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Junior Telecom Officer Exam. Solved Paper

2009

TC : TELECOM

Section–I

Question number 1-20 carry 1 mark each.

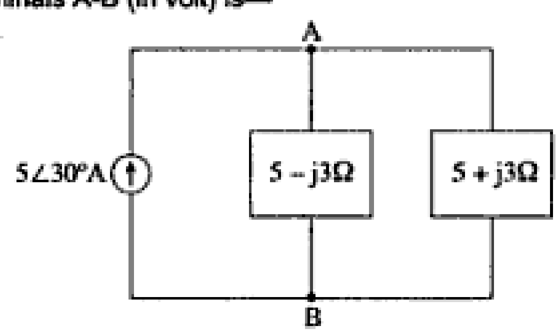
1. Which one of the following statements is **not** true ?
   (A) In an intrinsic semiconductor, concentration of electrons in the conduction band is same as the concentration of holes in the valence band
   (B) The probability of an energy state at the Fermi level being occupied by an electron is 1/2
   (C) Mobility of electrons is higher than that of holes
   (D) In an *n*-type semiconductor, concentration of holes is equal to that of the intrinsic concentration

2. ABCD parameters of a two-port network is defined as $\begin{bmatrix} V_1 \\ I_1 \end{bmatrix} = \begin{bmatrix} A & B \\ C & D \end{bmatrix} \begin{bmatrix} V_2 \\ -I_2 \end{bmatrix}$. If the port-2 is terminated by a resistance R_L, the admittance looking into the port-1 is—
   (A) $\frac{C + DR_L}{A + BR_L}$ (B) $\frac{CR_L + D}{AR_L + B}$
   (C) $\frac{CR_L + D}{A + BR_L}$ (D) $\frac{C + DR_L}{AR_L + B}$

3. The phenomenon of injection electro-luminescence is the basis of working of—
   (A) photodiodes (B) light emitting diodes
   (C) phototransistors (D) solar cells

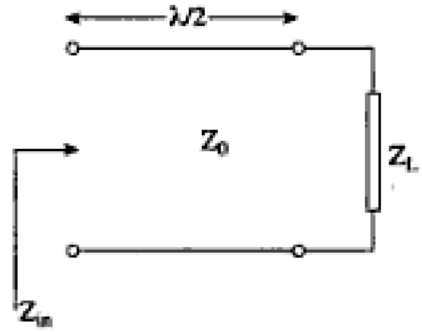
4. A parallel combination of N resistances is connected across an ideal current source of I Amperes. The expression for the current in the k^{th} resistor R_k is—
   (A) $\left(\frac{R_k}{R_1 + R_2 + \dots + R_N}\right) I$ (B) $\left(\frac{\frac{1}{R_k}}{\frac{1}{R_1} + \frac{1}{R_2} + \dots + \frac{1}{R_N}}\right) I$
   (C) $\left(\frac{R_k}{\frac{1}{R_1} + \frac{1}{R_2} + \dots + \frac{1}{R_N}}\right) I$ (D) $\left(\frac{\frac{1}{R_k}}{R_1 + R_2 + \dots + R_N}\right) I$

5. In the circuit shown in fig. given, the voltage across the terminals A-B (in volt) is—



   (A) $5\angle 30°$ (B) $12{\cdot}5\angle 30°$
   (C) $17\angle 30°$ (D) $25\angle 30°$

6. A half wave (*i.e.*, λ/2) lossless transmission line of characteristic impedance Z_0 is terminated to a load of impedance Z_L as shown in the fig. given. The input impedance as seen at the other end is—



   (A) $\frac{Z_L}{Z_0}$ (B) Z_L
   (C) $Z_L Z_0$ (D) $\frac{Z_L^2}{Z_0}$

7. A microstrip line has a strip width W and a grounded dielectric substrate of thickness *d* and relative permittivity ε_r. Which one of the following statements is **not** true ?
   (A) The effective dielectric constant ε_{eff} satisfies $1 < \varepsilon_{eff} < \varepsilon_r$
   (B) The effective dielectric constant ε_{eff} is a function of $\frac{W}{d}$
   (C) The characteristic impedance of the line is a function of $\frac{W}{d}$
   (D) The line can support pure TEM mode of wave propagation

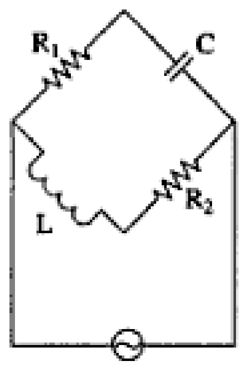
8. For a rectangular waveguide of internal dimensions *a* cm × *b* cm, *a* > *b*, the mode of wave propagation with the lowest cut off frequency is—
   (A) TE_{01} (B) TE_{10}
   (C) TE_{11} (D) TM_{11}

9. The most appropriate value (in Ω) of the radiation resistance of a quarter wave monopole antenna is—
   (A) 36·5 (B) 50
   (C) 73 (D) 120

10. Which one of the following is an active transducer ?
    (A) Photo-voltaic cell (B) Strain gauge
    (C) Photo-emissive cell (D) Synchro

11. Q-meter works on the principle of—
    (A) series resonance (B) parallel resonance
    (C) mutual inductance (D) self inductance

12. The bridge circuit shown in fig. given—



    (A) cannot be balanced
    (B) can be balanced but the frequency of excitation must be known
    (C) can be balanced for only one frequency
    (D) can be balanced at any frequency

13. Which one of the following statements is true for an 'ideal' power diode ?
    (A) Forward voltage drop is zero and reverse saturation current is non-zero
    (B) Reverse recovery time is non-zero and reverse saturation current is zero
    (C) Forward voltage drop is zero and reverse recovery time is zero
    (D) Forward voltage drop is non-zero and reverse recovery time is zero

14. In a MOSFET, the pinch-off voltage refers to—
    (A) drain-to-source voltage at which drain-to-source current is zero
    (B) gate-to-source voltage at which gate-to-source current is zero
    (C) drain-to-source voltage at which gate-to-source current is zero
    (D) gate-to-source voltage at which drain-to-source current is zero

15. Which of the following statements is true for DC switched mode power supply ?
    (A) It cannot provide isolation between input and output as in rectifiers
    (B) It cannot remove ripple as in DC switching mode regulators
    (C) It has two stage conversions : dc-ac and ac-dc
    (D) It is a type of chopper circuit

16. Which one of the following is a ceramic insulator ?
    (A) Mica (B) Porcelain
    (C) Liquid crystal (D) Synthetic fiber

17. Which one of the following represents a direct band-gap material ?
    (A) Si (B) Ge
    (C) GaP (D) GaAs

18. Which one of the following statements is **not true** ?
    (A) Rochelle salt exhibits ferroelectric property
    (B) Spontaneous polarization is a characteristic property of ferroelectric material
    (C) Spontaneous polarization of ferroelectric materials usually vanishes below ferroelectric Curie temperature
    (D) Ferroelectric materials exhibit hysteresis effect

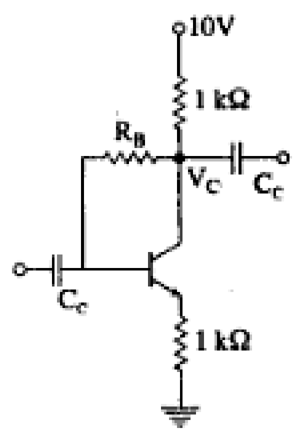
19. Which one of the following diodes contains a metal-semiconductor junction ?
    (A) Tunnel diode (B) Zener diode
    (C) Schottky diode (D) Gunn diode

20. Which one of the following statements is **not true** ?
    (A) Ferrites can be used in transformer cores only at very low frequencies
    (B) Ferrites are ferrimagnetic material
    (C) Ferrites show spontaneous magnetization below certain temperature
    (D) DC resistivity of ferrites is many orders of ten higher than that of iron

Question number 21-50 carry 2 marks each.

