DETAILED SOLUTIONS

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ESE 2025 : Prelims Exam
CLASSROOM TEST SERIES

E & T ENGINEERING

Test 18

Full Syllabus Test 2 : Paper-II

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

DETAILED EXPLANATIONS

1. **(b)**

The Address Resolution Protocol (ARP), allows a host to find the MAC (physical) address of a target host on the same physical network, given only the target IP address.

2. **(d)**

Characteristic equation:

$$1 + G(s)H(s) = s^6 + 3s^5 + 4s^4 + 6s^3 + 5s^2 + 3s + 2 = 0$$

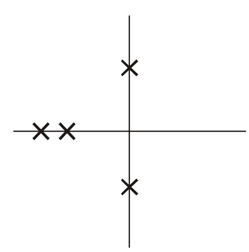
Using Routh-Hurwitz criterion,

s^6	1	4	5	2
s^5	3	6	3	0
→ s^4	2	4	2	0
s^3	0	0	0	0
	8	8	0	0
→ s^2	2	2	0	0
s^1	0	0	0	0
	4	0	0	0
s^0	2			

1st Auxiliary equation

$$A_1(s) = 2s^4 + 4s^2 + 2$$

$$\frac{dA_1(s)}{ds} = 8s^3 + 8s + 0$$



$2(s^2 + 1)(s^2 + 1) = 0 \Rightarrow s = \pm j, \pm j$. Hence, multiple poles exist on imaginary axis at $s = \pm j$. Therefore, the system is unstable and thus, the gain margin is not positive.

2nd Auxiliary equation

$$A_2(s) = 2s^2 + 2$$

$$\frac{dA_2(s)}{ds} = 4s$$

The characteristic equation can be written as,

$$(s^2 + 3s + 2)(s^4 + 2s^2 + 1) = 0$$

$$(s + 1)(s + 2)(s^4 + 2s^2 + 1) = 0$$

The real roots of the equation are given by $s = -1, -2$. Hence, out of 6 roots, 2 roots are real and 4 roots lie to the right of $s = -1$.

Therefore, only statements 1 and 3 are correct.

3. (d)

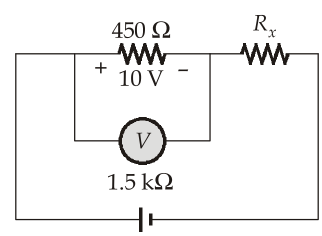
In series connection, $R_{eq} = R_1 + R_2$

where, $R_1 = \dfrac{V_1^2}{P_1}$ and $R_2 = \dfrac{V_2^2}{P_2}$

The power supplied by the bulbs in series,

$$P = \frac{V^2}{R_1 + R_2} = \frac{P_1 P_2}{P_1 + P_2} = \frac{5\times 10}{(5+10)} = \frac{50}{15} = \frac{10}{3}\text{ Watts}$$

4. (d)



Method I

Using voltage division rule,

$$10 = 50\left[\frac{450 \,||\, 1500}{R_X + 450 \,||\, 1500}\right]$$

$$\frac{1}{5} = \frac{\left(\frac{675}{2}\right)}{R_X + \frac{675}{2}}$$

$$2R_X + 675 = (5 \times 675)$$

$$R_X = \frac{4\times 675}{2}$$

$$R_X = 1350 = 1.35 \text{ k}\Omega$$

Method II

Equivalent resistance across voltmeter,

$$R_{eq} = 450 \,||\, 1.5 \text{ k}\Omega$$

$$R_{eq} = \frac{450\times 1500}{1950} = 346.15\ \Omega$$

Since the voltmeter reads 50 V, current in circuit,

$$I = \frac{10V}{346.15} = 28.89 \text{ mA}$$

The voltage across unknown resistance, R_x,

$$V_x = 50 - 10 = 40 \text{ V}$$

$$40 = R_x I$$

$$R_x = \frac{40}{28.89\times 10^{-3}} = 1.38 \text{ k}\Omega$$

5. (c)

Large pages reduce page table overhead. TLB improves address translation speed and demand paging optimizes memory usage. A high page fault rate degrades performance. Thus, statements 1, 2 and 4 only are correct.

6. (d)

- The timing and control unit generates control signals ($\overline{RD}, \overline{WR},$ ALE, etc) to manage data transfer.
- It synchronizes all internal and external operations using the system clock. It uses the system clock to generate the necessary timing pulses for each step of an instruction execution.
- It controls both memory and I/O operations (not just memory).
- The clock signals are provided to all parts of the system to ensure proper operation.

7. (a)

$$\text{step size} = \frac{1.26}{2^6 - 1} = \frac{1.26}{63} = 20 \text{ mV}$$

Maximum allowed error

$$= \pm 0.1\% \text{ of } V_{FS} \pm 1 \text{ mV}$$
$$= \pm 0.001 \times 1.26 \text{ V} \pm 1 \text{ mV}$$
$$= \pm 2.26 \text{ mV}$$

For input code $(000011)_2 = (3)_{10}$,

$V_{out} = 3 \times 20 = 60$ mV ±2.26 mV (Measurement result is within specification)

For input code $(000111)_2 = (7)_{10}$,

$V_{out} = 7 \times 20 = 140$ mV ±2.26 mV (Measurement result is within specification)

For input code $(001100)_2 = (12)_{10}$,

$V_{out} = 12 \times 20 = 240$ mV ±2.26 mV (Measurement result is within specification)

For input code $(111110)_2 = (62)_{10}$,

$V_{out} = 62 \times 20$

$= 1240$ mV

$= 1.24$ V ±2.26 mV (Measurement result is not within specification)

8. (c)

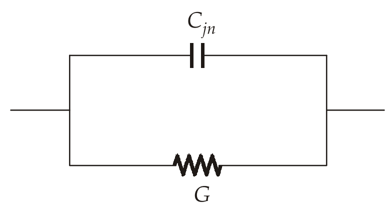
- The Ka-band (26-40 GHz) supports higher data rates due to its wider bandwidth. However, it is highly affected by rain attenuation because of its short wavelength, leading to signal degradation in heavy rain.
- The C-band (4-8 GHz) is widely used for satellite TV broadcasting and telecommunications because it suffers less atmospheric attenuation (especially from rain) compared to higher-frequency bands like Ku and Ka.
- The Ku-band (12-18 GHz) is extensively used for DTH (Direct-to-Home) satellite TV services, such as Dish TV, Tata sky and Direct TV as it requires smaller antennas than C-band.
- The X-band (8-12 GHz) is primarily used by the military and radar applications, including defense satellites and weather radar systems. It provides better resistance to Jamming and interference, making it suitable for secure military communications.

Hence, all the given statements are correct.

9. (a)

The junction capacitance is associated with the charge stored in the depletion region and dominates for reverse-biased diodes. Whereas, the diffusion capacitance dominates in strongly forward-biased diodes and is due to the charge carriers accumulating on either side of the junction.

Under reverse bias condition, the equivalent circuit of pn junction diode,



$\therefore$ $$Y = G + j\omega C_{jn}$$

where C_{jn} = junction capacitance

10. (d)

The output of second order under-damped system ($\xi < 1$) for unit step input is given by,

$$y(t) = 1 - \frac{e^{-\xi\omega_n t}}{\sqrt{1-\xi^2}}\sin(\omega_d t - \theta)$$

By comparing the given expression with standard form shown above, we get

$$\alpha = \xi\omega_n = 1$$

$$\omega_d = \sqrt{3} \text{ sec}$$

$$\omega_n = \sqrt{\alpha^2 - \omega_d^2} = 2 \text{ rad/sec}$$

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

$\therefore$ The transfer function,

$$T(s) = \frac{\omega_n^2}{s^2 + 2\xi\omega_n s + \omega_n^2} = \frac{4}{s^2 + 2s + 4}$$

- For a second-order system with unit-step input,

$$\text{Rise time, } t_r = \frac{\pi - \theta}{\omega_n\sqrt{1-\xi^2}}$$

$$\text{Settling time, } t_s = \frac{4}{\xi\omega_n}$$

$$\text{Delay time, } t_d = \frac{1 + 0.7\delta}{\omega_n}$$

Hence, the value of ω_n has direct effect on the rise time, delay time and setting time for given system.

- The peak overshoot does not exist for the second-order overdamped system ($\xi > 1$)

Hence, statement 2 and 3 is incorrect and statements 1 and 4 are correct.

11. (c)

Using voltage division rule,

$$V_c(j\omega) = V_i(j\omega)\left[\frac{\frac{-j}{\omega C}}{2\times 10^3 + \frac{-j}{\omega C}}\right]$$

$$V_c(j\omega) = V_i(j\omega)\left[\frac{1}{1 + j2\times 10^3 \times \omega \times C}\right]$$

Also,

$$V_0(j\omega) = \left[\frac{30\text{k}}{15k + 30k}\right] A V_c(j\omega)$$

$$V_0(j\omega) = \frac{2A}{3} V_c(j\omega)$$

$\therefore$

$$\frac{V_0(j\omega)}{V_i(j\omega)} = \frac{2A/3}{1 + j2\times 10^3 \times C \times \omega}$$

On comparing, $A = 6$ and $C = 5\ \mu F$.

12. (b)

Number of message bits = 2000 bits

TL segment size = Data + Header = 120 + 2000

= 2120 bits

Data supported by destination at a time

= 800 – 24

= 776 bits

2120 bits are divided into packets having a maximum of 776 bits. So,

Length of packet 1 = 776 bits

Length of packet 2 = 776 bits

Length of packet 3 = 568 bits

Total = 2120 bits

Network layer packets are transmitted via two networks, each of which uses a 26 bit header. Hence, the number of bits, including headers, delivered to the destination network is equal to

(24 + 24 + 776) + (24 + 24 + 776) + (24 + 24 + 568)

= 2(24 + 24+ 776) + (48 + 568)

= 2 × 824 + 616

= 1648 + 616

= 2264 bits

13. (b)

Angle of asymptotes meets at a common point, known as centroid.

Since complex poles occur in conjugate pairs, hence the root locus is symmetrical about real axis.

14. (a)

We have,

$$i(t) = 3 + A\sin(100t + 45°) + A\sin(300t + 60°)$$

$$i_{\text{RMS}} = \sqrt{(3)^2 + \left(\frac{A}{\sqrt{2}}\right)^2 + \left(\frac{A}{\sqrt{2}}\right)^2} = 5$$

$$= \sqrt{9 + A^2} = 5$$

$$A^2 = 16$$

$$A = \pm 4$$

$$|A| = 4$$

As, power dissipated by the circuit is 250 Watt i.e.

$$I_{rms}^2 R = 250$$

$$(5)^2 R = 250$$

$$R = 10\ \Omega$$

15. (c)

Let x_1 be the armature winding current and x_2 be the field winding current. The total current, $X = x_1 + x_2$.

Limiting error in total current,

$$\frac{\delta x}{X} = \left[\frac{x_1}{X}\frac{\delta x_1}{x_1} + \frac{x_2}{X}\frac{\delta x_2}{x_2}\right]$$

where,

Armature winding current,

$$x_1 = 96\text{A}$$

and $$\frac{\delta x_1}{x_1} = \pm 2\% \quad \text{(or)} \quad \pm 0.02\ \text{A}$$

Field winding current,

$$x_2 = 4\text{A}$$

and $$\frac{\delta x_2}{x_2} = \pm 1\% \quad \text{(or)} \quad \pm 0.01\ \text{A}$$

Total current,

$$X = x_1 + x_2 = 100\ \text{A}$$

$$\frac{\delta x}{X}\% = \pm\left[\frac{96}{100}\times 2\% + \frac{4}{100}\times 1\%\right]$$

$$= \pm\left[\frac{196}{100}\right] = \pm 1.96\%$$

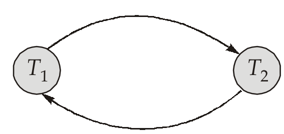
16. (d)

For a schedule to be conflict serializable, there should be no cycle present in its precedence graph.

