DETAILED SOLUTIONS

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ESE 2024 : Prelims Exam
CLASSROOM TEST SERIES

E & T ENGINEERING

Test 20

Full Syllabus Test 4 : Paper-II

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

DETAILED EXPLANATIONS

1. (c)

We know that current across capacitor is given by

$$i(t) = \frac{CdV(t)}{dt}$$

Now, for voltage we have,

$$V(t) = \frac{1}{C}\int i(t)dt$$

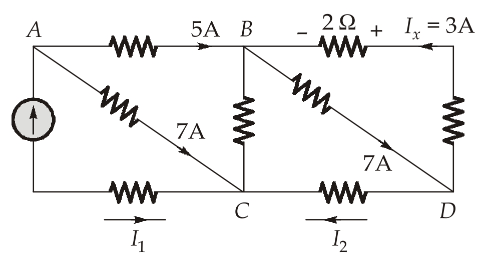
Thus, for an impulse current source, we get the constant voltage across capacitor. Hence, option (c) is correct.

2. (a)

According to given information,

The power dissipated across 2 Ω resistor is 18 W. It implies current must enter from positive terminal and leaves at negative terminal.

$$\therefore \quad I_x^2R = 18 \Rightarrow I_x = \sqrt{\frac{18}{2}} = 3\text{A}$$



∵ For DC source, inductor become short circuit.

Apply KCL at A,

$$7 + 5 + I_1 = 0$$
$$I_1 = -12 \text{ A}$$

Apply KCL at D,

$$3 + I_2 = 7$$
$$I_2 = 4 \text{ A}$$

We get I_1 = –12A and I_2 = 4A. Hence, option (a) is correct.

3. (c)

From KCL we get,

$$i_3 = i_1 - i_2$$
$$i_3 = 3\cos(\omega t) - 4\sin(\omega t)$$
$$\frac{i_3}{\sqrt{9+16}} = \frac{3}{\sqrt{9+16}}\cos(\omega t) - \frac{4}{\sqrt{9+16}}\sin(\omega t)$$
$$\frac{i_3}{5} = \frac{3}{5}\cos\omega t - \frac{4}{5}\sin(\omega t)$$

We know that,

$$\cos(53°) = \frac{3}{5} \text{ and } \sin(53°) = \frac{4}{5}$$

Thus,

$$\frac{i_3}{5} = \cos(53°)\cos\omega t - \sin(53°)\sin(\omega t)$$

$$\frac{i_3}{5} = \cos(\omega t + 53°) \qquad \because \cos(a + b) = \cos a \cdot \cos b - \sin a \cdot \sin b$$

$$i_3 = 5\cos(\omega t + 53°)$$

Now, on comparison we get,

$$I_3 = 5 \text{ and } \theta = 53°$$

Hence, option (c) is correct.

4. (c)

- Any parallel RLC network behaves as a band stop filter or band reject filter. The circuit's impedance is maximum at the resonance frequency, resulting in blocking of signals around the resonant frequency.
- Any series RLC network represents a band pass filter. The circuit's impedance is minimum at the resonance frequency, which allows signals to pass around the resonant frequency.
- At resonance, the impedance of the RLC circuit is purely resistive. Hence, the power factor of the circuit is unity i.e. the current is in phase with the voltage.

Hence, statement 1 and 2 are incorrect.
Therefore, option (c) is correct.

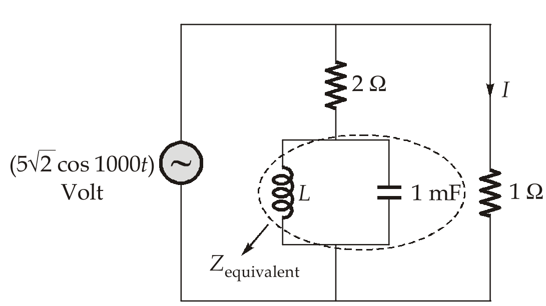
5. (a)

- Efficiency of the circuit, when maximum power is transferred to load is 50%. Therefore, statement (2) is incorrect.
- Tellegen's theorem state that, in any network, the sum of instantaneous power consumed by various elements of the branches is always equal to zero.

  $$\sum_{k=1}^{b} V_k i_k = 0 \quad \text{where } b \rightarrow \text{number of branches}$$

  Therefore, statement (3) is incorrect.
- Tellegen's theorem is valid for any type of lumped network as long as KVL and KCL equations are valid. Hence, Tellegen's theorem can be applied to any network: linear or non-linear, passive or active, time variant or time invariant.

6. (c)



According to given information, the current across 2 Ω resistor is zero.

It implies,
$$Z_{equivalent} = \infty$$
$$j\omega L \,||\, \frac{-j}{\omega C} = \infty$$
$$\frac{(j1000L)\left(\dfrac{-j}{1000 \times 10^{-3}}\right)}{(j1000L) + \left(\dfrac{-j}{1000 \times 10^{-3}}\right)} = \infty = \frac{1}{0}$$
$$(j1000L) + \left(\frac{-j}{1}\right) = 0$$
$$j(1000L - 1) = 0$$
$$1000L = 1$$
$$L = \frac{1}{1000} = 1\text{ mH}$$

The current across '1 Ω' resistance is given as
$$I_{max} = \frac{5\sqrt{2}}{1} = 5\sqrt{2}\text{ A}$$

Hence, option (c) is correct.

7. (a)

We know that,

Quality factor for series RLC circuit is given as
$$Q = \frac{1}{R}\sqrt{\frac{L}{C}}$$
$$Q = \frac{1}{10}\sqrt{\frac{10 \times 10^{-3}}{10^{-6}}}$$
$$Q = 10$$

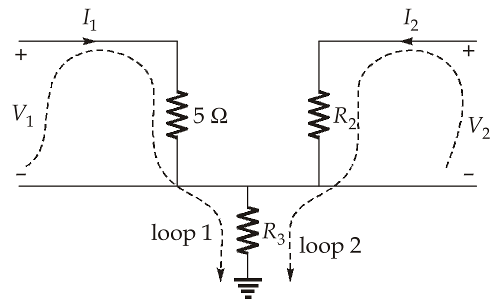
∵ Quality factor Q is defined as,
$$Q = 2\pi\frac{\text{Maximum energy stored in circuit}}{\text{Power dissipated per cycle}}$$
$$10 = \frac{2\pi \times \text{Maximum energy stored in circuit}}{100\pi}$$

∵ Power dissipated per cycle = 314 Watt = 100π Watt

Maximum energy stored in circuit = 500 J

Hence, option (a) is correct.

8. (d)



Applying KVL in loop 1 we get,

$$V_1 = (5 + R_3)I_1 + I_2R_3$$

From KVL in loop 2 we get,

$$V_2 = I_1R_3 + I_2(R_2 + R_3)$$

Thus, Z-parameters are given as

$$Z = \begin{bmatrix} 5+R_3 & R_3 \\ R_3 & R_2+R_3 \end{bmatrix}$$

For symmetricity, $Z_{11} = Z_{22} \;\Rightarrow\; 5 + R_3 = R_2 + R_3 \;\Rightarrow\; R_2 = 5\ \Omega$

For reciprocity, $Z_{12} = Z_{21} \;\Rightarrow\; R_3 = R_3 = 10\ \Omega$

$$Z = \begin{bmatrix} 15\ \Omega & 10\ \Omega \\ 10\ \Omega & 15\ \Omega \end{bmatrix}$$

Y-parameter matrix,

$$Y = \begin{bmatrix} Y_{11} & Y_{12} \\ Y_{21} & Y_{22} \end{bmatrix} = [Z]^{-1}$$

$$Y_{11} = \frac{Z_{22}}{Z_{11}Z_{22} - Z_{12}Z_{21}},\ Y_{12} = \frac{-Z_{12}}{\Delta Z},\ Y_{21} = \frac{-Z_{21}}{\Delta Z};\ Y_{22} = \frac{Z_{11}}{\Delta Z}$$

Where $\Delta Z = Z_{11}\,Z_{22} - Z_{12}\,Z_{21}$

Substituting the values, we get,

$$Y_{11} = \frac{15}{(15)^2 - (10)^2} = \frac{3}{25}\ ℧$$

$$Y_{12} = \frac{-2}{25}\ ℧$$

$$Y_{21} = \frac{-2}{25}\ ℧$$

$$Y_{22} = \frac{3}{25}\ ℧$$

$$Y = \begin{bmatrix} \frac{3}{25}\ ℧ & \frac{-2}{25}\ ℧ \\ \frac{-2}{25}\ ℧ & \frac{3}{25}\ ℧ \end{bmatrix}$$

Hence, option (d) is correct.

9. (a)

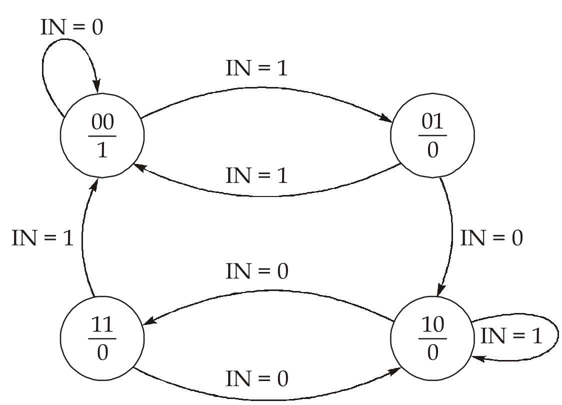
- To develop the network graph, each element is replaced either by a straight line or by an arc of a semicircle and all the independent sources are replaced by their internal resistances i.e., voltage source by a short circuit and current source by an open circuit. Thus, Number of branches in a network is always greater than or equal to the number of branches in the graph. (For example: Current source in a network branch does not result in a branch in the graph as it acts as open circuit)
- The branch of a tree are called twigs and those branches that are not part of a tree are called links or chords. Any tree of a network graph with n nodes has $(n - 1)$ twigs. Hence, the number of chords is given by $b - (n - 1) = b - n + 1$.
- The algebraic sum of elements of all the columns of an incidence matrix is zero. The order of the reduced incidence matrix is thus, $(n - 1) \times b$. Hence, the rank of the incidence matrix is $(n - 1)$.

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

10. (c)

$$[3x][4x] = 2x^3 + 2x^2$$
$$12x^2 = 2x^3 + 2x^2$$
$$12x^2 = (1 + x)2x^2$$
$$6 = 1 + x$$
$$x = 5$$

11. (c)



S.No	S_1	S_0	IN	S_1'	S_0'	Y
0	0	0	0	0	0	1
1	0	0	1	0	1	1
2	0	1	0	1	0	0
3	0	1	1	0	0	0
4	1	0	0	1	1	0
5	1	0	1	1	0	0
6	1	1	0	1	0	0
7	1	1	1	0	0	0

12. (a)

In order to satisfy the HOLD time of the register, the input to the register must remain stable until t_{HOLD} after the clock edge.

The fastest that a new change can propagate to the input of the register is found by taking the sum of the contamination delays along the shortest path to the input.

$$\therefore \quad t_{HOLD} \le t_{cd(register)} + t_{cd(logic)}$$
$$\le 0.1 + 0.2$$
$$t_{hold} \le 0.3 \text{ ns}$$

The largest value of register's HOLD time is t_{HOLD} = 0.3 ns.