21. At a frequency of 1 GHz, the equivalent inductance between the terminals of a $\lambda/8$ (λ represents wavelength) short-circuited lossless 50 Ω line is—
    (A) $5/\pi$ nH (B) $15/\pi$ nH
    (C) $25/\pi$ nH (D) $50/\pi$ nH

22. For the circuit shown in fig. given, the transistor parameters are $V_{BE} = 0 \cdot 7$ V, $\beta = 99$. If V_C is to be set at 7·5 V, the required value (in kΩ) of R_B is—



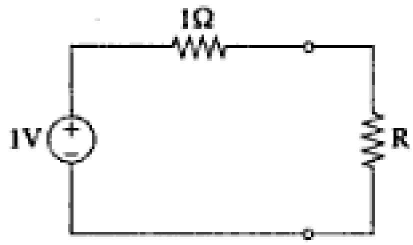
    (A) 172 (B) 136
    (C) 100 (D) 82

23. A quarter wave matching transformer is used to match a 30 Ω load to a line having characteristic impedance 120 Ω. The characteristic impedance of the quarter wave matching section is—
    (A) 50 Ω (B) 60 Ω
    (C) 120 Ω (D) 150 Ω

24. If the average power delivered to a load terminated to a lossless transmission line is 75% of that of the incident power, the VSWR on the line is—

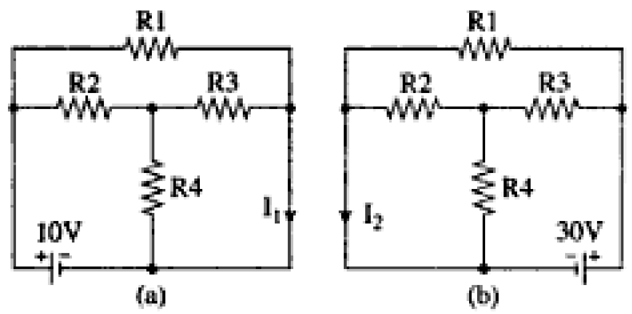
(A) $\frac{1}{3}$ (B) 1
(C) 2 (D) 3

25. For the circuit shown in fig. given, a value of R (in Ω), to which the voltage source would deliver 50% of the maximum deliverable power, is—



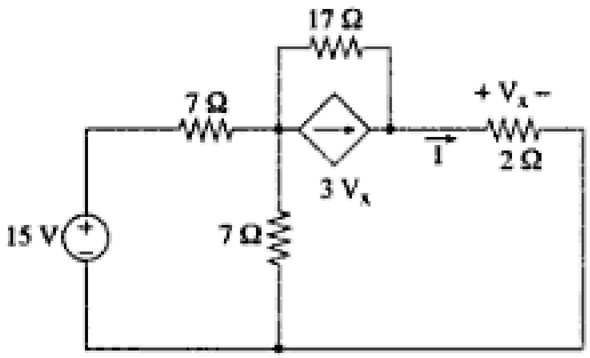
(A) 1 (B) 0·5
(C) 0·25 (D) $3-\sqrt{8}$

26. In the circuit shown in fig. (a) given, the current I_1 = 2A. The current I_2 in fig. (b) is—



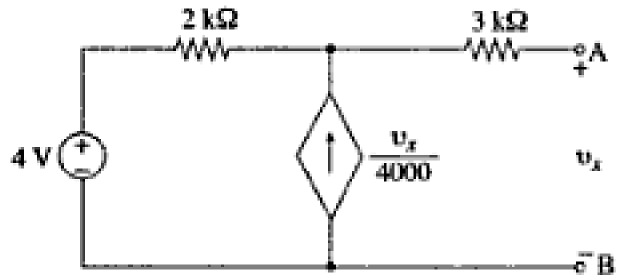
(A) – 6A (B) – 4A
(C) 4A (D) 6A

27. In the circuit shown in fig. given, the current I through 2Ω resistor is—



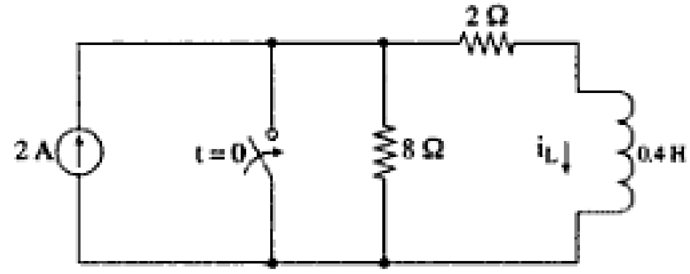
(A) – 94·34 mA (B) – 70·34 mA
(C) 70·34 mA (D) 94·34 mA

28. For the circuit shown in fig. given, the Thevenin's voltage and resistance at terminals A and B, respectively, are—



(A) 8 V and 5 kΩ (B) 8 V and 10 kΩ
(C) 4 V and 5 kΩ (D) 4 V and 10 kΩ

29. In the circuit shown in fig. given, the switch closes at t = 0. Assuming steady state condition for $t = 0^-$, the current i_L at t = 0·15 sec is (approximately)—



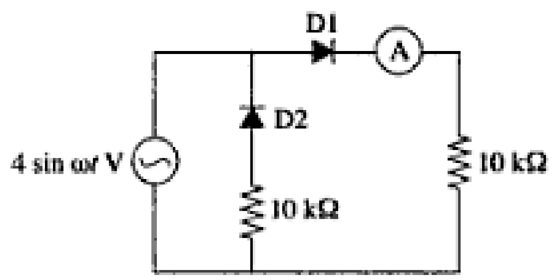
(A) 0·04 A (B) 0·5 A
(C) 0·76 A (D) 1·60 A

30. A PMMC instrument has a coil of dimensions 10 mm × 10 mm and the flux density in the air gap is 2 m W/m². The coil has 100 turns. If a current of 5 mA produces an angular deflection of 90°, the spring constant of the instrument is—

(A) $\frac{2}{\pi} \times 10^{-8}$ N-m/rad (B) $\frac{\pi}{2} \times 10^{-8}$ N-m/rad

(C) $\pi \times 10^{-8}$ N-m/rad (D) $\frac{1}{\pi} \times 10^{-8}$ N-m/rad

31. In the circuit shown in fig. given, assume the diodes are ideal and the ammeter is an average indicating meter with zero internal resistance. The ammeter reading is—



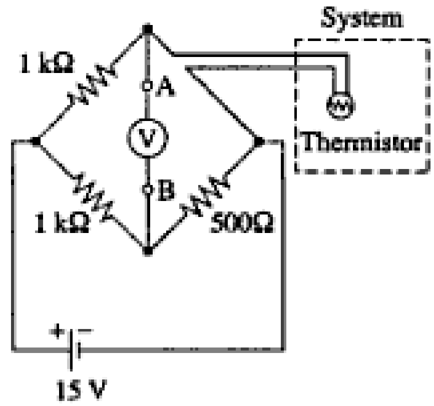
(A) $\frac{0 \cdot 4}{\pi}$ mA (B) $\frac{0 \cdot 8}{\pi}$ mA

(C) $\frac{0 \cdot 4}{\sqrt{2}}$ mA (D) $\frac{0 \cdot 8}{\sqrt{2}}$ mA

32. A capacitive transducer uses two quartz diaphragms of area 550 mm² each separated by a distance of 3·7 mm. A pressure of 750 kN/m² applied to the top diaphragm produces a displacement of 0·7 mm. The capacity is 390 pF when no pressure is applied to the diaphragm. The value of the capacitance after the application of pressure of 750 kN/m² is—

(A) 400 pF (B) 451 pF
(C) 481 pF (D) 500 pF

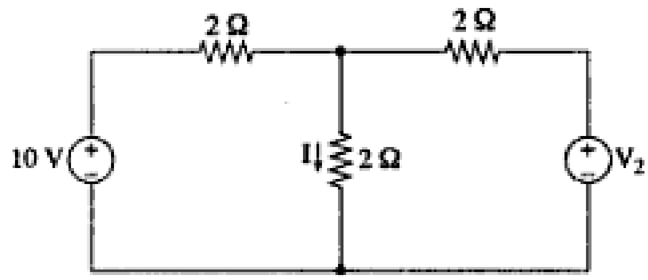
33. A thermistor has a resistance of 500 Ω at 30°C and has a temperature coefficient of – 5 Ω/°C. This thermistor is used to measure the temperature of a system by the arrangement shown in fig. given. If the system temperature falls to 20°C, the V_{AB} measured by the voltmeter is—



(A) $-\frac{10}{29}$ V (B) $-\frac{15}{29}$ V

(C) $\frac{10}{29}$ V (D) $\frac{15}{29}$ V

34. For the circuit shown in fig. given, if the current I = 3 A, then the voltage V_2 is—



(A) 2·5 V (B) 5 V

(C) 8 V (D) 10 V

35. A 0·1 A ammeter having a resistance of 10 Ω is to be converted to a 1 A ammeter by using a shunt resistance. Which one of the followings is the most appropriate shunt resistance ?