Schedule S_1

T_1	T_2
$R[X]$	
	$R[X]$
	$R[Y]$
$W[X]$	
$W[Y]$	
	$W[Y]$

Precedence Graph:



Since the precedence graph is having cycle, hence S_1 is not conflict serializable.

Schedule S_2

T_1	T_2
$R[X]$	
	$R[X]$
	$R[Y]$
$W[X]$	
	$W[Y]$
$W[Y]$	

Precedence Graph:

Since there are no cycles in the precedence graph, hence S_2 is conflict serializable.

Schedule S_3

T_1	T_2
$R[X]$	
$W[X]$	
	$R[X]$
$W[Y]$	
	$R[Y]$
	$W[Y]$

Precedence Graph:

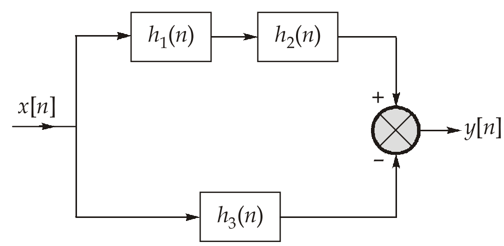
Since there are no cycles in the precedence graph, hence S_3 is conflict serializable.

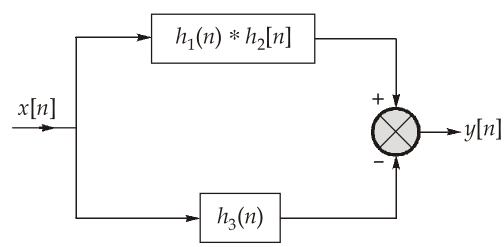
So, S_2 and S_3 conflict serializable.

17. (a)

- 8253/8254 consists of three independent 16-bit counters.
- It supports six operating modes : Mode 0 (Interrupt on Terminal Count), Mode 1 (Programmable One Shot), Mode 2 (Rate Generator), Mode 3 (Square wave generator). Mode 4 (Software Triggered Mode) and Mode 5 (Hardware Triggered Mode).
- It is used for time delays, frequency division, and waveform generation, not just clock generation.

18. (c)





From the given figure, overall impulse response,

$$h[n] = \{h_1[n] * h_2[n]\} - h_3[n]$$
$$= \{u(n-2) * \delta(n+2)\} - \{u(n) - u(n-3)\}$$
$$= u(n) - u(n) + u(n-3) \qquad [\because x(n) * \delta(n-n_0) = x(n-n_0)]$$

$$h(n) = u(n-3) = \sum_{k=0}^{\infty} \delta(n-3-k)$$

19. (d)

Radio horizon, $d = \sqrt{2r'h_t}$, where r' is the effective radius of the earth = $4r/3$.

$$d = \sqrt{2 \times \frac{4}{3} \times \frac{6370}{1000} \times 256} = 65.94 \text{ km}$$

20. (c)

Given, $D_p = 12\ \text{cm}^2/\text{s}$

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

Transmit time of holes in base,

$$\tau_t = \frac{W_b^2}{2D_p}$$

$$= \frac{(0.5\times10^{-4})^2}{2\times12} = \frac{2.5\times10^{-9}}{24}$$

$$\tau_t = 1.04 \times 10^{-10} \quad \text{(or)} \quad 0.1 \text{ nsec}$$

21. (a)

For parabolic graded index profile, $\alpha = 2$. The number of modes propagating in a graded index fiber is given by,

$$N = \frac{\alpha}{\alpha+2}\left(\frac{V^2}{2}\right)$$

$\therefore$
$$742 = \frac{2}{2+2}\cdot\frac{V^2}{2}$$

or
$$V = 55$$

As we know that

$$V = \frac{2\pi a(NA)}{\lambda}$$

$\therefore$
$$55 = \frac{2\pi\left(\frac{70}{2}\times10^{-6}\right)\times0.3}{\lambda}$$

On solving,
$$\lambda = 1.19 \times 10^{-6} \text{ m}$$
$$= 1.19\ \mu\text{m}$$

22. (c)

For a lead compensator, maximum phase lead is given by

$$\sin\phi_m = \frac{1-\alpha}{1+\alpha}$$

$$\alpha = \frac{1-\sin\phi_m}{1+\sin\phi_m} = \frac{1-\sin30^\circ}{1+\sin30^\circ} = \frac{1-\frac{1}{2}}{1+\frac{1}{2}} = \frac{1}{3}$$

The maximum phase lead occurs at

$$\omega_m = \frac{1}{\tau\sqrt{\alpha}}$$

Now,

Corner frequency due to zero, $\omega_{g1} = \frac{1}{\tau} = \omega_m\sqrt{\alpha} = 6\sqrt{\frac{1}{3}}$

$$= 3.46 \text{ rad/sec}$$

Corner frequency due to pole, $\omega_{g2} = \frac{1}{\alpha\tau} = \frac{\omega_m}{\sqrt{\alpha}} = 6\sqrt{3} \cong 10.4 \text{ rad/sec}$

$$\tau = \frac{1}{\omega_{g1}} = \frac{1}{6}\sqrt{3} = \frac{1.73}{6} = 0.28 \text{ sec/rad}$$

23. (d)

As per the question,

$$|V_C| = |V_L| = \frac{V_R}{2}$$

i.e.,

$$|X_C| = |X_L| = \frac{R}{2}$$

$$\frac{1}{\omega C} = \frac{10}{2}$$

$$C = \frac{1}{\omega \times 5}$$

Given $f = 50$ Hz, thus

$$C = \frac{1}{2\pi \times 50 \times 5} = \frac{1}{500\pi} = \frac{2}{\pi}\text{mF}$$

24. (a)

- LVDT is used as secondary transducer for the measurement of pressure with Bellows or Bourdon tube acting as a primary transducer.
- LVDT is simple in construction and rugged.
- LVDT is a frictionless device as there is no direct contact of the winding with the core.
- A Gauss meter is an instrument based on Hall effect that conditions and amplifies a Hall sensor output and provides its user with calibrated magnetic flux-density information.

25. (d)

Rotations per minute = 3000 rpm

or

$$\frac{3000}{60} = 50 \text{ rps}$$

In one track rotation it can read 512 kB

In 1 second (50 rotations) it can read 512 × 50 kB

$$\text{Time taken for 1 byte read} = \frac{1}{(512 \times 50 \times 1024)} = 38.15 \text{ ns}$$

⇒ For 4 bytes, it takes 152.6 ns

DMA will transfer 4 bytes in 40 nsec. So,

$$\text{Percentage of time that the CPU gets blocked during DMA operation} = \frac{40}{152.6} \times 100 \cong 25\%$$

26. (d)

- IOR is activated when the processor reads data from an I/O port.
- IOW is activated when the processor writes data to an I/O port.
- ALE is required for demultiplexing the address and data lines.
- Ready is used by slow I/O devices to indicate that they are ready for data transfer.

27. (d)

$$\text{For } x(t) = \cos(2\pi t)\frac{\sin(\pi t)}{\pi t} + \cos(2\pi t)\frac{\cos(\pi t)}{\pi t}$$

$$x(t) = \frac{\sin 3\pi t - \sin \pi t}{2\pi t} + \frac{\cos 3\pi t - \cos \pi t}{2\pi t}$$

Maximum frequency component in $x(t)$,

$$\omega_m = 3\pi \text{ rad/sec}$$

As per Nyquist Sampling theorem, for perfect reconstruction, sampling frequency

$$\omega_s \geq 2\omega_m$$

$$\frac{2\pi}{T_s} \geq 2 \times 3\pi$$

$$\frac{1}{T_s} \geq 3$$

$$T_s \leq \frac{1}{3}\text{sec}$$

28. (b)

- Flooding can cause the broadcast storm problem in wireless networks. In flooding routing technique, since every node forwards the packet to all its neighbors, excessive redundant transmissions occur, leading to congestion, collision and inefficient bandwidth utilization.
- Controlled flooding techniques like time-to-live (TTL) based flooding help limit the number of hops a packet can traverse, reducing excess transitions and mitigating the broadcast storm problem.
- Flooding does not lead to more efficient bandwidth utilization than unicast routing. In fact, it leads to redundant packet transmissions and increased bandwidth consumption, making it inefficient compared to unicast methods that deliver packets along an optimized route.
- Redundant transmission in flooding can lead to interference and reduced network performance, especially in wireless environments where multiple transmissions may collide, increasing retransmissions and network congestion.

29. (b)

We know that,

Electron distribution, $n(E) = N_c(E)f(E)$

given, $n(E) = 10^{14}\text{ cm}^{-3}$

$$N_c(E) = 3 \times 10^{14}\text{ cm}^{-3}$$

$$\therefore \quad f(E) = \frac{10^{14}}{3\times 10^{14}} = \frac{1}{3}$$

Hole distribution, $p(E) = N_V(E)[1 - f(E)]$

$$\therefore \quad p(E) = 3\times 10^{14}\left[1-\frac{1}{3}\right] \quad [\because N_c(E) = N_V(E)]$$

$$= 2 \times 10^{14}\text{ cm}^{-3}$$

30. (c)

$$\Delta T_{mod} = 0 \text{ for the single-mode fiber}$$
$$\Delta T_{mat} = 2.8 \text{ ns}$$
$$\Delta T_{WG} = 0.5 \text{ ns}$$
$$\Delta T_{total} = \sqrt{(\Delta T_{mod})^2 + (\Delta T_{mat})^2 + (\Delta T_{WG})^2}$$
$$\Delta T_{total} = \sqrt{0 + (2.8)^2 + (0.5)^2} = 2.9 \text{ ns}$$

The received pulse width is:

$$T_r = \sqrt{(T_t)^2 + (\Delta T_{total})^2}$$
$$T_r = \sqrt{(2.5)^2 + (2.9)^2} = 3.8 \text{ ns}$$

The maximum allowed bit rate for the fiber is given by

$$B \le \frac{1}{2T_r} = \frac{1}{2 \times 3.8 \times 10^{-9}} \text{ bits/sec}$$
$$B_{max} = 131.6 \text{ M bits/sec}$$

31. (d)

From the given state space representation, we can write

$$A = \begin{bmatrix} -2 & 4 \\ 2 & -1 \end{bmatrix}$$
$$B = \begin{bmatrix} 0 \\ -1 \end{bmatrix}$$

The determinant of controllability matrix,

$$|Q_c| = |[B \quad AB]| = \begin{vmatrix} 0 & -4 \\ -1 & 1 \end{vmatrix} = -4 \ne 0$$

∴ The system is controllable.

