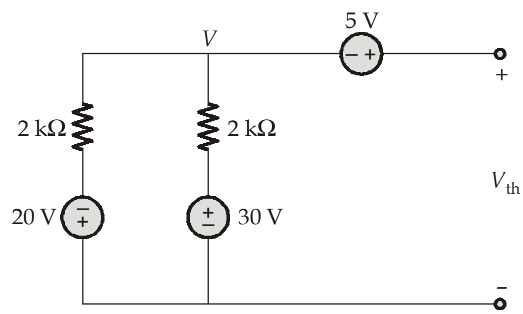
$$V_1 = I_2' \times 600$$

$$V_1 = \frac{I_2}{4} \times 600$$

$$Z_{12} = \frac{V_1}{I_2} = 150\ \Omega$$

17. (a)

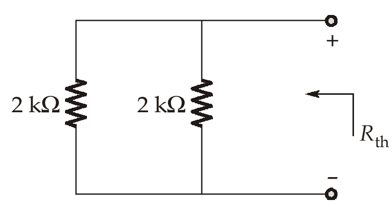
For maximum power transfer, $R_L = R_{th}$. Calculating Thevenin's equivalent of the given circuit:



$$V = \frac{30 \times 2k + (-20) \times 2k}{4k} = \frac{60-40}{4} = 5 \text{ volt}$$

$$V_{th} = 5 + V = 5 + 5 = 10 \text{ volt}$$

Finding R_{th},



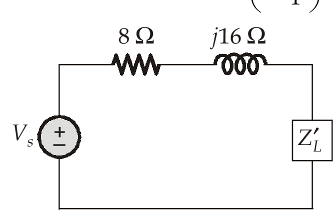
$$R_{th} = 2\ k\Omega \parallel 2\ k\Omega = 1\ k\Omega$$

Maximum power transferred, $P_{max} = \dfrac{V_{th}^2}{4R_{th}}$

$$P_{max} = \frac{10 \times 10}{4 \times (1k)} = 25 \text{ mW}$$

18. (b)

Referring to primary side, $Z_L' = \dfrac{Z_L}{k^2}$ where $k = \left(\dfrac{N_2}{N_1}\right) = 5$



$$Z_L' = \frac{50\angle -30°}{(5)^2} = 2\angle -30°$$

$$Z_s = 8 + j16 + 2\angle -30°$$

$$Z_s = (8+\sqrt{3}) + j15\ \Omega$$

19. (c)

To calculate the checksum:

Step-1: Add all the segments together using one's complement arithmetic.

$$\begin{array}{r} 1001001110010011 \\ 1001100001001101 \\ \hline 1\ \underbrace{0010101111100000}_{\text{16-bits}} \\ +1 \\ \hline \underbrace{0010101111100001}_{\text{16-bits}} \end{array}$$

$\therefore$ Result of the sum is 0010101111100001

Step-2: Take the one's complement of the result obtained from the addition step.

1's complement of the result : 1101010000011110

Hence, Checksum value = 1101010000011110

20. (c)

The highest frequency present in the modulated signal is

$$= f_c + nf_m$$

where $n = \beta + 1$, according to Carson's rule.

For $\beta = 5$

$$f_{\max} = f_c + (\beta + 1)f_m$$
$$= f_c + 6f_m$$
$$= 100 \text{ MHz} + 6 \times 15 \text{ kHz}$$
$$= 100090 \text{ kHz}$$

21. (b)

Given: Sampling frequency, f_s = 32,000 samples/s

Step size, Δ = 1.5 V

The slope overload occurs in a delta modulator.

$$\text{Quantization noise power, } N_q = \frac{\Delta^2}{12}$$

$$N_q = \frac{(1.5)^2}{12} = \frac{2.25}{12} = 0.1875 \text{ W}$$

22. (d)

Given: $$x_{AM}(t) = 10[1 + 0.5 \sin 2\pi f_m t] \cos 2\pi f_c t$$

Comparing with the standard AM expression:

$$x_{AM}(t) = A_c[1 + \mu \sin 2\pi f_m t] \cos \omega_c t$$

$$A_c = 10; \quad \mu = 0.5$$

$$\text{Peak envelope amplitude} = A_c(1 + \mu) = 10(1+0.5) = 15 \text{ V}$$

$$\text{Peak envelope power} = \left(\frac{15}{\sqrt{2}}\right)^2 = 112.5 \text{ W}$$

23. (b)

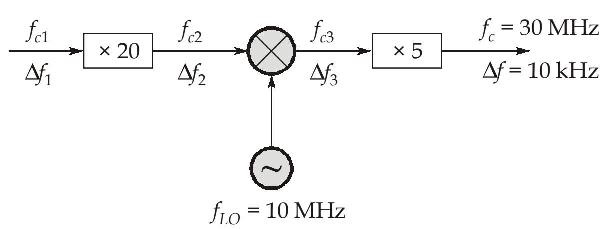
At low frequencies, a particular type of noise appears. The power spectral density of this noise increases as the frequency decreases. This noise is called flicker noise.

$$s(f) \propto \frac{1}{f}$$

Therefore, flicker noise becomes significant at low frequencies, generally below a few kHz.

24. (b)

From the figure:



Given: $$\Delta f = 10 \text{ kHz}; f_c = 30 \text{ MHz}$$

After the frequency multiplier:

$$f_{c3} \times 5 = 30 \text{ MHz}$$

$$f_{c3} = 6 \text{ MHz}$$

$\because$ Down conversion ($f_{LO} > f_{c2}$)

$$f_{c2} = f_{LO} - f_{c3}$$

$$f_{c2} = 10 \text{ M} - 6 \text{ M}$$

$$= 4 \text{ MHz}$$

25. (b)

$$\text{Correlation coefficient, } \rho_{XY} = 0.3$$

$$\begin{array}{r|l} m_X = 0 & m_Y = 0 \\ \sigma_X^2 = 1 & \sigma_Y^2 = 9 \end{array}$$

Now, $$\text{Covariance, } \sigma_{XY} = \rho_{XY} \cdot \sigma_X \cdot \sigma_Y$$

$$= 0.3 \times 1 \times \sqrt{9}$$

$$= 0.3 \times 3 = 0.9$$

26. (c)

Given: $T_b = 50\ \mu\text{sec}$

The bandwidth requirement for polar quaternary NRZ line coding is:

$$\text{BW} = \frac{1}{2T_b}$$

$$\text{BW} = \frac{1}{2\times 50\times 10^{-6}} = 10000\ \text{Hz}$$

Hence, BW = 10 kHz

27. (b)

Given: $s(t) = \cos(2000\pi t)\cos(5\sin 20\pi t) + \sin(2000\pi t)\sin(5\sin 20\pi t)$

$$s(t) = \cos(2000\pi t - 5\sin 20\pi t)$$

The instantaneous phase is: $\theta_i(t) = 2000\pi t - 5\sin 20\pi t$

The instantaneous frequency, $f_i = \dfrac{1}{2\pi}\dfrac{d}{dt}\theta_i(t)$

$$= \frac{1}{2\pi}\frac{d}{dt}[2000\pi t - 5\sin 20\pi t]$$

$$= \frac{1}{2\pi}[2000\pi - 5(\cos 20\pi t)\cdot 20\pi]$$

$$f_i = 1000 - 50\cos(20\pi t)$$

At $t = 0$; $\cos(20\pi t) = 1$

$$(f_i)_{\min} = 1000 - 50\times 1 = 950\ \text{Hz}$$

28. (a)

Given: Carrier frequency, $f_c = 75$ MHz; Bit rate, $R_b = 12$ Mbps

Lower side frequency, $f_L = f_c - \dfrac{R_b}{2}$

$= 75 - 6 = 69$ MHz

Upper side frequency, $f_U = f_c + \dfrac{R_b}{2}$

$= 75 + 6 = 81$ MHz

29. (b)

Designers must simulate across multiple fabrication process corners before a chip is certified as ready for production, or use system-level techniques to deal with the effects of variation.