(A) 0·1 Ω (B) 1·0 Ω

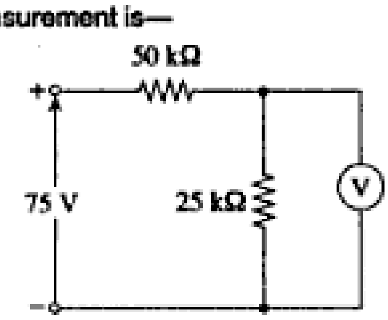
(C) 1·1 Ω (D) 1·2 Ω

36. The forward voltage drop of a power diode is V_D = 1·0 V at the diode current I_D = 200 A. Assuming the emission coefficient η = 2 and thermal voltage V_T = 25·7 mV, the reverse saturation current I_S (approximate) is—

(A) 71·08 μA (B) 51·20 μA

(C) 21·09 μA (D) 41·09 μA

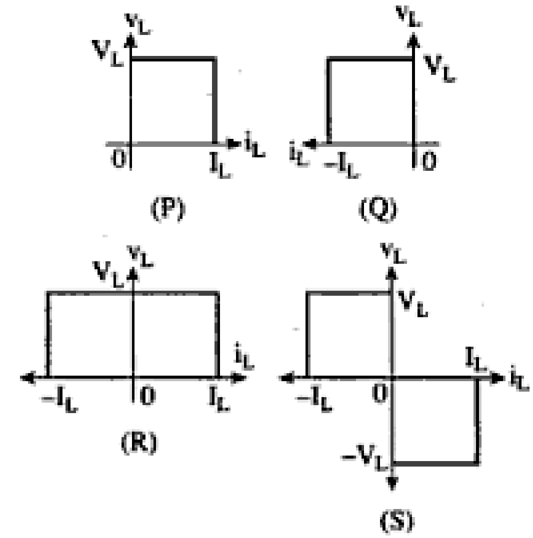
37. In the circuit shown in fig. given, the voltage across 25 kΩ resistor is to be measured by using a voltmeter of sensitivity of 1 kΩ/V. The magnitude of percentage error in the measurement is—



(A) 10 (B) 20

(C) 30 (D) 40

38. Fig. given shows some load voltage versus load current plots. Which one of them is not valid for the classification of dc-dc converters ?



(A) P (B) Q

(C) R (D) S

39. Two single phase inverters, one half-bridge and the other full-bridge, operating with equal inputs delivering power to identical loads. The ratio of, the power delivered, the first harmonic voltage and the total harmonic distortion, for full-bridge inverter to half-bridge inverter, respectively, are—

(A) 4, 2, 1 (B) 4, 2, 2

(C) 4, 1, 1 (D) 2, 1, 1

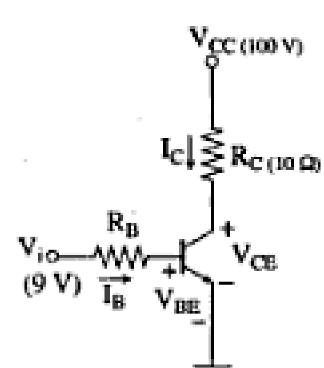
40. The correct match between Column A and Column B is—

Column A	Column B
P. DC Switch	1. Boost Converter
Q. Regulated DC-DC	2. Cycloconverter
R. AC-to-AC	3. Inverter
S. DC-to-AC	4. MOSFET

(A) R-1, Q-2, P-3, S-4 (B) S-1, P-2, Q-3, R-4

(C) P-1, R-2, Q-3, S-4 (D) S-1, Q-2, P-3, R-4

41. For the power transistor circuit shown in fig. given, $V_{CE(sat)}$ = 1·0 V, $V_{BE(sat)}$ = 1·5 V and β = 9. With an overdrive factor of 2·5, the required resistance R_B for saturation is—



(A) 2·73 Ω (B) 6·83 Ω

(C) 17 Ω (D) 22·5 Ω

42. For a lossless air-filled cubical cavity of internal dimension 5 cm on each sides, the resonant frequency for the TE_{101} mode is—

(A) $5\sqrt{2}$ GHz (B) 5 GHz
(C) $3\sqrt{2}$ GHz (D) 3 GHz

43. Which one of the following statements is not true ?

(A) For SCRs to be in the conduction state, the forward anode current must be greater than the latching current
(B) For SCRs to be in the forward blocking state, the forward anode current must be lower than the holding current
(C) When SCRs are in the conduction state, they can be turned off by applying suitable gate pulses
(D) When avalanche breakdown takes place, SCRs enter into the conduction state

44. Consider two metallic wires W_1 and W_2. They are made up of same material and each has circular cross section. The diameter of W_2 is twice that of W_1 and the length of W_2 is four times that of W_1. Which one of the following statements is true ?

(A) Resistance of W_1 is half that of W_2
(B) Resistance of W_1 is equal to that of W_2
(C) Resistance of W_1 is twice that of W_2
(D) Resistance of W_1 is eight times that of W_2

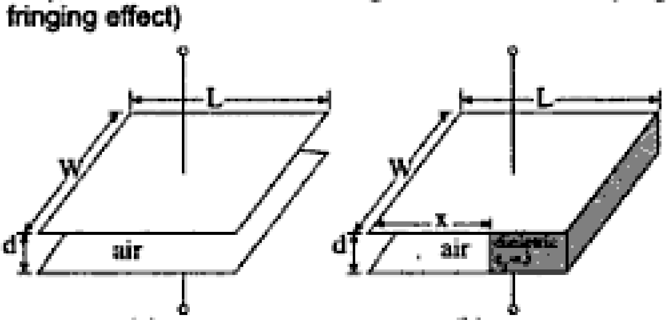
45. A current of 1 A flows through a circular loop of superconducting wire having mean diameter of 1 m, cross section area of 1 mm^2 and self inductance of $4\pi \times 10^{-7}$H. The current reduces to 0·99 A after 1 year. The resistivity of the wire is—

(A) $1{\cdot}275 \times 10^{-22}$ Ωm (B) $1{\cdot}275 \times 10^{-25}$ Ωm
(C) $1{\cdot}275 \times 10^{-24}$ Ωm (D) $1{\cdot}275 \times 10^{-23}$ Ωm

46. An npn transistor is operating in CE mode and carries a collector current I_c = 1 mA when the collector to emitter voltage V_{CE} = 1 V. If the early voltage for the transistor is 74 V and base to emitter voltage V_{BE} is kept constant, at V_{CE} = 11 V the collector current is—

(A) $\frac{15}{19}$ mA (B) 1 mA
(C) $\frac{19}{15}$ mA (D) $\frac{19}{12}$ mA

47. Two parallel plate capacitors shown in fig. (a) and fig. (b) given have capacitances C_1 and C_2, respectively. If $C_2 = 2C_1$, which one of the following relations is true ? (Neglect fringing effect)



(a) (b)

(A) $x = \frac{L}{4}$ (B) $x = \frac{L}{2}$
(C) $x = \frac{L}{3}$ (D) $x = \frac{2L}{3}$

48. A doped semiconductor specimen has Hall coefficient $3{\cdot}6 \times 10^{-4}$ m^3 C^{-1} and the resistivity 9×10^{-3} Ωm. Assuming single carrier conduction, the mobility and density of carriers in the specimen, respectively, are (approximately) —

(A) 0·04 $m^2 V^{-1} s^{-1}$ and $1{\cdot}74 \times 10^{22}$ m^{-3}
(B) 0·4 $m^2 V^{-1} s^{-1}$ and $1{\cdot}74 \times 10^{22}$ m^{-3}
(C) 0·04 $m^2 V^{-1} s^{-1}$ and $1{\cdot}74 \times 10^{18}$ m^{-3}
(D) 4·0 $m^2 V^{-1} s^{-1}$ and $1{\cdot}74 \times 10^{18}$ m^{-3}

49. If n, n_i, μ_n and μ_p, respectively denote electron concentration, intrinsic concentration, mobility of electrons and mobility of holes, the minimum conductivity of a semiconductor sample occurs at—

(A) $n = n_i\sqrt{\frac{\mu_p}{\mu_n}}$ (B) $n = n_i\sqrt{\frac{\mu_n}{\mu_p}}$
(C) $n = n_i\sqrt{\mu_n\mu_p}$ (D) $n = n_i\sqrt{\mu_n + \mu_p}$

50. GaAs has bandgap energy of 1·42 eV. The material would produce photon output at a wavelength of (Planck's constant = $6{\cdot}625 \times 10^{-34}$ J-s, $q = 1{\cdot}6 \times 10^{-19}$ C)—

(A) 0·553 μm (B) 0·653 μm
(C) 0·875 μm (D) 0·953 μm

Section–II

Question number 1-20 carry 1 mark each.

