DETAILED SOLUTIONS

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ESE 2020 : Prelims Exam
CLASSROOM TEST SERIES

E & T ENGINEERING

Test 24

Full Syllabus Test 8 : Paper-II

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

DETAILED EXPLANATIONS

1. (b)

A graph is connected if there exist at least one path between any two vertices (nodes) of the network. So it should have atleast N branches for one or more closed path to exist.

2. (b)

For parallel RLC circuit, $Q = R\sqrt{\frac{C}{L}}$

and $\xi = 1 \text{ (critically damped)} = \frac{1}{2Q}$

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

$$2R = \sqrt{\frac{L}{C}} = \sqrt{\frac{18}{2} \times 10^6}$$

$$2R = \sqrt{9} \times 10^3 = 3 \text{ k}\Omega$$

$$R = 1.5 \text{ k}\Omega$$

3. (c)

To have $v(t)$ and $i(t)$ in phase, the circuit must be in resonance at $\omega = 10^4$ rad/sec.

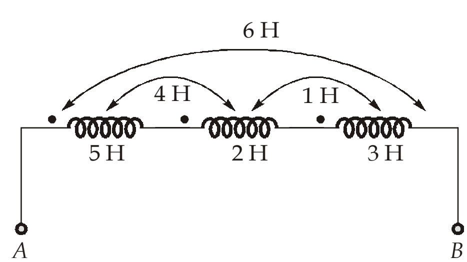
$$\omega_0 = \frac{1}{\sqrt{LC}} = 10^4 \text{ rad/sec}$$

$$\frac{1}{LC} = 10^8$$

$$C = \frac{1}{L \times 10^8} = \frac{1}{8 \times 10^5} = 1.25 \text{ μF}$$

4. (d)

The equivalent circuit with resultant dots can be drawn as

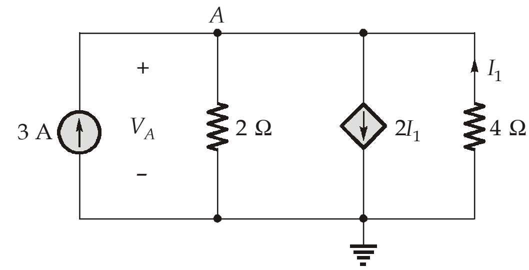


$\therefore$ $L_{AB} = L_1 + L_2 + L_3 + 2M_{12} + 2M_{13} + 2M_{23}$

$= 5 + 2 + 3 + 2(4) + 2(6) + 2(1) = 32$ H

5. (b)

By applying the KVL at node A, we get,



$$3\text{ A} + I_1 = 2I_1 + \frac{V_A}{2\,\Omega}$$

$$\frac{V_A}{2\,\Omega} + I_1 = 3\text{ A}$$

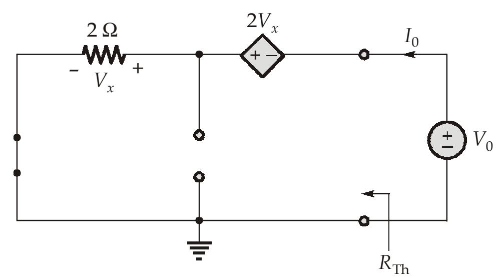
$$I_1 = -\frac{V_A}{4\,\Omega}$$

So, $$\frac{V_A}{2\,\Omega} - \frac{V_A}{4\,\Omega} = 3\text{ A} \Rightarrow \frac{V_A}{4\,\Omega} = 3\text{ A} \Rightarrow V_A = 12\text{ V}$$

The power delivered by the (3 A) source is equal to,

$$(3\text{ A})(V_A) = (3\text{ A})(12\text{ V}) = 36\text{ W}$$

6. (c)



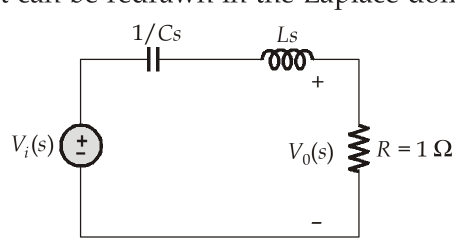
$$V_0 = -2V_x + V_x = -V_x$$

$$I_0 = \frac{V_x}{2\,\Omega} = \frac{-V_0}{2\,\Omega}$$

$$R_{Th} = \frac{V_0}{I_0} = -2\,\Omega$$

7. (b)

The given series RLC circuit can be redrawn in the Laplace domain as



Using voltage division rule, $$V_0(s) = \frac{1 \times V_i(s)}{1 + Ls + \frac{1}{Cs}} = \frac{Cs}{Cs + LCs^2 + 1}V_i(s)$$

$$\frac{V_0(s)}{V_i(s)} = \frac{1}{CL}\left[\frac{Cs}{s^2 + \frac{s}{L} + \frac{1}{LC}}\right] = \frac{s/L}{s^2 + \frac{s}{L} + \frac{1}{LC}} \quad \text{...(i)}$$

On comparing the given transfer function with equation (i), we get,

$$\frac{1}{L} = 2 \qquad \Rightarrow L = \frac{1}{2}$$

$$\frac{1}{LC} = 10 \qquad \Rightarrow \frac{C}{2} = \frac{1}{10}$$

or $$C = \frac{1}{10} \times 2 = \frac{1}{5} = 0.2\text{ F}$$

8. (c)

Using KCL, $I_1 + 3V_1 + I_2 = 0$

Using KVL, $V_1 - 4I_1 + 4I_2 = V_2$

$$V_1 - 4I_1 - 4(I_1 + 3V_1) = V_2$$

$$8I_1 = -11V_1 - V_2$$

Also, $8I_2 = -13V_1 + V_2$

After solving we get,

$$Y_{11} = \frac{-11}{8}\,℧, \quad Y_{12} = \frac{-1}{8}\,℧$$

$$Y_{21} = \frac{-13}{8}\,℧, \quad Y_{22} = \frac{1}{8}\,℧$$

9. (d)

Parameter	Condition for symmetry	Condition for reciprocity
z	$z_{11} = z_{22}$	$z_{12} = z_{21}$
y	$y_{11} = y_{22}$	$y_{12} = y_{21}$
T	$A = D$	$AD - BC = 1$
h	$h_{11}h_{22} - h_{12}h_{21} = 1$	$h_{12} = -h_{21}$