30. (d)

A metallic blob present between the drain and ground of the n-MOSFET inverter acts as a physical defect, a logical fault as the output is stuck at 0, and an electrical fault as a resistor short.

31. (d)

In nMOS fabrication, the bulk substrate used can be either bulk silicon or silicon-on-sapphire.

32. (d)

$$\text{Without fault: } F = \overline{\left(\overline{ABC}+D\right)+CD}$$

$$= \overline{(\overline{ABC}+D)}\,\overline{CD}$$

$$= (ABC\overline{D})(\overline{C}+\overline{D}) = ABC\overline{D}$$

With stuck-at-0 fault at T,

$$F = \overline{\left(\overline{ABC}+D\right)+0}$$

$$= \overline{(\overline{ABC}+D)}(1) = ABC\overline{D}$$

The input-output logical relationship is the same with and without the fault. Therfore, no input combination can detect the given fault.

33. (b)

The Chemical Vapour Deposition (CVD) process typically results in amorphous structures when depositing dielectric materials such as silicon dioxide (SiO_2) or silicon nitride (Si_3N_4).
The disordered state is called amorphous (or non-crystalline).

34. (b)

One of the main factors in reducing the latch-up effect is reduced n-well resistance. This is often achieved using retrograde wells, where the doping concentration increases with depth, thereby lowering resistance without affecting the surface threshold voltage.

35. (a)

Negative photoresists are more sensitive to light, but their photolithographic resolution is not as high as that of positive photoresists. Therefore, negative photoresists are used less commonly in the manufacturing of high-density integrated circuits.

36. (b)

- LOCOS is used to selectively grow field oxide in specific regions to isolate active devices.
- The active areas are protected by a silicon nitride mask during oxidation; hence, they are not etched away. The oxide grows only where the mask is absent. Hence, statement-2 is incorrect.
- "Bird's-Beak" is the well-known disadvantage of LOCOS, where lateral oxidation enroaches under the edges of the nitride mask, reducing the effective active area.

37. (a)

Using the Deal-Grove model, we can write

$$d_{OX}^2 + Ad_{OX} = B(t+\tau)$$

Here, $\tau = 0$, as no oxide is present at the start of the oxidation.

So, $$d_{OX}^2 + \sqrt{2}d_{OX} = 0.5(1)$$

$$d_{OX} = \frac{-\sqrt{2}+\sqrt{2+2}}{2}\,\mu\text{m}$$

Since d_{OX} is a positive quantity,

$$d_{OX} = \frac{\sqrt{4}-\sqrt{2}}{2} = 1-\frac{1}{\sqrt{2}}$$
$$= 1 - 0.707$$
$$= 0.293\ \mu\text{m}$$

38. (d)

Given, Numerical Aperture, NA = 0.15

$$\sin\theta_a = \text{N.A}$$
$$\Rightarrow \quad \theta_a = \sin^{-1}(0.15)$$
$$= 8.62°$$

39. (a)

We know that,

$$\text{V-number, } V = \frac{2\pi a}{\lambda}\times\text{N.A}$$
$$= \frac{2\pi\times 5}{1.3}\times 0.2 = 4.83$$

40. (a)

Given, Operating frequency, f = 12 GHz,

$$\lambda = \frac{c}{f} = \frac{3\times10^{10}}{12\times10^{9}} = 2.5\text{ cm}$$

The gain of a parabolic antenna is:

$$G = \eta\times\left(\frac{\pi d}{\lambda}\right)^2$$

In decibels:

$$G(\text{dB}) = 10\log\eta + 20\log\left(\frac{\pi d}{\lambda}\right)$$
$$15 = 10\log\eta + 20\log\left(\frac{\pi\times1.5}{2.5}\right)$$
$$15 - 5.5 = 10\log\eta \quad\Rightarrow\quad \eta = 8.9$$

41. (c)

$$\frac{1}{(C/N)_{\text{overall}}} = \frac{1}{(C/N)_{\text{up}}} + \frac{1}{(C/N)_{\text{down}}}$$

$$(C/N)_{\text{up}} \quad\Rightarrow\quad 10\log(C/N)_{\text{up}} = 30$$
$$\therefore \quad (C/N)_{\text{up}} = 10^3$$
$$(C/N)_{\text{down}} = 10\log(C/N)_{\text{down}} = 20$$
$$(C/N)_{\text{down}} = 10^2$$
$$\therefore \quad \frac{1}{(C/N)_{\text{overall}}} = \frac{1}{10^3}+\frac{1}{10^2}$$
$$(C/N)_{\text{overall}} = 90.9$$

42. (a)

Given,
$$f = 6 \text{ GHz}$$
$$d = 10 \text{ km}$$

The radius of the first Fresnel zone is,

$$r_1 = \sqrt{\frac{\lambda d_1 d_2}{d_1 + d_2}}$$

$$\lambda = \frac{c}{f} = \frac{3\times 10^8}{6\times 10^9} = 0.05 \text{ m}$$

$$d_1 = d_2 = 5 \text{ km } (\because \text{ midpoint consideration})$$

$$\therefore \quad r_1 = \sqrt{\frac{0.05\times 5000\times 5000}{10000}} = 11.18 \text{ m}$$

43. (a)

Ethernet can operate at speeds upto 100 Mbps, 1 Gbps, and higher.

44. (a)

IPv6 does not support tranditional broadcast addressing but uses multicast addresses.

45. (d)

Soft handoff is mainly used in CDMA-based cellular systems.

46. (a)

In a Go-Back-N ARQ,

Sender window size = $2^m - 1 = 63$

$$m = 6$$

$\therefore$ Each frame contains a sequence number ranging from 0 to $2^m - 1$.

$$0 \text{ to } 2^6 - 1 = 0 \text{ to } 63$$

47. (d)

- In a vertical micro-programmed control unit, the control signals are represented in an encoded binary format. Here, 'n' control signals require $\log_2 n$ bits for encoding. Hence, signal decoders are required.
- Horizontal microprogramming focuses on speed and parallelism. The operating speed of horizontal microprogramming is higher because there is no decoding delay, and control signals are applied directly.

48. (b)

- Time required for the non-pipelined processor,

$$T_{\text{non-pipeline}} = 5 \text{ ns} + 5 \text{ ns} + 4 \text{ ns} + 3 \text{ ns} + 4 \text{ ns}$$
$$= 21 \text{ ns}$$

- Time required for the pipelined processor,

$$T_{\text{pipeline}} = (t_p + t_{\text{register}})$$
$$= 5 \text{ ns} + 1 \text{ ns} = 6 \text{ ns}$$

$$\text{Speed-up} = \frac{T_{\text{non-pipeline}}}{T_{\text{pipeline}}} = \frac{21\text{ ns}}{6\text{ ns}} = 3.5$$

49. (d)

An Excess-3 code for a decimal digit is obtained by adding 3 to the decimal digit and then converting the result into its 4-bit BCD equivalent.

Excess-3 code for 9: (9 + 3 = 12) = 1100

Excess-3 code for 5: (5 + 3 = 8) = 1000

In Excess-3 addition, if a carry is generated from a 4-bit group, we add 0011 (decimal 3); otherwise, we substract 0011. We have,

$$\begin{array}{lr} & 1100 \\ \text{Carry} & +1000 \\ \hline \boxed{1} & 0100 \\ & +0011 \\ \hline & 0111 \end{array} \Rightarrow 14 \text{ in Excess-3 code}$$

50. (a)

Binary search on an array has a time complexity of $O(\log n)$, whereas for a linked list it is $O(n)$.