The characteristic equation of the system is given by

$$|[sI - A]| = \left| \begin{bmatrix} s & 0 \\ 0 & s \end{bmatrix} - \begin{bmatrix} -2 & 4 \\ 2 & -1 \end{bmatrix} \right| = \left| \begin{bmatrix} s+2 & -4 \\ -2 & s+1 \end{bmatrix} \right| = 0$$

$\Rightarrow$ $(s + 2)(s + 1) - 8 = 0$

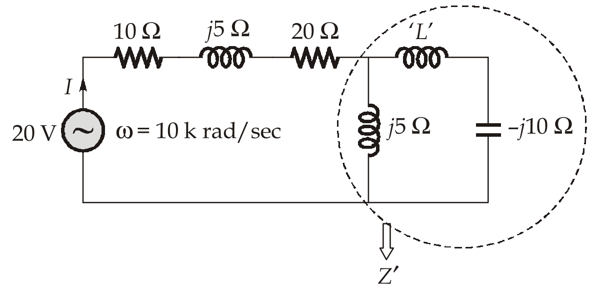
$s^2 + 3s - 6 = 0$

$\Rightarrow$ $s = 1.37, -4.37$

Since the poles lie in the right side of s-plane, hence the system is unstable.

32. (a)

From the circuit,



For current I to be zero; Z' must be ∞.

$$Z' = j5 || (j\omega L + (-j10)) = \infty$$

$$Z' = (j5) || (j(\omega L - 10)) = \frac{1}{0}$$

$$Z' = \frac{1}{0} = \frac{(j5)(j(\omega L - 10))}{j(\omega L - 5)}$$

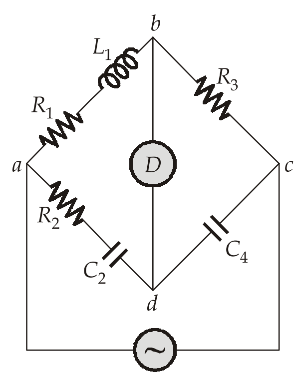
$$j(\omega L - 5) = 0$$

$$\omega L = 5$$

$$L = \frac{5}{\omega} = \frac{5}{10k} = 0.5 \text{ mH}$$

33. (d)

Let R_1 and L_1 be the effective resistance and inductance of the specimen respectively. The Owen's bridge circuit can be drawn as below,



At balance, $$(R_1 + j\omega L_1)\frac{1}{j\omega C_4} = R_3\left(R_2 + \frac{1}{j\omega C_2}\right)$$

On separating the real and imaginary part, we get

$$L_1 = R_2 R_3 C_4 = 840 \times 120 \times 0.2 \times 10^{-6}$$
$$= 20.16 \text{ mH}$$

and $$R_1 = R_3\frac{C_4}{C_2} = 120 \times \frac{0.2}{0.15} = 160\ \Omega$$

34. (d)

- Dijkstra's Algorithm is used for solving shortest paths in graphs with non-negative weights.
- Bellman-Ford Algorithm works even with negative weights but has $O(VE)$ complexity where V is the number of vertices and E is the number of edges.
- Kruskal's Algorithm is used for finding Minimum spanning Tree (MST), not shortest paths.
- Floyd-Warshall Algorithm is used to find the shortest paths between all pairs of vertices in a weighted graph in $0(V^3)$ time.

35. (c)

	MVI A, 6E H	$\Rightarrow$	$A \leftarrow$ 6E H
	SUI A8 H	$\Rightarrow$	$A \leftarrow$ 6E – A8
			= C6 H; Carry (CY) = 1
	JC DISPLAY	$\Rightarrow$	Since CY = 1, the program jumps to DISPLAY subroutine.
	OUT PORT 1		
	HLT		
DISPLAY :	XRA A	$\Rightarrow$	$A \leftarrow$ 00 H
			CY = 0, AC = 0, Z = 1, P = 1, S = 0
	OUT PORT 1	$\Rightarrow$	PORT 1 = 00 H
	HLT		

Hence, the data displayed at PORT 1 is 00 H.

Now flag register,

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

Hence, flag register content = 44 H

36. (b)

We can express $X(z)$ as

$$X(z) = z^2 + \frac{1}{2}z - \frac{5}{2} + z^{-1}$$

Then, by definition,

$$X(z) = x[-2]z^2 + x[-1]z + x[0] + x[1]z^{-1}$$

and we get

$$x[n] = \{....,0,1,\frac{1}{2},\underset{\uparrow}{-\frac{5}{2}},1,0.....\}$$

Therefore, $x(-2) = 1$, $x(-1) = 1/2$, $x(0) = -2.5$, $x(1) = 0$

We get, $x(-2) - x(0) = 1 + 2.5 = 3.5$

37. (c)

User overloading means that the number of users exceeds the available resources (e.g. subcarriers time slots, spreading codes). Let's analyze each multiple access technique:

- SCMA (Sparse Code Multiple Access): SCMA supports user overloading beyond the available resources, it assigns users multidimensional sparse code books, allowing more users to share the same frequency and time resources.

- MC-CDMA (Multi-carrier CDMA): MC-CDMA spreads user data over multiple subcarriers using orthogonal codes. However, it does not inherently support overloading, as orthogonality must be maintained to avoid interference.
- IDMA (Interleave Division Multiple Access): IDMA allows overloading by using user-specific interleavers instead of orthogonal spreading codes. Even with more users than available resources, it separates them efficiently using iterative decoding.
- LAS-CDMA (Large Area Synchronized Code Division Multiple Access): It uses a new set of spreading codes to separate users on a wireless channel, and does not support user overloading.

38. (d)

We know that, the probability of a state having energy level 'E' being occupied by an electron is given by the Fermi-Dirac distribution function as,

$$f(E) = \frac{1}{1+e^{(E-E_F)/kT}}$$

Given,
$$E = E_C + \frac{kT}{4};\ E_F = E_C - 0.26$$

$$f(E) = \frac{1}{1+e^{\left(E_C+\frac{kT}{4}-E_F\right)/kT}}$$

$$= \frac{1}{1+e^{\left(\frac{0.26}{kT}+\frac{1}{4}\right)}} = \frac{1}{1+e^{\left(\frac{0.26}{0.026}+0.25\right)}}$$

$$f\left(E_C+\frac{kT}{4}\right) \approx e^{-10.25}$$

39. (c)

- Since S is deterministic, the randomness in R is entirely due to N.
  Given that $N \sim N(0, \sigma^2)$, the received signal R follows:
  $R/S \sim N(S, \sigma^2)$
  The conditional PDF of R given S is Gaussian given by

$$f_{R/S}(r/s) = \frac{1}{\sqrt{2\pi\sigma^2}} e^{-\frac{(r-s)^2}{2\sigma^2}}$$

- The signal power is given by:

$$P_s = E[S^2]$$

  The noise power is: $P_N = \sigma^2$
  By definition, the signal-to-noise ratio (SNR) is:

$$\text{SNR} = \frac{\text{Signal power}}{\text{Noise power}} = \frac{E[S^2]}{\sigma^2}$$

- Consider $S \sim N(\mu_s, \sigma_s^2)$ and $N \sim N(0, \sigma^2)$. Since, the sum of two independent Gaussian random variables is also Gaussian:

$$R = S + N \sim N(\mu_s + 0, \sigma_s^2 + \sigma^2)$$

$$R \sim N(\mu_s, \sigma_s^2 + \sigma^2)$$

- For binary phase shift keying (BPSK), the received signal is:

$$R = \pm\sqrt{E_b} + N$$

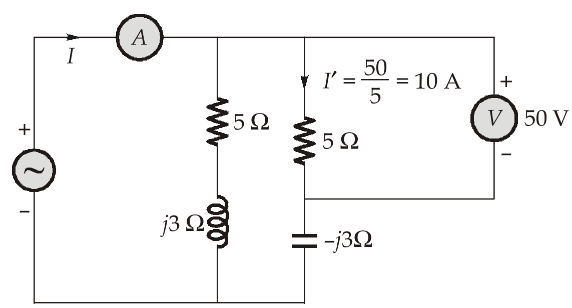
Here, $d_{min} = 2\sqrt{E_b}$. The probability of bit error for BPSK in an AWGN channel is given by

$$P_e = Q\left(\sqrt{\frac{d_{min}^2}{2\sigma^2}}\right) = Q\left(\frac{\sqrt{2E_b}}{\sigma}\right)$$

40. (c)

41. (b)

We have,



From current division rule, we get

$$I' = \frac{I \times (5 + j3)}{(5 + j3) + (5 - j3\Omega)} = 10 \text{ A}$$

$$I = \frac{10 \times 10}{5 + j3} = \frac{100}{(5 + j3)} \text{A}$$

$$\text{Ammeter reading, } |I| = \frac{100}{\sqrt{25 + 9}} = \frac{100}{\sqrt{34}} \text{A}$$

42. (b)

Velocity of electron beam, $V_{ox} = \sqrt{\frac{2eV}{m}} = \sqrt{\frac{2 \times 1.6 \times 10^{-19}}{9.1 \times 10^{-31}} \times 2000} = 26.5 \times 10^6$ m/s

Cutoff frequency, $f_c = \frac{V_{ox}}{4l} = \frac{26.5 \times 10^6}{4 \times 50 \times 10^{-3}}$

$= 132.5 \times 10^6$ Hz = 132.5 MHz

43. (b)

Assume P_{cu} as the full-load copper loss. At full load,

$$\frac{500\times10^3}{500\times10^3 + P_i + P_{cu}} = 0.95$$

$$\Rightarrow \quad P_i + P_{cu} = \left(\frac{500\times10^3}{0.95} - 500\times10^3\right) = \frac{5}{19}\times10^5\,\text{Watt} \quad \text{...(i)}$$

At 60% of the full load,

$$\frac{500\times10^3\times0.6}{500\times0.6\times10^3 + P_i + 0.36P_{cu}} = 0.95$$

$$\Rightarrow \quad \left(\frac{500\times10^3}{0.95} - 500\times10^3\right)\times0.6 = P_i + 0.36\,P_{cu}$$

$$\Rightarrow \quad \frac{5\times10^5}{19}\times0.6 = P_i + 0.36\,P_{cu}$$

$$P_i + 0.36\,P_{cu} = \frac{3\times10^5}{19} \quad \text{...(ii)}$$

From equation (i) and (ii),

$$0.64\,P_{cu} = \frac{2}{19}\times10^5\,\text{Watt}$$

$$P_{cu} = \frac{200}{19\times64}\times10^5 = 16.45\,\text{kW}$$

$$P_i = 9.87\text{ kW}$$

$$\text{Iron and copper loss at full load} = P_i + P_{cu} = (16.45 + 9.87)\text{ kWatt}$$

$$= 26.32\text{ kWatt}$$

44. (b)

		T-States	Machine Cycles
1000 H	MVI A, 10 H	7	2
LOOP :	ORA A	4	1
	DCR A	4	1
	LXI H, 1000 H	10	3
	NOP	4	1
	JNZ LOOP	7/10	2/3

Register A contains 10 H = $(16)_{10}$. The value of register A is decremented by 1 in each loop iteration until it becomes zero. Hence, the loop is executed 16 times.

$$\text{Total T-states} = 7 + 15\,(4 + 4 + 10 + 4 + 10) + 4 + 4 + 10 + 4 + 7$$

$$= 516$$

45. (d)

- FIR filters typically have a higher computational cost because they rely solely on feed forward coefficient (non recursive).
- IIR filters generally exhibit non linear phase characteristics especially in Butterworth, Chebyshev and elliptic filters.

This phase distortion occurs because of their recursive nature, unlike FIR filters, which can be designed with linear phase.

