DETAILED SOLUTIONS

# MADE EASY

India's Best Institute for IES, GATE & PSUs

**Test Centres:** Delhi, Noida, Hyderabad, Bhopal, Jaipur, Lucknow, Bhubaneswar, Indore, Pune, Kolkata, Patna

## ESE 2020 : Prelims Exam
## CLASSROOM TEST SERIES

## E & T ENGINEERING

## Test 6

**Section A :** Electronic Devices & Circuits + Advanced Communication Topics

**Section B :** Control Systems-1 + Microprocessors and Microcontroller-1

**Section C :** Network Theory-2 + Digital Circuits-2

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **1.** | (a) | **16.** | (b) | **31.** | (a) | **46.** | (c) | **61.** | (b) |
| **2.** | (d) | **17.** | (d) | **32.** | (d) | **47.** | (d) | **62.** | (b) |
| **3.** | (b) | **18.** | (b) | **33.** | (c) | **48.** | (d) | **63.** | (c) |
| **4.** | (c) | **19.** | (c) | **34.** | (b) | **49.** | (c) | **64.** | (c) |
| **5.** | (c) | **20.** | (b) | **35.** | (c) | **50.** | (b) | **65.** | (c) |
| **6.** | (b) | **21.** | (d) | **36.** | (c) | **51.** | (c) | **66.** | (c) |
| **7.** | (a) | **22.** | (c) | **37.** | (a) | **52.** | (d) | **67.** | (a) |
| **8.** | (c) | **23.** | (b) | **38.** | (d) | **53.** | (a) | **68.** | (b) |
| **9.** | (a) | **24.** | (a) | **39.** | (c) | **54.** | (c) | **69.** | (c) |
| **10.** | (b) | **25.** | (d) | **40.** | (b) | **55.** | (b) | **70.** | (a) |
| **11.** | (a) | **26.** | (b) | **41.** | (a) | **56.** | (d) | **71.** | (b) |
| **12.** | (c) | **27.** | (d) | **42.** | (a) | **57.** | (d) | **72.** | (d) |
| **13.** | (d) | **28.** | (c) | **43.** | (a) | **58.** | (c) | **73.** | (a) |
| **14.** | (d) | **29.** | (c) | **44.** | (a) | **59.** | (a) | **74.** | (c) |
| **15.** | (a) | **30.** | (c) | **45.** | (c) | **60.** | (a) | **75.** | (b) |

## DETAILED EXPLANATIONS
### Section A : Electronic Devices & Circuits + Advanced Communication Topics

**1. (a)**

Connecting a resistor from base of a transistor to ground/negative voltage helps in reducing the switching time of the transistor. When transistor saturate, there is stored charge in the base that must be removed before it turns off.

**2. (d)**

Maximum electric field, $E_{max} = \dfrac{2(V_{bi} + V_R)}{W}$

Where, $V_{bi}$ = 2 V; $|V_R| = 5$ V; $W$ = 7 μm

$$\therefore \quad E_{max} = \frac{2(2+5)}{7\times10^{-4}} \text{ V/cm}$$

$$E_{max} = 20 \text{ kV/cm}$$

**3. (b)**

Diffusion capacitance, $C_D = \dfrac{\tau I_f}{\eta V_T}$

or $C_D = \dfrac{\tau}{r_d}$ ; where $r_d$ = dynamic resistance

or $C_D = \tau g_d$ ; where $g_d$ = dynamic conductance

$$\therefore \quad 2 \times 10^{-7} = 5 \times 10^{-6} \times g_d$$

$$\therefore \quad g_d = \frac{2\times10^{-7}}{5\times10^{-6}} = 40 \text{ m℧}$$

**4. (c)**

The recombination rate, $R = \dfrac{\delta n}{\tau} = \dfrac{10^{15}}{10^{-6}} = 10^{21} \text{ cm}^{-3} \text{ sec}^{-1}$