10. (c)

For series RL circuit, the impedance angle (ϕ) is given by

$$\tan\phi = \frac{\omega L}{R}$$

where, $\omega = 2\pi f$, $\phi = 60°$, $L = 50$ mH and $R = 30\ \Omega$

$$\therefore \quad \tan 60° = \frac{\omega \times 50 \times 10^{-3}}{30}$$

or $$\sqrt{3} = \frac{\omega \times 50 \times 10^{-3}}{30}$$

or $$\omega = \frac{3\sqrt{3}}{5 \times 10^{-3}}$$

$$\therefore \quad f = \frac{\omega}{2\pi} = \frac{3\sqrt{3}}{10\pi} \text{ kHz}$$

11. (d)

For $t < 0$, source $2u(t) = 0$

Therefore, $i_L(0^-) = i_L(0^+) = 0$ A

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

For $t > 0$ $\quad i_C(0^+) = 2$ mA

$$\because \quad i_C(0^+) = C\frac{dv_C(0^+)}{dt}$$

$$\therefore \quad \frac{dv_C(0^+)}{dt} = \frac{i_c(0^+)}{C} = \frac{2 \times 10^{-3}}{4 \times 10^{-3}} = 0.5 \text{ V/sec}$$

12. (c)

$$\eta = \frac{E}{H}$$

$$E = \eta \times H$$

For lossless non-magnetic medium,

$$\eta = \frac{120\pi}{\sqrt{\varepsilon_r}} = 120\pi\sqrt{\frac{1}{36}}$$

$$E = \frac{120\pi \times 6}{6} = 120\pi = 377 \text{ V/m } = 0.377 \text{ kV/m}$$

13. (a)

For an electromagnetic wave propagating in two mediums,

$$\frac{\lambda_1}{\lambda_2} = \sqrt{\frac{\varepsilon_{r_2}}{\varepsilon_{r_1}}}$$

Here, $$\frac{\lambda_0}{\lambda} = \sqrt{\frac{\varepsilon_r \, \varepsilon_0}{\varepsilon_0}}$$

or $$\lambda_0 = \lambda\sqrt{\varepsilon_r} = 10\sqrt{16} = 40 \text{ cm}$$

14. (a)

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

15. (a)

Average power density, $$P = \frac{1}{2}\frac{|E|^2}{\eta} = \frac{1}{2}\frac{(30)^2}{120\pi} = \frac{3.75}{\pi} \text{ W/m}^2$$

Area of circular cross section $= \pi r^2 = \pi(1)^2 = \pi \text{ m}^2$

Power crossing the circular cross-section $= \dfrac{3.75}{\pi}(\pi) = 3.75$ W

16. (c)

For the given S-matrix,

$$S_{12} = S_{21} = 0.2\angle 90° \Rightarrow \text{Reciprocal}$$

and $$S_{11} \cdot S_{11}^* + S_{21} \cdot S_{21}^* = 0.5 \times 0.5 + 0.2\angle 90° \times 0.2\angle -90° \neq 1 \Rightarrow \text{Not lossless or lossy}$$

17. (c)

By faraday's law, $$\nabla \times \vec{E} = -\frac{\partial \vec{B}}{\partial t}$$

and $$\vec{B} = \nabla \times \vec{A}$$

∴ $$\nabla \times \vec{E} = -\frac{\partial}{\partial t}(\nabla \times \vec{A})$$

$$\nabla \times \vec{E} = \nabla \times \left(-\frac{\partial \vec{A}}{\partial t}\right)$$

$\therefore$
$$\vec{E} = -\frac{\partial \vec{A}}{\partial t}$$

18. (a)

$$F_1 = \frac{Q_1 Q_2}{4\pi\varepsilon_0 R^2} \quad \text{...(i)}$$

and
$$F_2 = \frac{Q_1 Q_2}{4\pi\varepsilon_r \varepsilon_0 R^2} \quad \text{...(ii)}$$

From equation (*i*) and (*ii*)
$$\frac{F_1}{F_2} = \frac{1}{\frac{1}{\varepsilon_r}} = \varepsilon_r$$

$$F_2 = \frac{6.4}{2.4} = \frac{1.6}{0.6} = 2.67\ \mu\text{N}$$

19. (b)

$$\Gamma = \frac{\eta_2 - \eta_1}{\eta_2 + \eta_1} = \frac{500-100}{500+100} = \frac{400}{600} = \frac{2}{3}$$

$\therefore$ Reflected electric field,
$$E_r = \Gamma \times E_i$$
$$= \frac{2}{3} \times 60 = 40\ \text{V/m}$$

and Reflected magnetic field,
$$H_r = \frac{-E_r}{\eta_1} = \frac{-40}{100} = -\frac{2}{5}\text{A/m}$$

20. (b)

$$D = 4\pi \frac{U_{max}}{P_{rad}},$$

For normalized intensity, $U_{max} = 1$

$$P_{rad} = \int_{\phi=0}^{2\pi} \int_{\theta=0}^{\pi/2} \sin\theta \cdot \sin\theta\, d\theta\, d\phi = 2\pi \int_{\theta=0}^{\pi/2} \left(\frac{1-\cos 2\theta}{2}\right) d\theta = \frac{\pi^2}{2}$$

$\Rightarrow$
$$D = \frac{4\pi}{\frac{\pi^2}{2}} = \frac{8}{\pi}$$

21. (b)

For air-filled waveguide,
$$f_{c1} = \frac{c}{2a} = \frac{3 \times 10^{10}}{2 \times 7.5} = 2\ \text{GHz}$$

For waveguide (2)
$$f_{c2} = \frac{c}{2a\sqrt{\varepsilon_r}}$$

$$2 \times 10^9 = \frac{3\times10^{10}}{2a\sqrt{25}} = \frac{3\times10^{10}}{2\times a\times5}$$

$$a = \frac{3\times10^{10}}{4\times5\times10^9} = \frac{30}{20} = 1.5 \text{ cm}$$

22. (a)

For short circuited transmission line,

$$Z_{in} = jZ_0 \tan\beta l$$

where,
$$\beta = \frac{2\pi}{\lambda} = \frac{2\pi}{c/f} = \frac{2\pi}{\frac{3\times10^{10}}{3\times10^{10}}} \text{ rad/cm}$$

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

and
$$\beta l = 4\pi \text{ rad}$$

∴
$$Z_{in} = jZ_0 \tan(4\pi)$$

$$Z_{in} = 0$$

23. (d)

Check for controllability -

$$Q_C = [B : AB] = \begin{bmatrix}0\\1\end{bmatrix} : \begin{bmatrix}0\\-4\end{bmatrix} = \begin{bmatrix}0 & 0\\1 & -4\end{bmatrix}$$

∵
$$\rho(A) \neq \rho(Q_C)$$

and
$$|Q_C| = 0$$

∴ System is uncontrollable.