1. The characteristic equation of a level triggered T flip-flop, with T as input and Q as output is—

(A) $Q(n+1) = T\overline{Q} + \overline{T}Q$
(B) $Q(n+1) = \overline{T}$
(C) $Q(n+1) = Q$
(D) $Q(n+1) = TQ + \overline{TQ}$

2. The Nyquist plot of G ($j\omega$) H ($j\omega$)of a closed loop control system encloses the point (– 1, j0) in GH-plane. The gain margin of the system in dB, is—

(A) greater than zero (B) less than zero
(C) zero (D) infinite

3. For the LTI system described by $2\frac{d^2y(t)}{dt^2} + 3\frac{dy(t)}{dt} + 4y(t) = r(t) + 2r(t-1)$ and having zero initial conditions, the transfer function $\frac{Y(s)}{R(s)}$ is—

(A) $\frac{1 + 2e^{s}}{2s^2 + 3s + 4}$ (B) $\frac{2s^2 + 3s + 4}{1 + 2e^{s}}$
(C) $\frac{1 + 2e^{-s}}{2s^2 + 3s + 4}$ (D) $\frac{2s^2 + 3s + 4}{1 + 2e^{-s}}$

4. An amplitude modulated double sideband suppressed carrier signal is given by $[1 + a_m \cos 2\pi f_s t] \cos 2\pi f_m t \cos 2\pi f_c t$, where f_c is the frequency of the carrier signal. The modulating signal is—

(A) $a_m \cos 2\pi f_s t$
(B) $a_m \cos 2\pi f_s t \cos 2\pi f_m t$

(C) $[1 + a_m \cos 2\pi f_a t] \cos 2\pi f_m t$

(D) $1 + a_m \cos 2\pi f_a t$

5. Which one of the following expressions represents a frequency modulated signal ?

(A) $A_c \cos 2\pi [f_c t + m(t)]$

(B) $\left[1 + \int_0^t m(\tau)\, d\tau\right] \cos 2\pi f_c t$

(C) $A_c\, m(t) \cos 2\pi f_c t$

(D) $Ac \cos 2\pi \left[f_c t + \int_0^t m(\tau)\, d\tau\right]$

6. A binary pulse communication system transmits a normalized pulse $p(f)$ over bit duration T_b. If the pulse $p(f)$ has Fourier transform $P(f)$, the condition for zero intersymbol interference in the absence of noise is—

(A) $\sum_{n=-\infty}^{\infty} P\left(f - \frac{n}{T_b}\right) = 1$ (B) $\sum_{n=-\infty}^{\infty} P\left(f - \frac{n}{T_b}\right) = T_b$

(C) $\sum_{n=-\infty}^{\infty} P\left(f - \frac{n}{T_b}\right) = \frac{1}{T_b}$ (D) $\sum_{n=0}^{\infty} P\left(f - \frac{n}{T_b}\right) = T_b$

7. The magnitude response of an ideal equalizer for rectifying a distortion characterized by T sinc $(fT)\, e^{-j\pi fT}$ is—

(A) $|\,T \text{ sinc } (fT)\,|$ (B) $\frac{T}{\text{sinc } (fT)}$

(C) $\frac{\pi f}{\sin (\pi f T)}$ (D) $\frac{\sin (\pi f T)}{T}$

8. If the minimum sampling frequency required to reconstruct a band limited analog signal from its samples is 8 kHz, the maximum frequency present in the signal is—

(A) 16 kHz (B) ≥ 16 kHz

(C) 4 kHz (D) > 4 kHz

9. Which one of the following statements is not true ?

(A) The two cavity klystron tube is used as an amplifier

(B) A reflex klystron uses only a single cavity and operates as an oscillator

(C) In klystron tubes, the bunching of electrons is caused by velocity modulation

(D) Klystrons belong to the category of crossed-field tubes

10. In a microprocessor, the program counter points to the address location from where the—

(A) current byte is to be fetched

(B) next byte is to be fetched

(C) next byte is to be stored

(D) current byte is to be added

11. Which one of the following statements is not true for a TWT ?

(A) The interaction region usually consists of a slow wave helix structure

(B) A static axial magnetic field keeps the electron beam focused

(C) Continued interaction takes place between the waves on a travelling wave structure and the electron beam

(D) TWT amplifiers are suitable only for narrowband microwave communication systems.

12. The minimized form of the Boolean expression F (A, B, C) = π (0, 2, 3) is—

(A) $A + \overline{B}C$ (B) $A + B\overline{C}$

(C) $\overline{A}\,\overline{C} + B$ (D) $\overline{A}\,\overline{B}\,\overline{C} + \overline{A}B$

13. Number of address lines required to address 8 k bytes of memory is—

(A) 13 (B) 14

(C) 15 (D) 16

14. The standard binary code for alpha numeric characters is—

(A) ASCII (B) GRAY

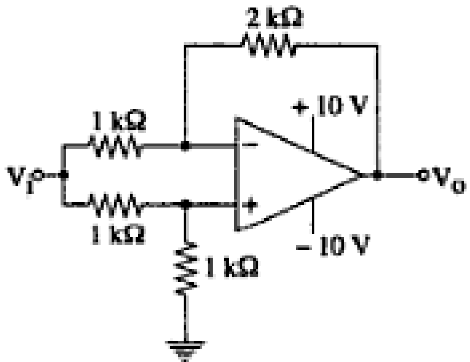
(C) BCD (D) Excess-3

15. The 2's complement of the binary number 1101100 in BCD is—

(A) 12 (B) 13

(C) 14 (D) 15

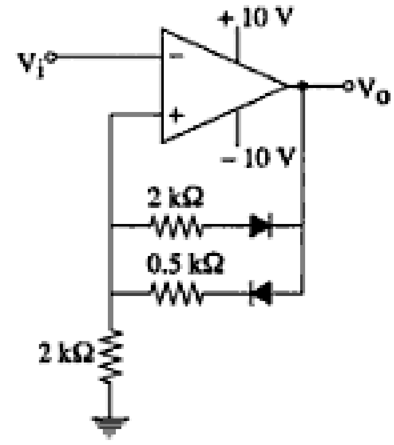
16. In the op-amp circuit shown in fig. given, the voltage ratio V_0/V_i is—



(A) − 2 (B) − 1

(C) − 0·5 (D) 0·5

17. For the Schmitt trigger circuit shown in fig. given, assuming diodes and op-amp are ideal, the values of lower and upper threshold points of voltage transfer characteristics, respectively, are—



(A) − 8 V, + 5 V (B) − 5 V, + 5 V

(C) − 5 V, + 8 V (D) − 8 V, + 8 V

18. Which one of the following Boolean expressions is not correct ?

(A) $\overline{x+y} = \bar{x}\,\bar{y}$ (B) $\overline{\bar{\bar{x}}+y} = \bar{x}\,\bar{y}$

(C) $\overline{\bar{\bar{x}}\,\bar{\bar{y}}} = \bar{x}+\bar{y}$ (D) $\overline{\bar{x}+\bar{y}} = \bar{x}\,\bar{y}$

19. A Boolean function can be expressed—

(A) as sum of maxterms or product of minterms

(B) as product of maxterms or sum of minterms

(C) partly as product of maxterms and partly as sum of minterms

(D) partly as sum of maxterms and partly as product of minterms

20. Among the following logic families, the one having the lowest power dissipation and highest noise margin is—

(A) Schottky TTL (B) TTL

(C) ECL (D) CMOS

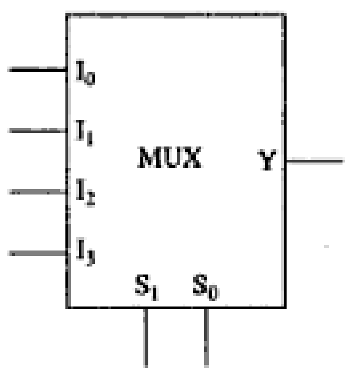
Question number 21-50 carry 2 marks each.