- FIR filters usually require a higher order than IIR filters to achieve a comparable frequency response. This leads to more computations per sample making IIR filters more efficient for real-time applications. However, FIR filters are often preferred for applications requiring linear phase.
- IIR filters can be realized using.
  → **Direct Form (I and II)** – Simple implementation but sensitive to coefficient quantization.
  → **Cascade Form:** Reduces numerical errors by breaking down the filter into second-order sections.
  → **Parallel Form:** Uses partial fraction expansion; useful in DSP implementations.

46. (a)

- As the width of the depletion region varies with bias, reverse bias p-n junction isolation introduces bias-dependent parasitic capacitance.
- Resistive isolation using the bulk resistivity of the layer Requires large area of the wafer, provide a sufficiently high resistance thereby increasing the IC size.
- Silicon dioxide (SiO_2) is the native oxide of silicon and possesses excellent insulating properties. It can be grown directly on the silicon substrate and provides good electrical isolation with low parasitic capacitance. This makes it a best choice for silicon ICs with low parasitic capacitance.
- Oxide other than native isolation is suitable for ICs of III-IV semiconductors.

Thus,

A → 4, B → 1, C → 2, D → 3

47. (b)

The induced E-field, $$E(x) = -\left(\frac{kT}{q}\right)\frac{1}{N_d(x)}\frac{dN_d(x)}{dx}$$

We have, $$\frac{dN_d(x)}{dx} = -10^{19}$$

$$\therefore \quad E(x) = -0.026\times\frac{1}{10^{16}-10^{19}x}(-10^{19})$$

At $x = 0$, $$E(0) = -0.026\times\frac{-10^{19}}{10^{16}} = 26\text{ V/cm}$$

48. (a)

It is case of asynchronous TDM with

$$f_{m1} = 3\text{ kHz};\ f_{m2} = 1\text{ kHz};\ f_{m3} = 1\text{ kHz};\ f_{m4} = 1\text{ kHz}$$

Since the signals are sampled at Nyquist rate, hence,

$$f_{s1} = 6\text{ kHz};\quad f_{s2} = 2\text{ kHz};\quad f_{s3} = 2\text{ kHz};\quad f_{s4} = 2\text{ kHz}$$

$$\therefore \quad R_s = n(f_{s1} + f_{s2} + \ldots.. + f_{s4})$$

Given, n = 1 bit/sample, thus

$$R_b = (6 + 2 + 2 + 2)\text{kHz} = 12 \text{ kHz}$$

$$(\text{Transmission BW})_{\min} = \frac{12 \text{ kHz}}{2} = 6 \text{ kHz}$$

49. (d)

Using Gauss's divergence theorem,

$$\oiint_S 5\vec{r}\cdot\hat{n}\,ds = \iiint_V \vec{\nabla}\cdot 5\vec{r}\,dV = 5\iiint_V \vec{\nabla}\cdot\vec{r}\,dV$$

where, $\vec{r}$ is position-vector i.e., $\vec{r} = x\hat{a}_x + y\hat{a}_y + z\hat{a}_z$ and $dV = dx\,dy\,dz$

$$= 5\times 3\iiint dV = 15\text{ V} \qquad (\because\ \vec{\nabla}\cdot\vec{r} = 3)$$

where V is the total volume enclosed by the surface.

50. (b)

- All crystalline solids contain vacancies, and it is not possible to create such a material that is free of these defects.
- Impurity defects arise when some foreign atoms may occupy a normal atomic site in the host lattice, a substitutional impurity, or a non regular atomic site, an interstitial impurity. Hence, impurity point defects are of two types: substitutional and interstitial.

Hence, statements 2 and 3 are not correct.

51. (a)

At resonance,

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

$$\text{Inductance, } L = \frac{1}{4\pi^2 f_0^2 C} = \frac{1}{4\pi^2\times(500\times10^3)^2\times 350\times10^{-12}}$$

$$= 289.49\ \mu\text{H} \approx 290\ \mu\text{H}$$

Let R be the resistance of coil,

$$\therefore \quad R + 0.5 = \frac{\omega_0 L}{Q} = \frac{2\pi\times500\times10^3\times290\times10^{-6}}{90} = 10.10\ \Omega$$

Effective resistance of coil, $R = 10.10 - 0.5 = 9.6\ \Omega$

52. (b)

We know that,

$$Q = CV$$

$$Q = 1.5\times10^{-6}\times 800$$

$$Q = 1.2\text{ mC}$$

Now,

To obtain Q = 1.2 mC at 600 V,

Equivalent capacitance required is $C_{eq} = \dfrac{Q}{V}$

$$C_{eq} = \frac{1.2 \times 10^{-3}}{600}$$

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

To obtain C_{eq} = 2 μF using 8 μF capacitance, four capacitors must be connected in series. Therefore, option (b) is correct.

53. (c)

Resistance potentiometers are simple in construction and made from low-cost materials, making them economical for many applications. They have high electrical efficiency and provides sufficient output for further control operations without any further amplification. Thus, given statements are correct regarding resistance potentiometer.

54. (c)

Microprogramming is used in CISC processors and enables easy modification of the instruction set, by changing the microcode rather than the hardware. It is generally slower than hardwired control which uses fixed logic circuits to generate control signals directly, leading to faster execution. RISC processors support simpler instructions and hardwired control unit which help in fast execution. Thus, statements 1 and 4 are correct.

55. (d)

- When an interrupt occurs, the CPU suspends the execution of the current instruction sequence (i.e., stops executing main program instructions).
- The CPU acknowledges the interrupt and branches to interrupt service routine (ISR), which is a subroutine designed to handle that interrupt.
- The CPU does not continue the main program execution after acknowledging the interrupt, it first executes the ISR.
- The CPU does not wait for the next instruction from the interrupting device; instead, it executes the ISR and then resumes the main program execution.

56. (d)

- PLAs has programmable AND array followed by programmable OR array and can be used to implement any Boolean function in SOP form.
- They are more efficient than ROMs when functions share common product terms, reducing redundancy.
- PLAs can be used in sequential circuits if flip-flops are included.
- PLAs are used to build a reconfigurable digital circuit. Hence, statement 3 is not correct.

57. (c)

We know that,

$$\left[\frac{C}{N}\right]_D = [EIRP] + \left[\frac{G}{T}\right]_D - [\text{Losses}]_D - [k] - [B]$$

Given,

$$\frac{C}{N} = 22\ \text{dB}$$

$$\text{EIRP} = 37\ \text{dBW}$$

$$\text{Losses} = 3.4 \text{ dB}$$
$$f = 4 \text{ GHz}$$
$$l = 40000 \text{ km}$$
$$k = -228.6 \text{ dB} \qquad [\because k = 10\log(1.38 \times 10^{-23}) = -228.6 \text{ dB}]$$
$$B = 36 \text{ MHz}$$

$\because$ $$10\log(36 \times 10^6) = 10[6 + 2\log_{10} 6]$$
$$= 10[6 + 2 \times 0.778]$$
$$= 10[6 + 1.556] = 75.6$$

$\therefore$ $$B \cong 75.6 \text{ dB Hz}$$

Free space path loss, $$\text{FSL} = 32.5 + 20\log_{10} f(\text{MHz}) + 20\log_{10}(l(\text{km}))$$
$$= 32.5 + 20\log_{10}4000 + 20\log_{10}40000$$
$$= 196.58 \text{ dB}$$

Thus, $$\left[\frac{G}{T}\right]_D = -[EIRP]_D + \left[\frac{C}{N}\right]_D + [\text{Losses}] + [\text{FSL}] + [k] + [B]$$

$\therefore$ $$\left[\frac{G}{T}\right]_D = -37 + 22 + 3.4 + 196.58 - 228.6 + 75.6$$
$$= -31.98 \text{ dB}$$

58. (a)

Given, pn-junction

$$\frac{P_n}{P_p} = \frac{3}{2}$$

The hole concentrations on either side of the junction are related as

$$P_n = P_p \exp\left(-\frac{qV_0}{kT}\right)$$

Contact potential, $$V_0 = \frac{kT}{q}\ln\left(\frac{P_n}{P_p}\right)$$
$$= 26\times10^{-3}\ln\left(\frac{P_n}{P_p}\right)$$
$$= 26 \times 10^{-3}(\ln(3) - \ln(2))$$
$$= 26 \times 10^{-3}(1.098 - 0.693)$$
$$= 0.01$$
$$\simeq 10 \text{ mV}$$

59. (c)

- Hysteresis loss increases because it is proportional to frequency.
- Eddy current loss is proportional to $(\text{frequency})^2$ so it increases, not decreases.
- Magnetizing reactance increases, reducing magnetizing current.
- Since the V/f ratio decreases due to higher frequency, the core flux density decreases and core saturation is less likely.

60. (d)

In case of immediate addressing mode, move operation is not permitted when destination is a segment register. We can only load a data into a segment register by, first loading it into a general purpose register (or memory) and then moving it to the segment register. Hence, instruction "MOV DS, 5000H" is invalid.

61. (d)

Given, $X(f)$ extends from $-\omega_0$ to ω_0

$H(f)$ extends from $-2\omega_0$ to $2\omega_0$

$y(t)$ represents convolution of $h(t)$ and $x(t)$. The convolution in time domain leads to multiplication in frequency domain.

Hence, $Y(f) = H(f)\cdot X(f)$. Since $X(f)$ is non-zero for $-\omega_0 < \omega < \omega_0$, thus, spectrum of $y(t)$ extends from $-\omega_0$ to ω_0.

62. (b)

Using Deal-Grove equation,

$$x_0^2 + Ax_0 = B(t + \tau)$$

$$x_0 = \frac{B(t+\tau)}{x_0} - A \qquad \text{...(1)}$$

For the given plot,

$$x_0 = \frac{0.3(t+\tau)}{x_0} - 0.6 \qquad \text{...(2)}$$

Comparing (1) and (2), we get

$$A = 0.6,\ B = 0.3$$

So, linear rate constant $= \dfrac{B}{A}$

$$= \frac{0.3}{0.6} = 0.5\ \mu\text{m/hour}$$

63. (a)

Continuity equation give the rate of carriers buildup in the bulk of semiconductor,

$$\frac{\partial \delta_n}{\partial t} = D_p \frac{\partial^2 \delta_n}{\partial x^2} - (R - G);$$

where R = carrier recombination rate = δ_n/τ_n and G = generation rate = 0

We get,

$$\frac{\partial \delta_n}{\partial t} = D_p \frac{\partial^2 \delta_n}{\partial x^2} - \frac{\delta_n}{\tau_n}$$

64. (a)

The binary symmetric channel has channel capacity of $1 - H(P)$, where

$H(P) = -P\log_2 P - (1-P)\log_2(1-P)$ is the shannon entropy of a binary distribution with probabilities P and $1 - P$.