Check for observability,

$$Q_o = [C^T : A^T C^T]$$

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

∵
$$\rho(A) \neq \rho(Q_o)$$

Also
$$|Q_o| = 0$$

∴ System is unobservable.

24. (b)

Given,
$$T(s) = \frac{1+4Ts}{1+Ts} = \frac{1+T_1 s}{1+\alpha T_1 s}$$

where,
$$T_1 = 4\,T;\ \alpha T_1 = T$$

∴
$$\alpha = \frac{T}{4T} = \frac{1}{4}$$

Maximum phase shift is,
$$\sin\phi_m = \frac{1-\alpha}{1+\alpha}$$

$$\therefore \qquad \sin\phi_m = \frac{1-\frac{1}{4}}{1+\frac{1}{4}} = \frac{3}{5}$$

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

$$\therefore \qquad \phi_m = \tan^{-1}\left(\frac{3}{4}\right)$$

25. (c)

For the given $G(s)$, the sinusoidal transfer function is

$$G(j\omega) = \frac{K}{j\omega(1+j0.2\omega)(1+j0.05\omega)}$$

$$= \frac{K}{-0.25\omega^2 + j\omega(1-0.01\omega^2)}$$

At the phase crossover frequency ω_{pc}, the $G(j\omega)$ is real.

$\therefore$ equate imaginary part to zero and solve for ω_{pc}.

$$\therefore \qquad \omega_{pc}(1 - 0.01\,\omega_{pc}^2) = 0$$

Since $\omega_{pc} \neq 0$

$$\therefore \qquad 1 - 0.01\,\omega_{pc}^2 = 0$$

$$\Rightarrow \qquad \omega_{pc} = 10 \text{ rad/s}$$

The Nyquist plot intersects the real axis at a point where $G(j\omega)$ is real.

$$|G(j\omega)|_{\omega=\omega_{pc}} = \frac{K}{0.25\omega_{pc}^2} = \frac{K}{0.25\times 100} = \frac{K}{25} = 0.04\text{ K}$$

Given that, gain margin = 20 dB,

$$20\log\frac{1}{|G(j\omega)|_{\omega=\omega_{pc}}} = 20\text{ dB}$$

$$\frac{1}{|G(j\omega)|_{\omega=\omega_{pc}}} = 10$$

$$|G(j\omega)|_{\omega=\omega_{pc}} = 0.1$$

i.e. $\qquad 0.1 = 0.04\text{ K}$

$$K = \frac{0.1}{0.04} = 2.5$$

26. (c)

The response has two exponentially decaying terms with different time constants.

So, the system is overdamped.

27. (d)

Given, $$E(s) = \frac{4(s+6)}{s(s+8)}$$

$\therefore$ $$e(\infty) = \lim_{s\to 0}[sE(s)] \quad \text{(Using final value theorem)}$$

or, $$e(\infty) = \lim_{s\to 0}\left[s\frac{4(s+6)}{s(s+8)}\right] = \lim_{s\to 0}\left[\frac{4(s+6)}{(s+8)}\right] = \frac{4\times 6}{8} = 3$$

28. (d)

Given, $$R(s) = \frac{1}{s}$$

$\therefore$ $$\frac{C(s)}{R(s)} = \frac{\frac{K}{s}}{1+\frac{K}{s}} = \frac{K}{s+K}$$

Also, $$\frac{E(s)}{R(s)} = \frac{1}{1+G(s)H(s)} = \frac{s}{s+K}$$

or, $$E(s) = \left(\frac{s}{s+K}\right)\times\frac{1}{s} = \frac{1}{s+K}$$

$\therefore$ $$e(t) = e^{-Kt}\,u(t)$$

$\therefore$ $$I_e = \int_0^\infty e^2(t)\,dt = \int_0^\infty e^{-2Kt}dt = \left[\frac{e^{-2Kt}}{-2K}\right]_0^\infty = -\frac{1}{2K}[0-1] = \frac{1}{2K} = \frac{1}{2\times 0.25} = 2$$

29. (a)

From the given figure,

characteristic equation of the closed loop system,

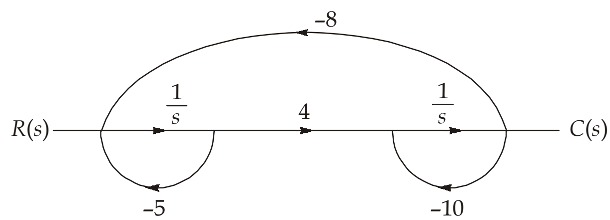
$$(s+4)^2 + 4 = 0$$
$$s^2 + 8s + 20 = 0$$
$$2\xi\sqrt{20} = 8$$
$$\xi = \frac{4}{\sqrt{20}} = \frac{2}{\sqrt{5}}$$

for 2% tolerance, settling time, $$t_s = \frac{4}{\xi\omega_n} = \frac{4}{\frac{2}{\sqrt{5}}\sqrt{20}} = \frac{4}{4}$$

$\therefore$ $$t_s = 1 \text{ sec}$$

30. (c)

The signal flow graph of the above given block diagram,



By applying Mason's gain formula, $\dfrac{C(s)}{R(s)} = \dfrac{\Sigma P_i \Delta_i}{\Delta}$

$$= \frac{\dfrac{4}{s^2}}{1+\dfrac{5}{s}+\dfrac{10}{s}+\dfrac{32}{s^2}+\dfrac{50}{s^2}} = \frac{\dfrac{4}{s^2}}{1+\dfrac{15}{s}+\dfrac{82}{s^2}}$$

$$\frac{C(s)}{R(s)} = \frac{4}{s^2+15s+82}$$

31. (a)

