IES MASTER

Institute for Engineers (IES/GATE/PSUs)

ESE 2018

Prelims Exam
Paper - II

ELECTRONICS & COMMUNICATION ENGINEERING

DETAILED SOLUTION (SET-A)

Office Address

DELHI: F-126, Katwaria Sarai, New Delhi - 110 016

Ph: 011-41013406, Mobile: 8130909220, 9711853908

NOIDA: B-23 A, 5th Floor, Gaurav Deep Heights, Near Fortis Hospital
Sector 62, Noida- 201305 **Ph:** 0120 415 1100

Explanation of Electronics and Telecommunication Engg. Prelims Paper-II (ESE - 2018)

SET - A

1. Consider the following statements regarding the formation of P-N jucntions:

1. Holes diffuse across the junction from P-side to N-side.
2. The depletion layer is wiped out.
3. There is continuous flow of current across the junction.
4. A barrier potential is set up across the junction.

Which of the above statements are correct?

(a) 1 and 3 (b) 2 and 3

(c) 1 and 4 (d) 2 and 4

Ans. **(c)**

Sol. Diffused electrons come into contact with holes on the P-side and are eliminated by recombination. In the similar way holes diffused from P-side to n-side resulting in recombination. The net result is the diffused electrons and holes are gone, leaving behind the charged ions adjacent to the interface in a region with no mobile carriers called depletion region.

This creates an electric field that provides a force opposing the continued exchange of charge carriers. When the electric field is sufficient to arrest further transfer of holes and electrons, the depletion region has reached its equilibrium. This diffusion is halted by electric potential formed at the junction called barried potential.

Hence statement 1, 4 are true

2, 3 are false

2. Silicon devices can be employed for a higher temperature limit (190 ºC to 200 ºC) as compared to germanium devices (85 ºC to 100 ºC). With respect to this, which of the following are incorrect?

1. Higher resistivity of silicon
2. Higher gap energy of siliocn
3. Lower intrinsic concentration of silicon
4. Use of silicon devices in high-power applications

Select the correct answer using the code given below:

(a) 1, 2 and 4

(b) 1, 2 and 3

(c) 1, 3 and 4

(d) 2, 3 and 4

Ans. **(b)**

Sol. When silicon devices can be employed for higher temperature limit (190°C to 200°C) when compared to germanium devices (85°C to 100°C) implies that silicon devices can be used in high-power applications as they support flow of high amounts of currents. That is statement-4 is true therefore statements 1, 2, 3 are incorrect as per options

3. For an n-channel silicon JFET with a = 2 × 10^{-4} cm and channel resistivity $\rho = 5\Omega$-cm, $\mu_n = 1300\,\text{cm}^2/\text{V-s}$ and $\varepsilon_0 = 9\times10^{-12}$ F/m, the pinch-off voltage, V_p, is nearly

(a) 2.30 V (b) 2.85 V

(c) 3.25 V (d) 3.90 V

Ans. **(b)**

Sol. Pinch off voltage, $V_p = \frac{qN_Da^2}{2\in}$

$\because \quad \sigma = N_D q \mu_n$

$\therefore \quad \frac{1}{\rho} = N_D q \mu_n$

$\Rightarrow \quad N_D = \frac{1}{\rho q \mu_n}$

$\therefore \quad V_p = \frac{qa^2}{2\in} * \frac{1}{\rho q \mu_n} = \frac{a^2}{2\in \cdot \rho \mu_n}$

$\Rightarrow \quad V_p = \frac{(2*10^{-4})^2}{2\times 9\times 10^{-14}\times 11.7\times 5\times 1300}$

$[\because \quad \varepsilon_r(\mathrm{Si}) = 11.7]$

= 2.92V

From the given option, nearest value is 2.85V.

4. In tunnel diode, the Fermi level lies

(a) inside valance band of p-type and inside conduction band of n-type semiconductors

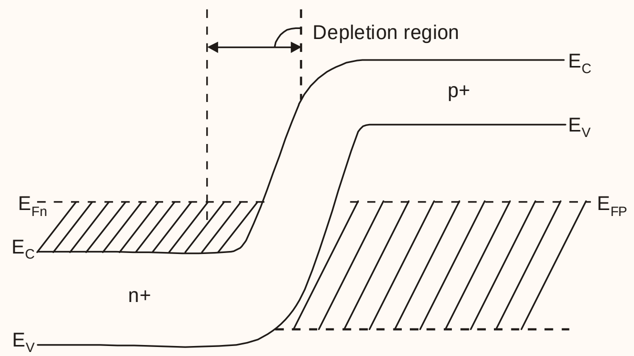
(b) in the energy band gap but closer to conduction band of n-type semiconductors

(c) in the energy band gap but closer to valence band of p-type semiconductors

(d) in the energy band gap but above valence band of p-type and below conduction band of n-type semiconductors.

Ans. **(a)**

Sol.



Energy band diagram of tunnel diode

Since both n and p junctions are highly doped so fermi levels lies inside valence band of p type and inside conduction band of n type semiconductor.

5. The h_{FE} values in the specification sheet of a transistor are $h_{FE(max)}$ = 225 and $h_{FE(min)}$ = 64. What value of h_{FE} is to be adopted in practice?

(a) 64 (b) 100

(c) 120 (d) 225

Ans. **(c)**

Sol. In design of a biasing network. Neither β_{dc}(max) nor β_{dc}(min) is considered. But it is the geometric mean of these two values:

$$\beta_{dc} = h_{fe} = \sqrt{(h_{fe})_{max}(h_{fe})_{min}}$$

$$h_{fe} = \sqrt{225\times 64}$$

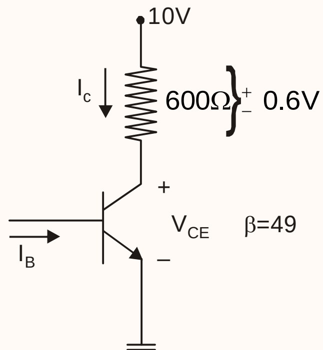
$$\boxed{h_{fe} = 120}$$

6. A transistor is connected in CE configuration with V_{CC} = 10V. The voltage drop across the 600Ω resistor in the collector circuit is 0.6 V. If $\alpha = 0.98$, the base current is nearly

(a) 6.12 mA (b) 2.08 mA
(c) 0.98 mA (d) 0.02 mA

Ans. (d)

Sol.



$\because \quad \alpha = 0.98$

$\therefore \quad \beta = \frac{\alpha}{1-\alpha} = 49$

From the circuit,

$$I_c = \frac{0.6}{600} = 1\text{mA}$$

Applying kVL

$10 - 600 \times 1\text{m} - V_{CE} = 0$

$\Rightarrow V_{CE} = 9.4\text{V} > V_{CE,sat}$

$\therefore$ Transistor is in active mode

So, $I_c = \beta I_B$

$$\Rightarrow \quad I_B = \frac{I_c}{\beta} = \frac{1\text{m}}{49} = 0.02 \text{ mA}$$

7. An amplifier, without feedback, has a gain A. The distortion at full output is 10%. The distortion is reduced to 2% with negative feedback (feedback factor $\beta = 0.03$). The values of A and A' (i.e., the gain with feedback) are, respectively, nearly

(a) 133.3 and 18.5 (b) 133.3 and 26.7
(c) 201.3 and 26.7 (d) 201.3 and 18.5

Ans. (b)

Sol.

From the data given

$$0.02 = \frac{0.1}{1+(0.03)A}$$

$\Rightarrow \quad 0.02 + (0.03)(0.02) A = 0.1$

$\Rightarrow \quad A = 133.3$

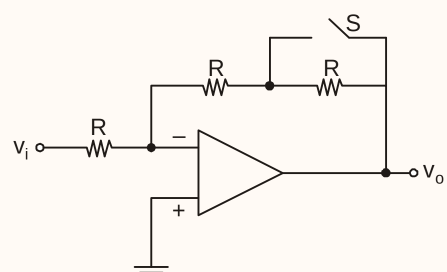
Also,

$$A_f = \frac{A}{1+A\beta}$$

$$\Rightarrow \quad A_f = \frac{133.3}{1+133.0.03}$$

$\Rightarrow \quad A_f = 26.7$

8. The magnitude of the gain $\frac{v_o}{v_i}$ in the inverting op-amp circuit shown in the figure is x with switch S open. When switch S is closed, the magnitude of the gain will be

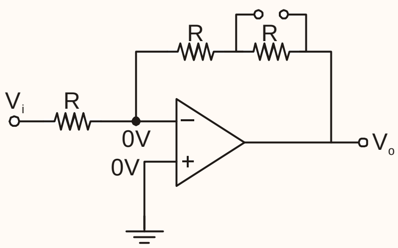


(a) x (b) $\frac{x}{2}$

(c) 2x (d) $\frac{2}{x}$

Ans. **(b)**

Sol. **Case 1:** Switch is open



By virtual ground 0V at inverting terminal

By nodal analysis

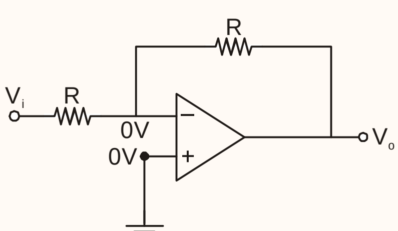
$$\frac{0-V_i}{R}+\frac{0-V_o}{2R} = 0$$

$$-\frac{V_i}{R} = \frac{V_o}{2R}$$

$$\left(\frac{V_o}{V_i}\right) = (-2)$$

given $\left(\frac{V_o}{V_i}\right)$ = x where x = – 2

Case-2: Switch closed



By virtual ground 0V at inverting terminal

$$\frac{0-V_i}{R}+\frac{0-V_o}{R} = 0$$

$$-\frac{V_i}{R} = \frac{V_o}{R}$$

$$\frac{V_o}{V_i} = (-1)$$

Then $\left(\frac{V_o}{V_i}\right) = -\frac{2}{2} = \frac{x}{2}$

9. An op-amp is used in a notch filter. The notch frequency is 2 kHz, lower cut-off frequency is 1.8 kHz and upper cut-off frequency is 2.2 kHz. Then Q of the notch filter is

(a) 3.5 (b) 4.0

(c) 4.5 (d) 5.0

Ans. **(d)**

Sol.

Quality factor, $Q = \frac{f_0}{f_2 - f_1} = \frac{2}{2.2-1.8} = 5$

$\therefore$ Q = 5

10. In op-amp based inverting amplifier with a gain of 100 and feedback resistance of $47k\Omega$, the op-amp input offset voltage is 6 mV and input bias current is 500 nA. The output offset voltage due to an input offset voltage and an input bias current, are

(a) 300 mV and 23.5 mV

(b) 606 mV and 47.0 mV

(c) 300 mV and 47.0 mV

(d) 606 mV and 23.5 mV

Ans. **(d)**

Sol. Given data

Gain = $\frac{R_f}{R_1} = 100$

Input offset Voltage $(V_1 - V_2)$ 6 mV

Input bias current = 500 nA

Output off set voltage $(V_D)_{offset}$ due to input offset is given by

$$(V_o)_{offset} = \left(1+\frac{R_f}{R_1}\right)(|V_1 - V_2|)$$

$$= (1 + 100)\ (6\ m)$$

$$= 101 \times 6\ m$$

$$= 606\ mV$$

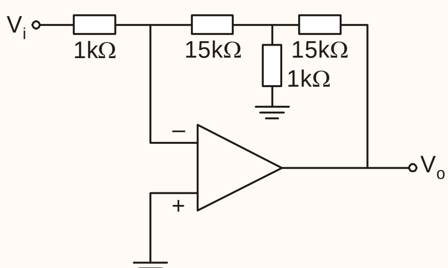
Output offset voltage $(V_o)_{offset}$ due to input bias current

$$(V_o)_{offset} = (R_f)I_B$$

$$= (4\ fk) \times (500\ n)$$

$$= 23.5\ mV$$

11. What is the gain of the amplifier circuit as shown in the figure?

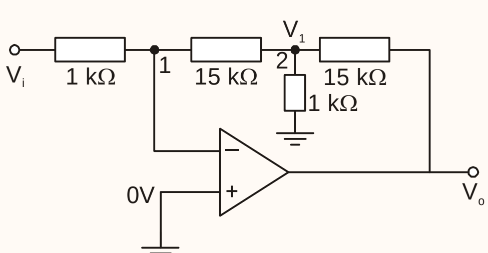


(a) 255 (b) 31

(c) –31 (d) –255

Ans. (d)

Sol.



Applying nodal analysis at node '1' we get

$$\frac{0-V_i}{1K}+\frac{0-V_1}{15K} = 0$$

$$-\frac{V_i}{1K} = \frac{V_1}{15K}$$

$$-15\ V_i = V_1 \qquad ...(1)$$

Applying nodal analysis at node '2' we get

$$\frac{V_1-0}{15K}+\frac{V_1}{1K}+\frac{V_1-V_0}{15K} = 0$$

$$\frac{V_1}{15K}+\frac{V_1}{1K}+\frac{V_1}{15K} = \frac{V_0}{15K}$$

$$V_1\left(\frac{17}{15K}\right) = \frac{V_0}{15K}$$

$$V_0 = 17\ V_1$$

$$V_0 = 17\ (-15\ V_i) \qquad \text{[From equation (1)]}$$

$$\boxed{\frac{V_o}{V_i} = -255}$$

12. The Kirchhoff's current law works on the principle of conservation of

1. charge
2. energy
3. power

Which of the above is/are correct?

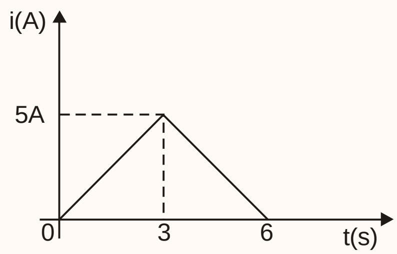
(a) 1 only (b) 2 only

(c) 3 only (d) 1, 2 and 3

Ans. (a)

Sol. The Kirchoff's current law works on the principle of conservation of charge.

13. A waveform shown in the figure is applied to a resistor of 20Ω. The power dissipated in the resistor is



(a) 100W (b) 600W
(c) 900W (d) 1000W

Ans. **(d)**

Sol. The power is given by, P = i^2R

For t = 0 to t = 3 sec.

$$P = \left(\frac{5}{3}t\right)^2 \times 20$$

$$= \left(\frac{5}{3}\times 3\right)^2 \times 20$$

= 500 W

$\therefore$ Total power dissipated = 2 × P

= 1000 W

14. A coil of wire of 0.01 mm^2 area of 1000 turns is wound on a core. It is subjected to a flux density of 100 mWb/mm^2 by a 1A current. The energy stored in the coil is

(a) 2.0J (b) 1.5J
(c) 1.0J (d) 0.5J

Ans. **(d)**

Sol. N = 1000

A = 0.01 mm^2

B = 100 mWb/mm^2

ϕ = B.A. = 1 mWb = 10^{-3} Wb

from, N.ϕ = Li

$$L = \frac{1000\times 10^{-3}}{1} = 1\,H$$

Stored energy, $E = \frac{1}{2}Li^2 = \frac{1}{2}\times 1\times (1)^2$

$$\boxed{E = 0.5J}$$

15. A sinusoidal voltage waveform has frequency 50 Hz and RMS voltage 30V. The equation representing the waveform is

(a) V = 30sin50t
(b) V = 60sin20t
(c) V = 42.42sin314t
(d) V = 84.84 sin314t

Ans. **(c)**

Sol. V_{rms} = 30 V,

f = 50Hz

$V_{max} = 30\sqrt{2} = 42.42\,V$

$\omega = 2\pi f = 314$

The equation represeting waveform is

$V(t) = V_{max}\sin\omega t$

$$\boxed{V(t) = 42.42\sin 314t}$$

16. The current in a coil of self-inductance of 4H changes from 10A to 2A in t seconds and the induced emf is 40V. The time t is

(a) 0.2s (b) 0.4s
(c) 0.6s (d) 0.8s

Ans. **(c)**

Sol. The voltage through an inductor is given by

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

For a specific time Δt,

$$V = L\frac{\Delta I}{\Delta t}$$

Given, V = 40 V

$\Delta I = 10 - 2 = 8$ A

L = 4 H

$$\therefore\ 40 = 4 \times \frac{8}{\Delta t}$$

$\therefore$ Time, t = 0.8 seconds

17. Consider the following statements with respect to a relay:

1. A relay is energized if NC contacts are opened.
2. The pickup current is the minimum relay coil current required to keep a relay energized.

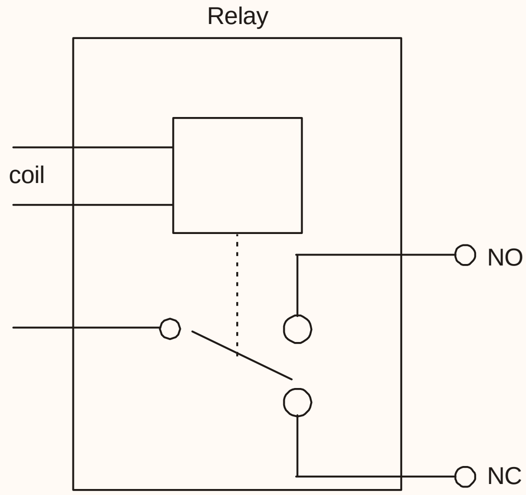
Which of the above statements is/are correct?

(a) 1 only (b) 2 only

(c) Both 1 and 2 (d) Neither 1 nor 2

Ans. **(c)**

Sol. In a relay, there are two switches, normally open (NO) and normally closed (NC)



When coil is not energized, NC contacts are closed when coil is energized, NO contacts are closed.

18. A 20 kVA, 2000/200 V, singlel-phase transformer has a leakage impedance of 8%. What voltage applied to the HV side will result in full-load current flow in the LV side, when the LV side is short-circuited?