65. (d)

$$\nabla \cdot \vec{D} = \rho_v$$

Given,
$$\vec{D} = \hat{a}_x \sin y + \hat{a}_y y$$

$$\nabla \cdot \vec{D} = \frac{\partial D_x}{\partial x} + \frac{\partial D_y}{\partial y} + \frac{\partial D_z}{\partial z}$$

$$\rho_v = 0 + 1 + 0 = 1 \text{ C/m}^3$$

66. (b)

Dielectric loss in solid dielectric,

$$L = \frac{E^2 f \in_r \tan\delta}{1.8\times 10^{12}} \text{ W/cm}^3$$

$$L = \frac{(60)^2 \times 10^6 \times 50 \times 3.6 \times 0.002}{1.8\times 10^{12}}$$

$$= 0.72 \text{ mW/cm}^3$$

67. (b)

Gauge factor (GF) is given by

$$GF = \frac{\Delta R / R}{\text{strain}}$$

$$\Delta R = GF \times \text{strain} \times R$$

$$= 2 \times 120 \times 500 \times 10^{-6}$$

$$= 12 \times 10^{-2} = 0.12\ \Omega$$

68. (b)

When working on 240 V supply,

$$E_b = V - I_a R_a = 240 - (12 \times 2.5) = 210 \text{ V}$$

Since $E_b \propto N\phi$, it can't change instantaneously when supply voltage drops to V_2 = 210 V since speed and field are constant. Thus,

$$I_a = \frac{E_b - V}{R_a} = \frac{210 - 210}{2.5} = 0 \text{ A}$$

After the current momentary drop to zero, the motor will start to decelerate because the back EMF is now greater than the applied voltage. As the speed decreases, the back EMF will also decrease resulting in an increase in armature current. We know that Torque, $T \propto \Phi I_a$. Since the load torque is constant and the field is separately excited i.e. ϕ is constant, the armature current must remain constant at 12 A in the steady state to maintain this torque. Thus, I_a becomes zero momentarily and then rise to 12 A.

69. (c)

- MOV DPTR,#5678 H: The data is specified in the instruction itself, hence immediate addressing mode.
- MOV R_2, A: The data is stored in the CPU register, hence register addressing mode.
- MOV @R_1, B: The address of the destination data is specified in the register, hence register indirect addressing mode.

- MOV R_4, 7FH: The address of the source data is specified by the 8-bit data in the instruction, hence direct addressing mode.

70. (c)

- $$t\delta(t) = 0$$

  Using the property of impulse function $x(t)\cdot\delta(t) = x(0)$. We get,

  $$t\delta(t) = 0 \quad \rightarrow \quad \text{option (a) is true}$$

  By sampling property of delta function:

  $$f(t)\ \delta(t - t_0) = f(t_0)\delta(t - t_0)$$
  $$\cos(t)\ \delta(t - \pi) = \cos(\pi)\ \delta(t - \pi) = (-1)\delta(t - \pi)$$

  Hence, option (b) is true.

  The unit step function $u(t)$ is related to $\delta(t)$ as :

  $$\frac{du(t)}{dt} = \delta(t)$$
  $$\int u(t)dt = \text{Ramp function}$$

  Hence, option (c) is false.

- Using the property $f(x)\cdot\delta^{(n)}(x - a) = (-1)^n f^{(n)}(a)\delta(x - a)$, we get

  $$t\delta'(t) = -\delta(t) \rightarrow \text{option (d) is true}$$

71. (b)

- BIST embeds self-testing circuits inside ICs.
- Scan chain testing shifts test patterns through registers and used to control and observe internal flip-flops during testing to detect the faults.
- Boundary scan testing is used for board-level testing. It is used to test that the inputs and outputs of components on a board, or sub-systems on a chip, are connected correctly.
- DSP is a signal processing technique and not a fault detection technique in VLSI.

72. (c)

Given,
$$\alpha = 0.996 = \frac{I_C}{I_E}$$
$$I_C = 20 \text{ mA},$$
$$I_{CBO} = 5\ \mu\text{A}$$

∴
$$I_C = \alpha I_E + I_{CBO}$$
$$20 \times 10^{-3} = 0.996 \times I_E + 0.005 \text{ mA}$$

∴
$$I_E = \frac{20 - 0.005}{0.996} \text{mA}$$
$$I_E = 20.07 \text{ mA}$$

73. (a)

- White noise has a constant power spectral density across all frequencies.
- The autocorrelation function and PSD of a signal form a Fourier transform pair. Since PSD is constant, the autocorrelation function is an impulse function, meaning the noise values are uncorrelated.

- Since the white noise has zero mean and constant variance which do not change over time, White noise can be modeled as a stationary process.
- However, white noise is not necessarily Gaussian (it can have different distributions like uniform or poisson).

74. (c)

Comparing the given expression with the standard expression of electric field component for EM wave,

$$\vec{E} = E_0 e^{-\alpha z} \cos(\omega t - \beta z)\,\hat{y}$$

we get,

$$\beta = 2\pi \text{ rad/m}$$

$$\alpha = \frac{1}{50} = 0.02$$

$\Rightarrow$ Propagation constant, $\gamma = \alpha + j\beta = 0.02 + j2\pi (\text{m}^{-1})$

75. (d)

- While copper atoms do have a single electron in their valence (or outermost) shell, when multiple copper atoms come together, these valence electrons get sent into a cloud which forms metallic bonds between the copper atoms. This makes copper diamagnetic — it repels magnetic fields.
- Iron metal has curie temperature of 1043K.
- Alnico is material with high coercivity at high temperature.

76. (d)

Error due to Counts:

In a $4\frac{1}{2}$ digit DMM

Maximum display is 19999 counts.

For 100 V full scale, 19999 counts correspond to 100 V.

$$1 \text{ count value is} = \frac{100}{19999} \simeq 0.005 \text{ V}$$

For 8 count value is 8 × 0.005 = 0.04 V

Error due to Percentage:

0.6% of the reading (75 V)

$$0.6\% \times 75 = \frac{0.6}{100} \times 75 = 0.45$$

$$\text{Total maximum error} = 0.45 + 0.04 = 0.49 \text{ V}$$

(or)

$$\text{Maximum error} = \frac{\%\text{ error reading}}{100} \times \text{Reading value} + \frac{\text{F.S value} \times \text{No. of count}}{\text{Max. Range}}$$

$$= \frac{0.6}{100} \times 75 + \frac{100 \times 8}{19999} = 0.49 \text{ V}$$

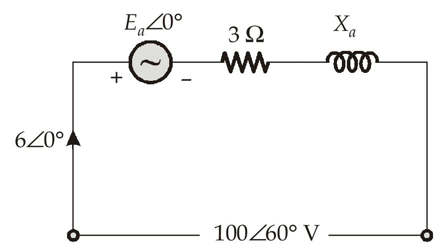
77. (d)

We have,

$$VI\cos\phi = P$$
$$100 \times 6\cos\phi = 300\text{ W}$$
$$\cos\phi = \frac{1}{2}$$
$$\therefore \quad \phi = 60°$$

(lagging because of reactive nature of the circuit)

The operating conditions in terms of voltage and current of the armature circuit are shown in figure.



From the circuit,

$$\frac{100\angle 60° - E_a\angle 0°}{3 + jX_a} = 6\angle 0°$$

($\overline{E_a}$ is in-phase with $\overline{I_a}$)

or
$$50 + j50\sqrt{3} - E_a = 18 + 6jX_a$$

$\Rightarrow$
$$E_a = 32\text{ V}$$

and
$$X_a = \frac{50\sqrt{3}}{6} = \frac{25}{\sqrt{3}} = 25 \times 0.577$$
$$= 14.43\ \Omega \cong 14.5\ \Omega$$

78. (d)

The excitation inputs to the Flip-Flops are:

$$J_2 = \overline{Q_1} \quad J_1 = \overline{Q_2} \quad J_0 = Q_1$$
$$K_2 = Q_0 \quad K_1 = Q_2 \quad K_0 = \overline{Q_1}$$

CLK No.	P.S			Excitation of FFS before active CLK edge						N.S		
	Q_2	Q_1	Q_0	J_2	K_2	J_1	K_1	J_0	K_0	Q_2^+	Q_1^+	Q_0^+
1	0	0	1	1	1	1	0	0	1	1	1	0
2	1	1	0	0	0	0	1	1	0	1	0	1
3	1	0	1	1	1	0	1	0	1	0	0	0
4	0	0	0	1	0	1	0	0	1	1	1	0
5	1	1	0	0	0	0	1	1	0	1	0	1

Hence, the sequence of the counter is : 001 → 110 → 101 → 000 → 110 → ....

79. (d)

The input signal $x(n) = \cos\left(\frac{\pi}{2}n\right)$ has a frequency $\omega_0 = \frac{\pi}{2}$. Hence, the response of the system to $x(n)$ is

$$y(n) = \left|H(e^{j\omega_0})\right|\cos\left(\omega_0(n-\tau_g(\omega_0))\right)$$

$$= \left|H\left(e^{j\pi/2}\right)\right|\cos\left(\frac{\pi}{2}\left(n-\tau_g\left(\frac{\pi}{2}\right)\right)\right)$$

$$y(n) = 2\cos\left(\frac{\pi}{2}(n-2)\right)$$

$$= 2\cos\left(\frac{\pi}{2}n-\pi\right) = -2\cos\left(\frac{\pi}{2}n\right)$$

80. (b)

- Flip-chip has shorter interconnects, reducing inductance.
- DIP is outdated for high-speed processors due to larger size and long pins.
- Due to its reduced inductance and resistance, the BGA packaging permits enhanced thermal and electrical performance.
- Tape-automated bonding (TAB) is a process that places bare integrated circuits onto a printed circuit board (PCB) by attaching them to fine conductors in a polyamide or polyimide film, thus providing a means to directly connect to external circuits. It is suitable for high pin-count ICs.

81. (a)

at $t = 0^-$

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

at $t > 0$

$$V_c(\infty) = 1 \text{ V}$$

$$V_c(t) = 1\left(1-e^{-\frac{t}{RC}}\right)$$

$$\frac{dV_c(t)}{dt} = \frac{1}{RC}e^{-\frac{t}{RC}}$$

$$\frac{dV_c(0^+)}{dt} = \frac{1}{RC}$$

82. (d)

At $t = t_0$,

The input is changed from $3u(t)$ to $u(t)$. So, the steady state value changes from 3 to 1 after $t = t_0$. So, option (d) is best suited.

83. (c)

Since the two resistors are in parallel, the equivalent resistance is given by

$$R_p = \frac{R_1 R_2}{R_1 + R_2} = \frac{25\times 50}{25+50}$$

$$R_p = \frac{25\times 50}{75} = \frac{50}{3}\,\text{k}\Omega$$

$$\text{Thermal noise voltage, } V_n = \sqrt{4R_p kTB} = \sqrt{4\times\frac{50}{3}\times 10^3\times 1.38\times 10^{-23}\times 290\times 120\times 10^3}$$

$$= \sqrt{32.016\times 10^{-12}} = 5.65\,\mu\text{V}$$

84. (a)

The given equation is the point form of continuity equation. It provides that the current through closed surface or outward flow of positive charge is balanced by decrease of positive charge in the volume enclosed by the closed surface i.e. it represents the principle of conservation of charge. Hence, statements 1 and 2 are correct.

85. (a)

For given solenoid,

Generated magnetic field

$$H = \frac{NI}{l} = \frac{4000\times 5}{0.5} = 40000\ \text{A/m}$$

Given, increase in magnetic induction in gaseous medium,

$$= 2\times 10^{-8}\ \text{Wb/m}^2$$

So, $\mu_0 M = 2\times 10^{-8}\ \text{Wb/m}^2$

$$M = \frac{2\times 10^{-8}}{4\pi\times 10^{-7}} = 15.915\times 10^{-3}\ \text{A/m}$$

∴ Magnetic susceptibility of gas,

$$x_m = \frac{M}{H} = \frac{15.915\times 10^{-3}}{40000} = 3.98\times 10^{-7}$$

86. (a)

Deflection sensitivity is defined as the amount of deflection of the electron beam per unit voltage applied to the deflection plates usually expressed in mm/V. It depends on several factors:

- The deflection sensitivity is inversely proportional to the accelerating voltage.
- Higher accelerating voltage results in greater electron velocity, making the beam harder to deflect, reducing sensitivity.
- Deflection sensitivity is inversely proportional to the distance between the deflecting plates.
- Deflection sensitivity is directly proportional to the length of the deflecting plates.
- The deflection sensitivity is not directly affected by frequency but by the frequency response of the vertical amplifier and the CRT bandwidth.