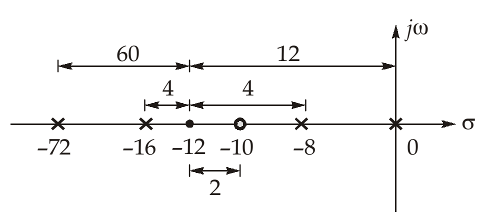
Given, $$G(s)H(s) = \frac{K(s+10)}{s(s+8)(s+16)(s+72)}$$

Magnitude conditions for given open loop from system function,

$$|G(s)H(s)| = 1$$

thus $$\left|\frac{K(s+10)}{s(s+8)(s+16)(s+72)}\right| = 1$$

i.e., $$K = \frac{\Pi\,(\text{vector distances from OL poles to } s = -12)}{\Pi\,(\text{vector distances from OL zeros to } s = -12)}$$



$$K = \frac{12\times 4\times 4\times 60}{2} = 5760$$

32. (c)

33. (d)

34. (d)

35. (c)

36. (b)

We know that,

deflection torque, $T_d = I^2 \frac{dM}{d\theta}$

where, $\frac{dM}{d\theta} = \frac{d}{d\theta}[-6\cos(\theta + 30°)]$

$\frac{dM}{d\theta} = 6 \sin(\theta + 30°)$ mH/degree

$\frac{dM}{d\theta}$ at a deflection of 60° is,

$$\left(\frac{dM}{d\theta}\right)_{\theta = 60°} = 6 \sin(60° + 30°) \text{ mH/degree} = 6 \times 10^{-3} \text{ H/degree}$$

$\therefore$ $T_d = I^2 \frac{dM}{d\theta} = (50 \times 10^{-3})^2 \times 6 \times 10^{-3}$

$= 15 \times 10^{-6}$ N-m $= 15$ μN-m

37. (b)

38. (d)

We know that,

Voltage produced by piezo-electric crystal,

$E_0 = Pgt$

$\therefore$ Pressure, $P = \frac{E_0}{gt} = \frac{100}{0.055 \times 1.5 \times 10^{-3}} \text{N/m}^2$

$\therefore$ $P = 1.2 \text{ MN/m}^2$

force applied, $F = PA = 1.2 \times 10^6 \times 5 \times 5 \times 10^{-6} = 30$ N

39. (c)

40. (d)

Deflection sensitivity, $s = \frac{D}{E_d} = \frac{Ll_d}{2dE_a}$

$\therefore$ There is no relation between the deflection sensitivity and deflection voltage.

41. (b)

Given, maximum number of pulses,

$n_{max} = 10000$ pulses

$t_r = 50$ ms

for, Ramp type DVM, $n_{max} = t_r \times f_{clk}$

$\therefore$ $f_{clk} = \frac{n_{max}}{t_r} = \frac{10000}{50 \times 10^{-3}}$

$f_{clk} = 200$ kHz

42. (d)

Gauge factor, $G_f = 1 + 2\gamma + \frac{\Delta\rho/\rho}{\in}$

by neglecting piezoresistive effect, $G_f = 1 + 2\gamma$

$$\text{Poisson's ratio, } \gamma = \frac{G_f - 1}{2} = \frac{4.2 - 1}{2} = 1.6$$

43. (b)

44. (c)

45. (b)

When $V_S < 0$ V,

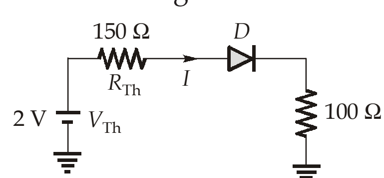
$$V_L = \frac{R}{R+R} \cdot V_S = \frac{1}{2} \times (-10) = -5 \text{ V}$$

When $V_S > 0$ V $\quad V_L = V_{in}$

$$\therefore \quad V_{L(avg)} = \frac{10(T/2) + (-5)(T/2)}{T} = 2.5 \text{ V}$$

46. (c)

Drawing the Thevenin's equivalent circuit we get



$$\therefore \quad I = \frac{2 - 0.7}{250 + 30} = \frac{1.3}{280} \text{A} \simeq 4.643 \text{ mA}$$

47. (b)

$$R_{in} = r_\pi + (\beta + 1)R_E$$

Now, in this transistor configuration,

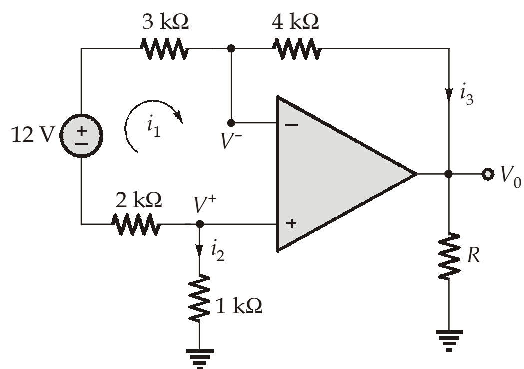
$$R_E = r_\pi/\beta$$

$$\therefore \quad R_{in} = r_\pi + (\beta + 1)\frac{r_\pi}{\beta} \approx r_\pi + r_\pi = 2r_\pi$$

48. (d)

Negative feedback increases the bandwidth.

49. (b)



$$V^+ - V^- = 0 \quad \text{(due to virtual ground)}$$

Applying KVL at loop i_1

$$12 - 3ki_1 - 0 - 2ki_1 = 0$$

$$i_1 = \frac{12}{5\times10^3} = 2.4\text{ mA} = i_3$$

$$i_2 = -i_1 = -2.4\text{ mA}$$

∴ $$V_0 = V^- - i_3(4\text{ k}\Omega)$$

$$V^- = V^+ = i_2(1\text{ k}\Omega) = -2.4\text{ V}$$

So, $$V_0 = (-2.4) - (2.4\times 4) = -12\text{ V}$$

50. (d)

$$I_C = I_S \exp\left(\frac{V_{BE}}{V_T}\right)$$

$$V_0 = -V_{BE} = -V_T \ln\left(\frac{I_C}{I_S}\right)$$

$$I_C = \frac{1}{135.336}\times10^{-6}$$

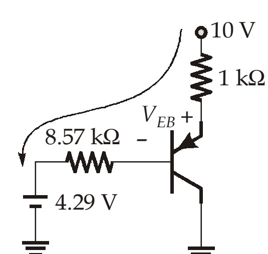
$$I_C = 7.389\text{ nA}$$

∴ $$V_0 = -25\times10^{-3}\times\ln(7.389) \approx -50\text{ mV}$$ [Note: $e^2 = 7.389$]