**5. (c)**

Current in strip, $I = neAv_d$

where, $v_d$ is drift velocity = $\dfrac{E}{B}$

$$\therefore \quad v_d = \frac{1.5\times10^{-3}}{0.3} = 5\times10^{-3} \text{ m/sec}$$

$\therefore$ Current, $I = 8 \times 10^{28} \times 1.6 \times 10^{-19} \times 5 \times 10^{-6} \times 5 \times 10^{-3}$

$$\therefore \quad I = 320 \text{ A}$$

**6. (b)**

Given: Peak electric field, $E = 4 \times 10^5$ V/cm

Width of depletion region on $n$-side,

$$W_N = 2\ \mu\text{m} = 2 \times 10^{-4}\ \text{cm}$$

Peak electric field, $$|E| = \frac{q}{\epsilon} N_D W_N$$

$$\therefore \quad N_D = \frac{E\varepsilon_{si}}{qW_N} = \frac{4\times10^5 \times 1\times10^{-12}}{1.6\times10^{-19}\times2\times10^{-4}} = 1.25\times10^{16}\ \text{cm}^{-3}$$

**7. (a)**

Given: Drift velocity, $v_d = 50$ m/sec and Length, $L = 20\ \mu$m

Time taken to travel 20 μm distance,

$$t = \frac{L}{v_d} = \frac{20}{50} = 0.4\ \mu\text{s}$$

**8. (c)**

**9. (a)**

In Schottky diode, forward current is due to thermionic emission.

**10. (b)**

Change in temperature, $\Delta T = 50°C - 25°C = 25°C$

The reduction in the power due to derating factor,

$$\Delta P_d = \Delta T \times (\text{derating factor})$$

$$\therefore \quad \Delta P_d = 25°C \times 3\ \text{mW/°C}$$

$$\Delta P_d = 75\ \text{mW}$$

∴ Net power dissipation rating at 50°C = 300 mW – 75 mW = 225 mW

**11. (a)**

Open-circuit voltage in solar cell,

$$V_{OC} = V_T \ln\left[1 + \frac{I_L}{I_s}\right]$$

If no light falls on solar cell, $I_L = 0$

$$\therefore \quad V_{OC} = V_T \ln[1] = 0\ \text{V}$$

We know that, reverse current $I_s$

$$I_s = \frac{qAD_n n_i^2}{L_n N_A} + \frac{qAD_p n_i^2}{L_p N_D}$$

For $N_D >> N_A$ $$I_s \approx \frac{qAD_n n_i^2}{L_n N_A}$$

So, when $N_D >> N_A$, $V_{OC}$ depends on $N_A$.

**12. (c)**

**13. (d)**

Given: $I_{DSS}$ = 10 mA, $V_p$ = –4 V

$$I_D = I_{DSS}\left[1-\frac{V_{GS}}{V_p}\right]^2$$

By KVL in the input loop,

$$-2.5 - V_{GS} = 0 \quad \Rightarrow \quad V_{GS} = -2.5 \text{ V}$$

$$I_D = 10\times10^{-3}\left[1-\frac{2.5}{4}\right]^2 \simeq 1.4\times10^{-3} \text{ A}$$

By KVL in the outer loop,

$$15 - I_D \times 2\text{ k}\Omega - V_{DS} = 0$$

$$V_{DS} = 15 - I_D \times 2\text{ k}\Omega = 15 - 2.8$$

$$V_{DS} = 12.2 \text{ V}$$

**14. (d)**

Common base current gain,

$$\alpha = \frac{\Delta I_C}{\Delta I_E} = \frac{0.995\times10^{-3}}{1\times10^{-3}} = 0.995$$

∴ Common collector current gain,

$$\gamma = 1+\beta = 1+\frac{\alpha}{1-\alpha} = \frac{1}{1-\alpha} = \frac{1}{1-0.995}$$