The clock period must be long enough for the data to pass through the entire circuit and be ready and stable for setup before the next period begins. The data in this circuit must propagate through the register and the combinational logic.

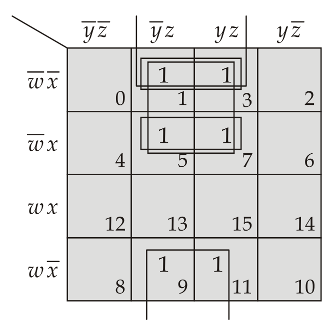
$\therefore$ Clock period is

$$t_{clk} \ge t_{pd(reg)} + t_{pd(logic)} + t_{setup(reg)}$$
$$\ge 5 + 3 + 2$$
$$t_{clk} \ge 10 \text{ ns}$$

$\therefore$ The smallest value t_{clk} = 10 ns

13. (c)

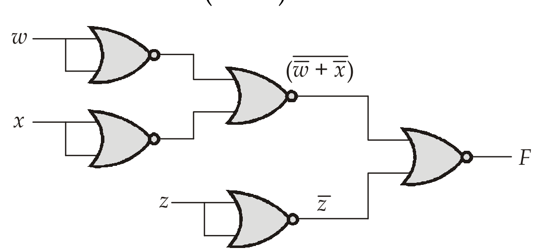
$$F(w, x, y, z) = \Sigma m(1, 3, 5, 7, 9, 11)$$



$$F = \bar{w}z + \bar{x}z = z(\bar{w} + \bar{x})$$

$$F = z(\bar{w} + \bar{x}) = \overline{\overline{z(\bar{w} + \bar{x})}}$$

$$F = \overline{\bar{z} + (\overline{\bar{w} + \bar{x}})}$$



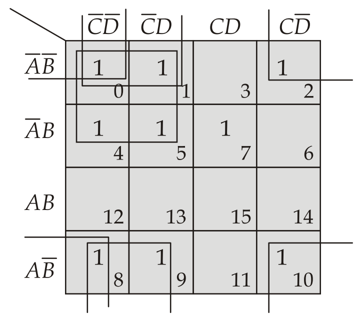
14. (c)

- Mealy machine is difficult to design.
- Due to dependence of output on the asynchronous input, Mealy Machine has asynchronous output generation.

15. (c)

From the given figure

$$F_4 = \overline{A}\overline{C} + \overline{B}\overline{C} + \overline{B}\overline{D}$$



$\therefore \quad F_4(A, B, C, D) = \Sigma m(0, 1, 2, 4, 5, 8, 9, 10)$

16. (c)

The conversion time t for a dual slope ADC is given by

$$t = 2^N \cdot T_C + \frac{V_a}{V_R} \cdot 2^N \cdot T_C$$

where, N is the number of bits in the digital output.

T_C is the time period of the clock.

V_a is the analog voltage.

V_R is the reference voltage.

The largest V_a can be equal to V_R.

$\therefore$ When $V_a = V_R$

$$t_{max} = 2^{N+1} \cdot T_C$$

$$t_{max} = 2^{13} \cdot \frac{1}{10^5}$$

$$t_{max} = 2^{13} \times 10^{-5} \text{ sec}$$

17. (a)

- A group of four bits is called nibble.
- A group of bits processed by a digital system at a time is called word.

18. (b)

The analog output voltage V_0 is given by

$$V_0 = K(8b_3 + 4b_2 + 2b_1 + b_0)$$

where b's are 1 or 0 depending on the input code.

For $b_3 = 1$, $b_2 = b_1 = 0$ and $b_0 = 1$, $V_0 = 4.5$ V

$$\therefore \quad K = \frac{4.5}{8+1} = \frac{1}{2}$$

Therefore, the analog output voltage for the input code 0011 will be

$$V_0 = \frac{1}{2}[8 \times 0 + 4 \times 0 + 2 \times 1 + 1]$$

$$V_0 = \frac{3}{2} = 1.5 \text{ V}$$

19. (b)

$$\text{Number of RAM chips required} = \frac{4 \times 1024 \times 8}{1024 \times 4} = 8 \text{ chips}$$

$$\text{Number of EPROM chips required} = \frac{2 \times 1024 \times 8}{2 \times 1024 \times 8} = 1 \text{ chip}$$

20. (c)

The following program is used for finding the larger number from the given two numbers. The program is given below:

```
          LXI H, 0A02 H  ;  store destination address in H-L pair
          LDA 0A00 H     ;  load A with first number
          MOV B, A       ;  transfer to B
          LDA 0A01 H     ;  load A with second number
          CMP B          ;  compare A and B
          JZ FINISH      ;  go to finish if the two numbers are equal
          JC LOOP 1      ;  if CY = 1, (A < B) otherwise (A > B)
          MOV M, A       ;  Store the contents of A in destination address when A > B
          JMP FINISH
LOOP 1 :  MOV M, B       ;  Store the contents of B in destination address when A < B
          FINISH
          HLT
```

21. (b)

The value of N is to be calculated as follows:

The time required to execute this routine

$$t = [10 + N * (6 + 4 + 4) + (N - 1) \times 10 + 7]T$$

$$2 \times 10^{-3} = [10 + N \times 14 + (N - 1) \times 10 + 7] \times 320 \times 10^{-9}$$

$$\therefore \quad N = 260.125$$

$$N \cong 260$$

22. (c)

The maximum number of distinct opcodes will be $2^8 = 256$ for an 8 bit opcode.

23. (c)

PUSH a ⇒ Put a on the stack
PUSH b ⇒ Put b on the stack
PUSH c ⇒ Put c on the stack
POP AX ⇒ Store c in AX
POP BX ⇒ Store b in BX
SUB AX, BX ⇒ Store c-b in AX
POP BX ⇒ Store a in BX
ADD AX, BX ⇒ Store c – b + a in AX

Finally after execution, the program content of AX is (c – b + a).

24. (c)

Trap Flag (TF): If this flag is set to 1, the program can be run in single step mode. It is used for debugging.

Directional Flag (DF): It is used in string operations to access string from higher to lower memory address and vice-versa.

Interrupt Flag (IF): It is used to enable interrupts of 8086.

Zero Flag (ZF): It is set to 1 when result of an arithmetic operation results in zero.

25. (a)

The External Access input, $\overline{EA}$ is used to enable/disable external memory interfacing. If $\overline{EA}$ = 1, the external memory interfacing is disable, hence, upon reset, the program counter points to the first program instruction in the internal code memory.

26. (a)

- Unlike general-purpose computers, embedded systems are designed for a specific task or function, hence, they are highly domain and application specific.
- Not all embedded systems are real time. Some, embedded systems (eg. toys), may have less stringent timing requirements and prioritize factors like low power consumption or cost-effectiveness. Hence, statement 2 is incorrect.

27. (d)

To have the multiprocessing capabilities, 8086 microprocessor has to operate in the maximum mode which happens when pin $\text{MN}/\overline{\text{MX}}$ is low.

28. (d)

- Single-mode fibers have a higher bandwidth capability than multimode fibers due to no modal dispersion effects. Hence, the bandwidth-length product of multimode fiber is small as compared to single-mode fibers.
- A high value of numerical aperture is required in order to have a good coupling and low value of numerical aperture results in a narrow acceptance angle leading to large coupling losses.
- Incoherent source like LED can be used to couple the multimode fiber because of large core diameter.

29. (c)

Frequency separation of two adjacent modes is given by

$$\Delta v = \frac{c}{2nL}$$

$$L = \frac{c}{2n\Delta v} = \frac{3\times 10^{8}}{2\times 3.6\times 400\times 10^{9}}$$

$$= \frac{1000\times 1000}{2\times 1.2\times 4000}\times 10^{-6}$$

$$= \frac{625}{6}\,\mu\text{m}$$

The number of longitudinal modes are given as

$$K = \frac{2nL}{\lambda} = \frac{2\times 3.6\times 625\times 10^{-6}}{6\times 1.2\times 10^{-6}} = 625$$

30. (c)

- Doppler shift occurs when a satellite is in motion relative to an observer on the Earth's surface. The transmitted signal to a geostationary satellite suffers a negligible Doppler shift because they are stationary relative to the earth.
- A transponder consist of band pass filter to select a particular channel band of frequency.

31. (b)

Time period of the satellite is

$$T^2 = \frac{4\pi^2 a^3}{G.M} \qquad \text{G.M = Kepler's constant} = 3.98\times 10^5\ \text{km}^3/\text{sec}^2$$

$$a = R + h$$

$$= (6400 + 15000)\ \text{km}$$

$$= 21400\ \text{km}$$

$$T^2 = \frac{4\pi^2(21400)^3}{3.98\times 10^5} = \frac{4\pi^2(2.14)^3\times 10^{12}}{3.98\times 10^5}\,\text{sec}$$

Circumference of the orbit is

$$2\pi a = 2\pi \times 21400$$

$$= 2\times 3.14\times 21400$$

$$= 134392\ \text{km}$$

Velocity of the satellite in orbit

$$V_s = \frac{2\pi a}{T} = \frac{134392}{T} = \frac{2\pi\times 21400}{2\pi\times 2.14\sqrt{5.38\times 10^{6}}}$$

$$= 4.31\ \text{km/s}$$

32. (c)

Given data is

$$h_t = 18 \text{ m}; \; h_r = 2.5 \text{ m}$$

Maximum communication distance for LOS propagation is given by,

$$d = 4.12\left[\sqrt{h_t} + \sqrt{h_r}\right]$$
$$= 4.12\left[\sqrt{18} + \sqrt{2.5}\right]$$
$$= 4.12\left[3 \times 1.414 + \frac{5}{3.16}\right]$$
$$= 4.12[4.242 + 1.58]$$
$$= 4.12 \times 5.822$$
$$= 23.986$$
$$\cong 24 \text{ km}$$

33. (b)

- For $K > 1$; $d_0 > d_r$; Optical horizon greater than Radio horizon
  For $K < 1$; $d_0 < d_r$; Radio horizon greater than optical horizon

  where $K = \frac{d_0}{d_r}$ is the Microwave bending correction factor and

  d_0 = Distance of optical horizon in km
  d_r = Distance of radio horizon in km
- Fading is a phenomenon that occurs due to varying parameters and conditions of the channel during wireless propagation as a result of which the strength and quality of a radio signal fluctuate over time and distance. Fading occurs mainly in sky wave propagation.
  Fading is one of the main causes of distortion to the radio signal.
- $f_{\text{muf}} > f_c$ is derived from the secant law as below:

  $$f_{\text{muf}} = f_c \sec \theta_i$$

  where f_{mux} = maximum usable frequency
  f_c = critical frequency

34. (b)

$$\text{Delay}_{tr} = \frac{\text{Packet length}}{\text{Transmission rate}}$$

$$\text{Delay}_{pg} = \frac{\text{Distance}}{\text{Propagation speed}}$$

Delay_{pr} = Time required to process a packet in a router or a destination host.
Delay_{qu} = The time a packet waits in input and output queue in a router.