51. (d)

Truth Table:

A	B	C	Auxiliary generator (Y)
0	0	0	0
0	0	1	0
0	1	0	0
0	1	1	1
1	0	0	0
1	0	1	1
1	1	0	1
1	1	1	1

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

$Y = AB + BC + AC$

52. (b)

If any changes occur in the dominant entity, then they are also reflected in the sub-ordinate entity, but not vice-versa.

53. (a)

Given: $F = 60\% = 0.6$, $S = 6$

$$\text{Performance gain (or) Speed-up} = \left[(1-F)+\frac{F}{S}\right]^{-1}$$

$$= \left[(1-0.6)+\frac{0.6}{6}\right]^{-1}$$

$$= [0.4 + 0.1]^{-1}$$

$$\text{Speed-up} = 2$$

54. (c)

Ready queue : P_1, P_3, P_2, P_4, P_1, P_2, P_4, P_1, P_2

Gantt chart:

$P_1P_3P_2P_4$	$P_3P_2P_4P_1$	$P_2P_4P_1$	$P_4P_1P_2$	$P_1P_2P_4$	$P_2P_4P_1$	$P_4P_1P_2$	P_1P_2	P_2
P_1	P_3	P_2	P_4	P_1	P_2	P_4	P_1	P_2

0 2 4 6 8 10 12 14 15 17

Process id	B.T	C.T	TAT = CT – AT	WT = TAT – BT
P_1	5 ms	15 ms	15 ms	10 ms
P_2	6 ms	17 ms	17 ms	11 ms
P_3	2 ms	4 ms	4 ms	2 ms
P_4	4 ms	14 ms	14 ms	10 ms

$$\text{Average waiting time, WT} = \frac{10+11+2+10}{4} = \frac{33}{4} = 8.25\text{ ms}$$

55. (b)

The size of the page table may become too large to fit into contiguous memory space. Therefore, page tables are typically divided into multiple levels.

56. (d)

We know that,

Junction capacitance varies inversely with the square root of the voltage:

$$C_j \propto \frac{1}{V_r^{1/2}}$$

Thus,

$$\frac{5}{2.5} = \frac{V_r^{1/2}}{4^{1/2}}$$

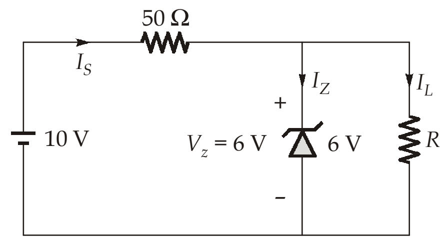
$$2 = \frac{V_r^{1/2}}{2}$$

$$V_r = 16\text{ V}$$

Thus, the reverse bias voltage is increase by 12 V.

57. (b)

We have,



$$I_S = I_Z + I_L$$

where,
$$I_S = \frac{10 - V_Z}{50}$$

$$I_L = \frac{V_Z}{R}$$

Now,
$$I_S > I_{Z\,(\text{min})} + I_L$$

$$\frac{10 - V_Z}{50} > \frac{5}{100} + \frac{V_Z}{R}$$

Given,
$$V_Z = 6\text{ V}$$

$$\frac{10 - 6}{50} > \frac{5}{1000} + \frac{6}{R}$$

$$\frac{4}{50} - \frac{5}{1000} > \frac{6}{R}$$

$$0.08 - 0.005 > \frac{6}{R}$$

$$0.075 > \frac{6}{R}$$

$$R > \frac{6}{0.075}$$

$$R > 80\ \Omega$$

Thus,
$$R_{\text{min}} = 80\ \Omega$$

58. (b)

1. From Gauss's law:

$$\oint \vec{D} \cdot \vec{ds} = Q = \int_{\text{Volume}} \rho_{vs} \cdot dV$$

2. From Maxwell's equation:

$$\oint \vec{E_s} \cdot \vec{dl} = -\int \frac{\partial \vec{B_s}}{\partial t} \cdot \vec{ds}$$

$$\vec{B_s} = \vec{B_0} e^{j\omega t} \quad \Rightarrow \quad \frac{\partial B}{\partial t} = j\omega \vec{B_s}$$

$$\oint \vec{E_s} \cdot \vec{dl} = \int -j\omega \vec{B_s}\, \vec{ds}$$

Hence, equation 2 is incorrect.

3. From Maxwell's equation:

$$\oint \vec{B_s} \cdot \vec{ds} = 0$$

Hence, equation 3 is correct.

4. From Maxwell's equation:

$$\oint \vec{H_s} \cdot \vec{dl} = \iint_s \left(\vec{J_s} + \frac{\partial \vec{D_s}}{\partial t} \right) \vec{ds}$$

$$\frac{\partial \vec{D_s}}{\partial t} = j\omega \vec{D_s}$$

$$\therefore \quad \oint \vec{H_s} \cdot \vec{dl} = \iint_s \left(\vec{J_s} + j\omega \vec{D_s} \right) \vec{ds}$$

Hence, equation 4 is incorrect.

59. (c)

We know that,

$$g_m = \frac{1}{r_e}; \text{ and } r_e = \frac{26}{I_{EQ}(\text{mA})}$$

$$\therefore \quad I_{EQ} \approx I_{CQ}$$

As I_{CQ} increases, I_{EQ} increases, thereby decreasing r_e. Thus, when r_e decreases, g_m increases.

60. (c)

61. (a)

Rate of generation of minority carriers:

$$\frac{dp}{dt} = \frac{\text{excess hole concentration}}{\text{minority carrier life time}}$$

At equilibrium (steady state):

$$\Delta p = \Delta n$$

$$\frac{dp}{dt} = \frac{10^{15}}{10 \times 10^{-6}} = 10^{20} \text{ e-h pairs/cm}^3\text{/s}$$

62. (c)

A Zener diode is biased in the reverse-bias region to operate as a reference diode, and its forward characteristics are the same as those of an ordinary diode.

63. (d)

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

$$\frac{\partial \beta}{\beta} = \frac{1}{(1-\alpha)} \cdot \frac{\partial \alpha}{\alpha}$$

$$\frac{\partial \beta}{\beta}(\%) = \left[\frac{1}{1-0.8} \right] \times 0.25\% = \frac{1}{0.2} \times 0.25\% = 1.25\%$$

64. (a)

- The input resistance of a MOSFET is much larger than the input resistance of a JFET.

$$R_i(\text{MOSFET}) > R_i(\text{JFET})$$

- JFETs have drain resistance of the order of 10^5 to 10^6 Ω, whereas MOSFETs have drain resistance of the order of 1 to 50 kΩ. Hence, the drain resistance of a JFET is much larger than that of a MOSFET.

$$r_d(\text{JFET}) > r_d(\text{MOSFET})$$

- The transconductance values of JFETs and MOSFETs are comparable.