21. For a linear system having the characteristic equation $s^4 + s^3 + 2s^2 + 2s + 3 = 0$, the number of roots in the right-half of s-plane is—

(A) 4 (B) 3

(C) 2 (D) 1

22. The Boolean function F (A, B, C) = π (0, 2, 4, 7) is to be implemented using a 4 × 1 multiplexer shown in fig. given. Which one of the following choices of inputs to multiplexer will realize the Boolean function ?



(A) $(I_0, I_1, I_2, I_3, s_1, s_0) = (1, 0, \bar{A}, A, C, B)$

(B) $(I_0, I_1, I_2, I_3, s_1, s_0) = (1, 0, \bar{A}, A, B, C)$

(C) $(I_0, I_1, I_2, I_3, s_1, s_0) = (0, 1, \bar{A}, A, C, B)$

(D) $(I_0, I_1, I_2, I_3, s_1, s_0) = (0, 1, A, \bar{A}, B, C)$

23. An edge triggered synchronous binary counter is provided with a clock (CLK) and control inputs : active low clear ($\overline{CLR}$), active high load (L) and active high count (C). The correct matching combination between column A and column B is—

Column A

P. (CLK, $\overline{CLR}$, L, C) = (↑, 1, 1, X)

Q. (CLK, $\overline{CLR}$, L, C) = (↑, 1, 0, 1)

R. (CLK, $\overline{CLR}$, L, C) = (X, 0, X, X)

S. (CLK, $\overline{CLR}$, L, C) = (X, 1, 0, 0)

Column B

1. No change
2. Load inputs
3. Count next binary state
4. Clear outputs

where X = don't care.

(A) Q-1, R-2, S-3, P-4 (B) P-1, Q-2, R-3, S-4

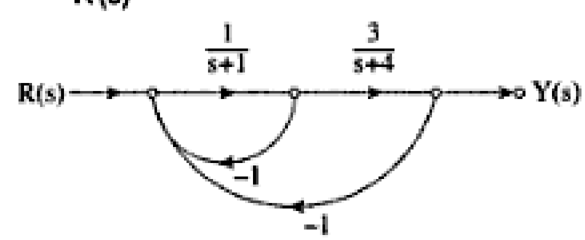
(C) Q-1, R-2, P-3, S-4 (D) P-1, Q-2, S-3, R-4

24. A 5-bit serial adder is implemented using two 5-bit shift registers, a full adder and a D flip-flop. The two binary words to be added are 11011 and 11011. The sum of the two numbers is stored in one of the shift registers and the carry in the D flip-flop. Assuming that the D flip-flop is set initially, the content of the sum shift register and the D flip-flop, respectively, are—

(A) 10111 and 0 (B) 11011 and 1

(C) 11101 and 0 (D) 10111 and 1

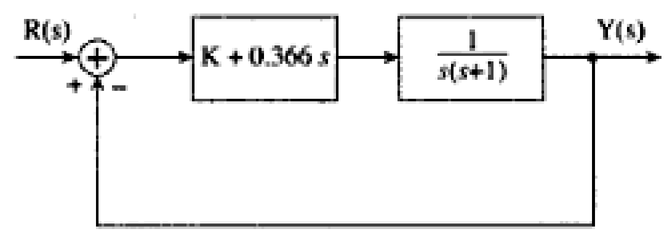
25. For the flow diagram shown in figure given, the transfer function $\frac{Y(s)}{R(s)}$ is—



(A) $\frac{3}{s^2+6s+11}$ (B) $\frac{3}{s^2+5s+4}$

(C) $\frac{3}{s^2+6s+8}$ (D) $\frac{-3}{s^2+6s+11}$

26. The compensated system shown in fig. given, has a phase margin of 60° at the crossover frequency of 1 rad/sec. The value of K is—



(A) 0·366 (B) 0·732

(C) 1·366 (D) 2·732

27. A time division multiplex system samples 96 voice channels at a rate of 8 kHz and encodes into 8 bits per sample. If one synchronization bit per frame is added, the transmitted data rate (Mbps) is—

(A) 6·208 (B) 6·152

(C) 6·144 (D) 0·768

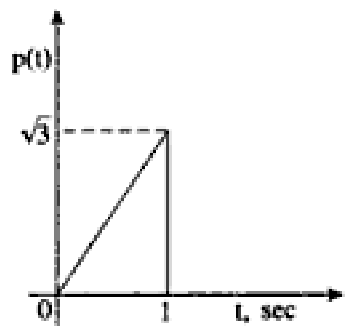
28. A geostationary satellite located at 36,000 km from the surface of the earth. The uplink free space loss is 1·583 dB higher than the downlink free space loss. If the downlink frequency is 10 GHz, the uplink free space loss (in dB) is—

(A) 10·25 (B) 20·5

(C) 102·5 (D) 205

29. In a uniform quantizer, the quantization noise is—
    (A) independent of the number of levels of the quantizer
    (B) proportional to square of the peak-to-peak voltage range of the quantizer
    (C) independent of the peak-to-peak voltage range of the quantizer
    (D) proportional to square of the number of levels of the quantizer

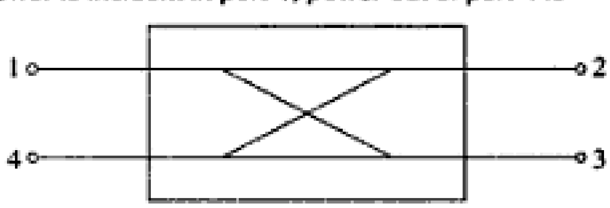
30. In a digital communication system, the transmitted pulse is shown in fig. given. The matched filter output at the sampling instant (*i.e.*, t = 1 sec) is—



(A) $\frac{\sqrt{3}}{2}$ (B) 1
(C) $\frac{1}{2}$ (D) $\frac{1}{6}$

31. An optical link uses a fiber having a power loss of 1 dB/km. A typical photo detector has responsivity 0·5 A/W. If the link is 3 km long and the detector is required to produce a current of 25 μA, the required transmitted power is—
    (A) 0 dBm (B) – 10 dBm
    (C) – 30 dBm (D) – 50 dBm

32. For the directional coupler shown in fig. given, the coupling is 20 dB and the directivity is 30 dB. If 10 W power is incident in port-1, power out of port-4 is—



(A) 0·1 mW (B) 1 mW
(C) 0·01 W (D) 0·1 W

33. In a microwave measurement with slotted rectangular waveguides, the distance between successive minima is found to be 2·5 cm. If the measurement has been carried out at a frequency of 10 GHz and the guide operates in TE_{10} mode, the cut off frequency $f_{c_{10}}$ for the guide is—
    (A) 6 GHz (B) 8 GHz
    (C) 10 GHz (D) 12 GHz

34. An antenna having a directivity of 2 at a frequency of 300 MHz will have a maximum effective aperture of—
    (A) $\frac{1}{8\pi} m^2$ (B) $\frac{1}{4\pi} m^2$
    (C) $\frac{1}{2\pi} m^2$ (D) $\frac{1}{\pi} m^2$

35. A microwave link operates under free space conditions at a frequency of 1 GHz and uses identical antennas at the transmitter and the receiver ends. The transmitter and the receiver are separated by a distance of 30 km. If – 30 dBm power is to be received when the transmitted power is 1 W, the antenna gain should be—
    (A) 100 π (B) 200 π
    (C) 300 π (D) 400 π

36. In connection with memory mapped I/O which one of the following statements is **not** true—
    (A) The processor treats an interface register as a part of the memory system
    (B) It reduces the memory space available
    (C) The processor cannot manipulate I/O data residing in interface registers with the same instructions that are used to manipulate memory location
    (D) Arithmetic or logical operation can be directly performed with I/O data