(a) 64V (b) 86V

(c) 132V (d) 160V

Ans. **(d)**

Sol. Base impedance referred to hv side

$(Z_b) = 200\,\Omega$

Leakage impedance referred to hv side,

$(Z_{eq.}) = 200 \times 0.08$

$= 16\,\Omega$

When rated current is flowing in lv, then rated current will also be flowing in hv.

$$\text{Rated hv current} = \frac{20 \times 1000}{2000} = 10$$

Let the voltage applied be V.

$\therefore$ from $I_{sc} = \frac{V}{Z_{eq.}}$

$V = I_{sc}.Z_{eq.}$

$= 10(16) = 160V \qquad \{As\ I_{sc} = I_{rated}\}$

19. The no-load current of a 220V DC motor is 2A with corresponding running speed of 1200 rpm. The full-load current is 40A with an armautre resistance being 0.25Ω. Assuming constant flux during this range of speed, the full-load speed will be

(a) 864 rpm (b) 948 rpm

(c) 1148 rpm (d) 1200 rpm

Ans. **(c)**

Sol. $R_a = 0.25\Omega$

Let the back emf during no load is E_{b1},

during full load is E_{b_2}.

$I_{a_1} = 2$ A, $\qquad I_{a_2} = 40$ A

Then, $\frac{E_{b_1}}{E_{b_2}} = \frac{k.N_1\phi_1}{k.N_2\phi_2}$

as $\phi_1 = \phi_2$

$$\frac{E_{b_1}}{E_{b_2}} = \frac{N_1}{N_2}$$

$E_{b_1} = V - I_{a_1}R_a; \qquad E_{b_2} = V - I_{a_2}R_a$

$$\frac{V - I_{a_1}R_a}{V - I_{a_2}R_a} = \frac{1200}{N_2}$$

$$N_2 = \frac{1200(220 - 40 \times 0.25)}{(220 - 2 \times 0.25)}$$

$\boxed{N_2 = 1148\text{rpm}}$

20. A 100 kVA, single-phase transformer has a full-load copper loss of 600W and iron loss of 500 W. The maximum efficiency occurs at a load of nearly

(a) 82.1 kVA (b) 83.3 kVA

(c) 91.3 kVA (d) 98.1 kVA

Ans. **(c)**

Sol. $P_i = 500$ W

$(P_{cu})_{fl} = 600$ W

Let the maximum efficiency occurs at 'k' times the full load. then,

$$k = \sqrt{\frac{P_i}{(P_{cu})_{fl}}} = \sqrt{\frac{500}{600}}$$

$\boxed{k = .913}$

The load, at which maximum efficiency occurs, is given by

$S_{max} = 0.913 \times 100$

$\boxed{S_{max} = 91.3\text{kVA}}$

21. The starting current in an induction motor is 5 times the full-load current, while the full-load slip is 4%. The ratio of starting torque to full-load torque is

(a) 1.4 (b) 1.2

(c) 1.0 (d) 0.8

Ans. **(c)**

Sol. Given that, $I_{st} = 5.I_{fl}$

$s_{fl} = 0.04$

If τ_{st} = starting torque

τ_{fl} = full load torque

s_{fl} = full load slip

I_{st} = starting current

I_{fl} = full load current

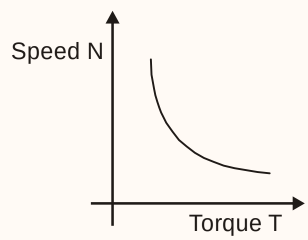
then, $\frac{\tau_{st}}{Z_{fl}} = s_{fl}\cdot\left(\frac{I_{st}}{I_{fl}}\right)^2$

$= (0.04)(5)^2$

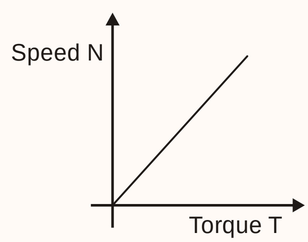
$$\boxed{\frac{\tau_{st}}{\tau_{fl}} = 1}$$

22. The applicable speed-torque curve for a DC series motor is

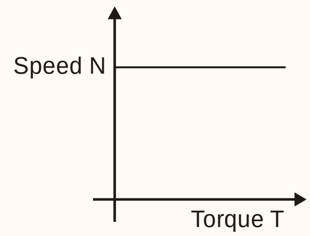
(a)



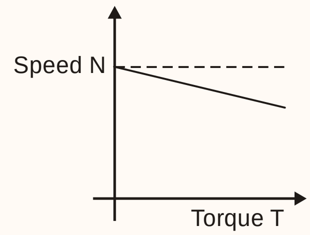
(b)



(c)



(d)



Ans. **(a)**

Sol. For dc series motor, torque is inversely proportional to the speed.

The torque speed curve for a dc series motor is a rectangular hyperbola.

23. A transformer has a core loss of 140 W at 40Hz, and 99 W at 30 Hz. The hysteresis and eddy-current losses at 50 Hz, respecitvely, are

(a) 110 W and 30 W

(b) 135 W and 30 W

(c) 110 W and 50 W

(d) 135 W and 50 W

Ans. **(d)**

Sol. Let the hysteresis loss be P_h and eddy current loss be P_e.

if we assume constant flux density, i.e. B_{max} = constant,

then, $P_h = k_1.f$

$$P_e = k_2.f^2$$

$$P_h + P_e = P_i$$

For f = 40 Hz,

$$k_1(40) + k_2(1600) = 140 \quad \text{.... (i)}$$

for $f = 30\text{Hz}$

$$k_1(30) + k_2(900) = 99 \quad \text{... (ii)}$$

Solving equations (i) and (ii)

$$k_1 = 2.7\,, \quad k_2 = 0.02$$

For f = 50 Hz,

$$P_h = k_1(50) = 2.7 \times 50 = 135\text{W}$$

$$P_e = k_2(50)^2 = (0.02) \times 50^2 = 50 \text{ W}$$

24. If a transformer is designed for maximum efficiency at rated current and voltage, the full-load copper loss will be

(a) much less than the core loss

(b) much greater than the core loss

(c) equal to the core loss

(d) not definable by these given parameters

Ans. **(c)**

Sol. If the maximum efficiency of transformer occurs at 'k' times full load, then

$$k = \sqrt{\frac{P_i}{(P_{cu})_{fl}}}$$

where, P_i core loss.

here, $(P_{cu})_{fl}$ full load copper loss.

Maximum efficiency occurs at rated current and voltage, so k = 1

$$k = \sqrt{\frac{P_i}{(P_{cu})_{fl}}} = 1$$

$$\therefore \boxed{P_i = (P_{cu})_{fl}}$$

$\therefore$ Full load copper loss will be equal to the core loss.

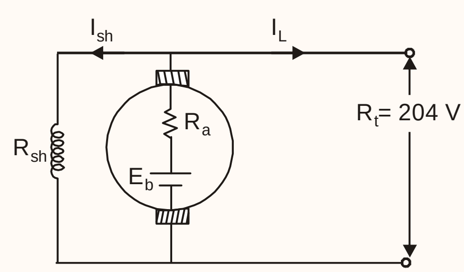
25. A shunt generator has an induced emf of 224V. When supplying a load, the terminal voltage falls to 204 V. the armature and shunt field resistances are 0.05Ω and 20Ω, respectively. The load current, neglecting the armature reaction, is

(a) 376.0 A (b) 389.8 A

(c) 400.0 A (d) 410.2 A

Ans. **(b)**

Sol. The shunt generator equivalent circuit is shown below



$R_a = 0.05\Omega$ $E_b = 224\text{V}$

$R_{sh} = 20\Omega$ $V_t = 204\text{V}$

$$I_{sh} = \frac{V_t}{R_{sh}} = \frac{204}{20} = 10.2\text{A}$$

$$E_b - I_a R_a = 204$$

$$E_b - (I_L + I_{sh})R_a = 204$$

$224 - (I_L + 10.2)(0.05) = 204$

$\boxed{I_L = 389.8A}$

26. A single-phase, 1100/200V, 50 Hz transformer has a core with a square cross-section, each side being 15cm. The maximum flux density in the core is not to exceed 12000 lines/cm^2. The primary and secondary number of turns are, respectively

(a) 1100 and 200

(b) 550 and 100

(c) 275 and 75

(d) 184 and 33

Ans. **(d)**

Sol. Given that, $V_1 = 1100V \quad V_2 = 200V$

$f = 50Hz$

Area of core $(A_C) = 15 \times 15 = 225 cm^2$

$B_{max} = 12000 lines/cm^2$

$= 12000 \times 10^{-8} \dfrac{Weber}{cm^2}$

$B_{max} = 1.2 \times 10^{-4} \dfrac{Weber}{cm^2}$

$\phi_{max} = B_{max}.A_C = 1.2 \times 10^{-4} \times 225 = 0.027$

$\therefore$ from $V = 4.44 f \phi_{max} T$,

$$T_1 = \frac{V_1}{4.44 f \phi_{max}} = \frac{1100}{4.44 \times 50 \times 0.027}$$

$T_1 = 183.5 \approx 184$ turns

$$T_2 = \frac{V_2}{4.44 f \, \phi_{max}} = \frac{200}{4.44 \times 50 \times 0.027}$$

$T_2 = 33.4 \approx 33$ turns

27. A short-circuit test performed on high-voltage side of 20 kVA, 2000/400 V, single-phase transformer gave the results as 60V, 4A 100W. If the low-voltage side is delivering full-load current at 0.8 p.f. lag at 400V, the voltage applied to the high-voltage side is nearly

(a) 2190V (b) 2170V

(c) 2150V (d) 2132V

Ans. **(d)**

Sol. During short circuit,

$V_{sc} = 60$ V

$I_{sc} = 4$ A

$P_{sc} = 100$ W

If the equivalent resistance, reactance, impedance referred to hv side, are $r_{eq.}, x_{eq}$ and z_{eq} respectively, then

$$r_{eq.} = \frac{P_{sc}}{(I_{sc})^2} = \frac{100}{(4)^2} = 6.25\Omega$$

$$Z_{eq.} = \frac{V_{sc}}{I_{sc}} = \frac{60}{4} = 15\Omega$$

$$x_{eq.} = \sqrt{Z_{eq.}^2 - r_{eq.}^2}$$

$$= \sqrt{(15)^2 - (6.25)^2}$$

$\boxed{X_{eq.} = 13.63\Omega}$

For full load, high voltage side current is I= 10A

Load voltage, when referred to hv side, will be equal to 2000 V

$\therefore$ Voltage applied to hv terminals is nearly equal to

$$V_1 = V_2' + I.r_{eq}\cos\phi + Ix_{eq}\sin\phi$$

$$= 2000 + (10)(6.25)(0.8) + (10)(13.63)(0.6)$$

$$V_1 = 2131.78$$

$$\boxed{V_1 = 2132\,V}$$

28. During short-circuit test of a transformer, core losses are negligible because

(a) the current on the secondary side is rated current

(b) the voltage on the secondary side is zero

(c) the voltage applied on the primary side is low

(d) full-load current is not supplied to the transformer

Ans. **(c)**

Sol. The core losses, i.e. eddy current and hysteresis loss are proportional to V^2 and $V^{1.6}$ respectively.

During short circuit test, the voltage applied to the transformer is low, so the core losses are very low as compared to their full load values. So they are assumed to be negligible.

29. Electrochemical breakdown in a dielectric occurs at

(a) very low temperatures only

(b) very high temperatures only

(c) very high temperatures concurrent with high humidity of the surroundings

(d) very low temperatures concurrent with ambient humidity above 50%

Ans. **(c)**

Sol.

Electrochemical breakdown in a dielectric occurs at high temperature. To avoid electrochemcial breakdown, the dielectric material should not be operated at high temperature.

Also electrochemical breakdown in a dielectric is accelerated by humidity.

30. Which of the following are the properties of Polytetrafluoroethyene?

1. Extreme heat resistant
2. Low resistance to most chemical reagents
3. Excellent insulating properties over a wide range of temperature
4. Non-hygroscopicity

Select the correct answer using the code given below:

(a) 1, 2 and 3

(b) 1, 3 and 4

(c) 1, 2 and 4

(d) 2, 3 and 4

Ans. **(b)**

Sol.

Polytetrafluoroethylene (PTTE) or teflon

1. PTFE is extremely heat resistant (upto 260°C).
2. PTEE has outstanding chemcial resistance i.e. being inert to most chemicals.
3. PTFE has an excellent insulating properties over a wide range of temperature upto 250°C.
4. PTFE is a non-hygroscopic material unlike other plastics.

31. For elements of the iron group, the net orbital dipole moment in the solid state is

(a) Zero (b) 10 – 20

(c) 10000 – 12000 (d) Infinity

Ans. **(a)**

Sol.

The elements of the iron group are important from the electrical engineering point of view. The net orobital dipole moment is the solid state for iron group materials is zero. Although, the individual atoms may have orbital dipole moments. This is because the incompletely filled shell in such atoms lies near the surface of the periphery of the atom on account of which there are strong interacting forces with the neighbouring atom.

32. Which of the following statements are correct in respect of magnetic materials with magnetic susceptibility $\frac{M}{H} = \chi$?

1. χ is dimensionless
2. The relative permeability of the medium equals $1+\chi$.
3. For non-magnetic medium, χ equals –1.

Select the correct answer using the code given below.

(a) 1, 2 and 3 (b) 1 and 3 only

(c) 2 and 3 only (d) 1 and 2 only

Ans. **(d)**

Sol.

Since, $B = \mu_0 (H + M)$

$\Rightarrow \mu_0\mu_r H = \mu_0 (H + M)$

$\Rightarrow (\mu_r - 1) H = M$

$\Rightarrow \frac{M}{H} = \mu_{r-1} = \chi_m$ (magnetic susceptibility)

Since, relative permeability is a dimensionless quantity, hence, χ_m will also be dimensionless.

Also, relative permeability of the medium.

$\mu_r = 1 + \chi$

Non-magnetic medium have no magnetic susceptibility to magnetic fields.

33. Which of the following represent the properties of carbon nanotubes ?

1. High electrical conductivity
2. Very high tensile strength
3. High thermal conductivity
4. Low thermal expansion coefficient.

Select the correct answer using the code given below.

(a) 1, 2 and 3 only (b) 1, 2 and 4 only

(c) 1, 3 and 4 only (d) 1, 2, 3 and 4

Ans. **(d)**

Sol.

- The electrical conductivity of carbon nano tube (CNT) lies in the range of 10^{-5} to 10^{-2} S/m
- Tensile strength of CNT is very high upto 63,000 MPa.
- CNT have high thermal conductivity. The thermal conductivity of an individual single wall CNT is 5 to 10 times greater than that of very conductive materials such as alluminium or copper.
- CNT have low thermal expansion coefficient.

34. An ammeter of 0 – 25 A range has a guaranteed accuracy of 1% of full-scale reading. The current measured is 5 A. The limiting error is

(a) 2% (b) 3%

(c) 4% (d) 5%

Ans. (d)

Sol.

Error while measuring 5A current

$= 25 \times \frac{1}{100} = 0.25\text{A}$

Reading will be (5 ± 0.25) A

So, limiting error = $\frac{\pm 0.25}{5} \times 100\%$

= ±5%

35. A variable reluctance tachometer has 180 teeth on its rotor. The speed of the shaft on which it is mounted is 1200 r.p.m. The frequency of the output pulses is

(a) 4800/s (b) 3600/s

(c) 2400/s (d) 1800/s

Ans. (b)

Sol.

Frequency of the output pulses

= (No. of teeth on rotor) × (speed of the shaft)

= (180 × 1200) /min

$= \left(\frac{180 \times 1200}{60}\right)$/sec

= 3600/sec.

36. What will be seen on the screen of a CRO, when a sinusoidal voltage signal is applied to the vertical deflection plate of this CRO with no simultaneous signal applied to the horizontal deflection plate ?

(a) A horizontal line

(b) A vertical line

(c) A sinusoidal signal

(d) A spot at the centre of the screen

Ans. (b)

Sol.

Since sinusoidal voltage signal is applied to the vertical deflection plate of CRO and no simultaneous signal is applied to the horizontal deflection plate, then,

$x = 0,\ y = A_m \sin \omega t$ (Let)

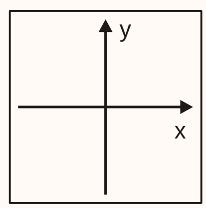


Fig. Screen of CRO

Case 1: at t = 0

$x = 0,\ y = 0$

Case 2: at $t = \frac{T}{4}$

$x = 0,\ y = A_m \sin \frac{2\pi}{T} \cdot \frac{T}{4} = A_m$

Case 3: at t = T/2

$x = 0,\ y = A_m \sin \frac{2\pi}{T} \cdot \frac{T}{2} = 0$

Case 4: at t = T

$$x = 0,\ y = A_m \sin\frac{2\pi}{T}\cdot T = 0$$

We can observe from these four cases, that the point moves only on vertical direction.

37. The Wheatstone bridge consists of a power source, 3 known resistors, a resistor whose value is to be measured and a null detector. Which of the following is ***not*** a source of errors in a Wheatstone bridge ?

(a) Limiting errors of the known resistors

(b) Poor sensitivity of the null detector

(c) Fluctuations in the power supply voltage

(d) Thermal e.m.f.s in the bridge circuit.

Ans. (c)

Sol.

Following are the sources of error in wheatstone bridge:

1. error in values of the known resistances.
2. insufficient null detector sensitivity, which may lead to error in detecting the balance point
3. Thermoelectric emf in the bridge and the galvanometer circuit.
4. Error committed by the operator in detecting the exact balance.

38. A vector impedance meter measures

(a) The magnitude of the impedance

(b) The power dissipation in the impedance

(c) The phase angle of the impedance

(d) Both the magnitude and the phase angle of the impedance.