65. (b)

For a galvanometer, the deflection torque is,

$$T_d = \text{BINA} \sin\theta$$

or

$$T_d = GI \sin\theta$$

where, Galvanometer constant, $G = \text{BNA}$

$$G = 100 \times 0.07 \times 40 \times 40 \times 10^{-6}$$

$$G = 1.12 \times 10^{-2} \text{ Wb}$$

66. (b)

We know that,

$$P = I^2R$$

Taking logarithms on both sides, we get:

$$\ln P = 2\ln I + \ln R$$

On differentiating, we get

$$\frac{\partial P}{P} = \pm\left(\frac{2\partial I}{I} + \frac{\partial R}{R}\right)$$

Substituting the given percentage errors:

$$\frac{\partial P}{P} = \pm\left(2\times\frac{2}{100} + \frac{7}{100}\right)$$

$$\frac{\partial P}{P} = \pm\left(\frac{4}{100} + \frac{7}{100}\right)$$

$$\frac{\partial P}{P} = 0.11 \quad \text{or} \quad 11\%$$

67. (a)

$$x(n) = (-0.4)^n u(n)$$

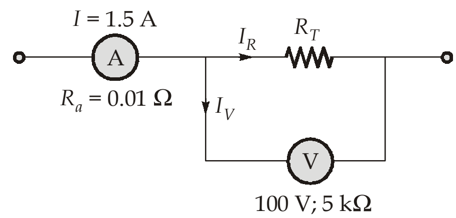
The energy of the signal is given by

$$E = \sum_{n=-\infty}^{\infty} |x(n)|^2 = \sum_{n=0}^{\infty} (-0.4)^{2n} = \sum_{n=0}^{\infty} (0.16)^n$$

$$E = \frac{1}{1-0.16} = \frac{1}{0.84} = \frac{25}{21} \text{Joule}$$

68. (a)

Given:



$$I_V = \frac{100}{5\times10^3} = 20\text{ mA} = 0.02\text{ A}$$

$$I_R = 1.5 - 0.02 = 1.48\text{ A}$$

$$R_T = \frac{V}{I_R} = \frac{100}{1.48} = \frac{10000}{148}\,\Omega = \text{true value of resistance}$$

$$R_m = \frac{V}{I} = \frac{100}{1.5} = \frac{1000}{15}\,\Omega = \text{measured value of resistances.}$$

$$\text{Error, } \in_r = \frac{R_m - R_T}{R_T}$$

$$\%\in_r = \left[\frac{\frac{1000}{15} - \frac{10000}{148}}{\frac{10000}{148}}\right]\times100$$

$$\%\in_r = \left[\frac{1000\times148}{15\times10000} - 1\right]\times100 = \left[\frac{148}{150} - 1\right]\times100$$

$$\%\in_r = \frac{-2}{150}\times100$$

$$\%\in_r = \frac{-4}{3}\%$$

$$\%\in_r = -1.33\%$$

69. (a)

$$R_{xy}(k) = x(k) * y(-k)$$

$y(-k)$ \ $x(k)$	1	3	1	2
3	3	9	3	6
1	1	3	1	2
2	2	6	2	4
1	1	3	1	2

Therefore, $R_{xy}(k) = \{3, 10, 8, 14, 7, 5, 2\}$

70. (b)

By applying KCL, we get

$$I + I_2 = I_1$$
$$I = I_1 - I_2$$
$$I = 200 - 100 = 100 \text{ A}$$

Now,
$$I_2 = 100 \pm 2.5\% = 100 \pm 100 \times \frac{2.5}{100}$$
$$I_2 = 100 \pm 2.5$$
$$\delta I = \delta I_1 + \delta I_2$$
$$\delta I = 2 + 2.5 = 4.5$$
$$\delta I\% = \frac{4.5}{100} \times 100 = 4.5\%$$
$$I = 100 \pm 4.5\%$$

71. (c)

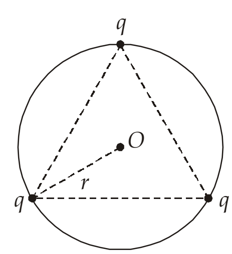
If meter A and meter B have sensitivities of 2 kΩ/V and 1 kΩ/V respectively, then meter A is more sensitive than meter B, as meter A requires half the current that meter B needs for full-scale deflection.

72. (c)

73. (d)

A ±1 count error occurs in a digital frequency meter due to gate time uncertainty.

74. (c)



The potential is a scalar quantity. Three identical charges, 'q', are placed at an equal distance, 'r', from the center of the circle. The potential at the center is the sum of the potentials due to each charge, given by:

$$V = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q}{r} + \frac{1}{4\pi\varepsilon_0} \cdot \frac{q}{r} + \frac{1}{4\pi\varepsilon_0} \cdot \frac{q}{r}$$

$\Rightarrow$
$$V = \frac{3}{4\pi\varepsilon_0} \cdot \frac{q}{r} = \frac{3q}{4\pi\varepsilon_0 r}$$

75. (c)

Given,
$$\vec{D} = 100\hat{a}_y n \text{ C/m}^2$$
$$\vec{E} = \frac{\vec{D}}{\varepsilon_0} = \frac{100 \times 10^{-9}}{\left(\frac{10^{-9}}{36\pi}\right)} = 100 \times 36\pi$$

$$\Rightarrow \qquad \vec{E} = 3600\pi \text{ V/m}$$

Since the distance between the plates is 0.02 m, the voltage difference between the plates is,

$$V = 3600\pi \times 0.02$$
$$= 226.2 \text{ V}$$

76. (d)

Given, $\vec{P} = \rho \sin\phi \hat{a}_\rho + \rho^2 z \hat{a}_\phi + z\cos\phi \hat{a}_z$

$$\text{Divergence of } \vec{P} = \nabla \cdot \vec{P} = \frac{1}{\rho}\frac{\partial}{\partial \rho}(\rho P_\rho) + \frac{1}{\rho}\frac{\partial}{\partial \phi}(P_\phi) + \frac{\partial}{\partial z}(P_z)$$

$$\Rightarrow \qquad \nabla \cdot \vec{P} = \frac{1}{\rho}\frac{\partial}{\partial \rho}(\rho^2 \sin\phi) + \frac{1}{\rho}\frac{\partial}{\partial \phi}(\rho^2 z) + \frac{\partial}{\partial z}(z\cos\phi)$$

$$\Rightarrow \qquad \nabla \cdot \vec{P} = 2\sin\phi + \cos\phi$$

At $\phi = \frac{\pi}{2}$: $\nabla \cdot \vec{P} = 2\sin\frac{\pi}{2} + \cos\frac{\pi}{2} = 2$

77. (a)

The group pattern is given by the array factor (AF):

$$\text{AF} = \frac{\sin\frac{N\psi}{2}}{\sin\frac{\psi}{2}} = \frac{\sin 4\frac{\psi}{2}}{\sin\frac{\psi}{2}}$$

where, $\psi = \beta d \cos\theta + \alpha$

putting $\beta = \frac{2\pi}{\lambda}; d = \frac{\lambda}{4}$ and $\alpha = 0$

$$\psi = \frac{\pi}{2}\cos\theta$$

$$\text{AF} = \frac{\sin\left[\frac{4\cdot\frac{\pi}{2}\cos\theta}{2}\right]}{\sin\left[\frac{\frac{\pi}{2}\cos\theta}{2}\right]}$$

$$\text{AF} = \frac{\sin[\pi\cos\theta]}{\sin\left[\frac{\pi\cos\theta}{4}\right]} = \frac{2\sin\left[\frac{\pi}{2}\cos\theta\right]\cos\left[\frac{\pi}{2}\cos\theta\right]}{\sin\left[\frac{\pi\cos\theta}{4}\right]}$$

$$= 4\cos\left[\frac{\pi}{4}\cos\theta\right]\cos\left[\frac{\pi}{2}\cos\theta\right]$$

78. (d)

The boundary conditions at the interface of two dielectrics are given by,

- $E_{t1} = E_{t2}$
- $D_{n1} - D_{n2} = \rho_s$
- $H_{t1} - H_{t2} = K$
- $B_{n1} = B_{n2}$

Thus, the normal components of magnetic flux density are continuous across the boundary.