∴
$$\gamma = \frac{1}{0.005} = \frac{1000}{5} = 200$$

**15. (a)**

In $n$-type Si sample,

The diffusion current density,

$$J_{(n\text{ diff})} = qD_n\frac{dn}{dx}$$

$$J_{(n\text{ diff})} = 1.6\times10^{-19}\times225\times\frac{[10^{18}-(7\times10^{17})]}{0.1}\text{A/cm}^2$$

$$J_{(n\text{ diff})} = 108 \text{ A/cm}^2$$

**16. (b)**

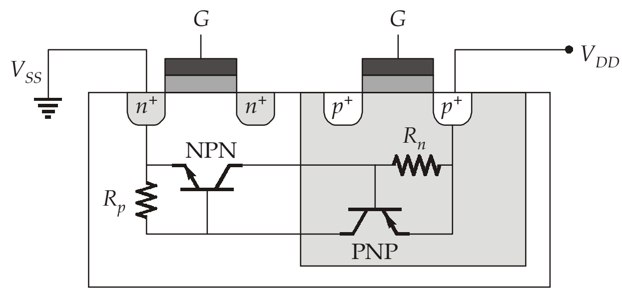
Channel resistance is controlled using gate to source voltage.

Under the pinch-off condition depletion region meets near the drain end and saturation current flows, since high electric field drifts the carriers in the depletion region.

**17. (d)**

A small reverse bias is applied between source and substrate to prevent latch-up condition.

The equivalent circuit that depicts the interaction of parasitic BJTs formed due to built-in transition layers is shown below.

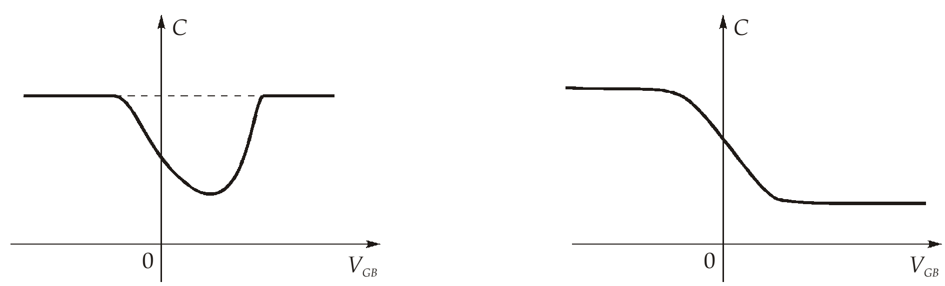



Latch up condition

**18. (b)**

**19. (c)**

The shape of $C$-$V$ plot for low and high frequency operation are




**For Low-frequency** **For High-frequency**

So, the given $C$-$V$ plots are obtained at high frequency.

The minimum capacitance for high frequency $C$-$V$ plot can be given by,

$$C_{min} = \frac{C_s C_{ox}}{C_s + C_{ox}}$$

$$C_s = \frac{\varepsilon_s}{X_{d(max)}}$$

$$X_{d(max)} = \sqrt{\frac{2\varepsilon_s}{qN_A}(2\phi_F)}$$

$$\phi_F = \frac{kT}{q}\ln\left(\frac{N_A}{n_i}\right)$$

Even though $N_A$ is changed by a large value, the corresponding change in $\phi_F$ is very small.

So, as $N_A \uparrow \left(\frac{\phi_F}{N_A}\right)\downarrow X_{d(max)} \downarrow C_s \uparrow C_{min} \uparrow$

Hence, the correct relation between doping concentrations is $N_{A1} > N_{A2} > N_{A3}$.

**20. (b)**

Bit synchronization is done in physical layer. So, statement-2 is incorrect.

**21. (d)**

$$\text{Transmission time} = \frac{\text{Data size}}{\text{Bandwidth}} = \frac{50000 \times 8 \text{ bits}}{10^6 \text{ bits/sec}} = 400 \text{ msec}$$

$$\text{Propagation time} = \frac{\text{Distance}}{\text{Velocity}} = \frac{10000 \times 10^3 \text{ m}}{2 \times 10^8 \text{ m/sec}} = 50 \text{ msec}$$

**22. (c)**

$$(224)_{10} = (11100000)_2$$

Total number of hosts = $2^5 - 2 = 32 - 2 = 30$.