51. (b)

$$R_{Th} = 20\text{ k}\Omega \parallel 15\text{ k}\Omega = 8.57\text{ k}\Omega$$

and $$V_{Th} = \frac{15}{15+20}\times10 = 4.29\text{ V}$$



Applying KVL, we get, $$I_B = \frac{10-4.29-0.7}{101+8.57}\text{mA}$$

$$I_B = 46\ \mu\text{A}$$

∴ $$V_B = 4.29 + I_B R_{Th}$$

$$= 4.29 + 46\times10^{-6}\times8.57\times10^3 = 4.69\text{ V}$$

52. (a)

$$A_f = \frac{A}{1+A\beta} \quad \ldots(i)$$

$$\frac{\partial A_f}{\partial A} = \frac{1}{(1+A\beta)^2} \quad \ldots(ii)$$

$$\frac{\partial A_f}{A_f} = \frac{\partial A}{A}\left(\frac{1}{1+A\beta}\right)$$

$$\frac{1}{1000} = \frac{100}{1000}\left(\frac{1}{1+1000\beta}\right)$$

$$1 + 1000\beta = 100$$

$$1000\beta = 99$$

$$\beta = \frac{99}{1000} = 0.099$$

53. (b)

$$R = \frac{\eta\lambda_{\mu m}}{1.24}$$

By keeping η constant, as λ increases, responsivity increases.

54. (d)

$$\tau_d = \frac{\varepsilon_{si}}{\sigma} = \frac{1.03\times10^{-12}}{2} = 0.515\times10^{-12} = 0.515 \text{ ps}$$

55. (c)

$$|E(x)| = \left|\left(\frac{kT}{q}\right)\cdot\frac{1}{N_d(x)}\cdot\frac{dN_d(x)}{dx}\right| = \frac{-(0.026)\times(-10^{19})}{10^{16}-10^{19}\times0.5\times10^{-4}}$$

$$= \frac{(0.026)\times10^{19}}{9.5\times10^{15}}\text{V/cm} = 27.36 \text{ V/cm}$$

56. (c)

Since for n-type substrate the value of threshold voltage will be (+ve)

57. (b)

Thermal equilibrium minority concentration,

$$p_0 = \frac{n_i^2}{n} = \frac{n_i^2}{N_D} = \frac{10^{20}}{10^{16}} = 10^4 \text{ cm}^{-3}$$

Excess minority concentration due to light illumination,

$$G_L\tau_p = 10^{10}\times10^{-6} = 10^4 \text{ cm}^{-3}$$

Steady state minority concentration $= p_0 + G_L\tau_p = 2\times10^4 \text{ cm}^{-3}$

58. (b)

Given,
$$I_V \propto I_D$$
$$I_V = KI_D$$
$$K = \frac{\partial I_V}{\partial I_D} = \frac{40 \text{ mCd}}{1 \text{ mA}} = 40 \text{ Cd/A}$$

When $I_V = 1$ Cd,
$$I_D = \frac{I_V}{K} = \frac{1}{40} = 25 \times 10^{-3} \text{ A}$$

Now,
$$R = \frac{V_s - 1.6 \text{ V}}{I_D} = \frac{5 - 1.6}{25 \times 10^{-3}} = 136\ \Omega$$

59. (a)

$$Q_j = A_q\left(\frac{1}{N_A} + \frac{1}{N_D}\right) \cdot W$$

∴ $Q_j \propto W \Rightarrow$ Statement-1 is correct

And, statement-2 is incorrect.

60. (b)

$$I_B = \frac{I_C - I_{CEO}}{\beta} = \frac{1.2 \times 10^{-3} - 5 \times 10^{-6}}{50} = 23.9\ \mu\text{A}$$

61. (d)

62. (c)

Tetragonal: $a = b \neq c$, $\alpha = \beta = \gamma = 90°$

Monoclinic: $a \neq b \neq c$, $\alpha \neq 90°$, $\beta = \gamma = 90°$

Triclinic: $a \neq b \neq c$, $\alpha \neq \beta \neq \gamma$

Rhombohedral: $a = b = c$, $\alpha = \beta = \gamma \neq 90°$

63. (c)

All ferroelectrics are pyroelectric but converse is not always true.

64. (b)

65. (c)

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

H_C varies parabolically with temperature.

at $T = T_C$, $H_C = 0$

and $T = 0$ K, $H_C = H_0$ (maximum value)

66. (b)

$$B_{sat} = \mu_0(H + M_{sat})$$
$$0.95 = (4\pi \times 10^{-7})(50 + M_{sat})$$
$$\Rightarrow \quad \frac{0.95 \times 10^7}{4\pi} - 50 = M_{sat}$$
$$M_{sat} \simeq \frac{95}{4\pi} \times 10^5 \text{ A/m} \simeq 7.56 \times 10^5 \text{ A/m}$$

67. (a)

Magnetic leviation is a method by which an object is suspended with no support other than magnetic fields. Superconductors are ideal or perfect diamagnetic ($\mu_r = 0$) and have property of completely expelling magnetic field due to Meissner effect.

68. (c)

69. (b)

$$\text{Dielectric loss} = \frac{E^2 f \varepsilon_r \tan\delta}{1.8 \times 10^{12}} \text{W/cm}^3$$
$$\varepsilon_r = \frac{1.8 \times 10^{12} \times 0.45 \times 10^{-3}}{(30 \times 10^3)^2 \times 100 \times 0.005} = 1.8$$

70. (d)

71. (a)

Radius of a cell, $R = 0.64$ km

The coherent reuse factor $q = 12$

$$q = \frac{D}{R}; \text{ where } D = \text{distance from nearest cochannel cell.}$$
$$D = 12 \times 0.64 = 7.68 \text{ km}$$

72. (d)

Dopler shift, $\Delta f_d = \dfrac{V_m \cos\theta}{\lambda_c}$

Where, V_m = relative velocity of mobile

θ = angle between the motion of mobile and direction of the arrival of the scattered wave

Since $\theta = 90°$, $\Delta f_d = 0$

So, received carrier frequency = 900 MHz.

73. (c)

74. (c)

The skew rays changes direction by 90° at each reflection therefore $\gamma = 45°$.