79. (b)

Given,
$$f = 100 \text{ MHz}$$
$$\mu = 4\pi \times 10^{-7} \text{ H/m}$$
$$\sigma = 10^7 \text{ mho/m}$$

For copper, which is a perfect conductor:

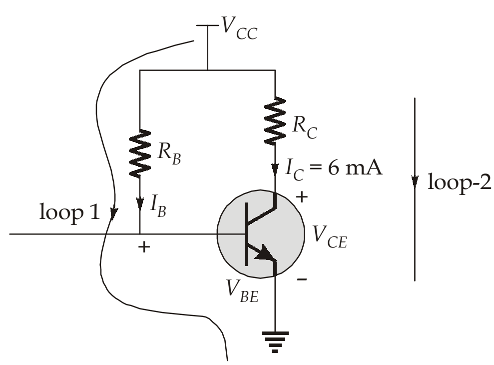
$$\alpha = \beta = \sqrt{\frac{\omega\mu\sigma}{2}}$$

$$\Rightarrow \quad \beta = \sqrt{\frac{2\pi\times100\times10^6\times4\pi\times10^{-7}\times10^7}{2}}$$

$$\Rightarrow \quad \beta = 20000\pi \text{ rad/m} = 0.2\pi \times 10^5 \text{ rad/m}$$

80. (b)

Given:
$$I_C = 6 \text{ mA}; \quad V_{CE} = 4 \text{ V}$$
$$\beta_F = 200; \quad V_{BE} = 0.7 \text{ V}$$



$$\text{Base current, } I_B = \frac{I_C}{\beta} = \frac{6}{200} = 3\times10^{-2}\text{ mA}$$

Applying KVL in loop-1:

$$R_B = \frac{V_{CC}-V_{BE}}{I_B} = \frac{10-0.7}{3\times10^{-2}} = 310 \text{ k}\Omega$$

Applying KVL in loop-2:

$$R_C = \frac{V_{CC}-V_{CE}}{I_C} = \frac{10-4}{6\times10^{-3}} = 1 \text{ k}\Omega$$

81. (b)

Copper bus-bars at electrical power substations are hallow due to the skin effect. Because of the skin effect, current tends to flow near the surface of the conductor and attenuates as it moves toward the interior of the conductor.

82. (a)

In air, $$\lambda_a = \frac{c}{f}$$

In copper, $$\lambda_c = 2\pi\delta = \frac{2\pi}{\sqrt{\pi f \mu\sigma}}$$, where δ is the skin depth

$$\therefore \quad \frac{\lambda_a}{\lambda_c} = \frac{(c/f)}{\left(\frac{2\pi}{\sqrt{\pi f \mu\sigma}}\right)} = \frac{c\sqrt{\pi f \mu\sigma}}{2\pi f} = \frac{c}{2}\sqrt{\frac{\mu\sigma}{\pi f}}$$

83. (b)

Given, $$\vec{E} = 5\sin(2\pi\times10^7 t - 0.5x)\hat{a}_z \text{ V/m}$$

Comparing with the standard expression of the electric field,

$$\vec{E} = E_0 \sin(\omega t - \beta x)\hat{a}_z,$$ we get

E_0 = 5 V/m, β = 0.5 rad/m, $\omega = 2\pi \times 10^7$ rad/s $\Rightarrow$ $f = 10^7$ Hz

Velocity, $$v = \lambda f = \frac{2\pi}{\beta}\times f$$

$$\Rightarrow \quad v = \frac{2\pi}{0.5}\times 10^7 \text{ m/s}$$

$$\Rightarrow \quad v = 4\pi \times 10^7 \text{ m/s}$$

We have, $$v = \frac{c}{\sqrt{\varepsilon_r}} = 4\pi\times10^7 \text{ m/s}$$

$$\Rightarrow \quad \frac{3\times10^8}{\sqrt{\varepsilon_r}} = 4\pi \times 10^7$$

$$\Rightarrow \quad \sqrt{\varepsilon_r} = \frac{3\times10^8}{4\pi\times10^7} = \frac{30}{4\pi}$$

$$\Rightarrow \quad \varepsilon_r = \left(\frac{30}{4\pi}\right)^2 = \frac{900}{16\pi^2} = \frac{56.25}{\pi^2} \simeq 5.7$$

Alternate:

We have, $$\beta = 0.5 \text{ rad/m}; \ \omega = 2\pi \times 10^7 \text{ rad/s}$$

$$v_p = \frac{c}{\sqrt{\epsilon_r}} = \frac{\omega}{\beta}$$

$$\frac{3\times10^8}{\sqrt{\epsilon_r}} = \frac{2\pi\times10^7}{0.5}$$

$$\epsilon_r = 5.7$$

84. (d)

We know that,

Theoretical density, $$\rho = \frac{nA}{V_c N_A}$$

where n = Number of atoms associated with each unit cell

V_c = Volume of the unit cell

A = Atomic weight

N_A = Avogadro's number = 6.022×10^{23} mol^{-1}

As an FCC crystal structure, $n = 4$

$$\rho = \frac{4 \times 60.2}{6.4 \times 10^{-29} \times 6.022 \times 10^{23}} \approx 6248 \text{ kg/m}^3$$

85. (a)

Statement 1: True → A Frenkel defect involves the displacement of an ion within the lattice; therefore, the mass remains the same and the density unchanged.

Statement 2: True → A Schottky defect occurs in ionic crystals with a high coordination number but a small difference in ionic sizes (e.g., NaCl).

Statement 3: False → A Frenkel defect occurs when the cation is much smaller than the anion (e.g., AgCl).

Therefore, only statement 1 and 2 are correct.

86. (c)

Statement 1: True → The overlapping bands allow free electrons.

Statement 2: True → The typical band gap: 0.7–1.1 eV (Si, Ge).

Statement 3: True → With no thermal energy, there are no free charge carriers.

Hence, all statements are correct.

87. (a)

Quartz → Piezoelectric

Iron → Ferromagnetic

Lead → Superconductor

Ferrites → Ferrimagnetic

88. (a)

89. (b)

In a BCC structure,

$$\text{Body diagonal} = \sqrt{3}a = 4r$$

So,

$$r = \left(\frac{\sqrt{3}}{4}\right)a$$

90. (b)

Ge ≈ 0.67 eV

Si ≈ 1.1 eV

GaAs ≈ 1.4 eV

Diamond ≈ 5.5 eV

91. (c)

Substitutional doping (e.g., phosphorus in silicon) increases free carriers while maintaining charge neutrality.

92. (c)

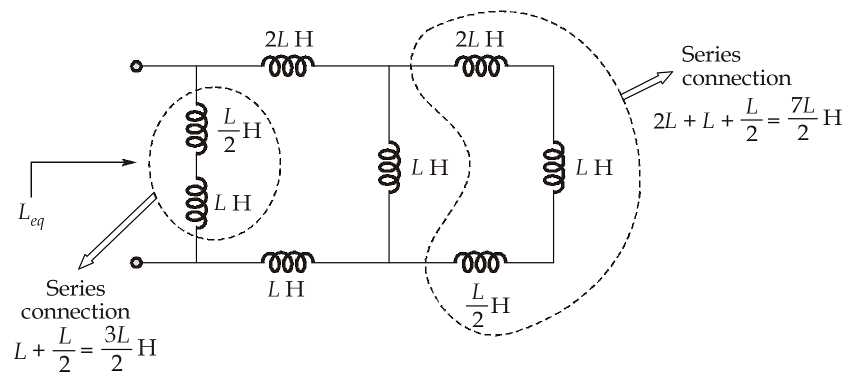
Ferrites → low eddy current loss + high resistivity → ideal for high-frequency applications.