- If we have n routers, we have $(n + 1)$ links. Therefore, we have $(n + 1)$ transmission delays related to n routers and the source, $(n + 1)$ propagation delays related to $(n + 1)$ links, $(n + 1)$ processing delays related to n routers and the destination and only n queuing delays related to n routers. Hence,

$$\text{Total delay} = (n + 1)\,(\text{Delay}_{tr} + \text{Delay}_{pg} + \text{Delay}_{pr}) + (n)\,(\text{Delay}_{qu})$$

35. (d)

- PGP (Pretty Good Privacy) is one of the protocol used to provide security at the application layer. It is designed to create authenticated and confidential e-mail.
- Simple Network Management Protocol (SNMP) is an Internet Standard protocol for collecting and organizing information about managed devices on IP networks and for modifying that information to change device behavior.
- Piggybacking delays the transmission of ACKs until the next outgoing data packet is ready. It combine the acknowledgement with the data frame to be sent , thereby improving efficiency and making better use of available channel bandwidth.

36. (a)

Dynamic cell splitting: This technique is based on utilizing the allocated spectrum efficiency in real time. In this splitting technique, cells are not splitted permanently. Depending on requirement of traffic, the splitting of the cells are carried out.

37. (b)

We have, Electric field, $E = 5\ \text{V/m}$

Current density, $J = 10\ \text{A/m}^2$

Charge density, $n = 9.1 \times 10^{16}\ \text{C/m}^3$

mass of charge particle, $m = 9.1 \times 10^{-31}$ kg

We know that, $J = \sigma E$

$$\sigma = \frac{J}{E} = \frac{10}{5} = 2\ \text{S/m}$$

$$\therefore \quad \sigma = \frac{nq^2\tau_c}{m}$$

$$\tau_c = \frac{\sigma \times m}{nq^2}$$

$$\tau_c = \frac{2 \times 9.1 \times 10^{-31}}{9.1 \times 10^{16} \times 1.6 \times 1.6 \times 10^{-38}}$$

$$\tau_c = 0.78\ \text{nsec}$$

Hence, option (b) is correct.

38. (b)

- Peltier effect: If two dissimilar metals are joined and current flows in the loop, then one junction goes to high temperature and other junction goes to low temperature, this phenomenon is called as petlier effect. It is the reverse of Seebeck effect.
- Peltier effect is used in the refrigeration. Thus, option (b) is correct.

39. (a)

Among the given metals, silver has the highest electrical conductivity.

40. (b)

We have, $$\frac{R_C}{R_A} \approx 0.8$$

For, $$0.732 \le \frac{R_C}{R_A} < 1 \Rightarrow \text{Crystal must be body centred cubic}$$

i.e. 1 atom at the center of the body and 8 atoms at the 8 corners of the unit cell.
Hence, option (b) is correct.

41. (a)

We have,

$$\text{FCC crystal structure} \Rightarrow n = 4,\ a = 2\sqrt{2}r$$

$$\text{Atomic weight, A} = 60.23 \text{ g/mol}$$

According to given information, we have,

$$(\rho_{measure} - \rho_{theoretical}) = 0.32 \text{ g/cm}^3$$

$$\rho_{theoretical} = \rho_{measure} - 0.32$$

$$\frac{nA}{VN_A} = 18 - 0.32 = 17.68 \text{ g/cm}^3, \text{ where } V = \text{volume of unit cell} = a^3$$

$$V = \frac{nA}{17.68 \times 6.023 \times 10^{23}} \text{cm}^3$$

$$V = \frac{4 \times 60.23}{17.68 \times 6.023 \times 10^{23}} \text{cm}^3$$

$\because$ $$V = a^3 = (2\sqrt{2}r)^3$$

$\therefore$ $$r = \left[\frac{4 \times 6.023}{17.68 \times 6.023 \times 10^{22} \times 16\sqrt{2}}\right]^{1/3} \text{cm}$$

$$r = \left[\frac{1}{17.68 \times 4\sqrt{2} \times 10}\right]^{1/3} \times 10^{-7} \text{cm}$$

$$r \approx 0.1 \text{ nm}$$

Hence, option (a) is correct.

42. (c)

Edge dislocation is a type of line defect that occurs when an extra half-plane of atoms exists in the middle of the crystal lattice whereas the screw dislocation is also a type of line defect which occurs when the planes of atoms in the crystal lattice trace a helical path around the dislocation line.

43. (d)

Temperature above which super conductor ($R = 0$) comes to normal state ($R \neq 0$) is called as transition temperature or critical temperature (T_c).

44. (c)

- A material in its superconducting state behaves as perfect diamagent and expel all magnetic fields due to the Meissner effect.
  Hence, statement (1) is correct.
- Critical magnetic field intensity for a super conductor varies with temperature as

$$H_c = H_0\left[1-\left(\frac{T}{T_C}\right)^2\right]$$

  Hence, statement (4) is incorrect.
- Type-I superconductor satisfy both Meissner's effect and Silsbee's rule. Hence, statement (2) is correct and statement (3) is incorrect.

45. (d)

46. (d)

The balanced source provides an output of 30 mV from each terminal to ground.

Thus, $V_2 = 30 \text{ mV}, V_1 = -30 \text{ mV}$

∴ Difference mode input

$$V_d = V_2 - V_1 = 60 \text{ mV}$$

Signal output voltage, $V_{os} = A_d V_d = 150 \times 60 \times 10^{-3}$

$$V_{os} = 9 \text{ V}$$

The common-mode input is zero. However, the common noise at the input terminals has magnitude of 600 mV.

∴ Noise output voltage

$$V_{on} = A_C V_C = 0.04 \times 600 \times 10^{-3} \text{ V}$$

$$V_{on} = 24 \text{ mV}$$

∴ Signal to noise ratio $= \frac{V_{os}}{V_{on}} = \frac{9}{24 \times 10^{-3}}$

$$= 375$$

47. (b)

To determine the minimum value of R_L that will turn the zener diode ON simply calculate the value of R_L that will result in a load voltage of $V_L = V_Z$.

i.e., $V_L = V_Z = \frac{V_i \times R_L}{R_L + R_S}$

Solving for R_L, we get

$$R_{L\,\min} = \frac{R_S V_Z}{V_i - V_Z} = \frac{220 \times 10}{20 - 10} = \frac{2200}{10}$$

$$R_{L\,\min} = 220\ \Omega$$

48. (d)

$$P_D = \frac{T_j - T_A}{\theta_{jA}}$$

$$P_D = \frac{200-50}{16} = 9.375 \text{ W} \simeq 9.4 \text{ W}$$

where; $\theta_{jA} = \theta_{jC} + \theta_{HA} = 16° \text{ C/W}$

49. (c)

The equation for g_m is given as

$$g_m = g_{m0}\left[1 - \frac{V_{GS}}{V_P}\right] \text{ where, } g_{m0} = \frac{2I_{DSS}}{|V_P|}$$

when $V_{GS} = -1 \text{ V}, g_m = 6 \text{ mS}$

Hence, $6 \times 10^{-3} = g_{m0}\left[1 - \frac{1}{2.5}\right]$

$$g_{m0} = \frac{6\times 10^{-3}\times 2.5}{1.5} = 10 \text{ mS}$$

Now, $g_{m0} = \frac{2I_{DSS}}{|V_P|}$

$$I_{DSS} = \frac{g_{m0}\cdot |V_P|}{2}$$

$$I_{DSS} = \frac{10\times 10^{-3}\times 2.5}{2}$$

$$I_{DSS} = 12.5 \text{ mA}$$

50. (c)

Given: $V_{CC} = 30 \text{ V}, R_L = 8\ \Omega$

$\because$ $V_{\text{rms}} = 8 \text{ V}$

$$V_{\text{peak}} = 8\sqrt{2} \text{ V}$$

$$I_{L(\text{peak})} = \frac{V_{L(\text{peak})}}{R_L} = \frac{8\sqrt{2}}{8} = \sqrt{2} \text{ Amp}$$

$\therefore$ The dc value of current drawn

$$I_{\text{dc}} = \frac{2I_{L(\text{peak})}}{\pi}$$

$$I_{\text{dc}} = \frac{2}{\pi}\times(\sqrt{2}) = \frac{2\sqrt{2}}{\pi} \text{A}$$

$$P_i(\text{dc}) = V_{cc}I_{dc} = \frac{30\times 2\sqrt{2}}{\pi} = 27 \text{ W}$$

51. (b)

The magnitude of closed loop gain = $A_{CL} = \left|\frac{R_f}{R_1}\right|$

$$A_{CL} = \frac{200}{2} = 100$$

The magnitude of output voltage is

$$V_0 = A_{CL} V_i$$
$$V_0 = 100 \times 50 \times 10^{-3} = 5 \text{ V}$$

For no distortion, $\left|\frac{dV_0}{dt}\right| \leq \text{SR}$

The maximum opamp frequency is given by

$$\omega \leq \frac{SR}{A_{CL} V_i} \quad \text{(for no distortion)}$$

$$\omega \leq \frac{0.4 \times 10^6}{5}$$

$$\omega \leq 80 \text{ krad/sec}$$

52. (d)

$$V_0 \text{ (offset due to } V_{i0}) = V_{i0}\left(1 + \frac{R_f}{R_1}\right)$$
$$= 6 \times 10^{-3}\left(1 + \frac{200}{2}\right)$$
$$= 6 \times 10^{-3}(101) = 606 \text{ mV}$$
$$V_0 \text{ (offset due to } I_{i0}) = I_{i0} R_f$$
$$= 120 \times 10^{-9} \times 200 \times 10^3$$
$$= 24 \text{ mV}$$

Therefore, the total offset voltage is given as

$$V_0\text{(total offset)} = V_0\text{(offset due to } V_{i0}) + V_0\text{(offset due to } I_{i0})$$
$$= 606 + 24 = 630 \text{ mV}$$

53. (c)

We know,

$$\frac{dA_f}{A_f} = \frac{1}{(1 + A\beta)} \frac{dA}{A}$$

$\beta A >> 1$

$$\frac{dA_f}{A_f} = \frac{1}{A\beta} \cdot \frac{dA}{A}$$

Given: $\frac{dA}{A} = 10 \qquad \beta = \frac{-1}{20} \qquad A = -1000$

$$\frac{dA_f}{A_f} = \frac{1}{\frac{1}{20}\times 1000}\times 10 = \frac{1}{5} = 0.2\%$$

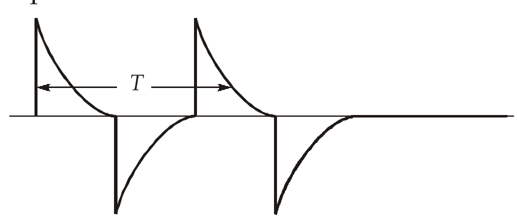
Thus, the gain change in a feedback amplifier is found to be 0.2%, which is quite small as compared without feedback.

54. (b)

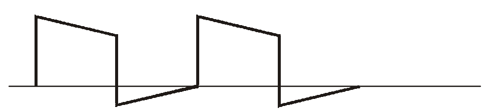
$$V_0 = V_i - V_c$$

where, V_c is the voltage across the capacitor.

(i) If $RC << \frac{T}{2}$, the capacitor charges and discharges very rapidly. The output waveform consist of positive and negative spikes as shown below:



(ii) If $RC >> \frac{T}{2}$, the capacitor charges and discharges very slowly and V_0 resembles V_i as shown below:



(iii) If RC is made progressively smaller than T, time constant will be small and capacitor will charge rapidly leading to a lower rise time.