Mathematically, deflection sensitivity of CRO is given by

$$S = \frac{Ll_d}{2dV_a}$$

87. (d)

$$\text{Supply voltage, } V_s = 440 \text{ V}$$
$$\text{Frequency, } f_s = 50 \text{ Hz}$$
$$\text{Rotor frequency at full load, } f_r = sf_s = 0.05 \times 50$$
$$f_r = 2.5 \text{ Hz}$$

The power transferred to the rotor (air-gap power) is

$$P_g = 10 \text{ kW}$$

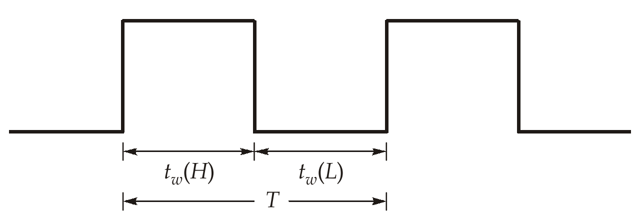
We have,
$$P_g = \frac{P_{\text{rotor copper loss}}}{s}$$
$$P_{\text{rotor copper loss}} = sP_g = 0.05 \times 10 \times 10^3 = 500 \text{ W}$$

The mechanical power output,

$$P_m = P_g - P_{\text{rotor copper loss}} = 10000 - 500 = 9500 \text{ W}$$

The output power is
$$P_{\text{out}} = P_m - \text{Mechanical losses} = 9500 - 500 = 9000 \text{ W} = 9 \text{ kW}$$

88. (c)



$$t_w(H) = 32 \text{ ns}$$
$$t_w(L) = 25 \text{ ns}$$

The maximum time period of the clock is

$$T_{\max} = t_w(H) + t_w(L) = 32 + 25 = 57 \text{ ns}$$

The maximum operating frequency for the given flip-flop,

$$f_{\min} = \frac{1}{T_{\max}} = \frac{1}{57 \times 10^{-9}} = 17.5 \text{ MHz}$$

89. (b)

Laplace transform of $u(t)$:

$$A(s) = \frac{1}{s}, \text{ for } Re(s) > 0$$

Fourier Transform of $u(t)$,
$$B(j\omega) = \frac{1}{j\omega} + \pi\delta(\omega)$$

90. (a)

- Epitaxy refers to a type of crystal growth or material deposition in which new crystalline layers are formed with one or more well-defined orientations with respect to the crystalline substrate. Hence, statement 1 is correct.
- Chemical vapour deposition is also called vapour phase epitaxy where gaseous precursors react to form the epitaxial layer. Hence, statement 2 is incorrect.
- CVD has fast deposition rate. Hence statement 3 is incorrect.
- Organometallic chemical vapour deposition (OMCVD) technique is used for epitaxial deposition using organo metallic compounds. Hence, statement 4 is correct.

91. (a)

- P-channel MOSFETs is easier and cheaper to produce than N-channel MOSFETs. Hence, statement 1 is not correct.
- The hole mobility is nearly 2.5 times lower than the electron mobility.Thus, a P-channel MOSFET occupies a larger area than the N channel MOSFET having the same ID rating and thus, has a lower packing density.
- NMOS transistors are often preferred in switching applications due to their smaller junction area and lower inherent capacitance.

92. (b)

- MSK is a type of continuous-phase FSK (CPFSK) with modulation index $h = 0.5$
- The Nyquist bandwidth for MSK is:

$$B_{\min} = \frac{R_b}{2} = \frac{1\text{ Mbps}}{2} = 500\text{ kHz}$$

93. (c)

The normal and tangential components of electric field for $z < 0$ is given by

$$\vec{E}_{n1} = 3\hat{a}_z$$

$$\vec{E}_{t1} = 5\hat{a}_x - 2\hat{a}_y$$

Applying boundary conditions,

$$\vec{E}_{t1} = \vec{E}_{t2} = 5\hat{a}_x - 2\hat{a}_y$$

$$\vec{D}_{n1} = \vec{D}_{n2}$$

$$\epsilon_1 \vec{E}_{n1} = \epsilon_2 \vec{E}_{n2}$$

$$4 \times 3\hat{a}_z = 3\vec{E}_{n2}$$

$$\Rightarrow \quad \vec{E}_{n2} = 4\hat{a}_z$$

Thus, for $z > 0$,

$$\vec{E} = \vec{E}_{n2} + \vec{E}_{t2}$$

$$= 5\hat{a}_x - 2\hat{a}_y + 4\hat{a}_z \text{ V/m}$$

94. (c)

Ideal insulating liquid has low dielectric dissipation factor as it indicates low energy loss in the form of heat when subjected to an alternating electric field.

95. (a)

- The RDRAM, developed by Rambus delivers address and control information using an asynchronous block oriented protocol. After an initial 480 ns access time, this produces the 1.6 GBps data rate.
- Rather than being controlled by the explicit RAS, CAS, R/W and CE signals used in the conventional DRAMs, RDRAM gets a memory request over the high-speed bus. This request contains the desired address, the type of operation, and the number of bytes in the operation.
- RDRAM system consists of a controller and a number of RDRAM modules connected via a common bus. The bus includes 18 data lines, separate 8 lines (RC) used for address and control signals. There is also a clock signal that starts at the far end from the controller propagates to the controller end and then loops back.
- A RDRAM module sends data to the controller synchronously to the clock master, and the controller sends data to an RDRAM synchronously with the clock signal in opposite direction.

96. (b)

The synchronous speed,

$$N_s = \frac{120 \times f}{P} = \frac{120 \times 50}{4} = 1500 \text{ rpm}$$

$$\text{Full load slip} = \frac{N_s - N_r}{N_s} = \frac{1500 - 1400}{1500} = \frac{1}{15}$$

$$T = \frac{I_2^2 R_2}{\omega_{syn}} \propto \frac{I_2^2 R_2}{s}$$

At starting, slip = 1. Thus,

$$\frac{T_{st}}{T_{fl}} = \left[\frac{I_2(st)}{I_2(fl)}\right]^2 s_{fl}$$

$$T_{st} = \left[\frac{6I_{fl}}{I_{fl}}\right]^2 \times \frac{1}{15} \times T_{fl}$$

$$= \frac{36}{15} \times 100\% \text{ of } T_{fl}$$

$$T_{st} = 240\% \text{ of } T_{fl}$$

97. (c)

$$f_1 = 4 \text{ variable function}$$
$$f_2 = 3 \text{ variable function}$$
$$f_1 = 4 \text{ variable function}$$

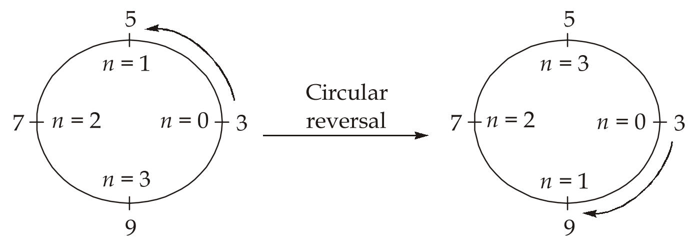
The 4 variables are connected to four select lines, hence the minimum configuration of demultiplexer required is 1 to 16 line demultiplexer.

98. (d)

We have, DFT[DFT $x[n]$] = DFT[$X(k)$]

Using the duality property of DFT, DFT[DFT $x[n]$] = $Nx[N - n]_{\text{mod } N}$

Hence, it corresponds to circular reversal of $x[n]$ scaled by a factor of N.



Hence $$\text{DFT[DFT } x[n]] = N\,x[-n] = \{\underset{\uparrow}{12}, 36, 28, 20\}$$

99. (b)

$$y(n) = \varepsilon\{x(n-1) = \frac{x(n-1)+x(-n-1)}{2}$$

$$x_1(n) \rightarrow y_1(n) \Rightarrow \frac{x_1(n-1)+x_1(-n-1)}{2}$$

$$x_2(\text{n}) \rightarrow y_2(\text{n}) \Rightarrow \frac{x_2(n-1)+x_2(-n-1)}{2}$$

$$x_3(\text{n}) \rightarrow y_3(n) \Rightarrow \frac{x_3(n-1)+x_3(-n-1)}{2}$$

Let $$x_3(n) = ax_1(n) + bx_2(n)$$

∴ $$y_3(n) = ay_1(n) + by_2(n) \quad \Rightarrow \quad \text{for system to be linear}$$

LHS $$y_3(n) = \frac{x_3(n-1)+x_3(-n-1)}{2}$$

$$y_3(n) = \frac{1}{2}\left[ax_1(n-1)+bx_2(n-1)+ax_1(-n-1)+bx_2(-n-1)\right]$$

$$= \frac{1}{2}\Big[a\left[x_1(n-1)+x_1(-n-1)\right]+b\left[x_2(n-1)+x_2(-n-1)\right]\Big]$$

$$y_3(n) = ay_1(n) + by_2(n) = \text{RHS}$$

Hence, system is linear.

Also the output depends on future value, hence the system is non-causal.

100. (b)

Given, $$I_{D1} = 2 \text{ mA at } V_{GS1} = 1 \text{ V}$$
$$I_{D2} = 32 \text{ mA at } V_{GS2} = 3 \text{ V}$$

When MOSFET is in saturation region, the drain current,

$$I_D = K_n\,(V_{GS} - V_T)^2$$

∴ $$\frac{I_{D1}}{I_{D2}} = \left(\frac{V_{GS1}-V_T}{V_{GS2}-V_T}\right)^2$$

$$\frac{2}{32} = \left(\frac{1-V_T}{3-V_T}\right)^2$$

$$0.25(3 - V_T) = 1 - V_T$$

$$0.75 - 0.25V_T = 1 - V_T$$

$$(1 - 0.25)V_T = 1 - 0.75$$

$$V_T = \frac{0.25}{0.75} = 0.33\text{ V}$$

101. (b)

Spectral efficiency (η) is given by

$$\eta = \frac{R_b}{B}$$

Since, $M = 32 \Rightarrow \log_2 32 = 5$ bits per symbol, therefore symbol rate,

$$R_s = \frac{R_b}{\log_2 M} = \frac{4}{5} = 0.8\text{ Msymbols/sec}$$

For a raised cosine filter, $B = R_s(1 + \alpha) = 0.8(1 + 0.5) = 1.2$ MHz

$$\eta = \frac{4}{1.2} = \frac{40}{12} = \frac{10}{3} = 3.33\text{ bps/Hz}$$

102. (b)

Cut-off frequency, f_c for dominant mode (TE_{10}) is,

$$f_c = \frac{c}{2a} = \frac{3\times10^{10}}{2\times2} = 7.5\text{ GHz}$$

Given, $f = 7$ GHz

$\because$ $f < f_c$, propagation constant is a real quantity and the wave attenuates inside the waveguide.