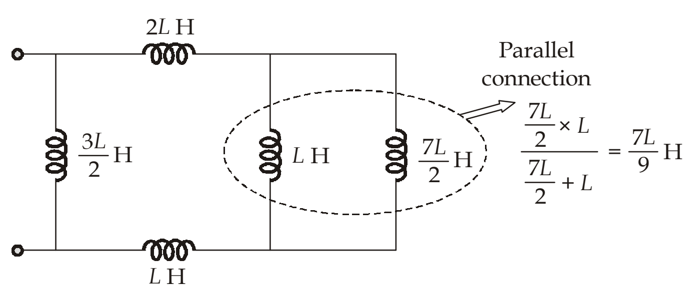
93. (b)

A non-linear network can satisfy associativity and bilaterality property.

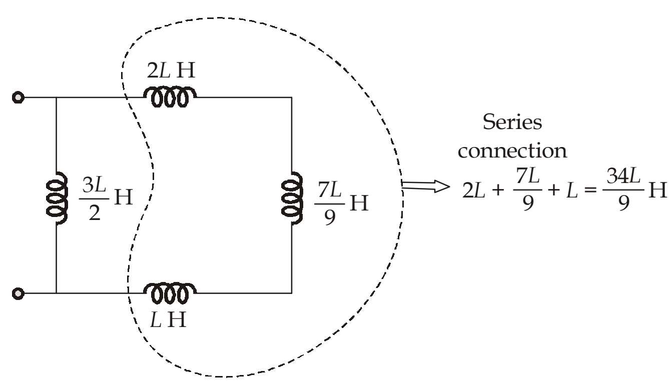
94. (c)

We have,





or



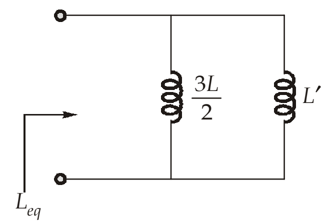
and
$$L_{eq} = \frac{3L}{2} \| \frac{34L}{9}$$

$$L_{eq} = \frac{102}{95} L \text{ H}$$

$$L_{eq} = 1.07L \text{ H}$$

Alternate:

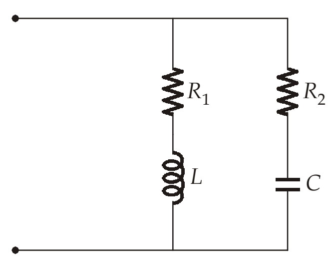
We have,



L_{eq} must be less than atleast $\frac{3L}{2}$H, and only option (c) is less than $\frac{3L}{2}$H.

95. (d)

We know that



$$\text{Resonant frequency, } f_0 = \frac{1}{2\pi\sqrt{LC}}\sqrt{\frac{R_1^2 - \left(\frac{L}{C}\right)}{R_2^2 - \left(\frac{L}{C}\right)}}$$

The circuit will never be in resonance if the term inside the square root is negative.

$$R_1^2 - \frac{L}{C} < 0$$

$$R_1^2 < \left(\frac{L}{C}\right)$$

or $$R_2^2 - \frac{L}{C} < 0$$

$$R_2^2 < \frac{L}{C}$$

Thus, if $$R_1^2 < \left(\frac{L}{C}\right) \text{ and } R_2^2 > \frac{L}{C}$$

or $$R_1^2 > \frac{L}{C} \text{ and } R_2^2 < \frac{L}{C}$$

Then, circuit will never be in resonance. Hence, option (d) is correct.

96. (b)

We have,

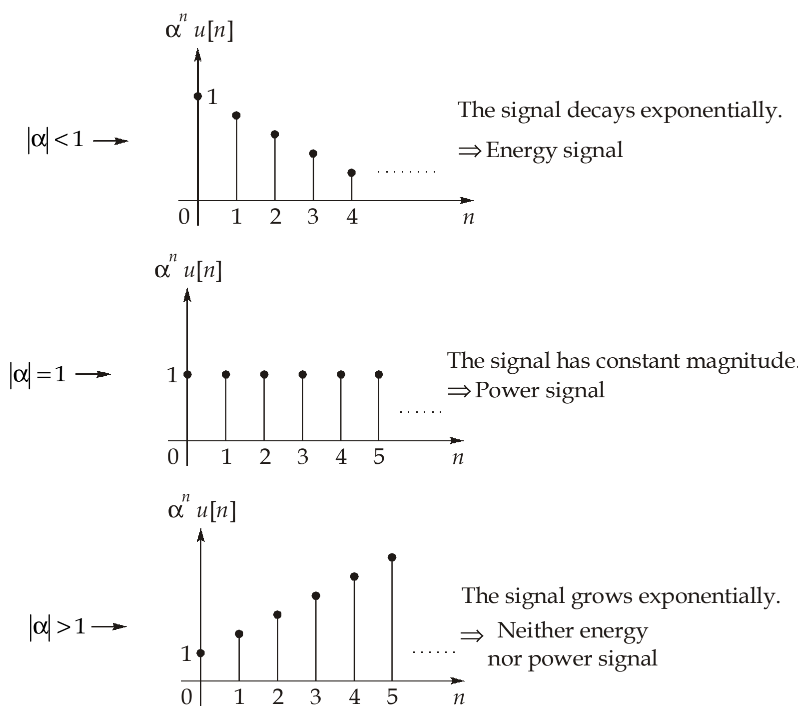
$$x(t) = 2\cos\Big(\underbrace{\frac{2\pi}{3}t}_{T_1 = 3}\Big) + \underbrace{\sin(\pi t)}_{T_2 = 2}$$

$\therefore$ The fundamental time period "T" $= \text{LCM}[T_1, T_2]$

$= \text{LCM}\,[3, 2] = 6$

Hence, the fundamental angular frequency of the signal is $\omega_0 = \frac{2\pi}{T} = \frac{2\pi}{6} = \frac{\pi}{3}\text{rad/s}$

97. (c)



98. (a)

We know,

$$\int_{t_1}^{t_2} x(t)\cdot\delta^m(t-t_0)dt = (-1)^m \frac{d^m}{dt^m}x(t)\Big|_{t=t_0}$$

where, 'm' is the order of differentiation and $t_1 < t_0 < t_2$; otherwise integration attains '0' value

$\therefore$ $$\int_2^4 t^3\cdot\ddot{\delta}(t-5)dt = 0$$ ($\because$ $t_0 = 5$ does not lie in the interval [2, 4])

99. (c)

Given, $x[n] = 5\,\delta[n] + \delta[n-2]$

$h[n] = (0.1)^n\, u[n]$

$\therefore$ Output, $y[n] = x[n] * h[n]$

$$= \{5\,\delta[n] + \delta[n-2]\} * \{(0.1)^n\, u[n]\}$$
$$= \{5\,\delta[n] * (0.1)^n\, u[n]\} + \{\delta[n-2] * (0.1)^n\, u[n]\}$$
$$= \underbrace{5(0.1)^n u[n]}_{n\geq 0} + \underbrace{(0.1)^{n-2} u[n-2]}_{n\geq 2}$$

At $n = 1$:

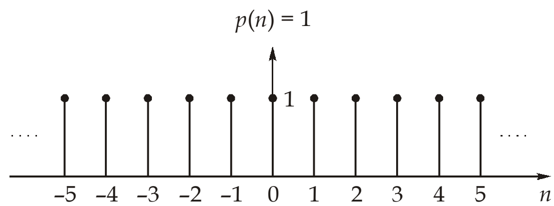
$$y[1] = 5(0.1)^1 = 0.5$$

At $n = 2$:

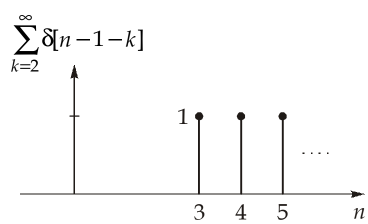
$$y[2] = 5 \times (0.1)^2 + 1 = 1.05$$

100. (c)

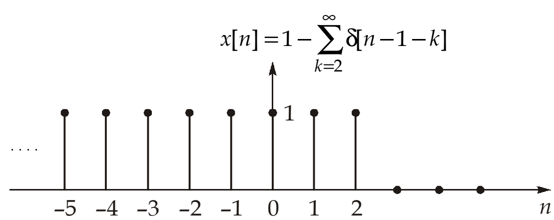
Step-1 :



Step-2 :



Step-3 :



$\Rightarrow$ $$x[n] = u[-(n-2)] = u[-n+2]$$

On comparing with $u[An - b_0]$,

$$A = -1,$$
$$b_0 = -2$$

$\Rightarrow$ $$(A + b_0) = (-1 - 2) = -3$$

101. (b)

The highest allowable input frequency of an ADC is:

$$f_H = \frac{1}{2\times\text{Conversion time}} = \frac{1}{2\times 500\,\mu\text{sec}}$$

$$f_H = 1 \text{ kHz}$$

102. (d)

A Flash type ADC has limited resolution.

103. (c)

Given,
$$(0.2)_x = (0.5)_{10}$$
$$2\times\frac{1}{x} = 5\times\frac{1}{10}$$
$$\frac{2}{x} = 0.5$$
$$x = \frac{2}{0.5} = 4$$

104. (d)

Given,
$$Y = \bar{A} + B\bar{C}$$

A \ BC	00	01	11	10
0	1	1	1	1
1				1

$$Y = \Sigma m(0, 1, 2, 3, 6)$$
$\therefore$
$$Y = \pi M(4, 5, 7)$$

105. (a)

Let the output of the 4 : 1 multiplexer be 'X'

$\therefore$
$$X = \bar{A}\bar{B}(1) + \bar{A}B(0) + A\bar{B}(1) + AB(A)$$
$$= \bar{A}\bar{B} + A\bar{B} + AB = \bar{B} + AB$$
$$X = A + \bar{B}$$
$\therefore$ Output,
$$Y = \bar{C}X + C(B)$$
$$= (A + \bar{B})\bar{C} + BC$$
$$= A\bar{C} + \bar{B}\bar{C} + BC$$

106. (d)

Given: $f_r = 6$ MHz; $Q = 60$

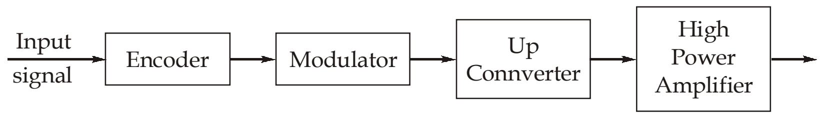
Q-factor is given as
$$Q = \frac{f_r}{BW}$$
$\therefore$
$$\text{BW} = \frac{f_r}{Q} = \frac{6\times10^6}{60} = 100\text{ kHz}$$

Lower 3 dB frequency:
$$f_L = f_0 - \frac{BW}{2} = 6\text{ MHz} - 0.05\text{ MHz}$$
$$= 5.95\text{ MHz}$$

Upper 3 dB frequency:
$$f_H = f_0 + \frac{BW}{2} = 6\text{ MHz} + 0.05\text{ MHz}$$
$$= 6.05\text{ MHz}$$

107. (b)

The block diagram of a satellite uplink system is:



108. (b)

Given, CMOS consumes, P_C = 5 μW

TTL consumes, P_T = 50 mW

$$\text{Power efficiency of CMOS} = \frac{50\times 10^{-3}}{5\times 10^{-6}} = 10{,}000$$

109. (c)

In a PLA, each product term can connect to both the true and complement of each input.

$$\therefore \quad \text{Connections} = (\text{Product terms}) \times (2 \times \text{Inputs})$$

$$= 8 \times (2 \times 4)$$

$$= 8 \times 8 = 64$$

110. (b)

The output voltage V_o is equal to

$$V_o = \overline{A+B}$$

111. (c)

$$A = \frac{A_{\text{mid}}}{\sqrt{1+\left(\frac{f_L}{f}\right)^2}} = \frac{100}{\sqrt{1+\left(\frac{1000}{20}\right)^2}} \approx \frac{100}{50} \approx 2$$

112. (c)

$$f = \frac{1}{2\pi RC\sqrt{6}}$$

$$C = \frac{1}{2\pi\times 9.7\times 10^3\times 5\times 10^3\times\sqrt{6}} = 1.34 \text{ nF}$$

113. (d)

$$f = \frac{1}{2\pi\sqrt{(L_1+L_2)C}} = \frac{1}{2\pi\sqrt{1.5\times 10^{-3}\times 0.2\times 10^{-6}}} = 9.19 \text{ kHz}$$

114. (b)

In cascode configuration, a Common Emitter (CE) stage is stacked on top of a Common Base (CB) stage; the CE output drives the CB input.

115. (a)

Given:
$$F = \frac{P_{D\max}}{P_{AC\max}} = 2$$

$$\therefore \quad P_{AC\ max} = \frac{P_{D\max}}{2} = \frac{2.5}{2} = 1.25\text{ W}$$

116. (c)

The value of voltage at the non-inverting input terminal is obtained using KCL:

$$\frac{V_+ - 18}{20\text{ k}\Omega} + \frac{V_+ - 15}{40\text{ k}\Omega} = 0$$

$$V_+ \times \left(1 + \frac{1}{2}\right) = 18 + \frac{15}{2}$$

$$\frac{3V_+}{2} = \frac{36+15}{2} = \frac{51}{2}$$

$$\therefore \quad V_+ = \frac{51}{3}$$

Thus,
$$V_o = (1+1)V_+ = 2 \times \frac{51}{3} = 34\text{ V}$$

117. (b)

V_x i.e. the non-inverting terminal voltage is equal to

$$V_o = \left(1 + \frac{R_2}{R_1}\right) \cdot V_x$$

$$\therefore \quad 9 = \left(1 + \frac{R_2}{R_1}\right) \times 3$$

$$\therefore \quad \frac{R_2}{R_1} = 2 \quad \text{or} \quad \frac{R_1}{R_2} = 0.5$$

118. (c)

Amount of feedback of the circuit is given as,

$$(1 + A\beta) = (1 + 10^3 \times 10^{-3}) = 2$$

$$\therefore \quad Z_{if} = \frac{10^3}{2} = 0.5\text{ k}\Omega$$

$$Z_{of} = \frac{100}{2} = 50\ \Omega$$

119. (d)

Given,
$$R_A = 1\text{ k}\Omega \text{ and } R_B = 2\text{ k}\Omega$$

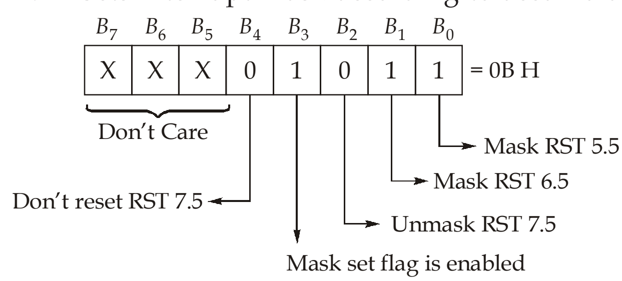
$$\text{Duty cycle} = \frac{R_A + R_B}{R_A + 2R_B} \times 100 = \frac{1+2}{1+4} \times 100 = \frac{3}{5} \times 100$$
$$= 60\%$$

120. (a)

LDA 4500 H $\Rightarrow$ [A] = 31 H
SUI 30 H $\Rightarrow$ [A] – [30 H] = [31 H] – [30 H]
= 01 H
CPI 0A H $\Rightarrow$ [A] – [0A H]; since [A] < 0A H, carry flag, C = 1
JC SKIP
SUI 07 H
SKIP: STA 4501 H [4501] = 01 H
HLT

121. (a)

Given: EI : Enables interrupts
MVI A, 0B H : Loads 0B H into accumulator
SIM : Sets interrupt mask according to accumulator contents.