55. (d)

$$40 \text{ rpm} = \frac{40}{60}\times 360 = 240\,\text{deg/sec}$$

For a 4 degree lag,

$$K_V = \frac{240}{4} = 60\,\text{sec}^{-1}$$

56. (a)

In frequency domain

- Bandwidth is equal to cutoff frequency given by

$$\omega_c = \omega_n = \sqrt{(1-2\xi^2) \pm \sqrt{4\xi^2 - 4\xi^2 + 2}}$$

Hence, if ξ increases, then bandwidth decreases.

- No resonant peak occurs for $\xi > \frac{1}{\sqrt{2}}$.
- Gain margin is a measure of relative stability.

Hence, statements 1, 2 and 3 are incorrect.

57. (c)

Here, encirclement around (–1, 0)

$$N = -2$$

According to Nyquist criterion, $N = P - Z$

where, P = Open loop poles in right side of s-plane.

Z = Closed loop poles in right side of s-plane.

We have, $P = 0$

$$N = -2, = 0 - Z$$

∴ $Z = 2$

- Closed loop system is unstable.
- Two poles of closed loop system are lying on the right half of s-plane.

58. (d)

$$\phi(t) = e^{At} = \begin{bmatrix} e^{-3t}\cos 2t & e^{-3t}\sin 2t \\ -e^{-3t}\sin 2t & e^{-3t}\cos 2t \end{bmatrix}$$

$$\frac{d\phi(t)}{dt} = Ae^{At}$$

$$= \begin{bmatrix} -3e^{-3t}\cos 2t - 2e^{-3t}\sin 2t & -3e^{-3t}\sin 2t + 2e^{-3t}\cos 2t \\ 3e^{-3t}\sin 2t - 2e^{-3t}\cos 2t & -3e^{-3t}\cos 2t - 2e^{-3t}\sin 2t \end{bmatrix}$$

Now, $$\left.\frac{d\phi(t)}{dt}\right|_{t=0} = A = \begin{bmatrix} -3 & 2 \\ -2 & -3 \end{bmatrix}$$

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

$$|sI - A| = (s + 3)^2 + 4$$

$= s^2 + 6s + 10$ gives the characteristic equation of the system.

For eigen values

$$s^2 + 6s + 13 = 0$$

$$s = \frac{-6 \pm \sqrt{36-52}}{2} = \frac{-6 \pm 4j}{2}$$

$$= -3 \pm 2j$$

59. (a)

Given, $$G(s) = \frac{10(s+10)}{s(s+2)(s+5)}$$

$$= \frac{10 \times 10\left(1+\frac{s}{10}\right)}{2 \times 5s\left(1+\frac{s}{2}\right)\left(1+\frac{s}{5}\right)} = \frac{10\left(1+\frac{s}{10}\right)}{s\left(1+\frac{s}{2}\right)\left(1+\frac{s}{5}\right)}$$

Being a type 1 system, initial slope is –20 dB/dec and the corner frequencies

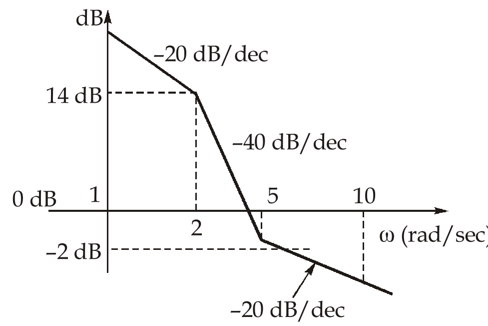
ω_1 = 2 rad/sec resulting in a slope of –20 dB/dec

ω_2 = 5 rad/sec resulting in a slope of –20 dB/dec

ω_3 = 10 rad/sec resulting in a slope of +20 dB/dec

At ω = 2 rad/sec, $M = -20 \log 2 + 20 \log 10 = 14$ dB

At ω = 5 rad/sec, $M' = 14 - 40 (\log 5 - \log 2) = -1.91 \approx -2$ dB



60. (a)

Integral control is based on the principle that the controller's output should be proportional to both the magnitude and duration of the error. The controller's output will continue to change it's value until the error is zero. This property enables integral action to eliminate offset error automatically. Hence, the PI controller is employed for eliminating the offset.

61. (d)

Substituting $s = x - 1$ in the equation, we get

$(x-1)^3 + 3(k+1)(x-1)^2 + (7k+5)(x-1) + (4k+7) = 0$

$x^3 - 3x^2 + 3x - 1 + 3(k+1)(x^2 - 2x + 1) + (7k+5)(x-1) + (4k+7) = 0$

$x^3 + x^2(3k + 3 - 3) + x(3 - 6k - 6 + 7k + 5) + 3k + 3 - 1 - 7k - 5 + 4k + 7 = 0$

$x^3 + 3kx^2 + (k+2)x + 4 = 0$

The Routh array is given by

$$\begin{array}{c|cc} x^3 & 1 & k+2 \\ x^2 & 3k & 4 \\ x^1 & \dfrac{3k^2+6k-4}{3k} & \\ x^0 & 4 & \end{array}$$

For roots to lie to the left of $s = -1$, all the elements in the first column of the Routh array must be positive. Hence,

$$3k > 0$$

$$k > 0$$

$$3k^2 + 6k - 4 > 0 \quad \Rightarrow \quad k < -2.63 \text{ or } k > 0.53$$

Hence, the Required range is $k > 0.53$.

62. (a)

Here,
$$T(s) = \frac{C(s)}{R(s)} = \frac{18}{s^2 + 2.6s + 18}$$

Therefore, the characteristic equation is
$$s^2 + 2.6s + 18 = 0 \equiv s^2 + 2\xi\omega_n^s + \omega_n^2 = 0$$

By comparison,
$$\omega_n^2 = 18 \Rightarrow \omega_n = 4.243 \text{ rad/sec}$$
$$2\xi\omega_n = 2.6$$
$$\xi = \frac{1.3}{4.243} = 0.3$$

Now, with derivative controller. ξ' has to be 0.8. The characteristic equation using derivative controller having transfer function $k_d s$ is modified as below:
$$s^2 + (2\xi\omega_n + \omega_n^2 k_d)s + \omega_n^2 = 0 \equiv s^2 + 2\xi'\omega_n s + \omega_n^2 = 0$$
$$2\xi\omega_n + \omega_n^2 k_d = 2\xi'\omega_n$$
$$k_d = (\xi' - \xi)\frac{2}{\omega_n} = (0.8 - 0.3)\frac{2}{4.243}$$
$$= \frac{0.5 \times 2}{4.243} = 0.24$$
$$k_d = 0.24$$

63. (a)

For a closed loop system using negative feedback, the closed loop gain is less than the open loop gain. We have,
$$A_{CL} = \frac{A_{OL}}{1 + A_{OL}\beta}$$

Hence, statement 4 is incorrect. Therefore, option (a) is the correct answer.

64. (b)

Single precision data format (32 bits)

$\Rightarrow$

S	BE	Mantissa
1 bit	8 bits	23 bits

Double precision data format (64 bits)

$\Rightarrow$

S	BE	Mantissa
1 bit	11 bits	52 bits

Thus, the number of bits occupied by mantissa is 52 in double precision floating point data. Hence, option (b) is correct.

65. (a)

We have, CAFE =

1	100 101	0 1111 1110
S	BE	M

- Sign = –Ve
- Mantissa = 011111110

$\because$ Bias = $(2^{n-1} - 1)$

- BE = 100101

AE = BE – Bias

Here, $n = 6$; Bias = 31 = 011111

$$AE = \begin{array}{r} 100101 \\ -\ 011111 \\ \hline 000110 \end{array} = 6$$

Now, combining all the data and representing it in $(-1)^S \times (1.M) \times 2^{AE}$ format, we get

$$-(1.011111110) \times 2^{+6} = (1011111.110)_2 = -95.75$$

Hence, option (a) is correct.

66. (a)

Von Neumann Architecture follows the concept of stored-program computer where data and instructions reside within a single memory unit whereas Harvard Architecture is a modern type of computer architecture that follows the concept of the relay-based model. The term 'relay' emerged from the Harvard Mark I relay-based computer, which stored instructions on punched tape and data in electro-mechanical counters.

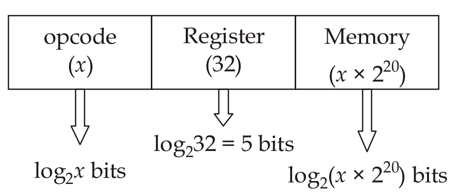
Therefore, option (a) is correct.

67. (d)

- Input Output Processor use two separate buses, one for memory and the other for I/O.
- Isolated I/O: Common bus(data and address) for I/O and memory but separate read and write control lines for I/O.
- Memory Mapped I/O: Common bus for data, address and control signals. Here, the I/O is treated as memory and both share the same address space.

68. (a)

We have,



Let number of opcodes is x

According to given information,

$$\log_2 x + 5 + \log_2(x \times 2^{20}) = 41$$

$$\log_2(x^2 \times 2^{20}) = 36$$

$$x^2 \times 2^{20} = 2^{36}$$

$$x^2 = 2^{16}$$

$$x = 2^8$$

$\therefore$ Memory size is $2^8 \times 2^{20} = 256$ MB

Hence, option (a) is correct.

69. (b)

We know that,

$$\text{Speedup } (S) = \frac{1}{(1-\text{cache\% used}) + \left[\dfrac{\text{Cache\% used}}{\text{Speedup using cache}}\right]}$$

$$S = \frac{1}{(1-F)+\left(\dfrac{F}{s}\right)}$$

$$\frac{1}{S} = (1-0.8)+\left(\frac{0.8}{20}\right)$$

$$S = \frac{1}{0.2+0.04} = 4.167$$

Hence, option (b) is correct.

70. (d)

- Reduced instruction set computer (RISC) support fixed length instructions and support hard wired control unit for real-time applications.
- Horizontal microprogram control unit offer improved flexibility because each control bit is independent of each other. Order of control unit design in terms of flexibility:
  Hardwired < Horizontal < Vertical
  Hence, all the given statements are correct. Therefore, option (b) is the correct answer.

Note: Order of control unit design in terms of speed:
Vertical < Horizontal < Hardwired

71. (a)

- In horizontal microprogrammed control unit ⇒ n bits gives n control signals.
- In vertical microprogrammed control unit ⇒ n bits gives 2^n control signals.

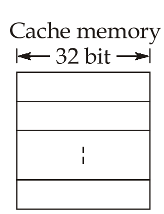
∴ The difference between number of control signals for vertical microprogrammed control unit and horizontal microprogrammed control unit is given as $(2^n - n)$.

We have, $n = 10$, then

$$2^{10} - 10 = 1014$$

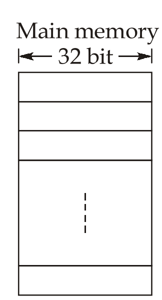
Hence, option (a) is correct.