$\Rightarrow$ Phase constant, $\beta_g = 0$ rad/m

103. (a)

- Czochralski method and metallization method are used in fabrication of semiconductors.
- Czochralski method is used for crystal growth to obtain single crystals of semiconductors.
- Metallization is a process in which a thin layer of metal is formed which is used to make interconnections between the components in a semiconductor device.

104. (a)

Effective instruction time = $P \times S + (1 - P) \times I$

where
P = Page fault rate = $1/k$
S = instruction time with page fault = $i + j$
I = instruction time without page fault = i

$\Rightarrow$ Effective instruction time = $\frac{i+j}{k} + \left(1 - \frac{1}{k}\right) \times i = i + \frac{j}{k}$

105. (c)

The maximum steady-state power output of a synchronous machine is given by,

$$P = \frac{VE}{X_S}\sin\delta$$

where
P = Power output
V = Terminal voltage
E = Excitation voltage (internal induced EMF)
X_s = Synchronous reactance
δ = Power angle

Thus, the maximum steady state power output depends on the excitation voltage (E), synchronous reactance (X_s) and power angle (δ). Hence, statements 1, 2 and 4 are correct.

106. (c)

A n-bit Gray code sequence can represent distinct positions based on the total number of unique codewords.

A n-bit Gray code represent 2^n distinct positions because it follows a binary reflected pattern, ensuring only one bit changes between consecutive values.

For a 6-bit Gray code:

$$\text{Total distinct positions} = 2^6 = 64$$

107. (b)

The maximum bit transmission rate so that there is no overlapping of light pulses on a fibre link is given by $\frac{1}{2T_r}$, also known as the bandwidth distance product,

$$(\text{BDP}) = \frac{1}{2T_{r\,(\text{per km})}} = \frac{1}{2\times 6\times 10^{-9}\ \text{s/km}}$$

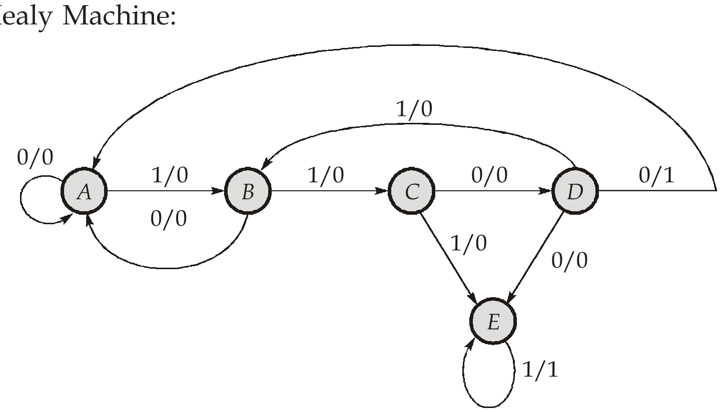
$$\text{BDP} = 83.33\ \text{Mbps-km}$$

Dispersion-limited length of the fiber is

$$l_{max} = \frac{\text{BDP}}{\text{Bit rate}} = \frac{83.33\ \text{Mbps-km}}{10\ \text{Mbps}} = 8.333\ \text{km}$$

108. (d)

State Diagram of Mealy Machine:



Number of states = $5 \le 2^n$, where n is the number of flip-flops

$\therefore$ Number of flip flops = 3

109. (c)

Bandwidth, $B = \omega_2 - \omega_1 = 101 - 99 = 2$ k rad/sec

For a parallel RLC circuit, $B = \dfrac{1}{RC} = 2 \times 10^3$

$$\Rightarrow \quad C = \frac{1}{100 \times 10^3 \times 2 \times 10^3} = 5 \text{ nF}$$

Lower half power frequency, $\omega_1 = \omega_0 - \dfrac{B}{2}$

$$\Rightarrow \quad \omega_0 = \omega_1 + \frac{B}{2} = 99 + 1 = 100 \text{ k rad/sec}$$

Resonant frequency, $\omega_0 = \dfrac{1}{\sqrt{LC}}$

$$\Rightarrow \quad LC = \frac{1}{\omega_0^2} \quad \Rightarrow \quad L = \frac{1}{10^{10} \times 5 \times 10^{-9}} = 20 \text{ mH}$$

110. (c)

- Axial ratio is defined as the ratio between amplitude of one component of electric field and another component of electric field. For circularly polarized wave, since both the components have equal magnitude, hence the axial ratio is 1. For linearly polarized wave, the orthogonal components of the field are zero, hence, the axial ratio is infinite.
- Brewster's angle exist for only parallely polarized (p-polarized) waves.
- Snell's law of refraction relates the sines of the angles of incidence and refraction at an interface between two optical media to the indexes of refraction of the two media and is applicable to all polarizations of light.

111. (b)

Burger vector: 'b' = $\dfrac{1}{2}[1 \quad 0 \quad 1]$

Direction 't' = $[1 \quad 2 \quad 1]$

Given is the mixed dislocation, it can move only in a plane containing both b and t.

Let the indices of slip plane be $(h\ k\ l)$

Then, $t_1h + t_2k + t_3l = 0$

$\Rightarrow \quad h + 2k + l = 0$ ...(i)

and $b_1h + b_2k + b_3l = 0$

$$\frac{1}{2}h + \frac{1}{2} \times 0k + \frac{1}{2}l = 0 \quad \text{...(ii)}$$

Solving equations (i) and (ii), we get

$$\frac{1}{2}h = -\frac{1}{2}l$$

$$h = -l$$

From equation (i),

$$2k = -h - l = 0$$

$$k = 0$$

Slip plane is $(h\ k\ l) = (1\ \ 0\ \ \bar{1})$

112. (b)

Number of instructions, $n = 100$

Number of stages in pipeline, $k = 5$. Assuming CPI = 1,

Total cycles required for execution of instructions = $k + n - 1 = 5 + 100 - 1 = 104$ clock cycles

Since, PO stage takes more clock cycles,

$$\text{Number of stall cycles} = (40 \times 2) + (40 \times 1) + (20 \times 0) = 120 \text{ cycles}$$

Total number of cycles required for execution = 104 + 120 = 224 cycles

113. (c)

In 8085, TRAP is a non-maskable interrupt with interrupt vector address 0024 H. When it occurs, its vectored address 0024 H is placed on the lower address bus which also acts as the data bus.

114. (d)

Schottky TTL reduces propagation delay by preventing transistor saturation using Schottky diodes. However, it does not lower power consumption, it actually consumes more than standard TTL and Noise immunity remains similar to conventional TTL.

115. (b)

- AMPS has minimal initial equipments.
- It covered approximately 2200 sq. miles of area.
- It has provisions for cell sectoring and cell splitting to increase capacity on demand basis.

116. (c)

Given, depletion width, $W = 0.457$

$$\frac{N_a}{N_d} = 200$$

We know that, depletion width on n-side,

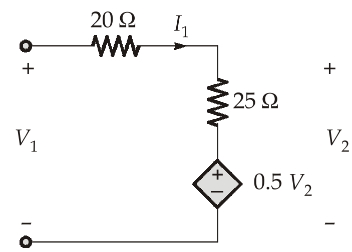
$$x_n = \frac{W}{1+\frac{N_d}{N_a}} = \frac{0.457}{1+\frac{1}{200}} = \frac{0.457}{1+0.005}$$

$$x_n \simeq 0.455\ \mu\text{m}$$

117. (b)

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

If $I_2 = 0$, then the circuit becomes:



Applying KVL:

$$V_1 - 20I_1 - 25I_1 - 0.5V_2 = 0$$

$$V_1 = 45I_1 + 0.5V_2 \quad \text{...(1)}$$

Also, we can write,

$$V_2 = 25I_1 + 0.5V_2$$

$$V_2 = 50I_1 \quad \text{...(2)}$$

Solving (1) and (2):

$$Z_{11} = \frac{V_1}{I_1} = 70\ \Omega$$

118. (b)

Gain margin is used to indicate the closeness of the intersection of the negative real axis made by the plot of $G(j\omega)H(j\omega)$ to the $(-1 + j0)$ point. It is calculated at the phase cross over frequency i.e. the frequency at which Nyquist plot of $G(j\omega)H(j\omega)$ intersects the negative real axis or the phase angle of $G(j\omega)H(j\omega) = -180°$.

119. (b)

The average poynting vector is given as,

$$P = \frac{E^2}{2\eta_0} = 5\ \text{W/m}^2$$

The average energy density is,

$$W_{avg} = \frac{1}{2}\epsilon_0 E^2 = P_{avg}\eta_0 \epsilon_0 = P_{avg}\sqrt{\frac{\mu_0}{\epsilon_0}}\,\epsilon_0 = \frac{P_{avg}}{\sqrt{\mu_0 \epsilon_0}}$$

So,

$$W_{avg} = \frac{5}{3\times 10^8} = 1.67\times 10^{-8}\ \text{J/m}^3$$

120. (a)

- Type-II superconductors exhibit a partial Meissner effect (allowing some magnetic field penetration in the mixed state).
- No superconductor with a critical temperature above room temperature has been discovered yet.

121. (b)

$$\text{Offset} = \log_2(\text{page size})$$
$$= \log_2(4\text{ kB})\ \log_2(4 \text{ X } 210) = 12 \text{ bits}$$

Since virtual address is of 57 bits, hence, 57 – 12 = 45 bits used for page number.

$$\text{PTE} = 8 \text{ bytes}$$

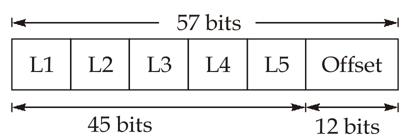
For every level, page table should fit into a page.

So, number of entries in a page = $\dfrac{4\text{ kB}}{8B} = 2^9$

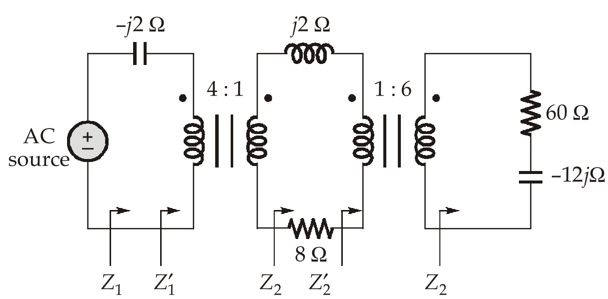
Bits to index the page table for a level = $\log_2(2^9)$ = 9 bits

$$\text{Number of levels} = \left\lceil \frac{45}{9} \right\rceil = 5$$

Following is representation



122. (d)



$$\frac{Z_2'}{Z_2} = \frac{1}{36} \Rightarrow Z_2' = \left[\frac{60-12j}{36}\right]\Omega$$

$$Z_2' = \left(\frac{5}{3} - \frac{j}{3}\right)\Omega = \frac{5-j}{3}\Omega$$

So,
$$Z_2 = 8 + 2j + \frac{5-j}{3} = \frac{24+6j+5-j}{3} = \frac{29+5j}{3}$$

$$\frac{Z_1'}{Z_2} = 16 \Rightarrow Z_1' = 16\left(\frac{29}{3} + \frac{5}{3}j\right)$$

So,
$$Z_1 = -2j + Z_1' = -2j + 16\left(\frac{29+5j}{3}\right)$$
$$= \frac{-6j+464+80j}{3} = \frac{464+74j}{3}$$
$$Z_1 = \left(\frac{464+74j}{3}\right)\Omega$$

Z_1 is the impedance seen by ac source.