122. (d)

123. (b)

124. (d)

LXI H, 1234 H $\rightarrow$ (HL) = 1234 H
XRA A $\rightarrow$ (A) = 00 H
DCR A $\rightarrow$ $(00)_H$ – 1 = –01 H = FF H
CMP H $\Rightarrow$ FF H – 12 H
$\Rightarrow$ FF H + $\overline{12}$ H + 1

12 H = 00010010
$\overline{12}$ H = 11101101
1
–12 H = 11101110 = EE H

$\Rightarrow$ FF H = 1111 1111
EE H = 1110 1110
(FF H + EE H) = ED H = 1110 1101

Flags: CY = $\overline{1} = 0$
P = 1
AC = 1
Z = 0
S = 1

Since, it is a comparison operation, the result is not stored in the accumulator.

Flag Register							
S	Z	X	AC	X	P	X	CY
1	0	0	1	0	1	0	0

$$(A) = FF\ H, \text{(Flag register)} = 10010100 = 94\ H$$

$$\therefore \quad PSW = \boxed{\text{Accumulator}}\boxed{\text{Flag register}} = (FF94)\ H$$

125. (d)

126. (c)

127. (a)

128. (c)

129. (d)

Fetching and executing an instruction happens in the Instruction Cycle, also known as the Fetch-Decode-Execute Cycle.

130. (d)

Given: Number of conductors, $Z = 240$

Number of parallel paths, $A = P = 4$ (i.e., lap connected)

Generated emf, $E_b = 480$ V, Speed of rotation $(N) = 800$ rpm

Emf equation of DC machine:

$$E_b = K\phi\,\omega_m$$

$$E_b = \frac{NP\phi}{60}\times\frac{Z}{A}$$

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

$$\phi = \frac{120}{800} = 0.15\text{ Wb}$$

131. (c)

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

132. (d)

Given that

$$x(t) = \frac{1}{T_0} + \sum_{k=1}^{N}\frac{2}{T_0}\cos k\omega_0 t$$

$$a_0 = \frac{1}{T_0}, \quad a_k = \frac{2}{T_0}$$

At the Fourier series coefficient a_n is independent of 'k'. So signal cannot be sawtooth, half rectified (or) rectangular. Hence, impulse train.

133. (c)

$$\frac{di}{dt} = 500 \text{ mA/s}$$

$$e_z = M\frac{di_2}{dt} = M(500 \text{ mA/s}) = 100 \text{ mV}$$

$$M = k\sqrt{L_1 L_2} = \sqrt{L_1 L_2} = \frac{1}{5}$$

$$\frac{L_1}{L_2} = \frac{L_1^2}{L_1 L_2} = (0.4)^2 \times 25 = 4$$

$$\frac{N_1}{N_2} = \sqrt{\frac{L_1}{L_2}} = 2$$

$$N_1 = 2N_2 = 200$$

134. (d)

$$\text{Ah efficiency} = \frac{\text{Ah during discharge}}{\text{Ah during charge}} = \frac{12 \times 4}{20 \times 3} = 0.8 \text{ (or) } 80\%$$

135. (d)

$$E = \frac{\phi ZN}{60}\left(\frac{P}{A}\right)$$

A = 2 for wave-wound generators,

So,
$$\phi = \frac{60E}{ZN}\left(\frac{A}{P}\right) = \frac{60 \times 240}{800 \times 600} \times \frac{2}{4} = 0.015 \text{ Wb}$$

Leakage coefficient,
$$\lambda = \frac{\text{Total flux per pole}}{\text{Working flux per pole}} = \frac{0.018}{0.015} = 1.20$$

136. (c)

For the given load,
$$T \propto N^2$$

$$T \propto I_a^2$$

$$E_b \propto NI_a$$

$$\frac{N_2}{N_1} = \frac{1}{2}$$

$$\frac{T_2}{T_1} = \left(\frac{N_2}{N_1}\right)^2 = \frac{1}{4} = \left(\frac{I_{a_2}}{I_{a_1}}\right)^2$$

So,
$$\frac{I_{a_2}}{I_{a_1}} = \frac{1}{2}$$

$$\frac{V_2}{V_1} = \frac{E_{b_2}}{E_{b_1}} = \frac{N_2}{N_1} \times \frac{I_{a_2}}{I_{a_1}}$$

$$= \frac{1}{2} \times \frac{1}{2} = \frac{1}{4}$$

$$\% \text{ Reduction} = \frac{V_1 - V_2}{V_1} \times 100 = \left(1 - \frac{1}{4}\right) \times 100$$
$$= 75\%$$

137. (c)

As compared to the constant-current system, the constant-voltage system of charging offers 10% reduced efficiency.

138. (c)

Given: Iron loss of transformer, P_i = 900 W.

Copper loss of transformer, P_{cu} = 1600 W

Let maximum efficiency occurs at x times the full load. Then,

$$x = \sqrt{\frac{P_i}{P_{cu}}} = \sqrt{\frac{900}{1600}} = \frac{3}{4} = 0.75$$

For maximum efficiency, output power at unity power factor is:

$$P_{out} = 0.75 \times 40 \times 1 = 30 \text{ kW}$$

139. (c)

Compensating windings in a DC generators are added to neutralize the cross-magnetizing effect of armature reaction, which distorts the main magnetic flux, causing poor commutation and unstable operation, especially with rapid load changes.

140. (a)

141. (a)

Doping introduces donor/acceptor levels, leading to more charge carriers and hence higher conductivity.

142. (a)

Directional covalent bonds restrict slip, resulting in hardness and brittleness.

143. (a)

Low conductivity leads to low eddy current losses, making ferrites suitable for high-frequency applications.

144. (d)

In an induction-type energy meter, normally the flux due to the shunt magnet does not lag the supply voltage exactly by 90°. The reason is that the shunt coil has some resistance. Due to this, the phase angle is less than 90°, as a result, the torque on the disc is not zero at zero power factor.

145. (a)

Both statements are correct, and statement (I) is the correct explanation of statement (II).

146. (c)

It can run programs that are larger in size than physical memory by keeping only important data and instructions that are needed at any given time.

147. (a)

148. (c)

- Thermally grown oxides (whether wet or dry) are generally preferred over "deposited" oxides (such as CVD oxides) for critical interface layers. Grown oxides form a chemical bond with the silicon substrate, resulting in a cleaner interface with fewer defects and trap states compared to deposited oxides, which merely sit on the surface. Hence, statement-I is true.
- The rate of growth of wet oxidation is higher than that of dry oxidation, and better-quality oxide is obtained with dry oxidation. Hence, statement-II is false.

149. (c)

Thevenin's theorem can be applied to networks having initial conditions.

150. (b)

The transfer function itself is in the frequency domain, but it is routinely used to perform time-domain analysis. For instance, the inverse Laplace transform gives the output response in the time domain. Hence, transfer-function based analysis is valid in both the time domain and the frequency domain.

The state model is primarily a time-domain approach. Therefore, statement (II) is correct.

The transfer function model is application only to LTI systems, whereas the state model is applicable to any system. Therefore, statement-I is correct.

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