72. (c)

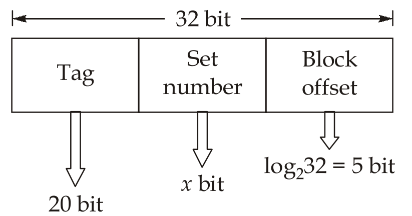


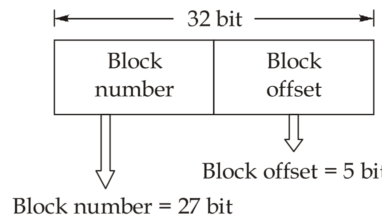
Cache = 16 kB = $2^{14} = 2^9 \times 2^5$ bits

Number of lines = 2^9



Size of memory = 4 GB = $2^{32} = 2^{27} \times 2^5$ bits





$$\text{Number of sets} = \frac{\text{Number of lines}}{K} = 2^x$$

We have,

$$20 + x + 5 = 32$$
$$x = 7$$
$$\text{Number of sets} = \frac{\text{Number of lines}}{K}$$
$$2^7 = \frac{\text{Number of lines}}{K} \qquad \because \text{Number of lines} = 2^9$$
$$K = \frac{2^9}{2^7}$$
$$K = 2^2$$
$$K = 4$$

73. (c)

- % modulation; $\mu < 1$, so as to avoid envelope distortion.
- $f_m << f_c$, so that the envelope may be visualized satisfactorily. To avoid diagonal clipping, the time constant of envelope detector $\frac{1}{f_c} < RC < \frac{1}{f_m}$. Here, it is assumed that the spectral content of the message signal is negligible for frequencies outside the interval $-f_m \le f \le f_m$ i.e., message signal is baseband in nature.

74. (b)

$A_c = 10$ V, $f_c = 12$ MHz, $A_{m1} = 4$ V
$f_{m1} = 500$ Hz, $A_{m2} = 2$ V, $f_{m2} = 2$ kHz

For a multi-tone AM signal,

$$\mu_t = \sqrt{\mu_1^2 + \mu_2^2}$$
$$\mu_1 = \frac{A_{m1}}{A_c} = \frac{4}{10} = 0.4$$
$$\mu_2 = \frac{A_{m2}}{A_c} = \frac{2}{10} = 0.2$$
$$\mu_t = \sqrt{0.16 + 0.04} = \sqrt{0.2} = \frac{1.414}{3.16} = 0.44$$
$$P_t = P_c\left[1 + \frac{\mu_t^2}{2}\right]$$

where, $P_c = \frac{A_c^2}{2} = \frac{100}{2} = 50$ Watt

$\therefore$ $P_t = 50\left[1 + \frac{0.2}{2}\right]$

$= 50 \times 1.1 = 55$ W

75. (b)

- In FM modulation, noise immunity is better than AM and PM as noise primarily affects the amplitude and phase of the modulated signal.
- Greater frequency deviation in frequency modulation can improve noise performance because it increases the signal-to-noise ratio.
- In FM modulation, it is possible to operate more channels on the same frequency.

76. (c)

Given (7, 4) Hamming code.

One of the code word given = 0001011.

Hamming code is a single error correcting code i.e. $t = 1$ with the minimum hamming distance between the codewords,

$$d_{min} \geq 2t + 1$$
$$d_{min} \geq 2 \times 1 + 1$$
$$d_{min} \geq 3$$

i.e, d_{min} should be at least equal to 3.

option (1)
0001011
0011010
0010001

$d_{min} = 2$ (not valid)

option (2)
0001011
1110100
1111111

$d_{min} = 7$ (valid codeword)

option (3)
0001011
0011101
0010110

$d_{min} = 3$ (valid codeword)

option (4)
0101100
0001011
0100111

$d_{min} = 4$ (valid codeword)

77. (d)

Bit duration is

$$T_b = \frac{1}{4\times10^6} = 0.25\ \mu s$$

The signal energy per bit is

$$E_b = \frac{1}{2}A_c^2T_b$$

The average probability of error is

$$P_e = Q\left(\sqrt{\frac{E_b}{N_0}}\right) = \frac{1}{2}erfc\left(\sqrt{\frac{E_b}{2N_0}}\right)$$

$$= Q\left(\sqrt{\frac{A_c^2T_b}{2N_0}}\right) = \frac{1}{2}erfc\left(\sqrt{\frac{A_c^2T_b}{4N_0}}\right)$$

$$= \frac{1}{2}erfc\left(\sqrt{\frac{4\times10^{-12}\times1}{4\times10^6\times4\times2\times10^{-19}}}\right)$$

$$= \frac{1}{2}erfc\left(\sqrt{\frac{10000\times10^3}{10^6\times4\times2}}\right)$$

$$= \frac{1}{2}erfc\left(\sqrt{\frac{10}{4\times2}}\right)$$

$$= \frac{1}{2}erfc\left(\sqrt{1.25}\right)$$

$$\cong \frac{1}{2}erfc(1.12)$$

78. (b)

$$R_{XY}(\tau) = E[X(t+\tau)Y(t)]$$

Replacing τ with –τ we get

$$R_{XY}(\tau) = E[X(t-\tau)Y(t)]$$

Now replacing t-τ with t we obtain

$$R_{XY}(-\tau) = E[X(t)Y(t-\tau)] = R_{YX}(\tau)$$

$$E[\{X(t+\tau) \pm Y(t)\}^2] = E[X^2(t+\tau) \pm 2X(t+\tau)Y(t) + Y^2(t)]$$

$$= E[X^2(t+\tau)] \pm 2E[X(t+\tau)Y(t)] + E[Y^2(t)]$$

$$= R_X(0) \pm 2R_{XY}(\tau) + R_Y(0)$$

$$R_X(0) \pm 2R_{XY}(\tau) + R_Y(0) \geq 0$$

Hence, $$|R_{XY}(\tau)| \leq \frac{1}{2}[R_X(0) + R_Y(0)]$$

We have, $$R_Y(\tau) = R_X(\tau) * h(\tau) * h(-\tau)$$

$$R_Y(\tau) = R_{XY}(\tau) * h(-\tau)$$

Using Cauchy Schwarz inequality,

$$\{E[XY]\}^2 \le E[X^2] \cdot E[Y^2]$$

$$\{E[X(t) \cdot Y(t+\tau)]\}^2 \le E[X^2(t)] \cdot E[Y^2(t+\tau)]$$

$$\{R_{XY}(\tau)\}^2 \le R_X(0) \cdot R_Y(0)$$

$$|R_{XY}(\tau)| \le \sqrt{R_X(0) \times R_Y(0)}$$

79. (c)

The granular noise occurs when

$$\frac{dm(t)}{dt} < \frac{\Delta}{T_s}$$

$$\frac{d(at)}{dt} < \frac{\Delta}{T_s}$$

$$a < \frac{\Delta}{T_s}$$

$$\Delta > aT_s$$

80. (d)

- Distance between adjacent signalling points for M-ary PSK,

$$d_{12} = 2\sqrt{E_s}\sin\left(\frac{\pi}{M}\right)$$

- DPSK uses two successive bits for its reception, error in first bit creates error in second bit and consecutively error propagates.
- f_1 and f_2 being the integer multiples of nR_b leads to continuous phase.

81. (d)

$$V_{pp} = 12\text{ V}, f_m = 20\text{ kHz}, L = 128$$

$$\text{Step-size } \Delta = \frac{V_{\max} - V_{\min}}{L} = \frac{V_{PP}}{L} = \frac{12}{128}$$

$$\Delta = \frac{3}{32}$$

$$\text{Maximum quantization error} = Q_e = \pm\frac{\Delta}{2}$$

$$= \pm\frac{3}{32 \times 2} = \pm\frac{3}{64}$$

$$= \pm 46.875\text{ mV}$$

$$\text{Noise power} = N_Q = \frac{\Delta^2}{12} = \left(\frac{3}{32}\right)^2 \times \frac{1}{12}$$

$$= \frac{9}{32 \times 32 \times 12} = \frac{3000}{32 \times 32 \times 4}\text{mWatt} \cong 0.732\text{ mWatt}$$

82. (b)

The maximum power received is

$$P_{R\max} = 2\ \mu W$$

The average power density is given by

$$P_{avg} = \frac{1}{2}\frac{|E|^2}{\eta_0} = \frac{1}{2}\frac{(50\times10^{-3})^2}{120\pi} = 3.315\ \mu W$$

Hence, the maximum effective aperture area is given by

$$A_{em} = \frac{P_{R\max}}{P_{avg}} = \frac{2\times10^{-6}}{3.315\times10^{-6}}$$

$$A_{em} = 0.603\ m^2$$

83. (d)

For copper wire, it is given that

$$\text{radius} = a = 1\ \text{mm} = 1\times10^{-3}\ \text{m},$$
$$\text{length} = L = 1\ \text{Km} = 1\times10^{3}\ \text{m}$$
$$\varepsilon_r = \mu_r = 1$$
$$\sigma = 5.8\times10^{7}\ \mho/\text{m}$$

The dc resistance is given by,

$$R_{dc} = \frac{L}{\sigma\cdot S}$$

where; S = Area of cross section of Cu wire

σ = Conductivity of copper

$$R_{d.c} = \frac{10^3}{5.8\times10^7\times(\pi\times a^2)}$$

$$R_{d.c} = \frac{10^3}{5.8\times10^7\times\pi\times10^{-6}} = 5.488\ \Omega$$

84. (b)

As the pair of field satisfies Maxwell's equation,

$$\vec{\nabla}\times\vec{E} = \frac{-\partial\vec{B}}{\partial t}$$

L.H.S $\Rightarrow$

$$\vec{\nabla}\times\vec{E} = \begin{vmatrix} \hat{a}_x & \hat{a}_y & \hat{a}_z \\ \frac{\partial}{\partial x} & \frac{\partial}{\partial y} & \frac{\partial}{\partial z} \\ 60\sin10^6 t\sin0.01z & 0 & 0 \end{vmatrix}$$

$$\vec{\nabla}\times\vec{E} = 0.6\sin10^6 t\cos0.01z\ \hat{a}_y$$

$$\text{RHS} = \frac{\partial\vec{B}}{\partial t} = \frac{\mu\partial\vec{H}}{\partial t} \quad \text{where } \mu = K \text{ (given)}$$

$$= K\frac{\partial}{\partial t}(0.6\cos 10^6 t\cos 0.01z\,\hat{a}_y)$$

$$= K(0.6)\cos 0.01z[-\sin 10^6 t][10^6]\hat{a}_y$$

$$= -K\times 6\times 10^5 \sin 10^6 t\cos 0.01z\,\hat{a}_y$$

Equating LHS with RHS,

$$0.6(\sin 10^6 t\cos 0.01z)\hat{a}_y = +K(6\times 10^5)\sin 10^6 t\cos 0.01z\,\hat{a}_y$$

On comparing $0.6 = K(6 \times 10^5)$

$$K = 1 \times 10^{-6}\ \text{H/m}$$

85. (c)

The vector field is irrotational, if the curl is zero.