Ans. (d)

Sol.

Vector impedance meter is used for measurement of magnitude and the phase angle of the impedance. It is used to meausre the impedance over wide range of frequency, from 400 kHz to 100 MHz.

39. A vector voltmeter can be used to measure

1. Complex insertion loss
2. Two-port network parameters
3. Amplifier gain and phase shift
4. Harmonic distortion

which of the above are correct ?

(a) 1, 2 and 4 (b) 1, 2 and 3

(c) 1, 3 and 4 (d) 2, 3 and 4

Ans. (b)

Sol.

The vector voltmeter is basically an instrument used to measure amplitude and phase. However it can be used for measurement of:

1. Complex insertion losses
2. Two-port network parameters
3. Amplifier gain and phase shift
4. Radio frequency distortions.
5. Complex impedance of mixers
6. Filter transfer function
7. Amplitude modulation index
8. 's' parameters of transistor

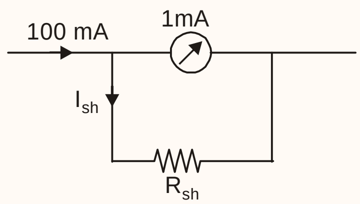
40. A 0 – 1 mA FSD ammeter is to be used to measure 0 – 100 mA full-scale deflection using a shunt. If the internal resistance of the meter is 200 Ω , what is the required shunt resistance ?

(a) 4.04Ω (b) 3.03Ω

(c) 2.02Ω (d) 1.01Ω

Ans. (c)

Sol.



Voltage across meter, V = 1 mA × 200 Ω

= 0.2 V

Hence, required shunt resistance,

$$R_{sh} = \frac{V}{I_{sh}} = \frac{0.2}{(100-1)\times 10^{-3}}$$

$$= \frac{200}{99}$$

$$= 2.02\Omega$$

41. In a 3-input CMOS NAND gate, the substrate terminals of NMOS transistors are grounded (lowest potential available in the circuit) and the substrate terminals of PMOS transistors are connected to V_{DD} (maximum positive potential available in the circuit). Which of the following transistors may suffer in this circuit from body bias effect ?

(a) 2 NMOS transistors

(b) 2 PMOS transistors

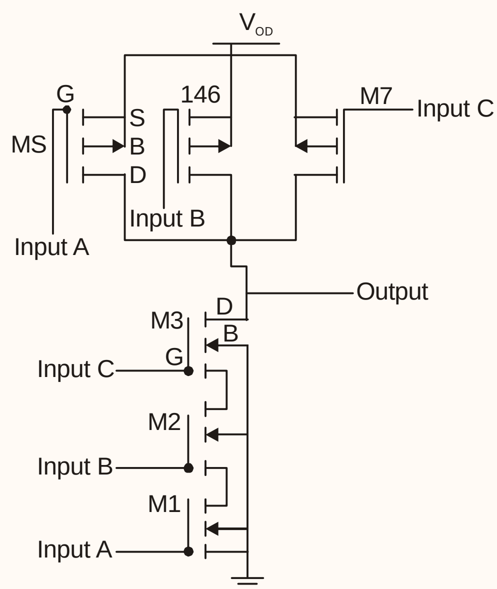
(c) 1 NMOS transistor

(d) 1 PMOS transistor

Ans. (a)

Sol. Body bias effect arises only if there is a potential difference between bulk and source voltage.

A 3 input CMOS NAND Gate consists of 3N MOS and 3 PMOS transistors as shown below:



As can be seen in the above diagram, only M_2 and M_3 are the two transistors where there is a potential difference between source and bulk. So 2-NMOS transistors suffer from body bias effect.

42. A strain gauge with gauge factor 4 and resistance 250 Ω undergoes a change of 0.15 Ω during a test. The measured strain is

(a) 150×10^{-4} (b) 15×10^{-4}

(c) 1.5×10^{-4} (d) 0.15×10^{-4}

Ans. (c)

Sol.

Gauge factor, $G_f = \frac{\Delta R / R}{\Delta l / l}$

$\Rightarrow G_f = \frac{\Delta R / R}{\text{strain}}$

$$\Rightarrow \text{strain} = \frac{\Delta R}{R} \cdot \frac{1}{G_f} = \frac{0.15}{250 \times 4} = \frac{0.15}{1000}$$

$= 1.5 \times 10^{-4}$

43. Unbonded strain gauge is mainly used in a

(a) Pressure transducer

(b) Force transducer

(c) Vibration transducer

(d) Displacement transducer

Ans. (b)

Sol.

Unbonded strain gauge is mainly used in displacement transducer.

44. A displacement of $\pm$ 12.5 mm results in a secondary voltage of 5 V in an LVDT. If the then secondary voltage is 3.2 V, the absolute value of the corresponding displacement would be

(a) 4 mm (b) 6 mm

(c) 8 mm (d) 10 mm

Ans. (c)

Sol.

In an LVDT

(Secondary voltage developed) $\propto$ displacement

i.e. $V \propto d$

$$\Rightarrow \frac{V_1}{V_2} = \frac{d_1}{d_2}$$

$$\Rightarrow \frac{5}{3.2} = \frac{12.5}{d_2}$$

$$\Rightarrow d_2 = \frac{12.5 \times 3.2}{5}$$

$$= \frac{40}{5}$$

$= 8$ mm

45. In large radar installations, it is required to translate the angular position of a shaft into digital information. This is most generally achieved by employing a code wheel. For unambiguous sensing of the shaft position, one employs a/an

(a) Octal code

(b) BCD code

(c) Binary Gray code

(d) Natural binary code

Ans. (c)

Sol. Requirement

Angular position of shaft is to be converted into digital information.

It means analog data must be converted into digital data.

Code wheel converts quantized data into coded form.

for unambiguous sensing of the shaft position. Binary gray codes are most suited.

46. An R-L-C series circuit is excited by a DC voltage. IF R = 40 Ω, L = 0.2 H and C = 100 μF, the resulting current response is said to be

(a) Critically damped (b) Undamped

(c) Over-damped (d) Under-damped

Ans. (d)

Sol. The characteristic equation for a second-order equation is given by

$$s^2 + \frac{R}{L}s + \frac{1}{LC} = 0$$

Putting the value,

$$s^2 + \frac{40}{0.2}s + \frac{10^6}{0.2 \times 100} = 0$$

$$\Rightarrow s^2 + 200s + 5 \times 10^4 = 0$$

$$\therefore \omega_n = \sqrt{5} \times 10^2 \text{ rad/sec.}$$

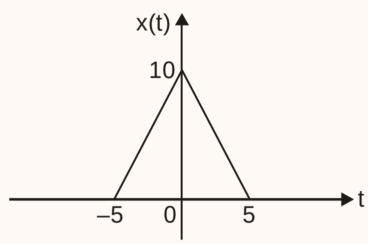
and $2\xi\omega_n = 200$

$$\xi = \frac{200}{\sqrt{5} \times 100 \times 2} = \frac{1}{\sqrt{5}}$$

Since, $\xi < 1$

$\therefore$ The system is under-damped.

47. If x(t) is as shown in the figure, its Laplace transform is



(a) $\dfrac{2e^{+5s} + 2e^{-5s}}{s^2}$

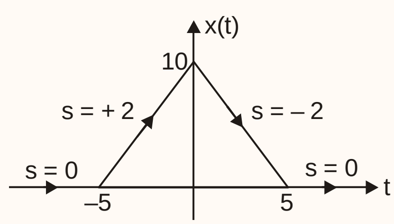
(b) $\dfrac{2e^{+5s} - 4 + 2e^{-5s}}{s^2}$

(c) $\dfrac{2e^{+5s} - 2 + 2e^{-5s}}{s^2}$

(d) $\dfrac{2e^{+5s} + 4 - 2e^{-5s}}{s^2}$

Ans. **(b)**

Sol.



$$x(t) = 2r(t+5) - 4r(t) + 2r(t-5)$$

$$L[r(t)] = \frac{1}{s^2}$$

$$L[r(t+5)] = \frac{e^{5s}}{s^2}$$

$$L[r(t-5)] = \frac{e^{-5s}}{s^2}$$

Laplace transform of x(t)

$$L[x(t)] = X(s) = \left[\frac{2e^{5s} - 4 + 2e^{-5s}}{s^2}\right]$$

48. The value of critical current density in a superconductor depends upon

1. Temperature
2. Magnetic field strength
3. Penetration depth

(a) 1, 2 and 3 (b) 1 and 3 only

(c) 2 and 3 only (d) 1 and 2 only

Ans. **(d)**

Sol.

According to Silsbee's rule,

Critical current, $I_c = 2\pi r H_c$

where, r = radius of superconductor wire

H_c = critical magnetic field strengh

Hence,

Critical current density,

$$J_c = \frac{I_c}{A} = \frac{2\pi r H_c}{A}$$

$$\Rightarrow J_c = \frac{2\pi r \cdot H_0\left[1 - \left(\frac{T}{T_c}\right)^2\right]}{A}$$

So, critical current density depends on temperature and magnetic field strength.
As superconductors are perfect diamagnetic, but in reality, the magnetic field penetrates the super conductor. Mathematically,

$B(x) = B_o e^{-x/\lambda_L}$

λ_L = london penetration depth

Now using Maxwell's equation

$\nabla \times \bar{B} = \mu_o \bar{J}$

$\Rightarrow \bar{J}_C = J_o e^{-x/\lambda_L}$

$\bar{J}$ = current density

Hence, $\bar{J}_C$ also depends on the penetration depth.

49. The maximum current in a series R-L-C network with variable frequency excitation is 1 A, when the applied voltage is 10V. The inductance has a value of 0.1 H. The Q-factor at the maximum current is 10. Then the value of C is

(a) $0.01\,\mu F$ (b) $0.1\,\mu F$

(c) $1.0\,\mu F$ (d) $10\,\mu F$

Ans. (d)

Sol. The resistance of the circuit can be found as,

V = IR (at resonance)

$R = \frac{10}{1} = 10\,\Omega$

Quality factor is given by

$Q = \frac{\omega_0 L}{R}$

$\Rightarrow \omega_0 = \frac{QR}{L} = \frac{10 \times 10}{0.1} = 1000$

Now, $\omega_0 = \frac{1}{\sqrt{LC}}$

Putting the value of ω_0 and L,

$1000 = \frac{1}{\sqrt{0.1 \times C}}$

$\therefore$ C = 10×10^{-6}

= $10\,\mu F$

50. In a two-element series network, the instantaneous voltages across the elements are

sin314 t and $3\sqrt{2}\sin(314t + 45°)$

The resultant voltage across the combination is expressed as Vcos(314t + θ). Then the values of V and θ are

(a) 5 and 36.8° (b) 3.5 and 36.8°

(c) 5 and –53.2° (d) 3.5 and –53.2°

Ans. (a)

Sol. V_1 = 1sin(314 t)

$V_2 = 3\sqrt{2}\sin(314 + 450)$

Taking voltage V_1 as reference

$V_1 = 1\angle 0°$

$V_2 = 3\sqrt{2}\angle 45°$

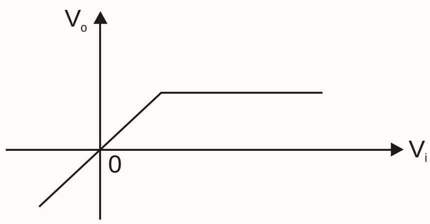
Total voltage, $V = V_1 + V_2$

$= 1\angle 0° + 3\sqrt{2}\angle 45°$

$= 5\angle 36.87°$

$\therefore$ V = 5cos(314 t + 36.87°)

51. The voltage transfer characteristics as shown in the figure will relate to a



1. Voltage regulator
2. Half-wave rectifier
3. Full-wave rectifier

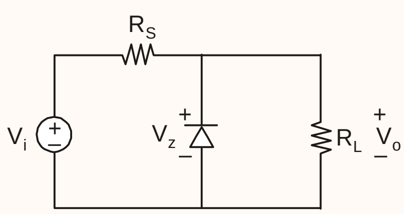
which of the above is/are correct ?

(a) 1 only (b) 2 only

(c) 1 and 2 (d) 1 and 3

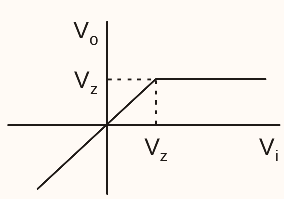
Ans. **(a)**

Sol. (i) Consider a zener diode as voltage regulator

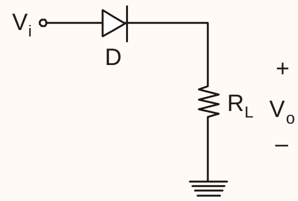


For $V_i \geq V_z$; ZD is ON ; $V_o = V_z$

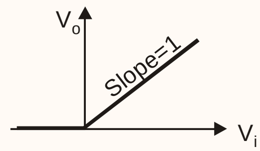
For $V_i < V_z$; ZD is OFF ; $V_o = V_i$



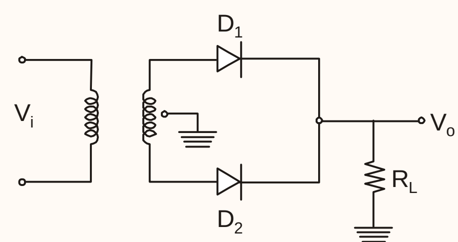
(ii) The transfer characteristic curve of a HWR is (considering ideal diodes)



V_i	D	V_o
$V_i < 0$	OFF	0
$V_i > 0$	ON	V_i

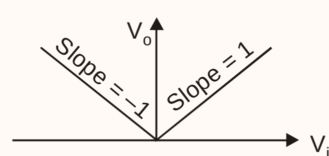


(iii) The transfer characteristic curve of a FWR is (considering centre tapped and ideal diode)



V_i	D_1	D_2	V_o
$V_i < 0$	OFF	ON	$-V_i$
$V_i > 0$	ON	OFF	V_i

$\therefore \; V_o = |V_i|$



Hence, option (a) is correct.

52. The gain of a bipolar transistor drops at high frequencies. This is due to

(a) Coupling and bypass capacitors

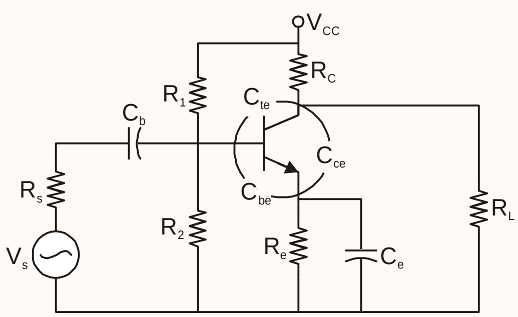
(b) Early effect

(c) Inter-electrode transistor capacitances

(d) The fact that reactance becomes high

Ans. (c)

Sol.



Internal capacitances :

C_{TE} = transition capacitance in picofarad

C_{be} = diffusion capacitance in picofarad

C_{ce} = pseudo capacitance in picofarad

External capacitances :

C_b = blocking capacitance

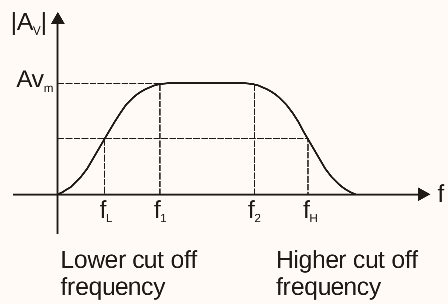
C_e = emitter capacitance (or) by pass capacitance

C_c = Coupling capacitance (or) collector capacitance

At lower frequency range external capacitance effects the gain

At higher frequency range internal capacitance effects the gain

hence ans (c) is correct



At higher frequency range internal capacitance effects the gain

53. A sample of germanium is made p-type be addition of indium at the rate of one indium atom for every 2.5×10^8 germanium atoms. Given, $n_i = 2.5 \times 10^{19}\ /m^3$ at 300 K and the number of germanium atoms per $m^3 = 4.4 \times 10^{28}$. What is the value of n_p?

(a) $3.55 \times 10^{18}/m^3$ (b) $3.76 \times 10^{18}/m^3$

(c) $7.87 \times 10^{18}/m^3$ (d) $9.94 \times 10^{18}/m^3$

Ans. (a)

Sol. Given that

1 indium atom is doped for every 2.5×10^8 Ge atom

intrinsic carrier concentration $(n_i) = 2.5 \times 10^{19}/m$

number of germanium atoms $= 4.4 \times 10^{28}$

$1 \rightarrow 2.5 \times 10^8$

$? \rightarrow 4.4 \times 10^{28}$

Concentration of p-type impurities

$$= \frac{4.4 \times 10^{28}}{2.5 \times 10^8}$$

$$= 1.76 \times 10^{20} \text{ atom}$$

We know

$$(N_A)\ (n_p) = n_i^2$$

$$(1.76 \times 10^{20})\ (n_p) = (2.5 \times 10^{19})^2$$

$$(n_p) = \frac{(2.5)^2 \times 10^{38}}{1.76 \times 10^{20}}$$

$$n_p = 3.551 \times 10^{18} \text{ /m}^3$$

54. For a transistor

$$h_{ie} = 1\text{ k}\Omega,\ h_{fe} = 30\Omega,\ h_{fe} = 0$$

$$h_{oe} = 20 \times 10^{-6}\ \mho\text{, and } R_L = 2.5\text{ K}\Omega$$

The transistor is used in a single stage CE amplifier. The voltage gain and power gain, respectively, are

(a) 75 and 1750 (b) 25 and 2250

(c) 75 and 2250 (d) 25 and 1750

Ans. (c)

Sol. Given data

$$h_{ie} = R_b = 1\text{ k}\Omega$$

$$h_{fe} = \beta = 30 = Ai$$

$$h_{re} \approx 0,$$

$$h_{oe} = 20 \times 10^{-6}\ \mho$$

$$R_L = 2.5\text{ k}\Omega = R_C$$

$$\therefore \text{ Voltage gain } (A_V) = \beta\left(\frac{R_c}{R_b}\right)$$

$$= 30\left(\frac{2.5k}{1k}\right)$$

$$= 30\ (2.5)$$

$$= 75$$

$$\text{Power gain} = A_V\, A_I$$

$$= (30)\ (75)$$

$$= 2250$$

55. An ADC has a total conversion time of 200 μs. What is the highest frequency that its analog input should be allowed to contain?