37. After execution of the following C program, the value of the sum printed is—

```
main ( )
{
    int i, n;
    float x, dx, sum;
    sum = 0;
    x = 2;
    for (i = 1; i <= 100; i++)
      {
        dx = x * (i – 1);
          sum = sum + dx;
          x = 2 * x;
          if (sum > x )
             break;
          }
    printf ("%f", sum);
    end;
}
```

(A) 68 (B) 20
(C) 16 (D) 4

38. If selection sort takes 3 ms to run an array of 200 elements, for a similar array of 4000 elements the selection sort is expected to take—
    (A) 1·2 s (B) 600 ms
    (C) 300 ms (D) 60 ms

39. In a stack based processor organization, postfix notation is used for evaluating arithmetic expressions. The postfix expression ABC*/D-EF/+ for A = 6, B = 2, C = 3, D = 3, E = 4 and F = 2 evaluates to—
    (A) 0 (B) 1
    (C) 2 (D) 3

40. In a 8085 microprocessor system, the active low chip select ($\overline{CS}$) signal is generated by passing address lines $A_{15}, \ldots, A_{10}$ through a 6 inputs NAND gate. For selecting the address range CCOO to CFFF, the inputs to the NAND gate are—

(A) $A_{10}, A_{11}, \overline{A}_{12}, \overline{A}_{13}, A_{14}\ A_{15}$

(B) $\overline{A}_{10}, \overline{A}_{11}, A_{12}, \overline{A}_{13}, \overline{A}_{14}, \overline{A}_{15}$

(C) $A_{10}, A_{11}, \overline{A}_{12}, A_{13}, A_{14}, A_{15}$

(D) $A_{10}, A_{11}, A_{12}, A_{13}, A_{14}, A_{15}$

41. In the context of 8085 microprocessor, the correct matching combination between Column A and Column B is—

Column A

P. ALE

Q. PSW

R. CMA

S. RLC

Column B

1. Rotate accumulator left
2. Compare with accumulator
3. Program status word
4. Address latch enable
5. Program stack word
6. Arithmetic logic enabled
7. Complement accumulator
8. Rotate accumulator left through carry

(A) P-6, Q-5, R-2, S-8 (B) P-4, Q-3, R-2, S-8

(C) P-4, Q-3, R-7, S-1 (D) P-6, Q-5, R-7, S-1

42. The content of the memory location 2070 H after the execution of the following 8085 program is—

```
LXIB   2070 H
MVI    A, 8FH
MVI    C, 68H
SUB    C
ANI    OFH
STAX   B
HLT
```

(A) 04 H (B) 07 H

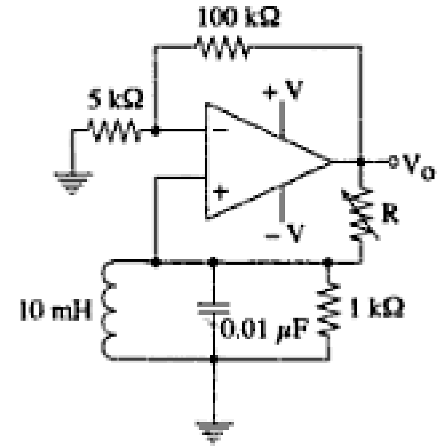
(C) 09 H (D) 0F H

43. A 8085 microprocessor program uses all available Jump instructions, each only once. For this program, the total memory (in Bytes) occupied by the Jump instructions is—

(A) 30 (B) 27

(C) 24 (D) 18

44. The circuit shown in fig. given oscillates at an angular frequency of ω at a particular R. The values of ω (in rad/sec) and R (in kΩ), respectively, are—



(A) 10^5 and 20 (B) 2×10^5 and 20

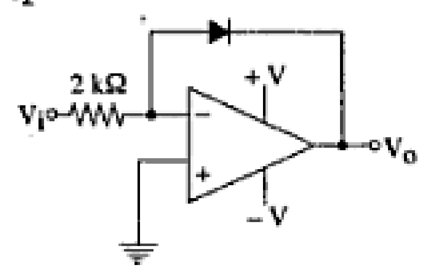
(C) 2×10^5 and 10 (D) 10^5 and 10

45. A combinational circuit accepts a 2 bit binary number and outputs its square in binary. To design this circuit using a ROM, the minimum size of ROM required is—

(A) 2×2 (B) 4×2

(C) 4×4 (D) 8×4

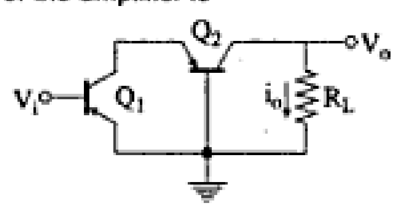
46. In the op-amp circuit shown in fig. given, assume the diode current follows the equation $I = I_S\, e^{V/V_T}$. If $V_0 = V_{0_1}$ for $V_i = 2V$ and $V_0 = V_{0_2}$ for $V_i = 4V$, the relation between V_{0_1} and V_{0_2} is—



(A) $V_{0_2} = V_{0_1}\sqrt{2}$ (B) $V_{0_2} = V_{0_1}\, e^2$

(C) $V_{0_2} = V_{0_1} \ln 2$ (D) $V_{0_2} = V_{0_1} + V_T \ln 2$

47. In the 2-stage amplifier circuit shown in fig. given, if the transconductances of transistor Q_1 and transistor Q_2 are g_{m1} and g_{m2}, respectively, the overall transconductance $g_{m0} = i_0/v_i$ of the amplifier is—



(A) $g_{m0} \approx g_{m1}$ (B) $g_{m0} \approx g_{m2}$

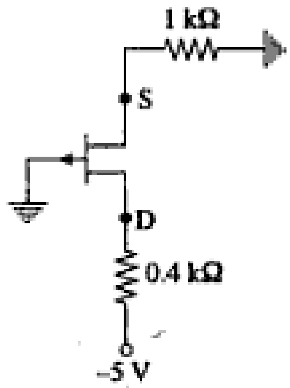
(C) $g_{m0} = g_{m1} + g_{m2}$ (D) $g_{m0} = g_{m1} - g_{m2}$

48. For the system with $G(s)H(s) = \dfrac{K(s+4)}{s(s+1)}$, the breakaway points in the root-loci plot approximately are—

(A) −7·46, −1 (B) −0·54, −1

(C) −7·46, −0·54 (D) 7·46, 0·54

49. For the circuit shown in fig. given, the *p*-channel JFET transistor parameters are I_{DSS} = 6 mA and V_P = 4V. The source-to-drain voltage V_{SD} and the region of operation of the transistor, respectively, are—



(A) 2·09 V and active region

(B) 2·09 V and saturation region

(C) 2·47 V and active region

(D) 2·47 V and saturation region

50. For the truth table given in fig., the minimized Boolean expression is—

Input			Output
x	*y*	*z*	*p*
0	0	0	1
0	0	1	0
0	1	0	0
0	1	1	1
1	0	0	0
1	0	1	1
1	1	0	1
1	1	1	0

(A) $p = xyz + \overline{x}y\overline{z} + x\overline{y}\,\overline{z} + \overline{x}\,\overline{y}z$

(B) $p = \overline{x \oplus y \oplus z}$

(C) $p = x\,\overline{(y \oplus z)} + \overline{x}\,(y \oplus z)$

(D) $p = x \oplus \overline{y} \oplus z$

Section–III

All questions carry 1 mark each.