Acceptance angle, $\theta_{as} = \sin^{-1}\left(\dfrac{NA}{\cos\gamma}\right) = \sin^{-1}\left(\dfrac{NA}{\cos 45°}\right)$

$$\theta_{as} = \sin^{-1}\left(\frac{\frac{1}{2}}{\frac{1}{\sqrt{2}}}\right) = \sin^{-1}\left(\frac{1}{\sqrt{2}}\right) = 45°$$

75. (c)

A high PRF will reduce the maximum range.

76. (c)

77. (a)

1. Packet switching is used by layer 3 i.e., network layer.
2. Circuit switching is an issue of physical layer.
3. IPv6 supports 128 bit address.
4. IPv4 is an unreliable datagram protocol. It is connectionless protocol. Each datagram is treated independently.

78. (b)

$$\left[\frac{C}{I}\right]_D = (34 - 34) + 40 - 24 + 4 = 20 \text{ dB}$$

79. (a)

Routing algorithms are executed at each and every node both in LS and DV.

In Link State Routing we use flooding to share updates hence more number of network message are required.

80. (c)

Bandwidth of the line = 1 Mbps

Round trip delay = 20 mSec

So, system can send 20,000 bits [$1 \times 10^6 \times 20 \times 10^{-3}$] during the time it takes for data to go from sender to receiver and the acknowledgement to come back. But system sends only 1000 bits.

So, Link utilisation $= \frac{1000}{20000} \times 100 = 5\%$

81. (c)

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

$$e_2 = M\frac{di_2}{dt} = M\,(500 \text{ mA/sec}) = 100 \text{ mV}$$

$$M = k\sqrt{L_1L_2} = \sqrt{L_1L_2} = \frac{1}{5}$$

$$\frac{L_1}{L_2} = \frac{L_1^2}{L_1L_2} = (0.4)^2 \times 25 = 4$$

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

$$N_1 = 2N_2 = 200$$

82. **(d)**

For optical amplification to take place in laser

$$\text{Length} = \frac{K\lambda}{2n}$$

where, K is any integer value 1, 2, 3, 4, ...
and n = refractive index of crystal.

and number of modes, $$K = \frac{2nL}{\lambda} = \frac{2 \times 1.8 \times 4 \times 10^{-2}}{0.5 \times 10^{-6}} = 288 \times 10^3$$

83. **(c)**

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

84. **(d)**

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

85. **(d)**

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

A = 2 for wave-wound generators.

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

Leakage coefficient, $$\lambda = \frac{\text{total flux/pole}}{\text{working flux/pole}} = \frac{0.018}{0.015} = 1.20$$

86. **(c)**

87. **(c)**

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

For series motor, $$T \propto I_a^2$$

$$E_b \propto NI_a$$

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

$$\frac{T_2}{T_1} = \left(\frac{N_2}{N_1}\right)^2 = \frac{1}{4} = \left(\frac{I_{a2}}{I_{a1}}\right)^2$$

So, $\frac{I_{a2}}{I_{a1}} = \frac{1}{2}$

$$\frac{V_2}{V_1} = \frac{E_{b2}}{E_{b1}} = \frac{N_2}{N_1} \times \frac{I_{a2}}{I_{a1}} = \frac{1}{2} \times \frac{1}{2} = \frac{1}{4}$$

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

88. (d)

Since both voltage and frequency are doubled, the flux density will remain constant.

With 1000 V at 50 Hz:

$$W_h = Af = 650 \text{ W} \quad \Rightarrow \quad A = \frac{650}{50} = 13$$

$$W_e = Bf^2 = 350 \text{ W} \quad \Rightarrow \quad B = \frac{350}{50 \times 50} = \frac{7}{50} = \frac{14}{100}$$

With 2000 V at 100 Hz:

$$W_h = Af = 13 \times 100 = 1300 \text{ W}$$

$$W_e = Bf^2 = \frac{14}{100} \times 100 \times 100 = 1400 \text{ W}$$

So, the new core loss will be, $P_{core} = W_h + W_e = 1300 + 1400 = 2700$ W

89. (b)

Load share of A, $S_A = \frac{Z_B}{Z_A + Z_B} S = \frac{2}{6} S = \frac{S}{3}$

Load share of B, $S_B = \frac{Z_A}{Z_A + Z_B} S = \frac{4}{6} S = \frac{2S}{3}$

Transformer B is over loaded by,

$$\frac{\frac{2S}{3} - \frac{S}{3}}{S} \times 100 = 33.3\%$$

90. (d)

Given induction motor,

$$\text{Synchronous speed} = \frac{120 f}{P} = \frac{120 \times 50}{6} = 1000 \text{ rpm}$$

The slip of motor while running at 960 rpm

$$\frac{1000 - 960}{1000} = \frac{40}{1000} = 0.04 \text{ or } 4\% \text{ slip}$$

Rotor impedance while running, $Z_r = (R_0 + jsX_0)$

Where R_0 = rotor resistance at stand still

X_0 = rotor reactance at stand still

$$Z_r = 3 + j0.04 \times 4 = (3 + j0.16)\ \Omega$$

91. (b)

$$a = \frac{R_2}{X_2} = \frac{0.01}{0.1} = 0.1$$

Full-load slip, $S_f = 0.04$

$$\frac{T_{max}}{T_f} = \frac{a^2 + S_f^2}{2aS_f} = \frac{(0.1)^2 + (0.04)^2}{2(0.1 \times 0.04)} = \frac{0.0116}{0.008} = 1.45$$

92. (a)

Nuclear power plants are used as base load plant due to technical problem of control. Hence statement-3 is not correct.

93. (c)

From the property of impulse $\delta(at+b) = \frac{1}{|a|}\delta\left(t + \frac{b}{a}\right)$

$$\int_{-2}^{2} (t-3)\delta(2t+2)\,dt = \frac{1}{2}\int_{-2}^{2} (t-3)\delta(t+1)\,dt$$

$$\int_{t_1}^{t_2} x(t)\delta(t-t_0)dt = x(t_0)\ ; \quad t_1 < t_0 < t_2$$

So, $$\frac{1}{2}\int_{-2}^{2} (t-3)\delta(t+1)\,dt = \frac{1}{2}(-1-3) = -2$$

94. (d)

Transient-time noise is more dominant at high frequencies.

Random noise power is proportional to the bandwidth over which it is measured.