(a) 2.5 kHz (b) 25 kHz

(c) 250 kHz (d) 0.25 kHz

Ans. (a)

Sol. Nyquist rate = 2 f_{max}

$$f_{max} = \frac{\text{Nyquist rate}}{2}$$

$$\text{Nyquist rate} = \frac{1}{\text{Conversion time}} = \frac{1}{200 \times 10^{-6}}$$

$$f_{max} = \frac{1}{400 \times 10^{-6}} = 2.5\text{kHz}$$

56. In case of high pass filter, the transfer function should be with

1. 1 pole and 1 zero
2. 2 poles and 2 zeroes
3. 2 poles and 1 zero

Which of the above are correct?

(a) 1, 2 and 3 (b) 1 and 3 only

(c) 2 and 3 only (d) 1 and 2 only

Ans. (d)

Sol. Transfer function of HPF :

$$1^{st} \text{ order HPF : } H(s) = \frac{RCS}{1+RCS}$$

Zero : s = 0

$$\text{Pole : } s = -\frac{1}{RC}$$

$$2^{nd} \text{ order HPF : } H(s) = \frac{ps^2}{s^2 + ab + c}$$

zero : s = 0, s = 0

pole : 2 poles

57. Consider the following opinions regarding the advantage and disadvantage of a Mealy model:

1. Advantage: Less number of states (hence less hardware)

   Disadvantage: Input transients are directly conveyed to output

2. Advantage: Output remains stable over entire clock period

   Disadvantage: Input transients persist for long duration at output

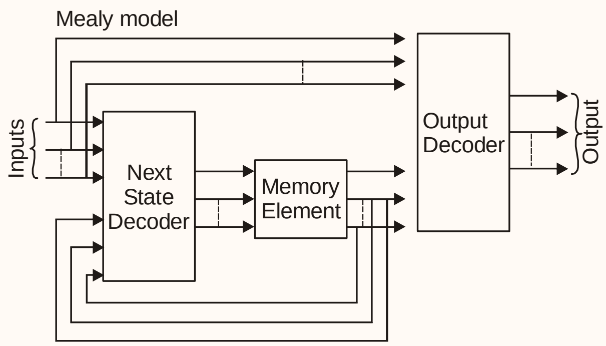
Which of the above is/are correct?

(a) 1 only (b) 2 only

(c) Both 1 and 2 (d) Neither 1 nor 2

Ans. **(a)**

Sol.



- The output of mealy machine is a function of present state as well as present input, so output does not remain stable over entire clock.
- Input changes may affect the output of the circuit so input transient are conveyed to the output.
- It require less number of states for implementing same function.

58. A resistance strain gauge is used to measure stress of steel which is stressed to 1200 kg/cm^2. If the gauge factor is 2.5 and the Young's modulus of steel is 2×10^6 kg/cm^2 the percentage change in resistance of the gauge is

(a) 0.05% (b) 0.10%

(c) 0.15% (d) 0.25%

Ans. **(c)**

Sol.

Since Young's modulus, $Y = \dfrac{\text{stress}}{\text{strain}}$

$\Rightarrow$ strain $= \dfrac{\text{stress}}{Y}$

$= \dfrac{1200}{2 \times 10^6}$

$= 6 \times 10^{-4}$

Gauge factor $G_f = \dfrac{\Delta R / R}{\Delta l / l}$

$\Rightarrow \dfrac{\Delta R}{R} = G_f \times \left(\dfrac{\Delta l}{l}\right)$

$= G_f \times$ strain

$= 2.5 \times 6 \times 10^{-4}$

$= 15 \times 10^{-4}$

So, percentage change is resistance,

$\dfrac{\Delta R}{R} \times 100 = 15 \times 10^{-4} \times 100$

$= 15 \times 10^{-2}$

$= 0.15\%$

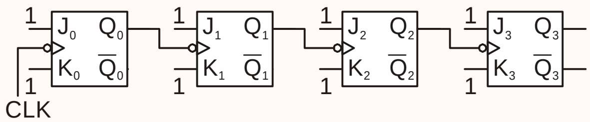
59. In a 4-stage ripple counter, the propagation delay of a flip flop is 30 ns. If the pulse width of the strobe is 30 ns, the maximum frequency at which the counter operates reliably is nearly

(a) 9.7 MHz (b) 8.4 MHz

(c) 6.7 MHz (d) 4.4 MHz

Ans. (c)

Sol.



$T_{CLK} \geq n(t_{pd})_{FF} + T_{strobe}$

T_{CLK} = Clock interval = ?

$(t_{pd})_{FF}$ = Propagation delay of 1 FF = 30 nsec

n = number of flip flop = 4

T_{strobe} = width of store signal = 30 nsec

$T_{CLK} \geq 4 \times (30)$ nsec + 30 nsec

$$f_{CLK} \leq \frac{1}{(120+30)\times 10^{-9}}$$

$(f_{CLK})_{max} = 6.66 \times 10^6 = 6.66$ MHz

60. For what minimum value of propagation delay in each filp-flop will a 10 bit ripple counter skip a count, when it is clocked at 10 MHz?

(a) 5 ns
(b) 10 ns
(c) 20 ns
(d) 40 ns

Ans. (b)

Sol. For ripple counter to count properly

$T_{CLK} \geq n(t_{pd})_{FF}$

T_{CLK} = clock interval

$$f_{CLK} = \frac{1}{T_{CLK}} = \text{clock frequency} = 10 \text{ MHz}$$

n = number of Flip Flops = 10

$(t_{pd})_{FF}$ = propagation delay of a flip flop

If ripple counter skip a count then

$T_{CLK} \leq n(t_{pd})_{FF}$

$$(t_{pd})_{FF} \geq \frac{T_{CLK}}{n}$$

$$(t_{pd})_{FF}|_{min} = \frac{1}{n f_{CLK}} = \frac{1}{10\times 10\text{MHz}} = 10 \text{ nsec}$$

61. In a master slave JK flip-flop

(a) both master and slave are positive edge-triggered

(b) both master and slave are negative edge-triggered

(c) master is positive edge triggered and slave is negative edge triggered

(d) master is negative edge triggered and slave is positive edge triggered

Ans. (c)

Sol.
- Master slave JK flip flop is a way to avoid the race around problem.
- A master slave JK flip flop is a combination of two clocked latches, the first is called master and the second is called slave.
- The master is positively clocked and the slave is negatively clocked implying thereby that when clock is high, master is active and slave is inactive.
- When clock is low, master is inactive and slave is active.

62. The phase detector circuit in the phase locked loop demodulators recognizes

(a) Voltage changes between the input and VCO signals

(b) frequency changes between the input and VCO signals

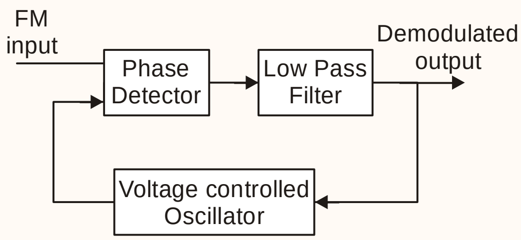
(c) impedance changes between the input and VCO signals

(d) resistance changes between the input and VCO signals

SCROLL DOWN

Ans. **(b)**

Sol.



- Phase detector is responsible for PLL to operate in lock mode.
- PLL is said to be operated in lock mode when frequency of FM input and VCO output is same.
- Phase detector recognizes frequency changes between the input and VCO signal.

63. Consider the following statements for signal flow graph:

1. It represents linear as well as non linear systems.
2. It is not unique for a given system.

Which of the above statements is/are correct?

(a) 1 only (b) 2 only

(c) Both 1 and 2 (d) Neither 1 nor 2

Ans. **(c)**

Sol.

The signal flow graph approach is valid for linear as well as non-linear systems.

One system can have different signal flow graph according to the order in which the equations are used to define the variable written on the left hand side. So it is not unique for a given system.

64. The power spectral density of the stationary noise process N(t) having auto correlation $R_{uu}(\tau) = Ke^{-3|\tau|}$ is

(a) $\frac{3K}{3+\omega^2}$ (b) $\frac{3K}{3-\omega^2}$

(c) $\frac{6K}{9+\omega^2}$ (d) $\frac{6K}{9-\omega^2}$

Ans. **(c)**

Sol. WIENER KHINCHIN THEOREM :

States that autocorrelation function of a wide sense stationary random process is the inverse Fourier Transform of power spectral density.

$$R_{uu}(\varepsilon) \xleftrightarrow{\text{F.T.}} S_{uu}(\omega)$$

$$R_{uu}(\varepsilon) = Ke^{-3|\varepsilon|}$$

$$S_{uu}(\omega) = \frac{K(2\times 3)}{(\omega^2+3^2)}$$

$$\boxed{S_{uu}(\omega) = \frac{6K}{9+\omega^2}}$$

Note : $e^{-a|t|} \xleftrightarrow{\text{F.T.}} \frac{2a}{a^2+\omega^2}$

65. A distance time signal is given as $x[n] = \cos\frac{\pi n}{9} + \sin\left[\frac{\pi n}{7}+\frac{1}{2}\right]$. The period N for the periodic signal is

(a) 126 (b) 32

(c) 252 (d) 64

Ans. **(a)**

Sol. A discrete time signal is

$$x[n] = \cos\frac{\pi n}{9} + \sin\left[\frac{\pi n}{7}+\frac{1}{2}\right]$$

$$x[n] = x_1[n] + x_2[n]$$

SCROLL DOWN

$$x_1[n] = \cos\frac{\pi n}{9}$$

$$N_1 = \frac{2\pi}{\omega_0}\times K$$

$$N_1 = \frac{2\pi}{\pi/9}\times K = 18K$$

$\boxed{N_1 = 18}$ for K = 1

$$x_2[n] = \sin\left[\frac{\pi n}{7}+\frac{1}{2}\right]$$

$$N_2 = \frac{2\pi}{\omega_0}\times K$$

$$N_2 = \frac{2\pi}{\pi/7}\times K$$

N_2 = 14 K

$\boxed{N_2 = 14}$ for K = 1

N = LCM (N_1 N_2) = 126

66. The angle θ_{AB} between the vectors A = $3a_x + 4a_y + a_z$ and B = $2a_y - 5a_z$ is nearly

(a) 83.7° (b) 73.7°

(c) 63.7° (d) 53.7°

Ans. **(a)**

Sol. $\vec{A} = 3a\hat{x} + 4a\hat{y} + a\hat{z}$

$\vec{B} = 2a\hat{y} - 5a\hat{z}$

$$\vec{A}\cdot\vec{B} = |\vec{A}|\,|\vec{B}|\cos\theta_{AB}$$

$$\vec{A}\cdot\vec{B} = 4\times 2 - 5 = 3$$

$$|\vec{A}| = \sqrt{9+16-1} = \sqrt{26}$$

$$|\vec{B}| = \sqrt{25+4} = \sqrt{29}$$

$$3 = \sqrt{26}\,\sqrt{29}\cos\theta_{AB}$$

$$\cos\theta_{AB} = \frac{3}{\sqrt{26}\,\sqrt{29}}$$

$\boxed{\theta_{AB} = 83.7°}$

67. When a transmission line section is first short circuited, and then open circuited it shows input impedances of 25Ω and 100Ω respectively. The characteristic impedance of the transmission line is

(a) 25Ω (b) 50Ω

(c) 75Ω (d) 100Ω

Ans. **(b)**

Sol. Given

$$Z_{sc} = 25\Omega$$

$$Z_{oc} = 100\Omega$$

$$Z_{sc}Z_{oc} = Z_o^2$$

$$Z_o^2 = 25\times 100$$

$\boxed{Z_o = 50\Omega}$

68. A signal m(t) = $10\cos[2\pi 100t]$ is frequency modulated. The resulting FM signal is x(t) = $20\cos\{2\pi 10^6 t + 15\sin(2\pi 100t)\}$ The FM bandwidth is nearly

(a) 3.2 kHz (b) 9.6 kHz

(c) 32 kHz (d) 100 kHz

Ans. **(a)**

Sol. Message signal :

$m(t) = 10\cos(2\pi\times 100t)$

maximum frequency component of message signal = f_{max} = 100 Hz

Frequency modulated signal is

$x(t) = 20\cos\left(2\pi\times 10^6 t + 15\sin(2\pi\times 100t)\right)$

Comparing with :

$x(t) = A_c\cos(\omega_c t + \beta\sin\omega_m t)$

$\boxed{\beta = 15}$

Bandwidth of FM signal = $(\beta+1)$ (2 f_{max})

= (15 + 1) × 2 × 100

= 16 × 2 × 100

= 3200 Hz

$\boxed{\text{Bandwidth} = 3.2\,\text{kHz}}$

69. The minimum value of modulation index β for and FM system required to produce a noticeable improvement in SNR over a comparable AM system with $\mu = 1$ is

(a) 0.61 (b) 0.52

(c) 0.47 (d) 0.38

Ans. **(c)**

Sol. SNR of FM system for, sinusoidal message signal = $\frac{3}{2}\beta^2$

SNR of AM system for sinusoidal message signal = $\frac{\mu^2}{2+\mu^2}$

Both the system are comparable.

$$\frac{3}{2}\beta^2 \geq \frac{\mu^2}{2+\mu^2}$$

$\boxed{\mu = 1}$

$$\frac{3}{2}\beta^2 \geq \frac{1}{2+1}$$

$$\beta^2 \geq \frac{2}{9}$$

$$\beta > \sqrt{\frac{2}{9}} = 0.471$$

$\boxed{\beta_{min} = 0.47}$

70. Consider the following statements pertaining to FIR filters:

1. These are non-recursive and hence stable.
2. These have high coefficient sensitivity.
3. These have linear phase characteristics
4. These are realized using feedback structures.

Which of the above statements are correct?

(a) 1 and 4 (b) 2 and 3

(c) 1 and 3 (d) 2 and 4

Ans. **(c)**

Sol. FIR filters in general can be represented in the following form:

$y[n] = a_0x[n] + a_1x[n-1] + a_2\, x[n-2] + \ldots a_n\, x[n-N]$

since there is no y[n] term on RHS, these are non-recursive.

Non-recursive systems have all poles at z = 0,

$\therefore$ they are stable systems. (1 is correct)

Coefficient sensitivity is related to filter structure and not to filter type. (2 is incorrect.)

FIR filters have linear phase characteristics. (3 is correct)

Since these are re-cursive, there is no feedback.

71. A signal is band limited to 3.6 kHz and three other signals are band limited to 1.2 kHz each. These signals are to be transmitted by means of time division multiplexing. If each signal is sampled at its Nyquist rate, then the speed of the commutator (by assuming 6 samples per rotation) is

(a) 864000 rpm (b) 144000 rpm

(c) 86400 rpm (d) 14400 rpm

Ans. (b)

Sol. Let signals are m_1, m_2, m_3, m_4

Signal	**Maximum frequency component**	**Sampling Frequency**
m_1	f_{m_1} = 3.6 K	f_{s_1} = 7.2 K
m_2	f_{m_2} = 1.2 K	f_{s_2} = 2.4 K
m_3	f_{m_3} = 1.2 K	f_{s_3} = 2.4 K
m_4	f_{m_4} = 1.2 K	f_{s_4} = 2.4 K

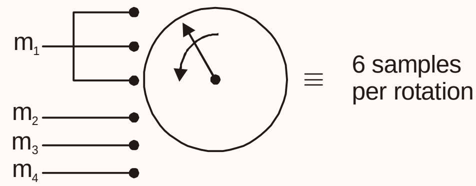
Speed of commutator = HCF$(f_{s_1}, f_{s_2}, f_{s_3}, f_{s_4})$ × 60 rpm

= HCF (7.2K, 2.4K, 2.4K, 2.4K) × 60 rpm

= 2.4 K × 60 rpm

= 144 K rpm

$$\boxed{\text{Speed} = 144{,}000 \text{ rpm}}$$



72. 1 Mpbs BPSK receiver detects waveform $S_1(t) = A\cos\omega_0 t$ or $S_2(t) = -A\cos\omega_0 t$ with a matched filter. If A = 1 mV, then the average bit error probability assuming single sided noise power expected density $N_0 = 10^{-11}$ W/Hz is nearly

(a) Q(0.63) (b) Q(0.16)

(c) $Q\left(\sqrt{0.1}\right)$ (d) $Q\left(\sqrt{0.3}\right)$

Ans. (c)

Sol. Given :

R_b = 1 Mbps

$$T_b = \frac{1}{R_b} = 10^{-6} \text{ sec}$$

A = 1 mV = 10^{-3} V

For BPSK :

Average bit error probability is

$$(P_e)_{min} = Q\left[\sqrt{\frac{A^2 T_b}{N_0}}\right]$$

$$= Q\left[\sqrt{\frac{10^{-6} \times 10^{-6}}{10^{-11}}}\right] = Q\left[\frac{1}{\sqrt{10}}\right]$$

$$\boxed{(P_e)_{min} = Q(0.316)}$$

$$\boxed{(P_e)_{min} = Q\left[\sqrt{\frac{1}{10}}\right] = Q\left[\sqrt{0.1}\right]}$$

73. The outputs of 18 numbers of 20 Hz low pass filters are sampled, multiplexed and A/D converted. If the sampling is at the Nyquist rate of 40 samples/s, corresponding to signal of 20 Hz bandwidth and if we use 3 bits/smaple to represent each voltage sample, the bit rate is