**23. (b)**

Statement (b) is not true.

A bridge operates at layer 2 (Data Link Layer), so it uses MAC address.

A router operates at layer 3 (Network Layer), so it uses IP addresses.

**24. (a)**

Statement-1 is true because TCP has its congestion control and flow control mechanisms.

UDP itself does not have any flow control or congestion control mechanism. Therefore, statement-2 is false.

**25. (d)**

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

**26. (b)**

Source address field of IP header is NOT modified by a router.

**27. (d)**

Computer and network security address four requirements:

**Confidentiality:** Requires that data only be accessible by authorized parties.

**Integrity:** Requires that only authorized parties can modify data.

**Availability:** Requires that data are available to authorized parties.

**Authenticity:** Requires that a host or service be able to verify the identity of a user.

**28. (c)**

In a pure silica fiber, ZMD exists at 1.276 μm.

**29. (c)**

$$\sigma_m = 12 \text{ ns/km}$$

$$\sigma_s = 17 \text{ ns/km}$$

Total rms pulse broadening, $\sigma_T = \sqrt{\sigma_m^2 + \sigma_s^2} = \sqrt{(12)^2 + (17)^2} = \sqrt{433} \text{ ns/km} \approx 20.81 \text{ ns/km}$

**30. (c)**

For a step-index fiber, total number of modes that can propagate in the fiber is,

$$M \approx \frac{V^2}{2}; \qquad V = \text{normalized frequency}$$

$$V = \frac{2\pi a}{\lambda}(\text{N.A.})$$

$$V \propto a; \qquad a = \text{core radius}$$

$$M \propto V^2 \propto a^2$$

$$\frac{M_2}{M_1} = \left(\frac{a_2}{a_1}\right)^2 = \left(\frac{2a_1}{a_1}\right)^2 = 4$$

$$M_2 = 4M_1$$

$$\%\ \text{Increment} = \frac{M_2 - M_1}{M_1} \times 100\% = \frac{4M_1 - M_1}{M_1} \times 100\% = 300\%$$

**31. (a)**

**32. (d)**

**33. (c)**

LOS distance, $d \propto \sqrt{h_t}$

$$\frac{d_2}{d_1} = \sqrt{\frac{h_{t2}}{h_{t1}}}$$

$$d_2 = 1.2d_1$$

So, $$\frac{h_{t2}}{h_{t1}} = \left(\frac{d_2}{d_1}\right)^2 = (1.2)^2 = 1.44$$

$$h_{t2} = 1.44h_{t1} = 1.44 \times 100 \text{ m} = 144 \text{ m}$$

**34. (b)**

$$[\text{FSL}] = 32.44 + 20\log_{10}(f_{\text{MHz}}\, d_{\text{km}}) \text{ dB}$$

$$f = 2 \text{ GHz} = 2000 \text{ MHz}$$

$$d = 16 \text{ km}$$

So, $$[\text{FSL}] = 32.44 + 20\log_{10}(2000 \times 16) \text{ dB}$$

$$= 32.44 + 60 + 20\log_{10}(32) \text{ dB}$$

$$= 92.44 + 100\log_{10}(2) \simeq 122.5 \text{ dB}$$

**35. (c)**

Linear velocity of a satellite in the circular orbit can be given by,

$$v = \frac{\text{Circumference of the orbit}}{\text{Orbital period}} = \frac{2\pi a}{T}$$