1. Who was the first woman to be elected as the President of the Indian National Congress ?
   (A) Sarojini Naidu (B) Sonia Gandhi
   (C) Indira Gandhi (D) Annie Besant

2. Which political leader delivered the famous 'I have a dream' speech ?
   (A) Jawaharlal Nehru (B) Winston Churchill
   (C) Martin Luther King (D) Rabindranath Tagore

3. Who established the organization 'Khudai Khidmatgar' ?
   (A) Hyder Ali
   (B) Gopal Krishna Gokhale
   (C) Maulana Abul Kalam Azad
   (D) Khan Abdul Ghaffar Khan

4. Analgesics are drugs used to prevent or relieve—
   (A) aches and pain
   (B) fever and high body temperature
   (C) hormone deficiency
   (D) stress and anxiety

5. The abbreviation CD stands for—
   (A) Circular Disc (B) Computer Device
   (C) Compact Disc (D) Code-Demodulator

6. Chandrayaan-I, India's first mission to the moon, has 11 scientific instruments that are being released on the surface of the moon. These instruments are together known as—
   (A) Moon Impact Probes
   (B) Terrain Mapping Cameras
   (C) Scientific Payloads
   (D) Spectrometers

7. The World Wide Web was invented by—
   (A) Tim Berners-Lee (B) Narayanmurthy
   (C) Sabeer Bhatia (D) Charles Babbage

8. How many diagonals does a quadrilateral have ?
   (A) one (B) two
   (C) four (D) eight

9. ISO 14000 standards deal with—
   (A) quality management
   (B) production management
   (C) human resource management
   (D) environmental management

10. Which Indian politician's autobiography is titled *The Story of My Life* ?
    (A) Morarji Desai (B) Mahatma Gandhi
    (C) Lal Krishna Advani (D) Atal Behari Vajpayee

11. The phrase 'through thick and thin' means—
    (A) big and small (B) thin and fat
    (C) large object (D) under all conditions

12. Picturesque means—
    (A) photogenic (B) simple
    (C) stimulating (D) ugly

13. Diligent means—
    (A) intelligent (B) energetic
    (C) modest (D) industrious

14. The opposite of miserly is—
    (A) spendthrift (B) generous
    (C) liberal (D) charitable

15. The opposite of ingratitude is—
    (A) sympathy (B) reward
    (C) thankfulness (D) stimulation

16. The appropriate missing word in the blank space in the sentence "I prefer coffee .... tea." is—
    (A) than (B) over
    (C) for (D) to

17. The appropriate missing word in the blank space in the sentence "Many relatives attended .... him during illness."

(A) of (B) on
(C) for (D) with

18. The article required before the word 'one-eyed' in the sentence "There was .... one-eyed beggar by the multiplex." is—

(A) the (B) a
(C) an (D) nil

19. The article required before the word University in the sentence "She met Professor Shah at .... University." is—

(A) a (B) an
(C) the (D) nil

20. Which one is the correct sentence amongst the following sentences ?

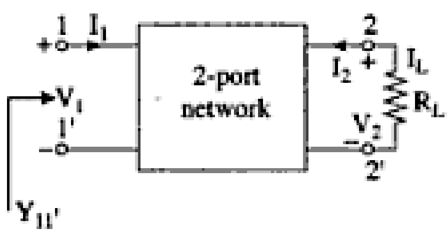
(A) Mr. Gupta, accompanied by his friends, were assembled on the lawns.
(B) Mr. Gupta, accompanied by his friends, are assembled on the lawns
(C) Mr. Gupta, accompanied by his friends, assembled on the lawns
(D) Mr. Gupta, accompanied by his friends, have assembled on the lawns

ANSWERS WITH HINTS

Section–I

1. (D) In an *n*-type semiconductor, concentration of holes is not equal to that of the intrinsic concentration.

2. (B) According to the question



ABCD parameters are given by relation

$$V_1 = AV_2 - BI_2 \quad \text{...(i)}$$
$$I_1 = CV_2 - DI_2 \quad \text{...(ii)}$$

From figure

$$V_2 = I_L R_L = -I_2 R_L$$
$$V1 = A(-I_2R_L) - BI_2$$
$$= -I_2[AR_L + B] \quad \text{...(iii)}$$
$$I_1 = C(-I_2R_L) - DI_2$$
$$= -I_2(CR_L + D) \quad \text{...(iv)}$$

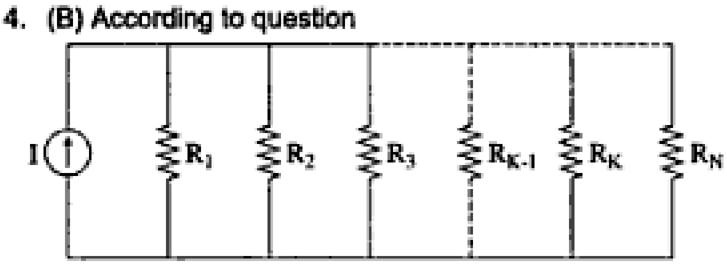
Admittance looking at the terminal

$$1 = \frac{I_1}{V_1} = \frac{CR_L + D}{AR_L + B}$$

Hence alternative (B) is the correct choice.

3. (B) The phenomenon of injection electro-luminescence is the basic of working of light emitting diodes.

4. (B) According to question



$$I_K = \frac{\frac{1}{R_K}}{\left(\frac{1}{R_1} + \frac{1}{R_2} + \dots\dots + \frac{1}{R_N}\right)} \times I$$

(Applying current divider rule)

5. (C) The given circuit

$$I_{AB} = 5\angle 30° \times \frac{5 + j3}{5 + j3 + 5 - j3}$$

or

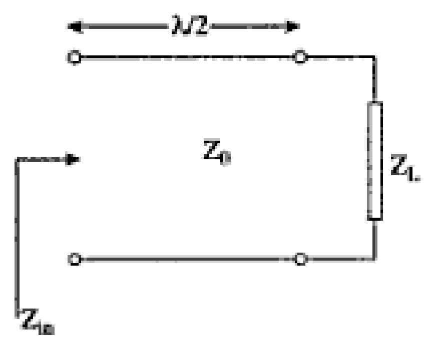
$$I_{AB} = 5\angle 30° \times \frac{5 + j3}{10}$$

and

$$V_{AB} = I_{AB} \times R_{AB}$$
$$= \frac{5\angle 30°}{10}(5 + j3)(5 - j3)$$
$$= \frac{5}{10}\angle 30°[25 - j^2 9]$$
$$= 17\angle 30°$$

Hence alternative (C) is the correct coice.

6. (B) The given figure



we have

$$Z_{in} = Z_0\left[\frac{Z_L + jZ_0 \tan \beta l}{Z_0 + jZ_L \tan \beta l}\right]$$
$$\beta l = \frac{2\lambda}{\lambda} \cdot \frac{\lambda}{2} = \pi$$
$$Z_{in} = Z_0\left[\frac{Z_L + jZ_0 \tan \pi}{Z_0 + jZ_L \tan \pi}\right]$$
$$Z_{in} = \frac{Z_0 Z_L}{Z_0} = Z_L$$

[Since tan π = tan (98 + 90°) or tan π = – cot 90° = 0]

Alternative Method

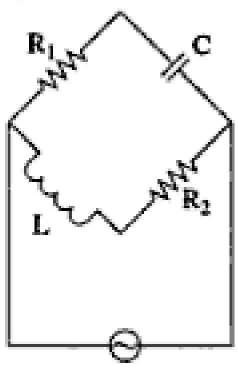
According to property of transmission line. The input impedance and load impedance becomes same after $\frac{\lambda}{2}$ length.

7. (D)

8. (B) The mode of wave propagation with the lowest cut-off frequency is TE_{10}.
9. (A) The radiation resistance of a quarter wave monopole antenna is half of the radiation resistance of a centre fed half dipole or simply dipole antenna.

i.e. $$\frac{73{\cdot}14}{2} = 36{\cdot}57 = 36{\cdot}5\ \Omega$$

10. (A) Photo-voltaic cell is an active transducer.
11. (A) Q-meter works on the principle of series resonance.
12. (D) The given bridge circuit



At balanced condition

$$R_1R_2 = LC$$

Thus, we conclude that balanced condition is independent from frequency. Hence, alternative (D) is the correct choice.