(a) 1.9×10^3 bits/s (b) 19×10^3 bits/s

(c) 2.16×10^3 bits/s (d) 21.6×10^3 bits/s

Ans. (c)

Sol. Given

Number of output = 18 = N

maximum frequency of 1 output

f_{max} = 20 Hz

$f_s = 40 \dfrac{\text{samples}}{\text{sec}}$

$n = 3 \dfrac{\text{bits}}{\text{sample}}$

Bit rate : $R_b = N \times n \times f_s$

$R_b = 18 \times 3 \times 40$

$$\boxed{R_b = 2160 \frac{\text{bits}}{\text{sec}}}$$

74. The minimum double sided Nyquist bandwidth for a QPSK modulator with an input data rate equal to 10 Mbps and a carrier frequency of 70 MHz is

(a) 72.5 MHz (b) 67.5 MHz

(c) 25.0 MHz (d) 5.0 MHz

Ans. (d)

Sol. Minimum bandwidth necessary to pass M-ary digitally modulated carrier.

$$= \frac{R_b}{\log_2 M}$$

$$= \frac{10 \times 10^6}{\log_2 4}$$

= 5 MHz

75. The value of $\nabla \cdot A$; where

$$A = 3xy\vec{a}_x + x\vec{a}_y + xyz\vec{a}_z$$

at a point (2, –2, 2) is

(a) –10 (b) –6

(c) 2 (d) 4

Ans. (a)

Sol. $\vec{A} = 3xy\hat{a}_x + x\hat{a}_y + xyz\hat{a}_z$

$$\nabla \cdot \vec{A} = \frac{\partial Ax}{\partial Ay} + \frac{\partial Ay}{\partial y} + \frac{\partial Az}{\partial z}$$

$$\nabla \cdot \vec{A} = \frac{\partial}{\partial x}(3xy) + \frac{\partial (x)}{\partial y} + \frac{\partial (xyz)}{\partial z}$$

$$\nabla \cdot \vec{A} = 3y + xy$$

At (2, –2, 2)

$$\nabla \cdot \vec{A} = -(6+4) = -10$$

76. The unit-impulse response of a system is $16e^{-2t} - 8e^{-t}$. Its unit-step response is

(a) $8 + e^{-t} - 4e^{-2t}$ (b) $8 + e^{-t} + 4e^{-2t}$

(c) $8e^{-t} - 8e^{-2t}$ (d) $e^{-t} - 4e^{-2t}$

Ans. (c)

Sol. Unit impulse response of a system :

$h(t) = 16\ e^{-2t} - 8\ e^{-t}$

Unit step response

$$\frac{ds(t)}{dt} = h(t)$$

$$s(t) = \int_{-\infty}^{t} h(t)dt$$

$$s(t) = \frac{16e^{-2t}}{(-2)} - \frac{8e^{-t}}{(-1)}$$

$s(t) = 8\ e^{-t} - 8\ e^{-2t}$

$$\boxed{s(t) = 8e^{-t} - 8e^{-2t}}$$

77. The low-frequency asymptote in the Bode plot of

$$G(s) = \frac{6(s^2 + 10s + 100)}{s^2(50s^2 + 15s + 1)}$$

has a slope of

(a) –10 dB/dec (b) –20 dB/dec

(c) –40 dB/dec (d) –60 dB/dec

Ans. **(c)**

Sol.

$$G(s) = \frac{6(s^2 + 10s + 100)}{s^2(50s^2 + 15s + 1)}$$

Low frequency assymptote slope depends upon the poles or zeros at origin. As, the number of poles at origin is two, so the low frequency slope of bode plote

= 2 (–20)

= –40 dB/decade.

78. For the open-loop system

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

the breakaway point is

(a) – 0.23 (b) – 0.42

(c) – 1.47 (d) – 3.47

Ans. **(b)**

Sol.

$$G(s)\cdot H(s) = \frac{k}{s\cdot(s+1)(s+2)}$$

$1 + G(s)\cdot H(s) = 0$

$$1 + \frac{k}{s(s+1)(s+2)} = 0$$

$k = -s\ (s + 1)\ (s + 2) = -\ (s^3 + 3s^2 + 2s)$

$$\frac{dk}{ds} = -\ (3s^2 + 6s + 2)$$

for breakaway point,

$$\frac{dk}{ds} = 0$$

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

$s = -\ 0.42,\ -\ 1.57$

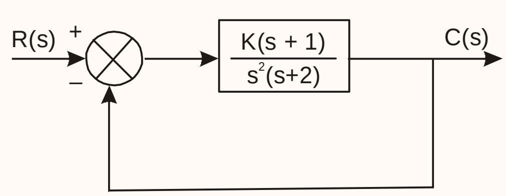
$s = -\ 1.57$ won't lie on RL. (As the total number of poles and zeros to right of it is even.)

So, the only breakaway point will be

$s = -\ 0.42$

79. Consider the stability of the system shown in the figure when analyzed with a positive real value of gain k in

1. open-loop configuration
2. closed-loop configuration



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Which of the following statements is correct?

(a) Both 1 and 2 are stable

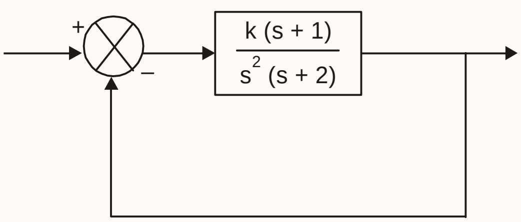
(b) 1 is stable and 2 is unstable

(c) 1 is unstable and 2 is stable

(d) Both 1 and 2 are unstable

Ans. **(c)**

Sol.



- For the open loop configuration, trangular function

$$= G(s)\cdot H(s) = \frac{k(s+1)}{s^2(s+2)}$$

Characteristic equation is given by

CE : s^2 (s + 2) = 0

poles $\Rightarrow$ $\boxed{s = 0,\ 0, -2}$

As, there are repeated poles on origin, the open loop system is unstable.

- For the closed loop configuration, transfer function

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

Characteristic equation is given by

CE: $$1+\frac{k(s+1)}{s^2(s+2)} = 0$$

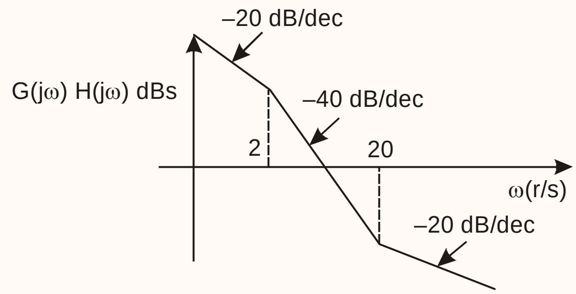
$s^3 + 2s^2 + ks + k = 0$

For above system to be stable,

$\boxed{2k > k}$ & $\boxed{k > 0}$

The above situation is valid for any positive value of k, so the closed loop system is stable.

80. The open-loop transfer function G(s) H(s) of the Bode plot as shown in the figure is



(a) $\frac{Ks(s+2)}{s+20}$ (b) $\frac{K(s+20)}{s(s+2)}$

(c) $\frac{K(s+2)}{s(s+20)}$ (d) $\frac{Ks(s+20)}{s+2}$

Ans. **(b)**

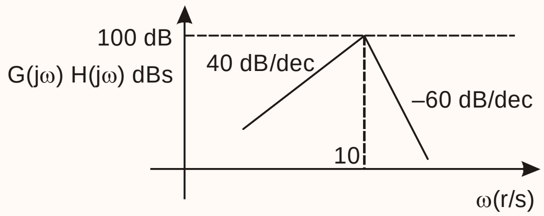
Sol.

- As initial slope of bode plot is –20 dB/decade, so transfer function will have a pole of order 1 at origin.
- The slope changes by a value of –20 dB/decade at $\omega = 2$ radian/second, so there will be a pole of order 1 at s = –2.
- The slope changes by a value of +20dB/decade at $\omega = 2$ radian/second, so there will be a zero of order 1 at s = – 20.

The correct transfer function will be

$$Tf = \frac{k(s+20)}{s(s+2)}$$

81. Which one of the following transfer functions represents the Bode plot as



(a) $\dfrac{Ks^2}{\left(1+\dfrac{s}{10}\right)^3}$ (b) $\dfrac{Ks^2}{\left(1+\dfrac{s}{10}\right)^4}$

(c) $\dfrac{Ks^2}{\left(1+\dfrac{s}{10}\right)^5}$ (d) $\dfrac{Ks^2}{\left(1+\dfrac{s}{10}\right)^2}$

Ans. (c)

Sol.

The initial slope of Bode plot is +40 dB/decade, so the transfer function will have zero of order 2 at origin.

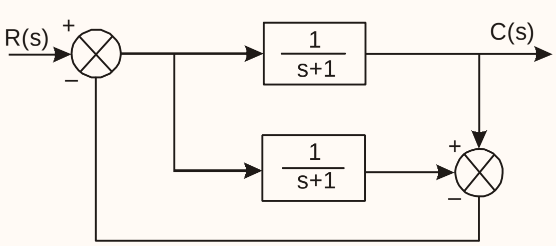
The slope of Bode plot changes by –100 dB/decade at ω = 10 rad/sec., so there will be pole of order 5 at s = –10.

The transfer function will be

$$TF = \frac{k_1 \cdot s^2}{(s+10)^5}$$

or $$TF = \frac{ks^2}{\left(1+\dfrac{s}{10}\right)^5}$$

82. The closed-loop transfer function $\dfrac{C(s)}{R(s)}$ of the system represented by the block diagram in the figure is

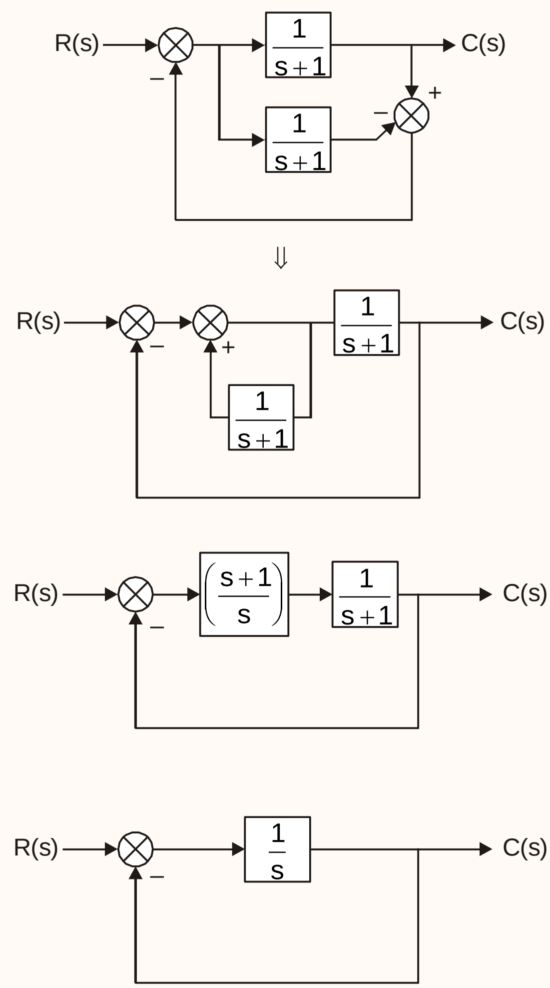


(a) $\dfrac{1}{(s+1)^2}$ (b) $\dfrac{1}{(s+1)}$

(c) s+1 (d) 1

Ans. (b)

Sol.



$$\frac{C(s)}{R(s)} = \frac{\dfrac{1}{s}}{1+\dfrac{1}{s}} = \left(\frac{1}{s+1}\right)$$

83. In a unity feedback control system, the open-loop transfer function is

$$G(s) = \frac{K(s+2)}{s^2(s^2+7s+12)}$$

Then the error constants K_P, K_v and K_a, respectively, are

(a) ∞, ∞ and $\frac{K}{6}$ (b) 0, 0 and $\frac{K}{6}$

(c) $\frac{K}{6}$, 0 and 0 (d) $\frac{K}{6}, \infty$ and ∞

Ans. (a)

Sol.

$$G(s) = \frac{k(s+1)}{s^2(s^2+7s+12)}$$

For a unity feed back systerm, k_p, k_v and k_a are given by

$$k_p = \lim_{s\to 0} G(s)$$

$$k_v = \lim_{s\to 0} s\cdot G(s)$$

$$k_a = \lim_{s\to 0} s^2\cdot G(s)$$

$$\therefore \quad k_p = \lim_{s\to 0} \frac{k(s+1)}{s^2(s^2+7s+12)} = \infty$$

$$k_v = \lim_{s\to 0} s\cdot\frac{k(s+1)}{s^2(s^2+7s+12)} = \infty$$

$$k_a = \lim_{s\to 0} s^2\cdot\frac{k(s+2)}{s^2(s^2+7s+12)}$$

$$= \frac{2k}{12} = \frac{k}{6}$$

84. Settling time is the time required for the system response to settle within a certain percentage of

(a) maximum value

(b) final value

(c) input amplitude value

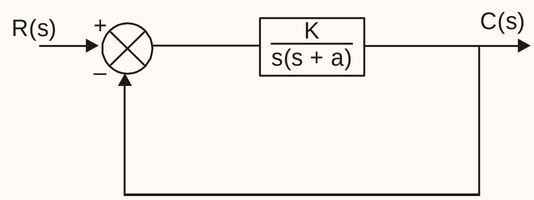
(d) transient error value

Ans. (b)

Sol.

Settling time is defined as the time for the response to reach, and stay within, 2% of its final value.

85. A unity feedback system is shown in the figure. What is the magnitude of K so that the system is under-damped?



(a) K = 0 (b) $K = \frac{a^2}{4}$

(c) $K < \frac{a^2}{4}$ (d) $K > \frac{a^2}{4}$

Ans. (d)

Sol.

The characteristic equation is given by

$$\text{CE}: \quad 1+\frac{k}{s(s+a)} = 0$$

$$s^2 + as + k = 0$$

Comparing with standard equation

$$s^2+2\xi\omega_n s+\omega_n^2 = 0$$

$$\omega_n = \sqrt{k}$$

$$\xi = \frac{a}{2\sqrt{k}}$$

For underdamped system,

$$\xi < 1$$

$$\frac{a}{2\sqrt{k}} < 1$$

$$\sqrt{k} > \frac{a}{2}$$

$$\boxed{k > \frac{a^2}{4}}$$

86. The transfer function G(s) of a PID controller is

(a) $K_1 + K_2 s + K_3 s^2$

(b) $K_1 + \frac{K_2}{s} + K_3 s$

(c) $K_1 + \frac{K_2}{s}$

(d) $K_1 s + K_2 s^2 + K_3 s^3$

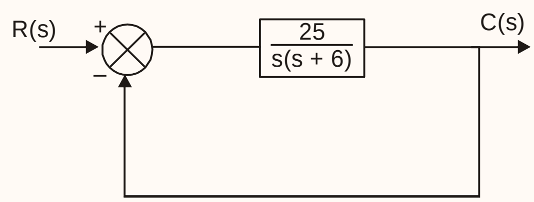
Ans. (b)

Sol.

The transfer function of a PID controller is

$$G(s) = k_1 + \frac{k_2}{s} + k_3 \cdot s$$

87. For a closed-loop system shown in the figure, what is the settling time for ±2% settling of the steady-state condition, assuming unit-step input?



(a) 0.33 s (b) 1.33s

(c) 2.33 s (d) 3.33 s

Ans. (b)

Sol.

Characteristic equation is given by

$$\text{CE: } 1 + \frac{25}{s(s+6)} = 0$$

$$s^2 + 6s + 25 = 0$$

Comparing with standard equation

$$s^2 + 2\xi\omega_n s + \omega_n^2 = 0,$$

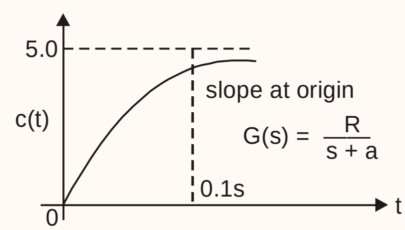
$$\omega_n = 5,$$

$$\xi = \frac{6}{2\times 5} = 0.6$$

The setting time for ± 2% of steady state condition is given by,

$$t_s = \frac{4}{\xi\omega_n} = \frac{4}{5\times 0.6} = 1.33 \text{ sec}$$

88. A unit-step input to a first-order system G(s) yields a response as shown in the figure. This can happen when the values of K and a, respectively, are



(a) 10 and 10 (b) 5 and 10
(c) 10 and 5 (d) 5 and 5

Ans. (*)

Sol.

None of the given option is correct.

Given transfer function, $G(s) = \frac{k}{(s+a)}$

Step response $C(s) = G(s)\cdot R(s)$

$$= \frac{k}{s(s+a)}$$

$$= \frac{k}{a}\left(\frac{1}{s} - \frac{1}{s+a}\right)$$

$\therefore$ taking inverse laplace transform,

$$c(t) = \frac{k}{a}\left(1-e^{-at}\right)$$

$$\frac{dc(t)}{dt} = k \cdot e^{-at}$$

at t = 0, slope $\frac{dc(t)}{dt} = 50$

$$k \cdot e^{o} = 50$$

$$\boxed{k = 50}$$

Again, the response may be assumed to attain 63.2% of value at t = 0.1 sec.

so, τ = 0.1 sec

The response, $c(t) = \frac{k}{a}\left(1-e^{-at}\right)$

The standard response is

$$c(t) = k_1\left(1-e^{-t/\tau}\right)$$

$\therefore$ $a = \frac{1}{\tau}$

$$a = \frac{1}{0.1} = 10 \text{ sec}$$

89. The open-loop transfer function of a sysrtem is

$$\frac{10K}{1+10s}$$

When the system is converted into a closed-loop with unity feedback, the time constant of the system is reduced by a factor of 20. The value of K is

(a) 1.9 (b) 1.6
(c) 1.3 (d) 1.0

Ans. **(a)**

Sol

- Open loop transfer function (OLTF)

$$= \frac{10k}{(1+10s)}$$

Comparing with standard equation, i.e.

$$\frac{k_1}{(1+s\tau_1)}$$

$$\tau_1 = 10$$

By using feedback, new time constant,

$$\tau_2 = \frac{10}{20} = 0.5$$

- Closed loop transfer function (CLTF)

$$= \frac{10k}{(10k+1+10s)}$$

$$= \frac{10k}{(10k+1)\cdot\left\{1+\left(\frac{10}{10k+1}\right)\cdot s\right\}}$$

Comparing with standard equation, i.e.