95. (b)

$$P_t = P_c\left(1 + \frac{\mu^2}{2}\right) = 400\left[1 + \frac{(0.75)^2}{2}\right] = 512.5 \text{ W}$$

96. (a)

Modulation index, $$\beta = \frac{K_f A_m}{f_m} = \frac{\Delta f}{f_m}$$

Carson's rule bandwidth, $BW = (1 + \beta)2f_m$

By increasing frequency deviation (Δf) by keeping modulating frequency (f_m) constant, both the modulation index (β) and bandwidth will increase.

Since f_m is kept constant, the frequency separation between the adjacent sideband components will remain constant.

97. (a)

Let, $m(t) = A_m\cos(2\pi f_m t)$. Then,

The maximum phase deviation of FM signal is,

$$\Delta\phi_{\text{max (FM)}} = \frac{A_m k_f}{f_m}$$

The maximum phase deviation of PM signal is,

$$\Delta\phi_{\text{max (PM)}} = A_m k_p$$

So,
$$\frac{A_m k_f}{f_m} = A_m k_p$$

$$f_m = \frac{k_f}{k_p} = \frac{10}{4}\text{ kHz} = 2.5\text{ kHz}$$

98. (b)

The destination SNR of a DSB-SC receiver can be given as,

$$\left(\frac{S}{N}\right)_d = \frac{S_r}{N_0 B}$$

Here, S_r = signal power at receiver input

B = message bandwidth = 10 kHz

$$\left(\frac{S}{N}\right)_d = 10^5 \text{ (or) } 50 \text{ dB}$$

$$N_0 B = 2\left(\frac{N_0}{2}\right)B = 2\times10^{-12}\times10^4 = 2\times10^{-8}\text{W}$$

so
$$S_r = \left(\frac{S}{N}\right)_d (N_0 B) = 10^5\times2\times10^{-8} = 2\times10^{-3}\text{W}$$

$$\text{channel loss} = 50 \text{ dB} \Rightarrow \frac{S_t}{S_r} = 10^5$$

S_t = Signal power at the transmitter output

So,
$$S_t = 10^5 \times 2 \times 10^{-3} = 200 \text{ W}$$

99. (b)

Squelch circuit (also called muting circuit) is used to keep the receiver audio turned off when there is no signal at the receiver input.

When the received signal is absent, the squelch circuit will turn-off the audio amplifier.

100. (d)

101. (d)

$$E[Y] = \int_{-\infty}^{\infty} \cos(\pi x) f_X(x)dx$$

$$f_X(x) = \begin{cases} 1 \; ; & -\frac{1}{2} < x < \frac{1}{2} \\ 0 \; ; & \text{otherwise} \end{cases}$$

So, $$E[Y] = \int_{-1/2}^{1/2} (1)\cos(\pi x)dx = 2\int_{0}^{1/2} \cos(\pi x)dx$$

$$= 2\left[\frac{\sin(\pi x)}{\pi}\right]_0^{1/2} = \frac{2}{\pi}\sin\left(\frac{\pi}{2}\right) = \frac{2}{\pi}$$

102. (c)

Both the given statements are valid for a Gaussian process.

103. (a)

Number of bits/sample, $n = \log_2(L)$

L = number of quantization levels

For $L = 4$, $n = \log_2(4) = 2$

For L = 64, $n = \log_2(64) = 6$

$$R_b \propto n$$

$$BW \propto R_b \propto n$$

Since n become 3 times, the BW requirement also become 3 times.

104. (c)

105. (b)

106. (c)

107. (d)

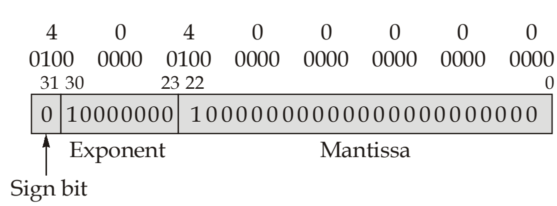
- Pseudocode is an informal language that has no syntax rules, and it is not meant to be compiled or executed. So, programmes do not have to worry about syntax errors while writing pseudocode and they have to focus all of their attention on the program's design.
- Hand tracing is a simple debugging process for locating hand to find errors in a program.

108. (b)

As one goes down the hierarchy,

- Cost per bit will decrease
- Capacity will increase
- Access time will increase

109. (d)



$$\text{Exponent} = (10000000)_2 = (128)_{10}$$

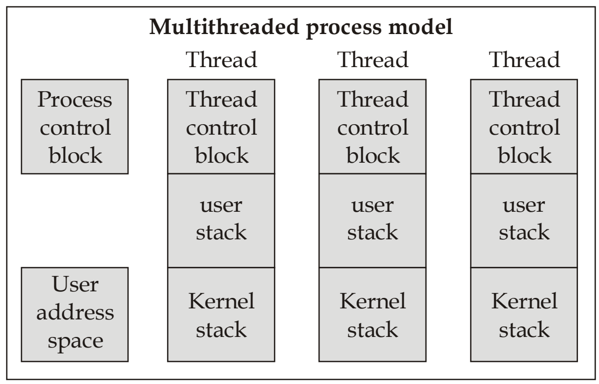
$$\text{Decimal equivalent} = +(1.100)_2 \times 2^{(128-127)} = +1.5 \times 2 = +3$$

110. (d)

$$\text{Memory cycle time} = 60 + 40 = 100 \text{ ns}$$

$$\text{Maximum data rate} = \frac{32 \text{ bits}}{100 \text{ ns}} = 320 \text{ Mbps}$$

111. (c)



In a multithreaded process model, each thread of a process contains a separate user stack and kernel stack; But, the user address space is common to all the threads of the process.

112. (b)

Banker's algorithm is used for deadlock avoidance.

113. (b)

The process will be interrupted at time 2 seconds in the first queue, time (2 + 7) seconds in the second queue, time (9 + 12) seconds in the third queue, time (21 + 17) in the fourth queue, and it will get terminated in the fifth queue. So, before completion of execution, the process gets interrupted 4 times.

114. (c)

Since 2^{24} bytes physical memory, physical address contains 24 bits. Since page size is 2^{10} bytes, page offset need 10 bits. So, page frame representation need (24 – 10) = 14 bits.

115. (a)

Belady's anomaly does not occur in LRU and optimal page replacement algorithms.

116. (b)

A prime attribute is an attribute that appears in some candidate key of given relation *R*.