$\therefore$ $\vec{\nabla}\times\vec{F} = 0$ .... For $\vec{F}$ to be irrotational

$$\vec{\nabla}\times\vec{F} = \begin{vmatrix} \hat{a}_x & \hat{a}_y & \hat{a}_z \\ \dfrac{\partial}{\partial x} & \dfrac{\partial}{\partial y} & \dfrac{\partial}{\partial z} \\ F_X & F_Y & F_Z \end{vmatrix}$$

$$\vec{\nabla}\times\vec{F} = \begin{vmatrix} \hat{a}_x & \hat{a}_y & \hat{a}_z \\ \dfrac{\partial}{\partial x} & \dfrac{\partial}{\partial y} & \dfrac{\partial}{\partial z} \\ x+2y+az & bx-3y-z & 4x+cy+2z \end{vmatrix}$$

$$\vec{\nabla}\times\vec{F} = \hat{a}_x\left[\frac{\partial}{\partial y}(4x+cy+2z)-\frac{\partial}{\partial z}(bx-3y-z)\right]-$$

$$\hat{a}_y\left[\frac{\partial}{\partial x}(4x+cy+2z)-\frac{\partial}{\partial z}(x+2y+az)\right]+$$

$$\hat{a}_z\left[\frac{\partial}{\partial x}(bx-3y-z)-\frac{\partial}{\partial y}(x+2y+az)\right]$$

$$\vec{\nabla}\times\vec{F} = \hat{a}_x[(c+1)]-\hat{a}_y[(4-a)]+\hat{a}_z[b-2] = 0$$

$\therefore$ $c = -1,\quad a = 4,\quad b = 2$

86. (b)

The flux is given by

$$\phi = \int_s \vec{B}\cdot\vec{ds}$$

Since $z = 0$, $\vec{ds} = dx\,dy\,\hat{a}_z$

$$\phi = \int_s \left[2.5\left(\sin\frac{\pi x}{2}\right)e^{-2y}\hat{a}_z\right]\cdot(dx\,dy\,\hat{a}_z)$$

$$\phi = \int_{x=0}^{2}\int_{y=0}^{\infty} 2.5\sin\frac{\pi x}{2}e^{-2y}dx\,dy$$

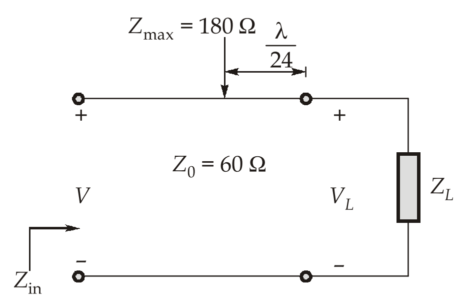
Separating the variables,

$$\phi = 2.5\left[\frac{-\cos\frac{\pi x}{2}}{\frac{\pi}{2}}\right]_0^2\left[\frac{-1}{2}e^{-2y}\right]_0^{\infty}$$

$$\phi = 2.5\times\frac{2}{\pi}[1+1]\left[\frac{1}{2}\right]$$

$$\phi = \frac{5}{\pi} = 1.5912 \simeq 1.6 \text{ Wb}$$

87. (c)



The maximum impedance of line is given by

$$Z_{max} = SZ_0$$

$$\therefore \quad S = \frac{Z_{max}}{Z_0}$$

$$S = \frac{180}{60} = 3$$

$$|\Gamma| = \frac{S-1}{S+1} = \frac{2}{4} = \frac{1}{2}$$

88. (d)

- According to maximum power transfer theorem, maximum power is transmitted from the source to the load, when $Z_L = Z_0$.
- For a quarter wave line, $Z_{in} = Z_0^2/Z_L$, hence it works as an impedance inverter and can transform a low impedance into high impedance and vice versa.
- A lossless line is also distortionless line but a distortionless line is not essentially a lossless line.

89. (d)

For TE_{02}, f_c is given by

$$f_c = \frac{c}{2}\sqrt{\left(\frac{m}{a}\right)^2 + \left(\frac{n}{b}\right)^2}$$

$$f_c = \frac{c}{b}$$

$$12 \times 10^9 = \frac{3\times 10^{10}}{b} \quad \Rightarrow \quad b = 2.5 \text{ cm}$$

∴ $$a = 2b \quad \Rightarrow \quad a = 5 \text{ cm}$$

For TE_{01}, $$f_c = \frac{c}{2b} = \frac{3\times 10^{10}}{2\times 2.5} = 6 \text{ GHz}$$

90. (c)

For TE_{11} mode,

$$X'_{11} = 1.841$$

$$f_c = \frac{X'_{11}}{a} \times \frac{1}{2\pi\sqrt{\mu\varepsilon}}$$

$$f_c = \frac{1.841}{3} \times \frac{3\times 10^{10}}{2\pi}$$

$$f_c = 2.93 \text{ GHz}$$

91. (d)

VI equation;

$$V = \left(\frac{100-80}{0-80}\right) I + 100 = \frac{20}{-80} I + 100 = 100 - 0.25I$$

Comparing with standard DC generator equation,

$$V = E_g - I_a R_a$$

$$R_a = 0.25\ \Omega$$

$$\text{Ohmic losses} = I_a^2 R_a = I_a^2 \times \frac{1}{4} = 50^2 \times \frac{1}{4}$$

$$= 2500 \times \frac{1}{4} = 625 \text{ Watts}$$

92. (b)

In an induction motor,

- The stator is stationary and the stator field rotates with the synchronous speed Ns.
- The rotor field rotates with synchronous speed and the rotor rotates at a speed less than the synchronous speed given by sNs (s = slip)

Hence, the relative speed between the rotor and stator magnetic fields is zero.

93. (c)

During the continuous operation of the transformer, the oxidation of oil leads to the formation of the semi solid hydrocarbon termed as sludge.

94. (a)

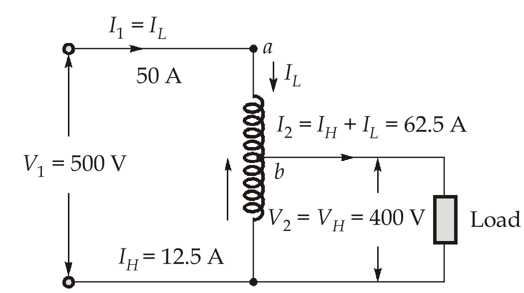
$$\text{Available flux} = \text{Flux density} \times \text{area}$$
$$= 1.5\,(6 \times 10.5 \times 10^{-4})$$
$$= 1.5 \times 63 \times 10^{-4}$$
$$= 94.5 \times 10^{-4}\ \text{Wb}$$
$$\text{Leakage coefficient} = 1.5 = \frac{\text{Available flux}}{\text{useful flux}}$$
$$\text{useful flux} = \frac{\text{Available flux}}{1.5}$$
$$= \frac{94.5 \times 10^{-4}}{1.5} = 63 \times 10^{-4}\ \text{Wb}$$
$$\text{emf} = \frac{\phi Z N}{60} \quad (\because \text{ for lap winding } P = A)$$
$$= \frac{63 \times 10^{-4} \times 800 \times 1000}{60} = 21 \times 4 = 84\ \text{V}$$
$$\text{emf} = 84\ \text{V}$$

95. (a)

For a two-winding transformer

$$S_{in} = S_{out} = V_H I_H = V_L I_L$$
$$\Rightarrow \quad 5 \times 1000 = 400\, I_H$$
$$I_H = \frac{5000}{400} = 12.5\text{A}$$
$$\Rightarrow \quad 5000 = V_L I_L$$
$$I_L = \frac{5000}{100} = 50\text{A}$$

The below figure shows the use of 2-winding transformer as an autotransformer to supply at 400 V from a 500 V source.



$$V_1 = V_H + V_L = 500 \text{ V}, \; V_2 = V_H = 400 \text{ V}$$
$$I_2 = I_H + I_L = 12.5 + 50 = 62.5 \text{ A}$$

The kVA output of the autotransformer

$$= \frac{V_2 I_2}{1000} = \frac{400 \times 62.5}{1000} = 25 \text{ kVA}$$

96. (a)

When the winding is uniformly distributed, the distribution factor K_d

$$K_d = \frac{\sin m\frac{\beta}{2}}{m \sin\frac{\beta}{2}} = \frac{\sin\left(\frac{\text{phase spread}}{2}\right)}{\frac{\text{phase spread}}{2}}$$

$$= \frac{\sin\left(\frac{120°}{2}\right)}{\frac{120}{2} \times \frac{\pi}{180°}} = \frac{3\sin 60°}{\pi} = \frac{3 \times \sqrt{3}}{2\pi}$$

$$= 3 \times 0.159 \times 1.73 = 0.825$$

Chording angle; $\theta = 180° - 160° = 20°$

Coil-span factor; $K_p = \cos\frac{\theta}{2} = \cos 10° = 0.984$

Winding factor, $K_w = K_d \times K_p = 0.825 \times 0.984$

$\cong 0.82$

97. (d)

$$I_a = \frac{V\angle 0 - E_f \angle -\delta}{jX_s}$$

As $|\vec{V}| > |\vec{E_f}|$ and $\vec{V}$ leads E_f, therefore machine is acting as a motor and operating at lagging p.f. (under-excited)

98. (b)

Rating of transformer,
40 kVA; 2500/250 V

$$I_1 = \frac{40 \times 10^3}{2500} = 16\text{A} \quad \text{(full load current)}$$

$I_{sc} = 12$ A

$W_{sc} = 400$ W (copper loss)

$I_{FL} = 16$A

For Cu loss: $W = I^2 R$

$W \propto I^2$

$$\frac{W_{sc}}{W_{CuFL}} = \left(\frac{I_{sc}}{I_{FL}}\right)^2 = \left(\frac{12}{16}\right)^2 = \frac{9}{16}$$

$$W_{CuFL} = \left(\frac{12}{16}\right)^2 W_{SC} = \frac{9}{16}\times 400 = 225 \text{ Watt}$$

So

$$\eta = \frac{xE_2I_2\cos\theta_2}{xE_2I_2\cos\theta_2 + x^2W_{CuFL} + W_I}\times 100$$

$$= \frac{0.5\times 40\times 10^3\times 0.6}{0.5\times 40\times 10^3\times 0.6 + 0.25\times 225 + 200}\times 100$$

$$= \frac{12000}{12000 + 56.25 + 200}\times 100$$

$$= \frac{12000}{12256.25}\times 100$$

$$= \frac{12000\times 100}{1225625}\times 100$$

$$= \frac{12000\times 4}{49025}\times 100$$

$$= \frac{12000\times 16}{1961} = \frac{192000}{1961} = 97.9\% \cong 98\%$$

99. (a)

$$T_s = 1.2T_f$$

$$T_{\max} = 1.8T_f$$

For maximum torque,

$$S_{mT} = \frac{R_2}{X_2}$$

$$\frac{T_s}{T_{\max}} = \frac{1.2}{1.8} = \frac{2S_{mT}}{1+S_{mT}^2} \qquad \text{[At starting, } s = 1\text{]}$$

$$2 + 2S_{mT}^2 = 6\, S_{mT}$$

$$S_{mT}^2 - 3S_{mT} + 1 = 0$$

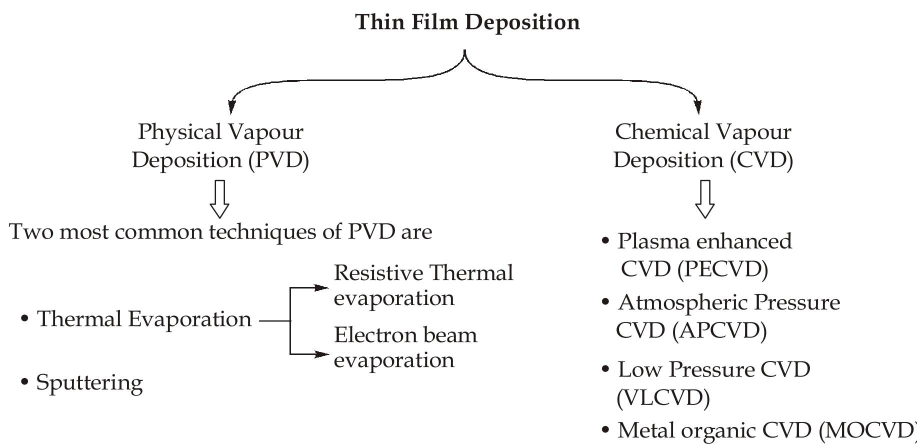
$$S_{mT} = \frac{3\pm\sqrt{9-4}}{2} = \frac{3\pm\sqrt{5}}{2}$$

$$= \frac{3\pm 2.23}{2} = 2.615,\ 0.385$$

Since value of slip is less than 1, $S_{mT} \cong 0.4$

100. (d)

Thin Film Deposition : A technology of applying a very thin film of material between a few nanometers to about 100 micrometers, or the thickness of few atoms, onto a "substrate" surface to be coated, or onto a previously deposited coating to form layers.