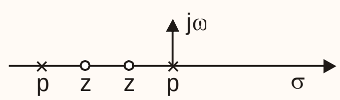
$$\left(\frac{k}{1+s\tau_2}\right)$$

$$\tau_2 = \frac{10}{10k+1} = 0.5$$

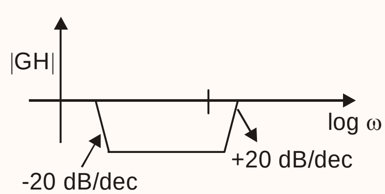
$$\frac{10}{0.5} = 10\ k + 1$$

$$\boxed{k = 1.9}$$

90. The pole-zero configuration of the transfer function of a compensator and the corresponding Bode plot are shown in the figure. The configuration is indicative of



$$TF = \frac{(1+2s)\ (1+0.75s)}{(1+16s)\ (1+0.1s)}$$



(a) lag compensator

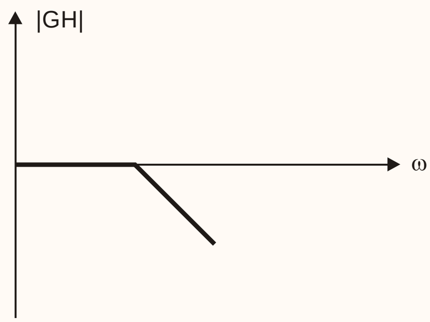
(b) lag-lead compensator

(c) P-D compensator

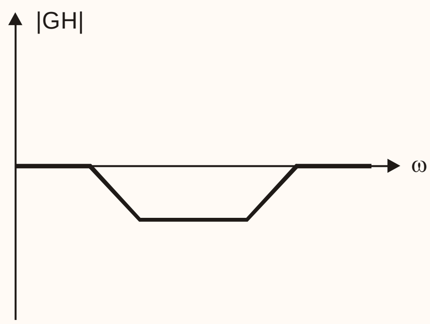
(d) lead compensator

Ans. **(b)**

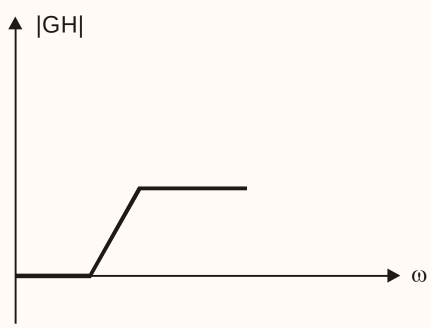
Sol. The bode plot of a lag compensator is of form $\Rightarrow$



The bode plot of a lag lead compensator is of form $\Rightarrow$



The bode plot of a lead compensator or PD controller is a form $\Rightarrow$



So, the given configuration is indicative of lag lead compensator.

91. Consider that a level of the memory hierarchy has a hit rate of 80%. Memory requests take 10 ns to complete if they hit in the level, and memory requests that miss in the level take 100 ns to complete. The average access time of the level is

(a) 110 ns (b) 100 ns

(c) 80 ns (d) 28 ns

Ans. **(d)**

Sol. Average access time = hit × 10 + min × 100

= 0.8 × 10 + (1 – 0.8) × 100

= (8 + 20) nsec

= 28 nsec

92. A program structure that permits repeated operation of a particular sequence of instructions is known as

(a) subroutine

(b) loop

(c) module

(d) microprogramming

Ans. **(a)**

Sol. A program structure that permits repeated operation of a particular sequence of instructions is known as subroutine.

93. If

$$V = \frac{10}{r^2}\sin\theta\cdot\cos\phi$$

the electric flux density at $\left(2,\frac{\pi}{2},0\right)$ is

(a) $32\cdot1\vec{a}_r$ pC/m^2 (b) $22\cdot1\vec{a}_r$ pC/m^2

(c) $10\cdot2\,\vec{a}_r$ pC/m^2 (d) $5\cdot8\,\vec{a}_r$ pC/m^2

Ans. **(b)**

Sol. $V = \frac{10}{r^2}\sin\theta\cos\phi$

$$\vec{E} = -\nabla V$$

$$\vec{E} = -\left[\frac{\partial V}{\partial r}a\hat{r} + \frac{1}{r}\frac{\partial V}{\partial\theta}a\hat{\theta} + \frac{1}{r\sin\theta}a\hat{\phi}\right] + \frac{1}{r\sin\theta}\frac{\partial}{\partial\phi}\left[\frac{10}{r^2}\sin\theta\cos\phi\right]a\hat{\phi}$$

$$\vec{E} = -\left[10\left(\frac{-2}{r^3}\right)\sin\theta\cos\phi a\hat{r} + \frac{10}{r^3}\cos\theta\cos\phi a\hat{\theta}\right] + \frac{1}{r\sin\theta}\times\frac{10\sin\theta}{r^2}(-\sin\phi)a\hat{\phi}$$

$$\vec{E} = -\left[\frac{-20}{r^3}\sin\theta\cos\phi a\hat{r} + \frac{10}{r^3}\cos\theta\cos\phi a\hat{\theta} + \frac{10}{r^3}(-\sin\phi)a\hat{\phi}\right]$$

$$\vec{E} = \frac{20}{r^3}\sin\theta\cos\phi a\hat{r} - \frac{10}{r^3}\cos\theta\cos\phi a\hat{\theta} + \frac{10}{r^3}\sin\phi a\hat{\phi}$$

$\vec{D} = \varepsilon_o\vec{E}$ (Electric flux density)

At point $\left(2,\frac{\pi}{2},0\right)$

r = 2

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

$\phi = 0$

$$\boxed{\vec{D} = 22.1a\hat{r}\ \ \text{PC/m}^2}$$

94. In an n-turn coil, the flux through each turn is (t^3–4t) mWb. The magnitude of the induced e.m.f. in the coil at t = 5s is 7.1 V. the number of turns in the coil is

(a) 10 (b) 100

(c) 121 (d) 1000

Ans. **(b)**

Sol.

Flux through each turn

$\phi = \left(t^3 - 4t\right)$ m Weber

$\boxed{\phi = \left(t^3 - 4t\right) \times 10^{-3} \text{ Weber}}$

Magnitude of induced emf at t = 5 sec = 7.1V

$$\text{emf} = \frac{-nd\phi}{dt}$$

$$|\text{emf}| = \frac{nd\phi}{dt} = 7.1$$

where n = no. of turns in coil

$$|\text{emf}| = +n\frac{d}{dt}\left(t^3 - 4t\right) \times 10^{-3}$$

$7.1 = +n(3t^2 - 4) \times 10^{-3}$

t = 5 sec

$7.1 = n(75 - 4) \times 10^{-3}$

$\boxed{n = 100 \text{ turns}}$

95. Consider the following statements:

1. For an isotropic medium, ε is a scalar constant.
2. For a homogeneous medium, ε, μ and σ are constant throughout the region.
3. In an anisotropic medium, D and E have the same direction
4. For certain crystalline medium, ε varies with the direction of E.

Which of the above statements are correct?

(a) 1, 2 and 3 (b) 1, 3 and 4

(c) 1, 2 and 4 (d) 2, 3 and 4

Ans. **(c)**

Sol.
- For an isotropic medium, the dielectric constant is same in all directions or ε is constant.
- $\vec{D} = \varepsilon\vec{E}$

then $\vec{D}$ and $\vec{E}$ will have same direction for isotropic material.

- For homogeneous medium ε (or σ) does not vary in the region or independent of (x, y, z).
- Crystalline materials are anisotropic, for anisotropic material, the dielectric constant is different in different direction.

$\varepsilon_r = F\left(a\hat{x}, a\hat{y}, a\hat{z}\right)$

ε varies with direction of $\vec{E}$

96. If a 75Ω line is terminated by a load of (120 + j80) Ω, the maximum and minimum impedances over the line are nearly

(a) 135Ω and 28Ω

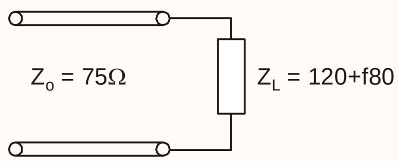
(b) 190.5 Ω and 28 Ω

(c) 135 Ω and 16 Ω

(d) 190.5 Ω and 16 Ω

Ans. (b)

Sol.



Maximum impedance : Zmax = Z_o × VSWR

Minimum impedance : $Z_{min} = \dfrac{Z_o}{VSWR}$

$$VSWR = \frac{1+|\Gamma_v|}{1-|\Gamma_v|}$$

$$\Gamma_v = \frac{Z_L - Z_o}{Z_L + Z_o} = \frac{120 + j80 - 75}{120 + j80 + 75}$$

$$\Gamma_v = \frac{45 + j80}{195 + j80}$$

$$|\Gamma_v| = \frac{\sqrt{(45)^2 + (80)^2}}{\sqrt{(195)^2 + (80)^2}} = 0.43$$

$$VSWR = \frac{1+0.43}{1-0.43}$$

$$\boxed{VSWR = 2.5}$$

Z_{max} = 75 × 2.5 = 188.15

$$Z_{min} = \frac{75}{2.5} = 30$$

Approximate answer is (b)

97. A product-of-sums (POS) expression leads to what kind of logic circuit?

(a) OR-AND circuit

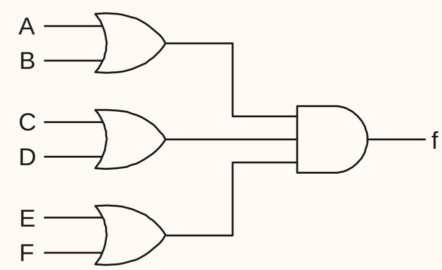
(b) NOR-NOR circuit

(c) AND-OR-INVERT circuit

(d) NAND-NAND circuit

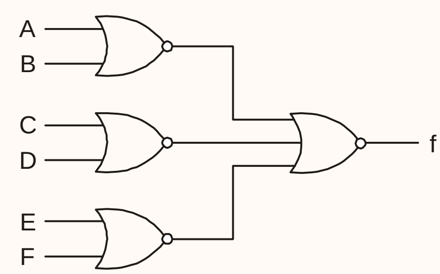
Ans. (a,b)

Sol. POS : Product of sum



$$\boxed{f = (A+B)\cdot(C+D)\cdot(E+F)}$$

Product of sum



98. In a certain material medium, a propagating electromagmagnetic wave attains 60% of the velocity of light. The distance at which the electromagnetic wave (f = 10 MHz) will have th same magnitude for the induction as well as the radiation fields is nearly

(a) 57.4 m (b) 29.0 m

(c) 5.8 m (d) 2.9 m

Ans. (d)

Sol. Electric field at radial distance is function of θ :

$$E_\theta = \frac{I_o dl \sin\theta e^{j\omega t} e^{-j\beta r}}{4\pi\varepsilon}\left\{\frac{j\beta^2}{\omega r} + \frac{\beta}{\omega r^2} - \frac{1}{\omega r^3}\right\}$$

Radiation field has $E_\theta \propto \frac{1}{r}$

Induction field has $E_\theta \propto \frac{1}{r^2}$

Electrostatics field has $E_\theta \propto \frac{1}{r^3}$

Magnitude of induction as well as radiation field is same

$$\left|\frac{I_o dl \sin\theta e^{j\omega t} e^{-j\beta r}}{4\pi\varepsilon} \times \frac{j\beta^2}{\omega r}\right| = \left|\frac{I_o dl \sin\theta e^{j\omega t} e^{-j\beta r}}{4\pi\varepsilon} \times \frac{\beta}{\omega r^2}\right|$$

$$\frac{\beta^2}{\omega r} = \frac{\beta}{\omega r^2}$$

$$r = \frac{1}{\beta}$$

$$r = \frac{\lambda}{2\pi}$$

$$\lambda = \frac{v}{f}$$

$$\lambda = \frac{0.6 \times 3 \times 10^8}{10 \times 10^6}$$

$$\boxed{\lambda = 18 \text{ m}}$$

$$r = \frac{18}{2\pi}$$

$$\boxed{r = 2.86 \text{ m}}$$

99. A measure of the mismatch between the maximum and minimum voltage and current variations along the transmission line is called SWR, i.e., standing wave ratio. SWR indicates how much power is delivered to the load, and how much is lost in the line. When SWR is 1, the percent reflected power is zero. When SWR is 1.5, the percent reflected power will be

(a) 4 (b) 8

(c) 25 (d) 40

Ans. (a)

Sol. $$\frac{P_{reflected}}{P_{incident}} = -|\Gamma_v|^2$$

$$SWR = \frac{1+|\Gamma_v|}{1-|\Gamma v|}$$

$$1.5 = \frac{1+|\Gamma_v|}{1-|\Gamma_v|}$$

$$\boxed{|\Gamma_v| = 0.2}$$

$$\frac{P_{reflected}}{P_{incident}} = -(0.2)^2 = -0.04 \times 100\% = -4\%$$

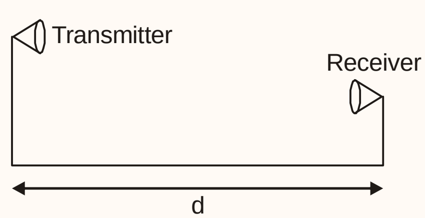
100. A communication link operating at 3 GHz has a 22.5 W transmitter connected to an antenna of 2.5 m^2 effective aperature. The receiving antenna has effective aperture of 0.5 m^2 and is located at 15 km line-of-sight distance from the transmitting antenna (assume lossless, matched antennas). The power delivered to the receiver is

(a) 12.5 μW (b) 125 μW

(c) 12.5 mW (d) 125 mW

Ans. (a)

Sol.



f = 3 GHz

P_t = 22.5 watt

A_{et} = 2.5 m^2

A_{er} = 0.5 m^2

d = 15 km

Power density at receiver = $\frac{P_t G_{dt}}{4\pi d^2}$

$$= \frac{22.5 G_{dt}}{4\pi(15\times10^3)^2}$$

$$\boxed{\text{Power desnity} = \frac{22.5 G_{dt}}{4\pi(15\times10^3)^2}}$$

$$\boxed{G_{dt} = \frac{4\pi}{\lambda^2} A_{et}}$$

$$\lambda = \frac{c}{f} = \frac{3\times10^8}{3\times10^9} = 0.1\text{m}$$

$$G_{dt} = \frac{4\pi}{(0.1)^2}\times2.5$$

$$\boxed{G_{dt} = 1000\,\pi}$$

Power density = $\frac{22.5\times1000\,\pi}{(15\times10^3)^2\times4\,\pi}$

$$= \frac{22{,}500}{4(15\times10^3)^2}$$

Power density = 2.5 × 10^{-5}

Power received = Power density × Effective area at receiver

= 2.5 × 10^{-5} × 0.5

= 12.5 × 10^{-6}

$$\boxed{\text{Power received} = 12.5\,\mu\text{watt}}$$

101. For a WR 90 waveguide, the cut-off frequency for TE_{20} mode is 16 GHz. Then the cut-off frequency for TE_{11} mode will be

(a) $4\sqrt{3}$ GHz (b) $6\sqrt{3}$ GHz

(c) $8\sqrt{5}$ GHz (d) $16\sqrt{5}$ GHz

Ans. (c)

Sol. Cut-off frequency of TE_{mn} mode

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

where, $v = \frac{C}{\sqrt{\mu_r \varepsilon_r}} = C = 3\times10^8$

For TE_{20} : f_c = 16 GHz

$$f_c = \frac{v}{2}\times\frac{m}{a}$$

$$f_c = \frac{3\times10^8\times2}{2\times a} = 16\times10^9$$

$$\boxed{a = 1.875\text{ cm}}$$

For TE_{11} mode :

$$f_c = \frac{v}{2}\sqrt{\frac{1}{a^2}+\frac{1}{b^2}}$$

For WR90 waveguide : aspect ratio $\frac{a}{b} = \frac{2}{1}$

$$f_c = \frac{v}{2a}\sqrt{1+\frac{a^2}{b^2}}$$

$$f_c = \frac{3\times10^8}{2\times1.875\times10^{-2}} = \sqrt{1+4}$$

$$\boxed{f_c = 8\sqrt{5}\text{ GHz}}$$

102. During wave propagation in an air-filled rectangular waveguide

1. wave impedance is never less than the free-space impedance
2. propagation constant is an imaginary number
3. TEM mode is possible if the dimensions of the waveguide are properly chosen

Which of the above are correct?