Radius of the orbit $(a)$ = 6400 + 29600 = 36000 km

From Kepler's third law,

$$T^2 = \frac{4\pi^2 a^3}{\mu}$$

$$T = \frac{2\pi a\sqrt{a}}{\sqrt{\mu}}$$

So,
$$v = \frac{2\pi a}{T} = \frac{2\pi a}{(2\pi a\sqrt{a}/\sqrt{\mu})} = \sqrt{\frac{\mu}{a}}$$

$$= \sqrt{\frac{4\times10^5\ \text{km}^3/\text{s}^2}{36000\ \text{km}}} = \frac{20}{6}\ \text{km/s} \approx 3.33\ \text{km/s}$$

**36. (c)**

$$\left(\frac{C}{N_o}\right) = \left(\frac{E_b}{N_o}\right)R_b$$

In decilogs,
$$\left[\frac{C}{N_o}\right] = \left[\frac{E_b}{N_o}\right] + 10\log_{10}(R_b)$$

$$= 9 + 10\log_{10}(4\times10^7)\ \text{dB-Hz}$$

$$\simeq 9 + 76 = 85\ \text{dB-Hz}$$

**37. (a)**

Power received,
$$P_r = \frac{P_t G_t}{4\pi R^2} A_{\text{eff}}$$

Given that,
$$P_t = 10\ \text{W}$$

$$[G_t] = 27\ \text{dB} \Rightarrow G_t = 500 \qquad [\text{Note}: 10\log_{10}(1000) = 30\ \text{dB}]$$

$$R = 4000\ \text{km} = 4\times10^6\ \text{m}$$

$$A_{\text{eff}} = 10\ \text{m}^2$$

So,
$$P_r = \frac{10\times500\times10}{4\pi\times16\times10^{12}}\ \text{W} = \frac{50}{64\pi}\ \text{nW} = \frac{25}{32\pi}\ \text{nW} \approx 0.25\ \text{nW}$$

**38. (d)**

Co-channel reuse ratio,
$$Q = \sqrt{3N} = \sqrt{3\times7} = \sqrt{21} \simeq 4.58$$

**39. (c)**

Cluster size,
$$N = 4$$

$$\text{Total number of cell clusters} = \frac{20}{4} = 5$$

Voice channels available = Voice channels per cluster = 1000

System capacity = 5 × 1000 = 5000

**40. (b)**

Maximum speed of the vehicle,

$$v_m = f_{dm} \times \lambda_c$$

$$f_{dm} = 70 \text{ Hz}$$

$$\lambda_c = \frac{3\times10^8}{900\times10^6} = \frac{1}{3}\text{ m}$$

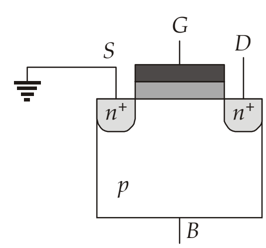
$$v_m = 70\times\frac{1}{3} = \frac{70}{3}\text{ mps}$$

$$v_m = \frac{70}{3}\times\frac{3600}{1000} = 84\text{ kmph}$$

**41. (a)**

**42. (a)**

**43. (a)**




For $p$-type substrate,

$$V_{SB} = +\text{ve} \quad (0 - (-V_B))$$

$$Q_d = \sqrt{2\varepsilon_{si}\, eN_d(2\phi_{FP} + V_{SB})}$$

and

$$\Delta V_T = \text{Change in threshold voltage} = \frac{\Delta Q_d}{C_{ox}}$$

So, $V_T$ increases with increase in $V_{SB}$ or $V_B$.

**44. (a)**

**45. (c)**

Single-mode fibers have smaller diameters compared to multi-mode fibers.