123. (c)

$$f_1(A, B, C) = \Sigma(1, 3, 5, 6)$$
$$f_2(A, B, C) = \pi(0, 2, 3, 7) = \Sigma(1, 4, 5, 6)$$
$$f_1 f_2 = \Sigma m(1, 5, 6)$$

For function f to be 0,

$$f_3(A, B, C) = \overline{[f_1(A,B,C) \cap f_2(A,B,C)]} = \Sigma(0, 2, 3, 4, 7)$$

Thus, Maximum minterms possible are 5.

124. (d)

As we know that:

$$V = \frac{2\pi a n_1 \sqrt{2\Delta}}{\lambda}$$

For single mode transmission in graded index fibre,
we know:

$$V = 2.405\left(\frac{2+\alpha}{\alpha}\right)^{1/2}$$

Hence above equation modifies to:

$$2.405\left(\frac{2+\alpha}{\alpha}\right)^{1/2} = \frac{2\pi a n_1 \sqrt{2\Delta}}{\lambda}$$

For parabolic refractive index profile, $\alpha = 2$. Thus, at a wavelength of 1.5 μm,

$$2.405\left(\frac{2+2}{2}\right)^{1/2} = \frac{2\pi \times a \times 1.47 \times \sqrt{2 \times 0.01}}{1.5 \times 10^{-6}}$$

On solving, $a = 3.9 \times 10^{-6}$ m $= 3.9$ μm

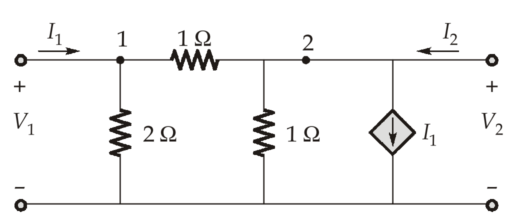
Hence, the maximum diameter of the core is $2a$.

$$d = 2a = 7.8 \text{ μm}$$

125. (c)

$$F_1 = A\bar{B}$$
$$F_2 = \bar{A}B$$

126. (c)



Applying nodal analysis at node 1:

$$\frac{V_1}{2} + \frac{V_1 - V_2}{1} = I_1$$

$$I_1 = \frac{3}{2}V_1 - V_2 \quad \text{...(i)}$$

Applying nodal analysis at node 2:

$$\frac{V_2}{1} + \frac{V_2 - V_1}{1} = -I_1 + I_2$$

Using equation (i), we get $$I_2 = \frac{1}{2}V_1 + V_2 \qquad \text{...(ii)}$$

Comparing equation (i) and (ii) with general equations of Y-parameter, we get

$$[Y] = \begin{bmatrix} \frac{3}{2} & -1 \\ \frac{1}{2} & 1 \end{bmatrix}$$

127. (c)

- Introduction of a lag compensator (low pass filter) results in attenuation of the high frequency signals, thereby reducing the noise signal level relative to the control signal. Hence, statement 1 is incorrect.
- The phase lag compensator introduces a phase lag and decreases the system's gain at higher frequencies. This decrease in gain at higher frequencies causes the gain crossover frequency to decrease, inherently reducing the system's bandwidth.

Thus, statements 2 and 3 are correct.

128. (d)

The skin depth is given by,

$$\delta = \frac{1}{\sqrt{\pi f \mu \sigma}} = \sqrt{\frac{\lambda}{\pi c \mu \sigma}}$$

Since σ is very large for a good conductor, hence the skin depth is much shorter than the wavelength (λ).

129. (c)

- Ferrites are ceramic compounds containing iron oxide and other metal oxides that exhibit ferrimagnetism.
- Ferrites have low electrical conductivity, which helps in reducing eddy current losses.
- Soft ferrites, which can be easily magnetized and demagnetized, are are well suited for use in radio frequency (RF) and high-frequency applications, such as inductors, transformers, etc.

130. (d)

$$\text{Effective Memory Access Time} = H_{\text{TLB}}(T_{\text{TLB}} + T_M) + (1 - H_{\text{TLB}})(T_{\text{TLB}} + T_M + T_M)$$
$$= 0.6(10 + 80) + (1 - 0.6)(10 + 80 + 80)$$
$$= 0.6(90) + 0.4(170) = 122 \text{ msec}$$

131. (d)

- The energy released in the fission reaction can be calculated with Einstein's equation, $E = \Delta m \cdot c^2$.
- A nuclear reactor is usually maintained at a critical state for stable operation. A supercritical state leads to an uncontrollable chain reaction.
- The coolant in a nuclear reactor's absorbs heat from the reactor core and transfers this heat to the steam generator in a heat exchanger.
- Breeder reactors generate more fissile material than they consume. This is achieved through the process of nuclear breeding, where non-fissile isotopes of uranium or plutonium are transformed into fissible isotopes through neutron capture and subsequent nuclear reactions.

Hence, statements 1, 3 and 4 only are correct.

132. (a)

From the circuit, we can write, $Y = (A \oplus B) \odot (C \oplus D) \odot (E \oplus F) = A \oplus B \oplus C \oplus D \oplus E \oplus F$

Y will be 1 when odd number of variables are 1. Thus, circuit can be used as odd number of 1's detector in the input combination.

Since all 26 input combinations are possible, there will be $\frac{2^6}{2} = 32$ input combinations for output $Y = 1$.

Number of possible input combinations for $Y = 0$ is $2^6 - 32 = 32$.

133. (b)

Every 60 minutes of phone calls equate to one Erlang. Let offered load be A. Thus,

$$A = \frac{Q_i t}{60} \text{ Erlangs}$$

where Maximum calls/hr, $Q_i = 3500$

Average calling time $(t) = 1.76$ minutes

$$A = \frac{3500 \times 1.76}{60} = 102.67 \text{ Erlangs}$$

134. (d)

- RTA can cause some diffusion, but it is minimal compared to conventional furnace annealing.
- RTA is actually performed at higher temperatures (typically 1000-1100°C) but for very short durations.
- Compared with the thermal process of using a furnace, the RTA process can complete a thermal process in a relatively short time. Therefore, thermal budget of the RTA process is substantially low and is suitable for a semiconductor process that has to control the diffusion and the contour of doping material.

135. (a)

In s-domain, we can write $I(s) = \frac{I_0}{s^2}$; $I_L(s) = \left[\frac{5}{s^2} - \frac{1}{s}\right] + \frac{1}{s+5}$

Using current division rule, $I_L(s) = I(s)\left[\frac{1}{1+sL}\right]$

$$\left[\frac{5}{s^2}-\frac{1}{s}\right]+\frac{1}{s+5} = \frac{I_0}{s^2(1+sL)}$$

$$\frac{5-s}{s^2}+\frac{1}{s+5} = \frac{I_0}{s^2[1+sL]}$$

$$\frac{(25)}{s^2(s+5)} = \frac{I_0/L}{s^2\left(s+\frac{1}{L}\right)}$$

Comparing the coefficients on both sides,

$$L = \frac{1}{5}=0.2\text{ H};\quad \frac{I_0}{L}=25 \quad\Rightarrow\quad I_0 = 25L = 5\text{A}$$

136. (a)

- PIV for diodes in bridge rectifier is V_m while in centre-tapped full wave rectifier, PIV is $2V_m$. So, less peak inverse voltage.
- Bridge rectifier has greater TUF with respect to secondary winding.
- The ripple factor for both centre-tapped and bridge rectifier is 0.48. Hence, statement 2 is not correct.

137. (c)

Miller effect increases the input capacitance, C_{in} of the CE amplifier resulting in a lower upper 3-dB frequency f_H,

$$f_H = \frac{1}{2\pi C_{in}R_{in}}$$

which limits the limits the high frequency response of the amplifier.

138. (a)

The drift current is determined by the thermal generation of electron-hole pairs near the junction, which then diffuse to the depletion region and are swept across by the electric field. The rate of this generation is generally independent of the barrier height.

139. (a)

- SOI technology significantly reduces parasitic capacitance because the insulating buried oxide (BOX) layer minimizes the junction capacitance between the transistor and the substrate.
- The buried oxide (BOX) layer acts as an insulator and isolates the active silicon layer from the bulk substrate, preventing the formation of large depletion regions, thereby lowering the junction capacitance and improving switching speed.

140. (a)

A hash function produces a fixed-size output (the hash value) for any input. This value is signed using the private key instead of the entire message, making the process faster and more efficient. The hash function's role is to reduce the size of the data that needs to be signed.

141. (a)

The sulfuric acid (H_2SO_4) concentration in a lead-acid battery is highest when the cell is fully charged. During discharge, the sulfuric acid is consumed, leading to the formation of $PbSO_4$ and water, which lowers the concentration of H_2SO_4.

142. (a)

Interrupts eliminate the need for the CPU to continuously check (Poll) for an event, allowing it to execute other tasks while waiting for an interrupt to occur. When an interrupt is triggered, the processor handles it immediately.

Interrupts allow the microcontroller to respond to important events only when needed, reducing unnecessary CPU usage compared to continuous polling. This improves efficiency.

143. (c)

Johnson counters require more decoding circuitry than ring counters. Ring counters has n states, and directly generate a single active output for each state, simplifying decoding. Johnson counters, however, cycle through more states (2n states), and thus requires additional decoding circuits. Thus, Statement (I) is true but Statement (II) is false.

144. (a)

- Gibbs phenomenon occurs when a periodic function with discontinuities is represented by a truncated Fourier series. Near the points of discontinuity, the series exhibits an overshoot (or undershoot), which does not vanish even if more terms are added.
- The overshoot remains around 9% of the jump discontinuity, no matter how many terms are taken in the Fourier series expansion.

145. (a)

Ferroelectric materials, like PZT (Lead Zirconate Titanate), exhibit remanent polarization, making them useful in non-volatile memory (FeRAM).

146. (a)

As the circuit has number of branches, $b = 8$

and number of nodes, $n = 5$

Thus,

number of current equations formed are equal to the number of linearly independent mesh equations,

$$= b - n + 1$$
$$= 8 - 5 + 1 = 4$$

and number of voltage equations formed are equal to the number of node equations,

$$= n - 1 = 5 - 1 = 4$$

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

147. (a)

Since the inductive impedance ($X_L = j\omega L$) and capacitive impedance ($X_C = 1/j\omega C$) depends on frequency, hence the equivalent network obtained from Δ-Y transformation relationships, in general is valid only for one frequency.

148. (b)

Loss tangent, $\tan \delta = \frac{J_c}{J_d}$, where J_c represents the conduction current density and J_d represents the displacement current density. Thus, it represents the loss of power due to propagation in a dielectric, when compared to that in a conductor. Hence, Both Statement (I) and Statement (II) are true but Statement (II) is not a correct explanation of Statement (I).

149. (c)

The determinant (Δ) in Mason's Gain formula accounts for the effect of feedback loops and their interactions within the signal flow graph. It helps in determining how the presence of loops influences the system's overall transfer function.

The determinant (Δ) is not calculated using forward paths. Instead, it is derived from the loop gains and their non-touching combinations as follows:

$$\Delta = 1 - \Sigma(\text{individual loop gains}) + \Sigma(\text{product of two non-touching loops}) - \Sigma(\text{product of three non-touching loops}) + \ldots\ldots$$

150. (a)

Mutual information is given by:

$$I(X : Y) = H(X) - H(X/Y)$$

For independent random variables X and Y,

$$H(X/Y) = H(X) \quad \Rightarrow \quad I(X : Y) = 0$$

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