(a) 1 and 2 only (b) 1 and 3 only
(c) 2 and 3 only (d) 1, 2 and 3

Ans. **(c)**

Sol. For TE mode:

1. $$\eta_{TE} = \frac{\eta_o}{\sqrt{1-\left(\frac{f_c}{f}\right)^2}}$$

$$\boxed{\eta_{TE} > \eta_o}$$

For TM mode :

$$\eta_{TM} = \eta_o\sqrt{1-\left(\frac{f_c}{f}\right)^2}$$

$$\boxed{\eta_{TM} < \eta_o}$$

For TM mode wave impedance is less than the free-space impedance

2. $$\gamma = \alpha + j\beta = \sqrt{j\omega\mu(\sigma + j\omega\varepsilon)}$$

103. For a 4-element broadside antenna array, ψ equals

(a) $\sin\phi$ (b) $\pi\cos\phi$
(c) $\frac{\cot\phi}{\sqrt{2}\,\pi}$ (d) $\pi\sin\phi$

Ans. **(b)**

Sol. For total phase shift :

$$\phi = \alpha + \beta d\cos\theta$$

For broadside array progressive phase shift between current element is zero

$$\alpha = 0$$

Distance between respective element

$$d = \frac{\lambda}{2}$$

$$\phi = 0 + \frac{2\pi}{\lambda}\times\frac{d}{2}\cos\theta$$

$$\boxed{\phi = \pi\cos\theta}$$

104. The open-loop transfer function of a system has two poles on the imaginary axis, one in the left-half and the other in the right-half, together with a zero at the origin of coordinates and also two zeros in the left-half of the s-plane. The closed-loop response for unity feedback will be stable if the encirclement of the critical point (–1, j0) is

(a) –1 (b) +1
(c) –2 (d) +2

Ans. **(b)**

Sol. For open loop system, number of poles in right half s-plane (P) = 1

From nyquist stability criterion,

$$N = P - Z$$

where, N = number of encirclement of point (–1, 0)

Z = number of zeros of $1 + G(s) \cdot H(s)$ or number of poles of closed loop system in right half plane.

For stability, $z = 0$,

so $\boxed{N = P = 1}$

105. The steady-state error for a Type 0 system for unit-step input is 0.2. In a certain instance, this error possibility was removed by insertion of a unity gain block. Thereafter, a unit ramp was applied. The nature of the block and new steady-state error in this changed configuration will, respectively, be

(a) integrator; 0.25 (b) differentiator; 0.25

(c) integrator; 0.20 (d) differentiator; 0.20

Ans. **(a)**

Sol. If steady state error to unit step input is e_{ss}, and positional error constant is k_p, then

$$e_{ss} = \frac{1}{1+k_p}$$

$$1 + k_p = \frac{1}{0.2}$$

$$k_p = 4$$

$$\therefore \quad k_p = \lim_{s \to 0} G(s) \cdot H(s) = 4$$

The error due to step input is made to zero, so type of system would have increased. Hence we can say that the unity gain block used is an integrator.

Now, the open loop transfer function will become,

$$G'(s) = \frac{G(s) \cdot H(s)}{s}$$

$$\therefore \text{ Now,} \quad k_v = \lim_{s \to 0} s \cdot \frac{G(s)H(s)}{s}$$

$$= \lim_{s \to 0} G(s)H(s)$$

$$= 4$$

New steady state error (e_{ss}) $\frac{1}{k_v} = \frac{1}{4} = 0.25$

106. Which one of the following refers to the frequency ω_k in the frequency response of an FIR filter?

(a) $\frac{16\pi}{M}(k+\alpha)$ (b) $\frac{8\pi}{M}(k+\alpha)$

(c) $\frac{4\pi}{M}(k+\alpha)$ (d) $\frac{2\pi}{M}(k+\alpha)$

Ans. **(d)**

Sol. Frequency sampling structure is an alternative structure for an FIR filter.

To derive the frequency sampling structure, we specify the desired frequency response at a set of equally spaced frequenies given by

$$\omega_k = \frac{2\pi}{M}(k+\alpha)$$

107. Three processors with their respective process IDs given by P_1, P_2 and P_3, having estimated completion time of 8 ms, 4 ms and 2 ms, respectively, enter a ready queue together in the order P_1, P_2 and P_3. What is the average turn time in the Round Robin Scheduling Algorithm with time 2 ms?

(a) 10 ms (b) 15 ms
(c) 20 ms (d) 25 ms

Ans. **(a)**

Sol. Given process id and their completion time is as follows :

Process Id	P_1	P_2	P_3
Completion time	8 msec	4 msec	2 msec

Process enter in the ready queue in the order P_1 P_2 P_3 and round robin scheduling algorithm is used with time quanta 2 msec

Gantt chart is given below :

P_1	P_2	P_3	P_1	P_2	P_1	P_1

0 2 4 6 8 10 12 14

Waiting time of P_1

$= 0 + (6 - 2) + (10 - 8)$

$= 0 + 4 + 2 = 6$ msec

Waiting time of P_2

$(2 - 0) + (8 - 4) = 2 + 4 = 6$ msec

Waiting time of P_3

$(4 - 0) = 4$ msec

Turn around time of process = Burst time of process + Waiting time of process

$TAT_{P1} = 8 + 6 = 14$ msec

$TAT_{P2} = 4 + 6 = 10$ msec

$TAT_{P3} = 2 + 4 = 6$ msec

Average turn around time

$$= \frac{14+10+6}{3} = 10 \text{ msec}$$

108. In the following 8085 assembly language program, assume that the carry flag is initially reset. What is the content of the accumulator after the execution of the program?

```
MVI   A,   04H
RRC
MOV   B, A
RLC
RLC
ADD  B
RCC
```

(a) 02H (b) 05H
(c) 15H (d) 25H

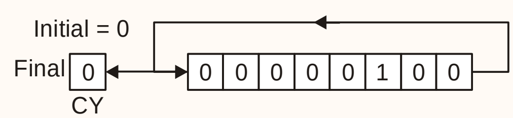
Ans. **(b)**

Sol. $\boxed{CY = 0}$

(1) MVIA, 04H

A = | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |

(2) RRC

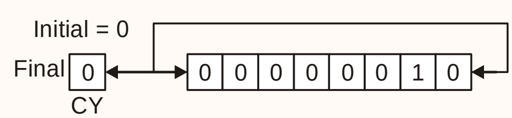


A = | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |

(3) MOV B, A

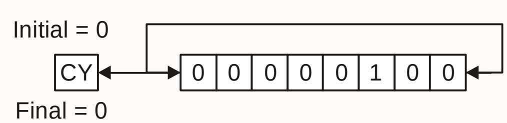
B $\boxed{02H}$

(4) RLC



| 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |

(5) RLC

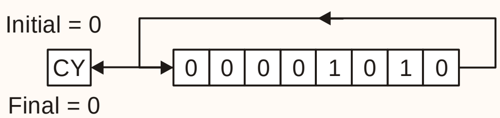


A $\boxed{08H}$

(6) ADDB

$$A + B = \begin{array}{r} 08\text{ H} \\ \underline{02\text{ H}} \\ \boxed{0A\text{ H}} \end{array}$$

(7) RRC



0	0	0	0	0	1	0	1

A $\boxed{05H}$

109. The technique for using one set of addresses inside a network and remapping those addresses to a different set of addresses that are seen outside the local network on the internet is called

(a) network address translation

(b) address resolution

(c) network address mapping

(d) virtual LAN

Ans. **(a)**

Sol. Network address translation enables the user to have a large set of addresses internally and one or small set of addresses externally.

110. What type of network is the Internet?

(a) Circuit-switched network

(b) Message-switched network

(c) Packet-switched network

(d) Cell-switched network

Ans. **(c)**

Sol. Internet is based on packet switched network, where small unit of data called packets are routed through network.

111. Which of the following statements is correct in respect of TCP and UDP protocols?

(a) TCP is connection-oriented, whereas UDP is connectionless

(b) TCP is connectionless, whereas UDP is connection-oriented

(c) Both are connectionless

(d) Both are connection-oriented

Ans. **(a)**

Sol. TCP is connection oriented, so it is suitable for highly reliable transmission whereas UDP is suitable for fast and normal information transmission.

112. A fixed radar station transmits 100 kW at 3 GHz. The smallest ocean-going ship has a radar cross-section of 200 m^2. The radar antenna gain is 16 dB. If detection requires a minimum of 1 nW/m^2 at the radar antenna, the effective range of the radar is nearly

(a) 7.1 km (b) 8.4 km

(c) 70.7 km (d) 84.0 km

Ans. **(b)**

Sol. Given P_t = 100 K watt

f = 3 GHz

$$\lambda = \frac{c}{f} = \frac{3\times10^{8}3}{3\times10^{9}} = 0.1\text{m}$$

$$\sigma = 200 \text{ m}^2$$

$$G_{(\text{dB})} = 16 \text{ dB} \Rightarrow G = 10^{1.6} = 39.8$$

$$S_{min} = 1\times10^{-9}\frac{\text{watt}}{\text{m}^2}\times A_{er}$$

$$S_{min} = 10^{-9} \times \frac{G \times \lambda^2}{4\pi}$$

$$S_{min} = 10^{-9} \times 39.8 \times \frac{(0.1)^2}{4\pi}$$

$$\boxed{S_{min} = 3.16 \times 10^{-11} \text{watt}}$$

$$R_{max} = \left[\frac{P_t G^2 \sigma \lambda^2}{(4\pi)^3 S_{min}}\right]^{1/4}$$

$$R_{max} = \left[\frac{100 \times 10^3 \times (39.8)^2 \times 200 \times (0.1)^2}{(4\pi)^3 \times 3.16 \times 10^{-11}}\right]^{\frac{1}{4}}$$

$$R_{max} = \left[\frac{316.808 \times 10^6}{3.16 \times 10^{-11} \times (4\pi)^3}\right]^{\frac{1}{4}}$$

R_{max} = $(5.05 \times 10^{15})^{1/4}$

R_{max} = 8430 m

$$\boxed{R_{max} = 8.4 \text{km}}$$

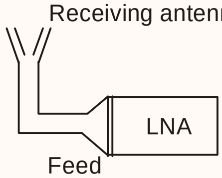
113. A receiving antenna with a gain of 40 dB looks at a sky with a noise temperature of 15 K. The loss between the antenna and LNA input due to the feed horn is 0-4 dB, and the LNA has a noise temperature of 40 K. The $\frac{G}{T}$ value is

(a) 11.2 dB/K (b) 13.4 dB/K

(c) 20.6 dB/K (d) 39.0 dB/K

Ans. (c)

Sol.

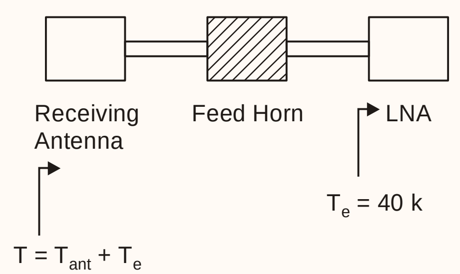


Gain of receiving antenna = 40 dB

noise temperature of receiving antenna = T_{ant} = 15 k

Loss between the natenn and LNA input due to Feed horn = 0.4 dB

Noise temperature of LNA = 40 k.



T = 40 k + 15 k = 55 k = 17.4 dBk

G = 40 – 0.4 = 39.6 dB

$$\boxed{\frac{G}{T} = G(\text{dB}) - T(\text{dBk}) = 39.6 - 17.4 = 22.2 \frac{\text{dB}}{\text{k}}}$$

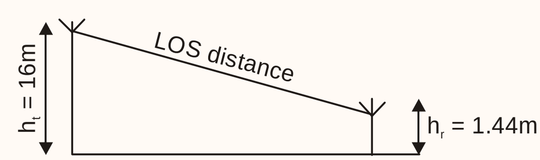
114. A company operating taxicabs communicates from its central office with the help of an antenna at the top of a 16 m tower. The antenna on the taxicabs is 1.44 m above the ground. The communication distance between the central office and a taxicab cannot exceed

(a) 18.6 km (b) 24.0 km

(c) 50.0 km (d) 62.3 km

Ans. (a)

Sol.



The communication distance between the central office and taxicab :

$$d = 3.57\left[\sqrt{h_t} + \sqrt{h_r}\right] \text{km}$$

$$d = 3.57\left[\sqrt{16} + \sqrt{1.44}\right] \text{km}$$

$$\boxed{d = 18.56 \text{km}}$$

115. The linear velocity of a satellite, when in a circular orbit, is

(a) directly proportional to its mass

(b) directly proportional to the square root of its mass

(c) directly proportional to the square of its mass

(d) independent of its mass

Ans. **(d)**

Sol. Linear velocity of a satellite

$$\boxed{v = \sqrt{\frac{GM}{r}}}$$

M = mass of the earth

Velocity of satellite is independent of its mass

116. For a system with a wavelength of 23.5 cm and a depression angle of $\sin^{-1}$ 0.94, the surface relief below which the surface will appear smooth is determined as limited nearly to

(a) 2.8 cm (b) 3.1 cm

(c) 3.5 cm (d) 4.0 cm

Ans. **(b)**

Sol. Given λ = 23.5 cm

depression angle γ = $\sin^{-1}$ (0.94)

According to Rayleigh criterion for Roughness

A surface is considered smooth at or below at height of h if.

$$h \le \frac{\lambda}{8 \sin\gamma}$$

$$h \le \frac{23.5}{8 \times 0.94}$$

$$\boxed{h \le 3.125 \text{ cm}}$$

117. The orbital period of a satellite in a circular orbit of 500 km above the Earth's surface, taking mean radius of the Earth as 6400 km and Kepler's constant μ as 4 × 10^5 km^3/s^2 is nearly

(a) 1.6 hours (b) 2.4 hours

(c) 3.2 hours (d) 6.4 hours

Ans. **(a)**

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

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

a = (6400 + 500) km = 6900 km

$$\mu = 4 \times 10^5 \frac{km^3}{S^2}$$

$$T^2 = \frac{4\pi^2 \times (6900 \times 10^3)^3}{4 \times 10^5 \times (10^3)^3}$$

$$T^2 = \frac{4\pi^2 \times (6900)^3}{4 \times 10^5}$$

$T^2 = (5694)^2$

T = 5694 sec

$$\boxed{T = 1.58 \text{hour}}$$

118. What is/are the advantage(s) of step-index mono-mode fibre optical cable?

1. Manufacturing process is simple
2. Bandwidth of several GHz-km is possible
3. Splicing is easier

Select the correct answer using the code given below.

(a) 1 only (b) 2 only

(c) 3 only (d) 1, 2 and 3

Ans. **(b)**

Sol. For single mode step index fiber

1. Manufacturing process is complex
2. High bandwidth upto GHz -km is possible.
3. splicing is relatively less easier.

119. Consider the following set of processes :

Process	P_1	P_2	P_3	P_4	P_5
Burst time	10 ms	29 ms	3 ms	7 ms	12 ms

First Come First Serve (FCFS), non-preemptive Shortest Job First (SJF) and Round Robin (RR) (quantum = 10 ms). Scheduling Algorithms for this process set would imply which of the following features?

1. The SJF policy results in less than half of the average waiting time obtained with FCFS scheduling.
2. The RR algorithm gives an intermediate value for the average waiting time.
3. Deterministic modelling takes a particular predetermined workload, and designs the performance of each algorithm for that workload.

Select the correct answer using the code given below.

(a) 1, 2 and 3 (b) 1 and 2 only

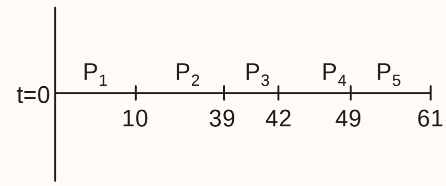
(c) 1 and 3 only (d) 2 and 3 only

Ans. **(a)**

Sol. Given set of processes and their burst time is as follows:

Process	P_1	P_2	P_3	P_4	P_5
Burst time	10 msec	29 msec	3 msec	7 msec	12 msec

First Come First Served (FCFS)



Waiting time of P_1 = 0 msec

Waiting time of P_2 = 10 msec

Waiting time of P_3 = 39 msec

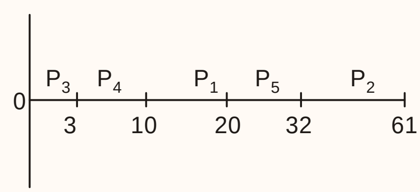
Waiting time of P_4 = 42 msec

Waiting time of P_5 = 49 msec

Average waiting time

$$= \frac{0+10+39+42+49}{5} = \frac{140}{5} = 28\text{ msec}$$

Shortest Job First (SJF)



Waiting time of P_1 = 10 msec

Waiting time of P_2 = 32 msec

Waiting time of P_3 = 0 msec

Waiting time of P_4 = 3 msec

Waiting time of P_5 = 20 msec

Average waiting time

$$= \frac{10+32+0+3+20}{5} = \frac{65}{5} = 13\,\text{msec}$$

Round Robin Scheduling (RR)

quantum = 10 msec

P_1	P_2	P_3	P_4	P_5	P_2	P_5	P_2
t= 0 – 10	10 – 20	20 – 23	23 – 30	30 – 40	40 – 50	50 – 52	52 – 61

Waiting time of P_1 = 0 msec

Waiting time of P_2

= 10 + (40 – 20) + (52 – 50)

= 10 + 20 + 2 = 32 msec

Waiting time of P_3 = 20 msec

Waiting time of P_4 = 23 msec

Waiting time of P_5

= 30 + (50 – 40) = 30 + 10 = 40 msec

Average waiting time

$$= \frac{0+32+20+23+40}{5} = \frac{115}{5} = 23\,\text{msec}$$

1. Average waiting of SJF scheduling

   = 13 msec

2. Average waiting time of FCFS scheduling = 28 msec

   Average waiting of SJF is less than half of the average waiting time of FCFS

3. Average waiting time of round robin is the intermediate value.

Deterministic modeling is a kind of analytic evaluation. It uses the given algorithm and the system work load to produce a formula or number to evaluate the performance of the algorithm for that workload.