## Section B : Control Systems-1 + Microprocessors and Microcontroller-1

**46. (c)**

Open loop transfer function of the given feedback control system.

$$G(s) = \frac{K}{(s+1)(1+2s)}$$

Steady state error due to step input,

$$e_{ss} = \frac{1}{1+K_P} \quad \text{where, } K_P = \lim_{s\to0} G(s)$$

$$K_p = \lim_{s\to0}\frac{K}{(s+1)(1+2s)} = K$$

also given $e_{ss} = 0.1$.

$$\frac{1}{1+K} = 0.1 \quad \Rightarrow \quad K = 9$$

**47. (d)**

**Forward paths:**

$P_1 \Rightarrow 1-2-3-4-5-6-7-8$

$P_2 \Rightarrow 1-2-3-6-7-8$

$P_3 \Rightarrow 1-2-4-5-6-7-8$

$P_4 \Rightarrow 1-2-4-5-3-6-7-8$

**Individual loops:**

$L_1 \Rightarrow 7-7$

$L_2 \Rightarrow 5-6-5$

$L_3 \Rightarrow 3-4-5-3$

$L_4 \Rightarrow 3-6-5-3$

$L_5 \Rightarrow 2-3-4-5-6-7-2$

$L_6 \Rightarrow 2-4-5-6-7-2$

$L_7 \Rightarrow 2-4-5-3-6-7-2$

$L_8 \Rightarrow 2-3-6-7-2$

**48. (d)**

Closed-loop gain is lower than the open loop gain for a negative feedback system.
Hence, statement-3 is incorrect.

**49. (c)**

Given, input signal $r(t) = (1 - e^{-t})u(t)$

$\therefore \quad R(s) = \frac{1}{s} - \frac{1}{s+1}$

response, $C(t) = (1 - e^{-2t})u(t)$

$\therefore \quad C(s) = \frac{1}{s} - \frac{1}{s+2}$

$\therefore$ Transfer function, $T(s) = \frac{C(s)}{R(s)} = \frac{\frac{1}{s} - \frac{1}{s+2}}{\frac{1}{s} - \frac{1}{s+1}}$

$\therefore \quad T(s) = \frac{2(s+1)}{(s+2)}$

**50. (b)**

**51. (c)**

Steady state error analysis relies on the use of final value theorem.

**52. (d)**

**53. (a)**

From the given system,
$$\frac{C(s)}{R(s)} = \frac{\frac{1}{Ks(1+3s)}}{1+\frac{1}{Ks(1+3s)}}$$

characteristic equation,
$$Ks(1 + 3s) + 1 = 0$$
$$3Ks^2 + Ks + 1 = 0$$
$$s^2 + \frac{1}{3}s + \frac{1}{3K} = 0$$
$$\omega_n^2 = \frac{1}{3K}; \quad 2\xi\omega_n = \frac{1}{3}$$
$$2\xi \times \frac{1}{\sqrt{3K}} = \frac{1}{3}$$

for under damped case, $\xi < 1$
$$\xi = \frac{1}{6}\sqrt{3K}$$
$$\xi < 1 \Rightarrow \frac{\sqrt{3K}}{6} < 1$$
$$3K < 36$$
$$K < 12$$

∴ Option (a) is possible.

**54. (c)**

```
MVI C, 7FH   ;   C = 7FH
MVI B, 3EH   ;   B = 3EH
MOV A, B     ;   A = 3EH = 0011 1110
RLC          ;   A = 0111 1100
RLC          ;   A = 1111 1000
ANA C        ;         1 1 1 1  1 0 0 0
                 (AND) 0 1 1 1  1 1 1 1
                 A ⇒   0 1 1 1  1 0 0 0 = 78H
```

So, the final contents of the accumulator will be 78H.

**55. (b)**

```
MVI A, 55H   ;   A = 55H
MVI C, 25H   ;   C = 25H
ADD C        ;   0 1 0 1  0 1 0 1
                 0 0 1 0  0 1 0 1
                          1   1
                 0 1 1 1  1 0 1 0   ; AC = 0 and CY = 0
```

DAA ; 0 1 1 1 1 0 1 0
0 0 0 0 0 1 1 0
1 1 1 1 1 1
1 0 0 0 0 0 0 0 = 80H

So, the final contents of the accumulator will be 80H.