117. (d)

118. (d)

Q_2	Q_1	Q_2^+	Q_1^+	T_2	T_1
0	0	1	0	1	0
0	1	0	0	0	1
1	0	1	1	0	1
1	1	0	1	1	0

Excitations required, $T_2 = Q_2 \odot Q_1$ and $T_1 = Q_2 \oplus Q_1$

119. (b)

120. (c)

Given,
$$(211)_x = (152)_8$$
$$2x^2 + x + 1 = 64 + 40 + 2$$
$$2x^2 + x + 1 = 106$$

Cross check by substituting options,

$\therefore$ option (c) satisties i.e., $x = 7$

121. (d)

$$\text{Output} = \text{BCD code} + 0011 \Rightarrow \text{Excess-3 code}$$

122. (b)

$$\text{Logic Swing} = V_{OH} - V_{OL} = 2.4 - 0.4 = 2.0 \text{ V}$$
$$\text{High State Noise Margin} = V_{OH} - V_{IH} = 2.4 - 2 = 0.4 \text{ V}$$
$$\text{Low State Noise Margin} = V_{IL} - V_{OL} = 0.8 - 0.4 = 0.4 \text{ V}$$
$$\therefore \quad X = 2.0 + 0.4 + 0.4 = 2.8 \text{ V}$$

123. (d)

124. (d)

$$Y = \bar{A}C + \left[(AB)(\bar{B} + C)\right]$$
$$= \bar{A}C + ABC = C(\bar{A} + AB) = (\bar{A} + B)C$$

125. (c)

$$CD = \sqrt{\lambda g} = \sqrt{0.4 \times 50}\ \mu\text{m} = \sqrt{20} = 2\sqrt{5} \simeq 4.47\ \mu\text{m}$$

126. (d)

In retrograde well technology, high-energy implantation is used. So, it can form the well under low-temperature and short-time conditions. Hence, it can reduce the lateral diffusion and increase the device density. The doping profile of the well, in this case, can have a peak at a certain depth in the silicon substrate. Because of high doping near the bottom, the well resistivity is lower than that of the conventional well, and the latch-up problem can be minimized.

Higher well doping at the bottom can also reduce the chance of punch through from the drain to the source.

127. (c)

128. (a)

129. (d)

130. (d)

131. (d)

A macro may also be used in a data segment.

132. (a)

An embedded system can be either real-time or non-real time system depending on the required application.

133. (c)

(Number of samples $N = 4$)

and $x_1(n) = \{x[3], x[0], x[1], x[2]\}$

$x_1(n) = x(n-1)$ [Circular right shift of $x(n)$]

Using time shift property of DFT

$$x(n-1) \xrightarrow{DFT} \left(e^{-j\frac{\pi}{2}}\right)^k X[k]$$

$$x(n-1) \xrightarrow{DFT} (-j)^k X[k]$$

$$X_1[k] = \{1, 1, 1, 1\}$$

134. (a)

Given, $H(z) = 6 + z^{-1} - z^{-2}$

by factoring the system function we find the zeros for the system.

The zeros of the given system are at

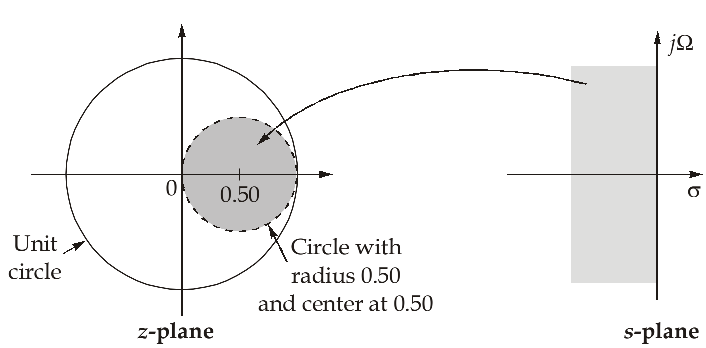
$$H(z) = \left(z+\frac{1}{2}\right)\left(z-\frac{1}{3}\right)$$

$\therefore$ $H(z)$ has zero at $z = \frac{-1}{2}, \frac{1}{3}$

Hence, the system is minimum phase system.

135. (d)

For the "backward difference method", the mapping of LHP of s-plane is as follows:



136. (d)

$$\lambda_g = \frac{\lambda_0}{\sqrt{1-\left(\frac{\lambda_0}{\lambda_c}\right)^2}}$$

137. (b)

138. (d)

Two local variables cannot have same name in the same module. But a local variable in one module can have the same name as a local variable in a different module. So, statement (I) is incorrect.

139. (a)

140. (a)

141. (c)

Star-delta starter is used to limit starting current. It is one of reduced voltage starting methods.

142. (a)

In mobile radio communication systems, the signal reception at the mobile units which are very near to cell site is low due to narrow antenna beamwidth (in the vertical plane) of a high-gain omnidirectional antenna used at the cell site. The large elevation angle caused by narrow beam width of the antenna causes the mobile unit to be in the shadow region. The larger the elevation angle, the weaker the reception level at the mobile unit located nearer to the cell-site due to the antenna's vertical radiation pattern.

143. (a)

144. (a)

With decrease in the size of QDs, the effective band-gap energy increases. As a result, light absorption and emission shift towards higher energies. Blue shift in the optical spectra of QDs with decrease in size can be observed. Photocurrent increases with decrease in QD size owing to the shift of conduction band towards more negative potential, which in turn improves the condition for charge injection. On the contrary, with increase in the size of QDs, better absorption in the visible region is observed. However, smaller sizes have better electron injection into the transporting layer than the bigger ones. This size-based optimization of efficient charge separation improves photoelectrochemical response and photoconversion efficiency. So a combination of different sized QDs must improve the photon absorption scenario, which will definitely improve the efficiency of SCs.

145. (c)

$$v = L\frac{di}{dt}$$

Thus, the potential drop across the inductor is proportional to the rate of change of the current.

For direct current, $\frac{di}{dt} = 0 \Rightarrow v = 0 \Rightarrow$ acts like a short circuit.

146. (a)

147. (c)

Slew rate is the maximum rate of change of the output voltage of the operational amplifier when a large amplitude step is applied to its input.

148. (a)

149. (c)

In a potentiometer, an electrically conductive wiper slides across a fixed resistive element.

150. (a)

❍❍❍❍