101. (c)

We have,

Number of transistors per unit area, Q = 1000.

Now,

$$\text{Packing density, } P = \log_{10}Q = \log_{10}10^3$$
$$P = 3$$

102. (b)

- The doping impurity is first ionized in high vacuum and then accelerated by high electric field before reaching the semiconductor substrate. The atoms enter the crystal lattice, collide with the host atoms, lose energy, and finally come to rest at some depth within the solid. The average penetration depth is determined by the dopant, substrate materials, and acceleration energy resulting in ion distributions with average depth from < 10 nm to 10 μm. Hence, designing of both very deep and shallow junction is possible.
- One of the main disadvantage of ion implantation doping process is that, the damages made by ions can't be recovered by annealing process. Therefore, statement (4) is incorrect.

103. (c)

- Czochralski technique converts EGS to single crystal silicon.
- Silicon float zone technique offers lower contamination compared to Czochralski method. In float zone technique, oxygen and carbon impurity concentration are much lower as compared to Czochralski method, since the melt does not come into contact with a quartz crucible.
- Both the statements are incorrect. Hence, option (c) is correct.

104. (c)

As per the scaling rule, minimum thickness of the oxide layer (t_{ox}) is directly proportional to the minimum channel length (L_{min}).

$$t_{ox} \propto L_{\text{min}}$$

Now, we have

$$t_{ox1} = 36 \text{ nm}, \quad L_{\text{min}1} = 1.2 \text{ μm}$$
$$t_{ox2} = ? \quad , \quad L_{\text{min}2} = 0.6 \text{ μm}$$

$$\frac{t_{ox1}}{L_{min1}} = \frac{t_{ox2}}{L_{min2}}$$

$$\frac{36\times10^{-9}}{1.2\times10^{-6}} = \frac{t_{ox2}}{0.6\times10^{-6}}$$

$$t_{ox2} = \frac{36\times10^{-9}\times0.6\times10^{-6}}{1.2\times10^{-6}}$$

$$t_{ox2} = 18 \text{ nm}$$

Hence, option (c) is correct.

105. (d)

- Schottky transistor prevents saturation and the stored base charge, thereby improving the switching speed.
- Noise Margins for CMOS chips ar greater than those of bipolar technology because the V_{OH}(min) is closer to the power supply Voltage and V_{OL}(max) is closer to 0.
- BiCMOS provides the combination of bipolar and CMOS technologies on a single chip providing high-switching speed, high current capabilities, low power consumption, etc.

Hence, all the given statements are correct.

106. (a)

Dry Oxidation	Wet Oxidation
$Si + O_2 \xrightarrow{1200°C} SiO_2$	$Si + H_2O \xrightarrow{900°C} SiO_2$
Slow process	Fast process
Good quality oxide	Inferior quality oxide
Thin oxide layer	Thick oxide layer

107. (b)

Scaling factor for gate dimensions W and L is $\frac{1}{\alpha}$. Therefore, the scaling factor for the gate area given by ($W \times L$) is $\left(\frac{1}{\alpha}\cdot\frac{1}{\alpha}\right) = \frac{1}{\alpha^2}$.

108. (c)

Number of transistors in VLSI IC = (10^4 – 10^6) transistors per unit area of substrate

Packing density, $P = \log_{10}Q$

For, 10^4 transistors, $P = \log_{10}10^4 = 4$

and for, 10^6 transistors, $P = \log_{10}10^6 = 6$

Hence, packing density P is in the range of (4 to 6) for VLSI.

Note:

S.No.	Level of integration	No. of transistors per unit area of substrate	Packing density P
1	Small scale integration (SSI)	1-10	$P < 1$
2	Medium scale integration (MSI)	10-100	$1 < P < 2$
3	Large scale integration (LSI)	100-10^4	$2 < P < 4$
4	Very large scale integration (VLSI)	10^4-10^6	$4 < P < 6$
5	Ultra large scale integration (ULSI)	greater than 10^6	$P > 6$

109. (c)

- In metals, when we increase the temperature, the relative movement of the atoms as well the free electrons increase. Because of which, there is more collisions and as a result, the resistance increases.
- In semiconductor, as temperature increases, the number of charge carrier increases, thereby increasing the conductivity or decreasing the resistance.

110. (a)

Given, Bandgap of semiconductor, $E_G = 2.5$ V

Wavelength of light emitted by LED is,

$$\lambda = \frac{1.24}{E_G \text{ (in eV)}}\mu\text{m} = \frac{1.24}{2.5}\mu\text{m} \approx 0.5\mu\text{m}$$

111. (a)

Given, Length of Si bar, $L = 0.1$ cm

Cross-sectional area, $A = 100\ \mu\text{m}^2$

Doping concentration, $N_D = 10^{17}\text{ cm}^{-3}$

Applied voltage, $V = 10$ V

Current, $I = \frac{V}{R}$, where $R = \frac{\rho L}{A}$

$$\rho = \frac{1}{nq\mu_n} = \frac{1}{10^{17} \times 1.6 \times 10^{-19} \times 500} = 0.125\ \Omega\text{-cm}$$

$$R = \frac{0.125 \times 0.1}{100 \times 10^{-8}} = 12.5 \times 10^3\ \Omega$$

$$I = \frac{10}{12.5 \times 10^3} = 0.8\text{ mA}$$

112. (a)

Given, mobility of holes, $\mu_p = 500\text{ cm}^2/\text{V-sec}$

Resistivity of p-type material, $\rho = 0.002\ \Omega\text{-cm}$

$\mu_p = \sigma R_H$

Hall coefficient, $R_H = \frac{\mu_p}{\sigma}$ (or) $R_H = \rho\mu_p$

$\therefore$ $R_H = 0.002 \times 500 = 1\text{ cm}^3/\text{C}$

113. (c)

Transition capacitance is the junction capacitance in a reverse biased diode. The rate of change of immobile charges w.r.t a change in reverse bias voltage is called transition capacitance, or space charge or depletion layer capacitance.

$$C_T = \frac{\varepsilon A}{W}$$

where W is the width of depletion region which changes with the reverse bias voltage. As depletion width increases, the transition capacitance will be decreased.

114. (c)

As per the Einstein relation,

$$D = \mu V_T$$

Hence, the charge carriers with higher mobility have higher diffusion constant i.e. high tendency to diffuse.

115. (c)

116. (b)

Given, maximum power rating of zener diode,

$$P_{D(\max)} = 200 \text{ mW}$$

$$\text{derating factor} = 1.5 \text{ mW/°C}$$

$$\therefore \quad P_{D(\text{derated})} = P_{D(\max)} - (1.5 \text{ mW/°C})\Delta T$$

where, $$\Delta T = 90 - 50 = 40°\text{C}$$

$$\therefore \quad P_{D(\text{derated})} = 200 \text{ mW} - (1.5 \times 40) \text{ mW}$$

$$= 140 \text{ mW}$$

117. (b)

Given depletion width of photodiode,

$$W = 10 \text{ μm}$$

Saturation velocity of charge carriers,

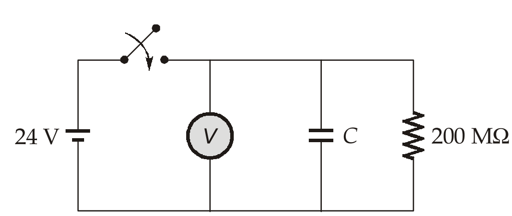
$$V_s = 10^8 \text{ cm/sec}$$

$\therefore$ Transit time,

$$\tau_t = \frac{W}{V_s} = \frac{10 \times 10^{-4}}{10^8} = 10 \times 10^{-12} \text{ sec}$$

$$\tau_t = 10 \text{ psec}$$

118. (c)



The discharge of capacitor can be expressed by relation

$$V_c(t) = Ve^{-t/\tau}$$

Where, $$\tau = RC$$

Taking natural log on both sides, we can write,

$$C = \frac{t}{R\ln\left(\frac{V}{V_c}\right)} = \frac{4\times 60}{200\times 10^6 \times \ln\left(\frac{24}{12}\right)}$$

$$= 1.731 \times 10^{-6}\text{ F}$$

$$= 1.731\ \mu\text{F}$$

119. (b)

Given,

$$E_a = 2000\text{ V},$$
$$L = 50\text{ cm} = 0.5\text{ m},$$
$$l_d = 1\text{ cm} = 1 \times 10^{-2}\text{ m}$$
$$d = 5\text{ mm} = 5 \times 10^{-3}\text{ m},$$
$$D = 2.5\text{ cm} = 2.5 \times 10^{-2}\text{ m}$$

We know deflection,

$$D = \frac{Ll_d}{2dE_a}\cdot E_d$$

So, deflecting plate voltage,

$$E_d = \frac{D\times 2d\,E_a}{L\,l_d}$$

$$= \frac{2.5\times 10^{-2}\times 2\times 5\times 10^{-3}\times 2000}{0.5\times 1\times 10^{-2}}$$

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

$$\text{Applied input voltage} = \frac{E_d}{\text{Amplifier gain}} = \frac{100}{50} = 2\text{ V}$$

120. (b)

Looking back into terminals x and y and using Thevenin's equivalent resistance,

$$R_t = R_3 + \frac{R_1R_2}{R_1 + R_2} = 1k + \frac{1k\times 1k}{1k+1k} = 1.5\text{ k}\Omega$$

$$\frac{I_m}{I} = \frac{R_t}{R_t + R_m}$$

$$\therefore \quad \frac{I_m}{I} = \frac{1.5\text{ k}\Omega}{1.5\text{ k}\Omega + 100\,\Omega} = \frac{1.5k}{1.6k} = 0.9375$$

$$\text{Error due to loading} = \left(1 - \frac{I_m}{I}\right)\times 100$$

$$= (1 - 0.9375) \times 100$$

$$= 6.25\%$$

121. (a)

$$R_x = \frac{C_1}{C_3}R_2 = \frac{0.5\mu F}{0.5\mu F}\times 2k = 2\ k\Omega$$

$$C_x = \frac{R_1}{R_2}\times C_3 = \frac{1k}{2k}\times 0.5\mu F = 0.25\ \mu F$$

The dissipation factor is given by,

$$D = \omega R_x C_x$$
$$= 2 \times 3.1416 \times 1000 \times 2 \times 1000 \times 0.25 \times 10^{-6}$$
$$= 3.1416$$

122. (a)

$$R_2 = \frac{0.9\text{ in}}{3.0\text{ in}}\times 5k = \frac{9}{30}\times 5k = 1500\ \Omega$$

$\therefore$
$$\frac{V_0}{V_t} = \frac{R_2}{R_1+R_2};$$

$$V_0 = \left(\frac{R_2}{R_1+R_2}\right)\times V_t$$

$$= \frac{1500}{5k}\times 5V = \frac{1500}{1k} = 1.5\text{ V}$$

123. (b)

- The torque-weight ratio of PMMC instruments is high, which gives a high accuracy.
- As the operating forces are large due to strong operating flux density, the errors due to stray magnetic fields are small.