**56. (d)**

Address 2020H: The contents of lower and higher address lines are same i.e. 20H. So, this indicates that the technique is I/O mapped I/O and the address of I/O device is 20H.
Data 24H: This indicates that the content of accumulator is 24H, which have to sent to I/O port.

$IO/\bar{M}$ (Logic High): $IO/\bar{M}$ high indicates that this is I/O operation.

$\overline{RD}$ (Logic High): $\overline{RD}$ logic high indicates that read operation is inactive.

$\overline{WR}$ (Logic Low): $\overline{WR}$ logic low indicates that write operation is active.

So, by observing all the statuses, the appropriate instruction is OUT 20H.

**57. (d)**

From the given root locus.

$$G(s)H(s) = \frac{K}{(s+4)(s^2+2s+2)}$$

Characteristic equation,
$$1 + G(s)H(s) = 0$$
$$s(s^2 + 2s + 2) + 4(s^2 + 2s + 2) + K = 0$$
$$s^3 + 6s^2 + 10s + (8 + K) = 0$$

| | | |
|---|---|---|
| $s^3$ | 1 | 10 |
| $s^2$ | 6 | $8+K$ |
| $s^1$ | $\frac{60-(8+K)}{6}$ | 0 |
| $s^0$ | $8+K$ | 0 |

Row $s^1 = 0$, at
$$8 + K = 60$$
$$K = 52$$

For intersection point with "$j\omega$" axis,
$$6s^2 + (8 + K) = 0$$
$$6s^2 + 60 = 0$$
$$s^2 = -10$$
$$s = \pm j\sqrt{10}$$

**58. (c)**

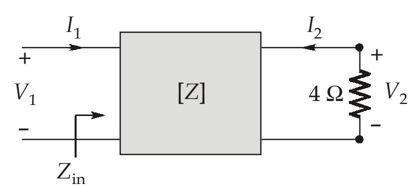
- $S_G^M = \dfrac{1}{1+GH}$ is less than unity i.e., insensitive to the parameter variations.
- In a closed-loop negative feedback control system, the control action is dependent on output.

**59. (a)**

**60. (a)**

## Section C : Network Theory-2 + Digital Circuits-2

**61. (b)**




Here,
$$V_2 = -4I_2$$

From given equations
$$-4I_2 = 3I_1 + 2I_2$$
$$-6I_2 = 3I_1$$

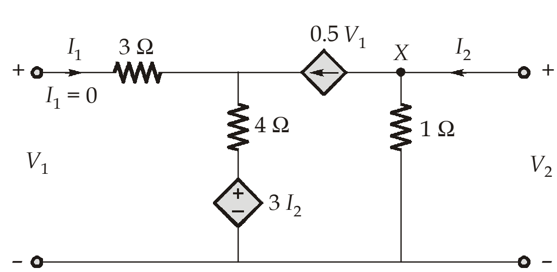
or
$$I_2 = -\frac{3}{6}I_1$$

∵
$$V_1 = 5I_1 + 3I_2 = 5I_1 - 3\left(\frac{3}{6}\right)I_1$$
$$V_1 = \frac{30-9}{6}I_1$$
$$\frac{V_1}{I_1} = \frac{21}{6} = 3.5\ \Omega$$

**62. (b)**

From $h$ parameter model,
$$V_1 = h_{11}I_1 + h_{12}V_2$$
$$I_2 = h_{21}I_1 + h_{22}V_2$$
$$h_{12} = \left.\frac{V_1}{V_2}\right|_{I_1=0}$$

The circuit can be redrawn as



By KVL at the left mesh,

we get, $V_1 = 4(0.5V_1) + 3I_2$

$V_1 = 2V_1 + 3I_2$

or $V_1 = -3I_2$ ...(i)