120. The cut-off wavelength for an optical fibre with $5\,\mu\text{m}$ core diameter and core cladding indices of refraction 1.484 and 1.402 is nearly

(a) $0.5\,\mu\text{m}$ (b) $1\,\mu\text{m}$

(c) $3\,\mu\text{m}$ (d) $6\,\mu\text{m}$

Ans. **(c)**

Sol. Given,

Core radius = $2.5\,\mu\text{m}$

n_1 = 1.484

n_2 = 1.402

λ_c = ?

$$\lambda_c = \frac{2\pi}{2.405} \times 2.5 \times NA$$

$$NA = \sqrt{n_1^2 - n_2^2} = 0.486$$

$$\lambda_c = \frac{2\pi}{2.405} \times 2.5 \times 0.486$$

$$\boxed{\lambda_c = 3.17\,\mu\text{m}}$$

Directions :

Each of the following thirty (3) items consists of two statements one labeled as statement I and the other as statements II. Examine these two statemnts carefully and select the correct answer to each of these items using the code given below.

Codes :

(a) Both statemnts I and statement II are individually true and statement II is the correct explanation of statement I

(b) Both statement I and statement II are indivudially true but statement II is not the correct explanation of statement I

(c) Statements I is true but statement II is false

(d) Statement I is false but statement II is true

121. Statement I :

The width of depletion layer of a P-N junction is increased under reverse bias.

Statement II :

Junction breakdown occurs under reverse bias.

Ans. (b)

Sol. When the reverse bias is applied the electrons at n-side will get pulled from junction region to the terminal region of n-side and similarly the holes at p-side junction will get pulled towards the terminal region of p-side. This results in increasing the depletion region width from its initial width. It results in increasing the elctric field strength.

When we apply the voltage increasingly across the reverse biased diode a point is reached where the current increases rapidly this is called junction breakdown.

Hence statement-I and statement-II are individuallly true.

122. Statement I :

In ideal case; the inverting and non-inverting input terminals of an operational amplifier are almost at the same potential.

Statement II :

It is common practice to connect the inverting and non-inverting terminals to the same point.

Ans. (c)

Sol. In an ideal op-amp the inverting and non inverting amplifiers are at same potential because in an ideal op-amp voltage gain (A_V) is,

As we know $V_o = A_V v_i$

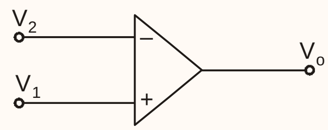
$$V_o = A_V (V_1 - V_2)$$

$$(V_1 - V_2) = \frac{V_o}{A_v}$$

$$(V_1 - V_2) = \left(\frac{V_o}{\infty}\right) \quad [\because A_v = \infty]$$

$$V_1 - V_2 = 0$$

$$V_1 = V_2$$



This concept of both the terminals being at same potential is due to ideal op-amp characteristics and not because of both the terminals connected to same point.

Hence statement-I is true statement-II is false.

123. Statements I :

Optocouplers are used to isolate low voltage circuits from high voltages.

Statements II :

Optocouplers are used to separate AC and DC ground.

Ans. (b)

Sol.

Optocouplers are used to provide electrical isolation between an input source and output load. An optocouper consists of light emitter, the LED and a light sensitive receiver which can be photo-diode, photo-transistor photo SCR (or) a photo triac.

Applications.

1. Electrical isolation between a lower voltage control signal and the higher voltage (or) current output signal.

2. DC and AC power control

3. Optocouplers are used to separate AC and DC grouped. Statement-I and Statement -II are individually correct.

124. Statement I :

Two ideal current sources with currents I_1 and I_2 cannot be connected in parallel

Statement : II

Superposition theorem cannot be applied to ideal current sources if these source are connected in casecade.

Ans. (d)

Sol. Statement 1 is wrong $\rightarrow$ two unequal current sources can e connected in parallel and the total current will be equal to the sum sources.

However, two equal current sources can't be connected in series.

Statement 2 is true $\rightarrow$ cascading two ideal sources will lead in open circuit of one source if the other source is opened.

Hence, superposition theorem will not apply.

125. Statement I :

When a transformer is loaded there is a change in its secondary voltage expressed as a percentage of secondary voltage on no-load, and this cahnge is called its regulation.

Statement II :

The change in secondary voltage is due to the transformer impednace and the load current. The regulation could be zero for leading load condition.

Ans. (a)

Sol. When transformer is loaded, there is a change in its secondary voltage.

Transformer voltage regulation is given by,

$$VR = \frac{E_2 - V_2}{E_2} \times 100$$

where, E_2 = no load secondary voltage

V_2 = full load secondary voltage.

From approximate equation for voltage requlation,

$$V.r. \left(\frac{I_2(R_{eq})_2 \cos\phi + I_2(X_{eq})_2 \sin\phi}{E_2}\right) \times 100$$

So, we can say that change in secondary voltage is due to transformer impedance $\{i.e.(R_{eq})_2 + j(X_{eq})_2\}$ and the load current (I_2).

If the leading Pf is considered then

$$V.R. = \left\{\frac{I_2(R_{eq})_2 \cos\phi - I_2.(X_{eq})_2 \sin\phi}{E_2}\right\} \times 100$$

Hence, voltage regulation can be zero, for $(R_{eq})_2 \cos\phi = (X_{eq})_2 \sin\phi$.

So, both statements are correct and statement II is the correct explanation of statement I.

126. Statement I :

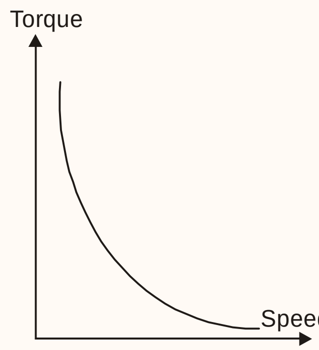
Series DC motors are used for cranes and locomotives.

Statement II :

Series DC motors provide high starting torques, a requisite for such applications.

Ans. (a)

Sol. The torque speed characteristic of dc series motor is given by



So, we can say that, the dc series motor provides high starting torque. So dc series motor are more suited for loads having high inertia, such as locomotives and cranes.

$\therefore$ Both statements are correct, and statement Ii is the correct explanation of statement-I.

127. **Statement I :**

An induction motor always runs at a speed less than its synchronous speed.

Statement II :

Synchronous speed of induction motor depends on the frequency of supply and number of poles.

Ans. **(b)**

Sol. An induction motor works on principle of electromagnetic induction which is possible, only when there is a relative speed between rotor, and synchronously rotating armature flux. so, an induction motor runs at a speed, less than its synchronous speed.

Synchronous speed (N_s) of induction motor

is given by , $N_s = \dfrac{120f}{P}$

$\therefore$ the synchronous speed depends upon frequency (f) and number of poles (P).

128. **Statement I :**

If a squirrel cage motor is started at full rated voltage, the power supply could be damaged.

Statement II :

For squirrel cage induction motors, starting current is high and power factor at starting is low.

Ans. **(d)**

Sol. For squirrel cage induction motors, starting current is high and power factor at starting is low.

Due to high current, there may be a dip in supply voltage, as line impedance drop will be high at high current.

Extremely high starting time may also lead to high heating of rotor and supply, but it is highly unlikely that power supply might get damaged.

So statement I is incorrect and statement II is correct.

If the sequirrel cage motor is started at full load, starting current is high and power factor i.

129. **Statement I :**

The increase of temperature of a dielectric causes increase of electronic polarizability.

Statement II :

Orientational polarization in dielectric is inversely proportional to temperature.

Ans. **(d)**

Sol.

Electronic polarisability (α_e),

$$\alpha_e = 4\pi \in_o R^3$$

i.e. electronic polarizability does not depend on temperature.
Orientational polarization (p_o)

$$p_o = \frac{Np_p^2E}{3kT}$$

i.e. orientational polarization (p_o) is inversely proportional to temperature.
So, statement (I) is incorrect and statement (II) is TRUE.

130. Statement I :

The break statement provides an early exit from for, while do/while and switch structures, and the execution continues with the first statement after the structure.

Statement II :

The continue statement, used in while, for do/while loop, skips the remaining statement in the body of that structure, and proceeds with the next iteration of the loop.

Ans. (b)

Sol. Break statement terminates the loop immediately and the next statement outside the loop is executed. Continue statement begins next iteration inside the loop. It skips the execution of statements inside the body of loop for the current iteration.

131. Statement I :

A thermocouple transducer is based on seebeck effect.

Statement I :

In a thermocouple transducer used for temperature measurement the cold jucntion is usually kept in ice bath.

Ans. (b)

Sol.

Thermocouple is a device used primarily for the measurement of temperature and the basic principle of the instrument is based on the seebeck effect. According to seeback effect, when two dissimilar conductor A and B, comprise a circuit, a current will flow in that circuit as long as the two junctions are at different temperature, one is called reference junction, which is kept at temperature 0°C (usually kept is ice bath) and other junction is called the detecting junction.
Hence, statement (I) is TRUE and statement (II) is also TRUE but statement (II) is not correct explanation.

132. Statement I :

A salient-pole rotor placed in a magnetic field can produce an emf. proportional to the speed of the rotating machine because fo its variable reluctance characteristic.

Statement II :

The above device is essentially a frequency tachometer using a suitable pulse shaping circuit and an electronic counter.

Ans. (b)

133. Statement I :

Sensors are almost always transducers, but transducers are not necessarily sensors.

Statement II :

Sensor are transducers that conver a physcial quantity to a measurable quantity.

Ans. (c)

Sol. Statement-I is true – sensors are almost always transducers.

Sensors are used to sense the change in any physical quantity. Transducers are the type of sensors which can measure the change in a physical quantity and convert one form of energy into others.

eg. LVDT – converts displacement into measurable voltage change.

Statement-II is false – sensors do not convert a physical quantity into measurable quantity. The just sense the portion of change in the quantity and not the actual value.

134. Statement I :

Piezoelectric transducers have very good frequency response.

Statement II :

Piezoelectric transducers can be used for measurement of both dynamic and static phenomena.

Ans. (c)

Sol.

Piezoelectric transducers are mainly used for measurement of displacement. However, they can be used for measurement of force, pressure or, acceleration also.

It has very good frequency response, higher mechanical and thermal stability, can withstand high stresses etc.

The steady state response of piezo-electric transducer to a constant displacement is zero. Hence, it cannot be used for measurement of static displacement.

i.e. statement (I) is TRUE but statement (II) is false.

135. Statement I :

A symmetrical two-port network is bound to reciprocal.

Statement II :

A symmetrical network will have the same magnitude of image impedance at both the ports.

Ans. (c)

Sol. A symmetrical two port network is not necessarily reciprocal.

The image impedances for both the ports of a symmetrical two port network are same.

136. Statement I :

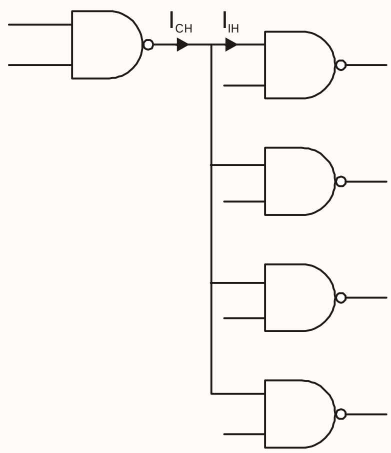
The maximum number of logic gate inputs that can be driven from the output of a single logic gate is called 'fan-out'.

Statement II :

'Fan-out' is due to the current sourcing when the output is high, and is due to the current sinking when the output is low. Thus two different values for 'fan-out' may result.

Ans. (a)

Sol.



Fan out = 4

for the figure show

The maximum number of inputs fed from the output of a single logic gate. This can not be any number because fan-out depends on current sourcing of the output when output is high of the logic gate and current sinking capability of the output when the output is low. Thus two different values of fanout may result.

Hence of the statements are true and statement II is explanation of statement-I

137. Statement I :

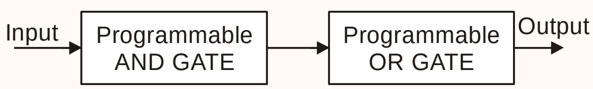
PLA contains a fixed AND array and a programmable OR array.

Statement II :

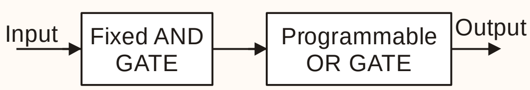
PROM contains a fixed AND array and a programmable OR array.

Ans. (d)

Sol. PLA contains programmable AND gate and programmable OR GATE



PROM contains fixed AND Gate and Programmable OR Gate



138. Statement I :

Stack works on the principle of LIFO

Statement II :

Stack pointer contains address of the top of the stack.

Ans. (a)

Sol. The last item to be inserted into a stack is the first one to be deleted from it. Stack pointer of the stack is used to track it.

139. Statement I :

I/O devices can be accessed using IN and OUT instructions.

Statement II :

Arithmetic and logic operations can be directly performed with I/O data.

Ans. (c)

Sol. Statement I is correct.

I/O devices can be assessed using IN and OUT instruction.

Statement II is incorrect.

This depends on the type of processor.

140. Statement I :

On executing the HLT instruction, the microprocessor enters into a half state and all the buses are tri-stated.

Statement II :

On executing the HLT instruction, the microprocessor is disconnected from the system bus till the reset is pressed.

Ans. (d)

Sol. After the execution of HLT instruction bus is in high impedance state.

The microprocessor will be connected to system bus when a non-markable interrupt (NM1) occurs, which is usually a reset in many cases.

II is correct.

141. Statement I :

Stack is organized as 8-bit storage in the microprocessor.

Statement II :

Stack is a set of memory locations in R/W memory reserved for storing information temporarily during the execution of a program.

Ans. (b)

Sol. Stack is a 8-bit storage.

Stack is used for temporary storage of memory location.

Both statements are correct. II is not an explanation of I.

142. **Statement I :**

Static RAM memory devices retain data for as long as power is supplied.

Statement II :

SRAM is used when the size of read/write memory required is large.

Ans. **(c)**

Sol.
- Static RAM memory is a random access memory that retains data bits in its memory as long as power is being supplied
- SRAM provides faster access to data and more expensive than DRAM. SRAM is used for a computer cache memory.
- DRAM is used in digital electronics where high capacity memory is required as it is cheaper.

Statement-I is true statement-II is false

143. **Statement I :**

The stator winding of a control transformer in a synchro pair has a high impedance per phase

Statement II :

The rotor of the control transformer is cylindrical in shape.

Ans. **(c)**

Sol. The stator winding of a control transformer in a synchro pair has high resistance to limit starting current.

The rotor of control transformer has salient poles.

144. **Statement I :**

The transportation lag in a system can be easily handled by using Bode plot.

Statement II :

The magnitude plot is unaffected and only the phase plot shifts by $-\omega T$ rad due to the presence of e^{-st}.

Ans. **(a)**

Sol. The transportation delay transfer function is given by

$$T(s) = e^{-sT}$$

Let, if initially, the transfer function was,

$$G_1(s) = G(s)$$

with $|G_1(\omega)| = G$

and $\angle G_1(\omega) = \phi_1$

Now, with transportation delay

$$G_2(s) = G_1(s) \cdot T(s)$$
$$G_2(s) = G(s) \cdot e^{-sT}$$
$$|G_2(\omega)| = G \qquad \{as\ |e^{-sT}| = 1\}$$
$$\angle G_2(\omega) = \phi_1$$

Now, with transportation delay,

$$G_2(s) = G_1(s) \cdot T(s)$$
$$G_2(s) = G(s) \cdot e^{-sT}$$
$$|G_2(\omega)| = G \qquad \{as\ |e^{-sT}| = 1\}$$
$$\angle G_2(\omega) = \phi_1 - \omega T$$

So, the bode magnitude plot is unaffected while the bode phase plot just shifts down by $-\omega T$.

Sp, transportation lag in the system can easily be handled by Bode plot.

145. Statement I :

Isolated I/O method isolates memory and I/O addresses.

Statement II :

In isolated I/O method, memory and I/O interfaces have their own individual address space.

Ans. (d)

Sol. In isolated I/O method, peripherals are accessed using the GP10 pins. In memory mapped I/O peripherals are accessed in the same fashion as memory is accessed. So there is no such I/O addresses in Isolated I/O method.

I is incorrect.

I/O interface are accessed using GPIO registers.

II is correct.

146. Statement I :

Peripherals are electromechanical and / or electromagnetic devices.

Statement II :

All the peripherals are digital and parallel

Ans. (c)

Sol. Peripherals can be various sensors such as a temperature sensor, pressure sensor etc.

These do not come under electromechanical or electromagnetic devices

But Peripherals are electromechanical and / or electromagnetic devices also.

I is incorrect.

Pheripherals can be analog as well

II is incorrect.

147. Statement I :

The internal interrupt is initiated by some exceptional condition caused by the program itself rather than by an external event.

Statement II :

External interrupt depends on external conditons that are independent of the program being executed at the time.

Ans. (d)

Sol. Internal interrupts can be caused by various modules inside an embedded system and not by the program.

I is incorrect.

External interrupts depend on external conditions and are independent of the program.

II is correct.

148. Statement I :

Swapping is sometimes called ‘roll-out/roll-in’.

Statement II :

Swapping is utilized in systems designed to support time-sharing.

Ans. (a)

Sol. When a process is not execute for long time then that process rollout and active process is rollin in the memory for execution. This mechanism enable the interleaved execution of the process. So multiple processes can execute concurrently. So swapping is utilized in system designed to support time sharing.

149. Statement I :

MS DOS and Windows products have always used implicit mounting when an attempt is first made to access the media.

Statement II :

Unix has traditionally used explicit mount command to access the removable medium.

Ans. (b)

150. Statement I :

Virtual memory is designated virtual because there is no such memory inside the computer.

Statement II :

Virtual memory uses some space of the hard disk as an extension of the primary storage of the computer.

Ans. (d)

Sol. Virtual memory is designated virtual as the memory management system makes CPU realize that it has large size main memory at its disposal while in reality only a limited amount of main memory is available.

It uses some space of hard disk as an extension of primary storage.

But hard disk is inside computer.

So I is incorrect, II is correct.