124. (d)

125. (c)

- Unlike resistance thermometers with a positive resistance coefficient (i.e., it increases with temperature), thermistors have a negative resistance coefficient (i.e., it decreases with temperature). The main advantages are the higher sensitivities as compared to platinum resistance elements. They exhibit large resistance change over small temperature ranges.
- Temperature-resistance relationship in thermistors is highly non-linear given as below:

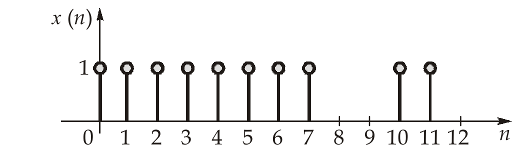
$$R_T = R_0 e^{\beta\left(\frac{1}{T}-\frac{1}{T_0}\right)}$$

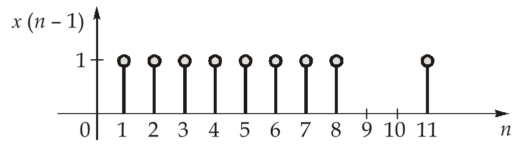
126. (c)

Gauge factor, $$GF = \frac{\Delta R/R}{\text{Strain}}$$

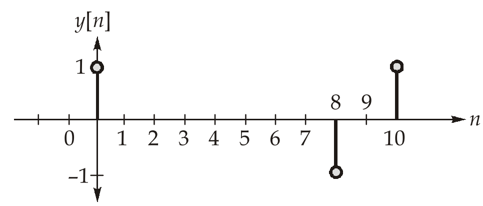
Change in resistance, $$\Delta R = R \times GF \times \text{Strain}$$
$$= 120 \times 2 \times 10^{-5}\ \Omega$$
$$\Delta R = 2.4 \times 10^{-3}\ \Omega$$

127. (c)





Subtracting the two signals, we get



$\Rightarrow$ $y[n]$ is periodic with period of $N = 10$

128. (c)

The given signal is half-wave symmetric and is neither even nor odd.

$\therefore$ Fourier series of the signal contain only odd harmonics.

129. (d)

Given ramp sequence,

$$x[n] = r[n+2] - r[n+1] - 3r[n-1] + 3r[n-2]$$
$$= (n+2)u[n+2] - (n+1)u[n+1] - 3(n-1)u[n-1] + 3(n-2)u[n-2]$$

The sum of coeffcients of shifted step sequences will result in the final value.

$\therefore$ $$x[\infty] = (n+2) - (n+1) - 3(n-1) + 3(n-2)$$
$$x[\infty] = -2$$

130. (b)

We know that, from the definition of DTFT,

$$X(e^{j\omega}) = \sum_{n=-\infty}^{\infty} x[n]e^{-j\omega n}$$

where, $$x[n] = \frac{1}{2\pi}\int_{-\pi}^{\pi} X(e^{j\omega})e^{j\omega n}\,d\omega$$

by putting $n = -1$,

$\therefore$ $$x[-1] = \frac{1}{2\pi}\int_{-\pi}^{\pi} X(e^{j\omega})e^{-j\omega}\,d\omega$$

$$\therefore \quad \int_{-\pi}^{\pi} X(e^{j\omega}) e^{-j\omega} d\omega = 2\pi x[-1]$$

$$= 2\pi[-2] = -4\pi$$

$$= -12.57$$

131. (b)

$$X[k] = \sum_{n=0}^{N-1} x[n] e^{-j\frac{2\pi}{N} nk}$$

$$g[n] = x[n-2]_{\text{mod N}}$$

$$G[k] = e^{-j\frac{2\pi}{N}(2)k} X[k]$$

$$G[1] = e^{-j\frac{2\pi}{4}(2)1} X[1] = e^{-j\pi} X[1]$$

$$G[1] = -X[1] = -7$$

132. (a)

$$r_{xx}(k) = \sum_{k=-\infty}^{\infty} x[n]\, x[n-k]$$

$$\sum_{k=-4}^{k=4} r_{xx}(k) = x[n]\, x[n+3] + x[n]\, x[n+2] + x[n]\, x[n+1] + x[n]\, x[n] + x[n]\, x[n-1]$$

$$+ x[n]\, x[n-2] + x[n]\, x[n-3] \qquad [\because x[n]x[n-4] = x[n]x[n+4] = 0]$$

$$= -2 - 5 + 2 + 10 + 2 - 5 - 2 = 0$$

133. (b)

The output of the given LTI system is,

$$y[n] = \sum_{k=-\infty}^{+\infty} h[k] e^{j\omega(n-k)} + \sum_{k=-\infty}^{+\infty} h[k] e^{j2\omega(n-k)}$$

$$= e^{j\omega n} \sum_{k=-\infty}^{+\infty} h[k] e^{-j\omega k} + e^{j2\omega n} \sum_{k=-\infty}^{+\infty} h[k] e^{-j2\omega k}$$

$$= e^{j\omega n} H(e^{j\omega}) + e^{j2\omega n} H(e^{j2\omega})$$

Since the input cannot be extracted from the above expression, the sum of the complex exponential is not an eigen function.

134. (d)

The linear phase of the FIR filter is a result of the symmetry of the impulse response.

135. (d)

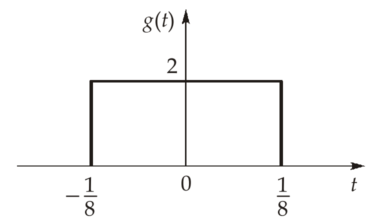
Given,
$$g(t) = \text{rect}(4t) * 4\delta(-2t) = 4\text{rect}(4t) * \delta(-2t)$$

$$g(t) = 2\text{rect}(4t) \qquad \left[\because \delta(-t) = \delta(t) \text{ and } \delta(2t) = \frac{1}{2}\delta(t)\right]$$

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

$$2\text{rect}(t) \xleftrightarrow{\text{CTFT}} 2\text{sinc}(f)$$

$$2\text{rect}(4t) \xleftrightarrow{\text{CTFT}} 2 \times \frac{1}{4}\text{sinc}\left(\frac{f}{4}\right)$$



$\therefore$
$$2\text{rect}(4t) \xleftrightarrow{\text{CTFT}} \frac{1}{2}\text{sinc}\left(\frac{f}{4}\right)$$

136. (c)

Superposition theorem is applicable only when more than one independent sources are present in the circuit. The response can be determined by considering each source individually and then combining the results.

Therefore, statement II is incorrect.

137. (a)

The input characteristics of transistors differ due to the manufacturing tolerances of different IC packages operating at different temperatures. Owing to these differences, the saturation voltages of the load transistors may be different. Let the base-emitter voltages of the transistors corresponding to saturation be 0.78, 0.79, and 0.80 V. The transistor with the base–emitter voltage of 0.78 V, when it enters saturation, will not allow other transistors to enter saturation and will take whole of the current supplied from the driver gate. This is known as current hogging.

138. (a)

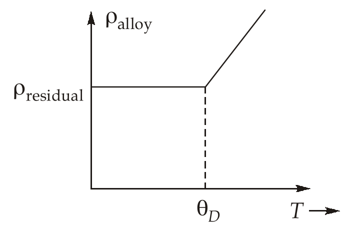
DMA Controller requests for the data bus lines from the microprocessor through the HOLD pin. Upon acknowledgement by the microprocessor through the HLDA pin, the DMA controller transfer the bulk data to the memory through these buses without an interrupt mechanism. Whereas in interrupt-driven I/O data transfer, the CPU constantly polls the I/O device or waits for an interrupt signal, making it less efficient for high volume I/O data transfer.

139. (b)

In a cryptosystem, the sender (Alice) use the public key to encrypt the data and the receiver (Bob) then uses it's private key to decrypt the data. However, it cannot be used in digital signature as there's no way to authenticate the source of the message. Mike could get a hold of Alice's public key (since it's public) and pretend that Bob is the person sending a message to Alice.To create a digital signature, Bob digitally signs his email to Alice using his private key. When Alice receives the message from Bob, she can verify the digital signature on the message came from Bob by using his public key. As the digital signature uses Bob's private key, Bob is the only person who could create the signature. Hence, in digital signature, we use the private and public keys of the sender.

140. (c)

- If percentage of alloy content is increased, then irregularities in atomic arrangement increases. Therefore, resistivity increases and conductivity decreases.
  Thus, statement-I is correct.



According to Matthiessen, beyond Debye temperature, the resistivity of the metal increases linearly with temperature. Therefore, statement-II is incorrect.
Hence, option (c) is correct.

141. (b)

The collector current in a BJT in common base mode increases slightly with the increase in collector base voltage due to early effect.
When V_{CB} become closer to avalanche breakdown voltage, avalanche multiplication factor increases and I_C increases sharply causing avalanche breakdown.

142. (b)

(I): Addition of zeros increase the system's relative stability by shifting the root locus to the left side in s-plane. The pole is located at the reciprocal of the time constant, and the farther the pole from the imaginary axis, the faster is the transient response. Hence, the response of the system becomes faster.

(II): Addition of poles reduces the system's relative stability by shifting the root locus to the right side in s-plane and thereby, slowing down the system response.

143. (b)

- A cache is a small, fast memory that holds copies of some of the contents of the main memory. Because the cache is fast, it provides higher-speed access for the CPU.
- Most frequently used block replacement algorithms in cache operations are Random and Least Recently Used (LRU).
- LIFO is never used as block replacement algorithms in cache operations due to its inherent inefficiency.

Hence, both the statements are correct.

144. (b)

The capture effect is defined as the complete suppression of the weaker signal at the receiver's limiter where the weaker signal is not amplified, but attenuated. When both signals are nearly equal in strength or are fading independently, the receiver may rapidly switch from one to another and exhibit flutter. The measurement of how well a receiver rejects a second signal on the same frequency is called its capture ratio.

145. (b)

146. (a)

In a turbine generator,the water pushes a series of blades mounted on a rotor shaft. The force of the fluid on the blades spins (rotates) the rotor shaft of a generator. The generator, in turn, converts the mechanical (kinetic) energy of the rotor to electrical energy.

147. (b)

148. (a)

149. (c)

The dual beam oscilloscope has two separate electron beams and therefore, two completely separate vertical channels.

150. (a)

- Bilinear Transformation only preserves the magnitude response of the analog filter.
- When the s-plane is mapped into z-plane using bilinear transformation, the non-linear relationship introduces distortion in frequency axis, which is known as frequency warping.

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