By KCL at node 'X', we get, $I_2 = \frac{V_2}{1} + 0.5\,V_1 = V_2 + 0.5\,V_1$

$= V_2 + 0.5(-3I_2)$

or $2.5I_2 = V_2$

$\therefore$ $V_1 = -3I_2 = -3\left(\frac{V_2}{2.5}\right) = -1.2\,V_2$

and $h_{12} = \frac{V_1}{V_2} = -1.2$

**63. (c)**

From transmission parameters,

$$V_1 = AV_2 - BI_2$$

$$I_1 = CV_2 - DI_2$$

From $h$-parameters, $V_1 = h_{11}I_1 + h_{12}V_2$

$$I_2 = h_{21}I_1 + h_{22}V_2$$

**64. (c)**

Given $[T]_\alpha = \begin{bmatrix} 4 & 5 \\ 3 & 4 \end{bmatrix}$ and $[T]_\beta = \begin{bmatrix} 3 & 4 \\ 2 & 3 \end{bmatrix}$

For cascade combination individual transmission line parameters are multiplied.

$\therefore$ $[T]_{\alpha,\beta} = [T]_\alpha \times [T]_\beta$

$$= \begin{bmatrix} 4 & 5 \\ 3 & 4 \end{bmatrix} \times \begin{bmatrix} 3 & 4 \\ 2 & 3 \end{bmatrix}$$

$$= \begin{bmatrix} 12+10 & 16+15 \\ 9+8 & 12+12 \end{bmatrix} = \begin{bmatrix} 22 & 31 \\ 17 & 24 \end{bmatrix}$$

**65. (c)**

The impedance matrix is given by,

$$\begin{bmatrix} V_1 \\ V_2 \end{bmatrix} = \begin{bmatrix} j\omega L_1 & -j\omega M \\ -j\omega M & j\omega L_2 \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \end{bmatrix}$$

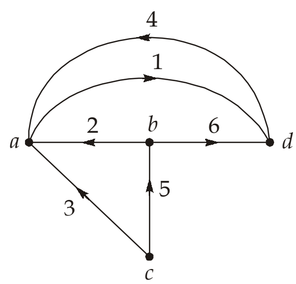
Here $L_1 = 3$ H, $L_2 = 8$ H, and $M = 2$ H

From figure (B), $L_{eq} = L_1 + L_2 + 2M = 3 + 8 + 4 = 15$ H

**66. (c)**

Every cutset has an even number of branches in common with every loop.

**67. (a)**




**68. (b)**

$$\text{Total propagation delay} = 50 + 20 = 70 \text{ ns}$$

$$f_{max} = \frac{1}{70} \times 10^9 = 14.28 \text{ MHz}$$

**69. (c)**

$$\text{Fan-out low} = \frac{I_{OL}}{I_{IL}} = \frac{0.02}{0.001} = 20$$

$$\text{Fan-out high} = \frac{I_{OH}}{I_{IL}} = \frac{0.02}{0.001} = 20$$

So, $\text{Fan-out} = \min\{20, 20\} = 20$

**70. (a)**

$$\frac{V_{FS}}{2^n - 1} \times 100 < (0.4) V_{FS}$$

$$\frac{1}{2^n - 1} < 0.004$$

$$2^n - 1 > 250$$

$\therefore$ $n_{min} = 8$

**71. (b)**

Total number of states 110011 = 6 States

Thus, the number of flip-flops required,

$$2^n - 1 \geq 6$$

$$n_{min} = 3$$

**72. (d)**

$$\text{Decimal equivalent of output} = \frac{V_a}{V_r} \times 2^N \times T_C$$

**73. (a)**

The expression for next state is,

$$Y^+ = AB + AY + \bar{B}Y = AB + \bar{B}Y$$

When $B = 1$, $Y^+ = A$

When $B = 0$, $Y^+ = Y$

So, the given circuit acts as a gated $D$-latch.

**74. (c)**

For transmission parameter,

$$A = D \Rightarrow \text{for Symmetry}$$

$$AD - BC = 1 \Rightarrow \text{for Reciprocity}$$

These conditions remain same for inverse transmission parameters too.

**75. (b)**

❍❍❍❍