13. (C) For 'ideal' power diode forward voltage drop as well as reverse recovery time must be zero.
14. (D)
15. (A) SMPS works like a DC chopper. By operating the ON/OFF switch very rapidly, ac ripple frequency rises which can be easily filtered by L and C filter circuits which are small in size and less weighty.
16. (B) Porcelain is a ceramic insulator.
17. (D)
18. (C) Spontaneous polarization of ferroelectric materials usually vanishes above ferroelectric curie temperature.
19. (C) Schottky diodes contains a metal-semiconductor junction.
20. (A)
21. (C) $f = 1$ GHz, $l = \frac{\lambda}{8}$, $Z_L = 0$, $Z_0 = 50\Omega$

$$Z_{in} = Z_0\left[\frac{Z_L + jZ_0 \tan\beta l}{Z_0 + jZ_L \tan\beta l}\right]$$

$$\beta l = \frac{2\pi}{\lambda}\cdot\frac{\lambda}{8} = \frac{\pi}{4}$$

$$Z_{in} = Z_0\left[\frac{jZ_0}{Z_0}\right] = jZ_0 = 50j$$

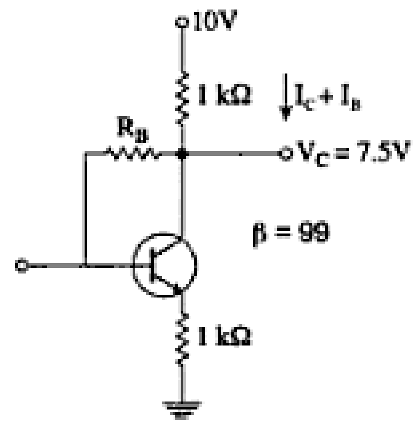
$$50j = jX_L = \omega L = 2\pi\times10^9\,L$$

$$L = \frac{50}{2\pi\times10^9} = \frac{50}{2\pi}\times10^{-9} = \frac{25}{\pi}\,nH$$

22. (A) $$I_C + I_B = \frac{10-7{\cdot}5}{1} = 2{\cdot}5\text{ mA}$$

$$\beta I_B + I_B = 2{\cdot}5$$

$$I_B = \frac{2{\cdot}5}{100} = 0{\cdot}025\text{ mA}$$



$$-7{\cdot}5 + 0{\cdot}7 + R_BI_B + 2{\cdot}5 = 0$$

$$R_B = \frac{7{\cdot}5 - 0{\cdot}7 - 2{\cdot}5}{0{\cdot}025} = 172\text{k}\Omega$$

23. (B) Given, $Z_L = 30\ \Omega$, $Z_{in} = 120\ \Omega$ (*i.e.* characteristic impedance of line) $Z_0 = ?$

For a quarter wave matching transformer

$$Z_{in} = \frac{Z_0^2}{Z_L}$$

or $$Z_0^2 = Z_{in}.\,Z_L = 120\times30 = 3600$$

or $$Z_0 = 60\Omega$$

24. (D) $$\text{VSWR} = \frac{1+|\Gamma|}{1-|\Gamma|}$$

where $|\Gamma|$ is reflection coefficient.

The reflected power (P_r) and incident power (P_i) is related by expression

$$P_r = |\Gamma|^2 P_i$$

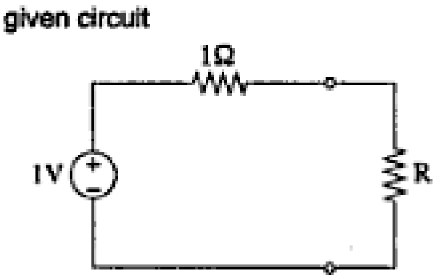
Given that average power delivered to a load is 75% of that of the incident power. It means the reflected power is 25%.

∴ $$|\Gamma|^2 = \frac{P_r}{P_i} = 0{\cdot}25$$

or $$|\Gamma| = 0{\cdot}5$$

Now, $$\text{VSWR} = \frac{1+0{\cdot}5}{1-0{\cdot}5} = \frac{1{\cdot}5}{0{\cdot}5} = 3.$$

25. (D) The given circuit



$$P_{max} = \frac{V_{th}^2}{4R_L} = \frac{V_{th}^2}{4R_{th}} = \frac{1^2}{4\times1} = \frac{1}{4}\text{ watt}$$

Now, according to question voltage source would deliver 50% of maximum deliverable power *i.e.*

$$P_{delivered} = 50\%\text{ of }P_{max} = I^2R$$

or $$\frac{1}{8} = \left(\frac{1}{R+1}\right)^2 R$$

or $$(R+1)^2 = 8R$$

or $$R^2 - 6R + 1 = 0$$

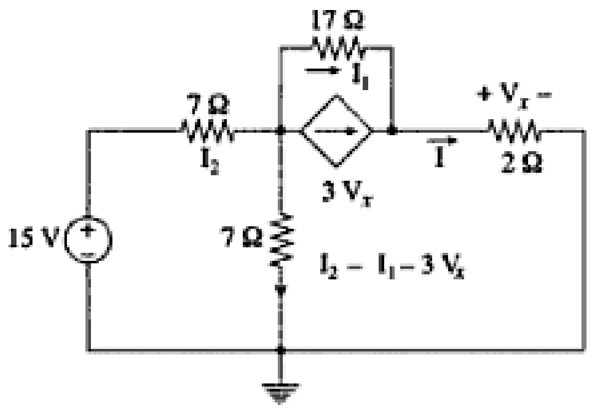
or $$R = \frac{6\pm\sqrt{6^2-4\times1\times1}}{2}$$

or $$R = \frac{6 \pm \sqrt{32}}{2} = \frac{6 \pm 4\sqrt{2}}{2}$$
$$= 3 - 2\sqrt{2} = 3 - \sqrt{8}$$

Hence alternative (D) is the correct choice.

26. (D)

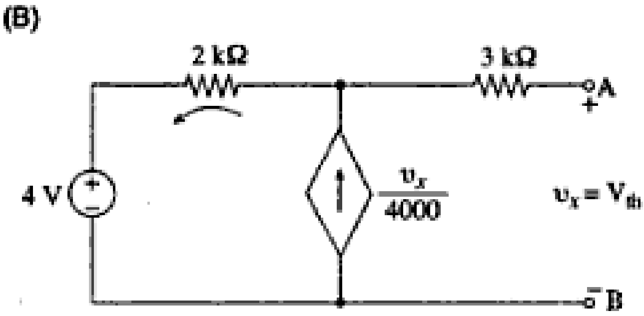
27. (A) $$I = I_1 + 3V_x \quad \text{...(i)}$$
$$-15 + 7\,I_2 + 7\,(I_2 - I_1 - 3V_x) = 0$$
$$-15 + 14\,I_2 - 7\,I_1 - 21\,V_x = 0$$



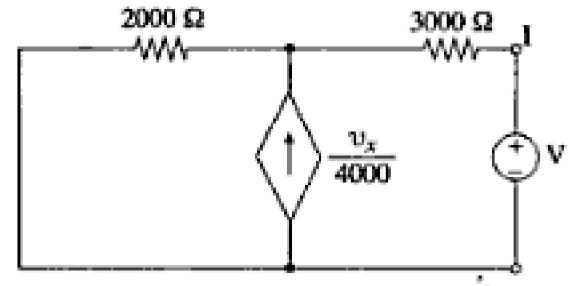
$$V_x = 2\,I$$
$$I = I_1 + 6\,I$$
$$I_1 = -5\,I$$
$$15 = 14\,I_2 + 35\,I - 21 \times 2\,I$$
$$15 = 14\,I_2 - 7\,I \quad \text{...(ii)}$$
$$17\,I_1 + 2\,I - 15 + 7\,I_2 = 0$$
$$17\,(-5\,I) + 2\,I - 15 + 7\,I_2 = 0$$
$$-85\,I + 2\,I - 15 + 7\,I_2 = 0$$
$$-83\,I + 7\,I_2 = 15$$

From equation (ii)
$$15 + 7\,I = 14\,I_2$$
$$\frac{15 + 7\,I}{2} - 83\,I = 15$$
$$15 + 7\,I - 166\,I = 30$$
$$15 - 159\,I = 30$$
$$I = -\frac{15}{159}$$
$$= -94{\cdot}34 \text{ mA}$$

28. (B)

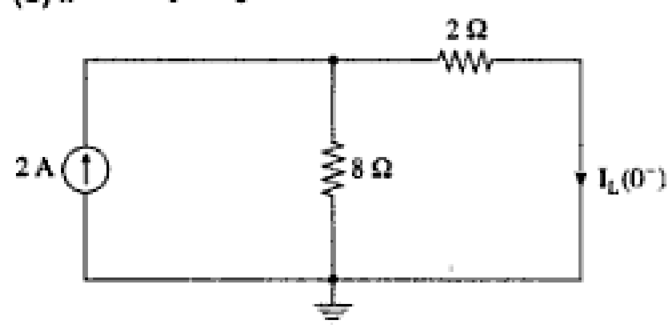


$$-V_{th} + 3 \times 0 + \frac{2V_x \times 10^3}{4000} + 4 = 0$$
$$-V_{th} + \frac{V_{th} \times 10^3}{2000} + 4 = 0$$
$$-\frac{V_{th}}{2} + 4 = 0$$
$$\Rightarrow \quad V_{th} = 8V$$



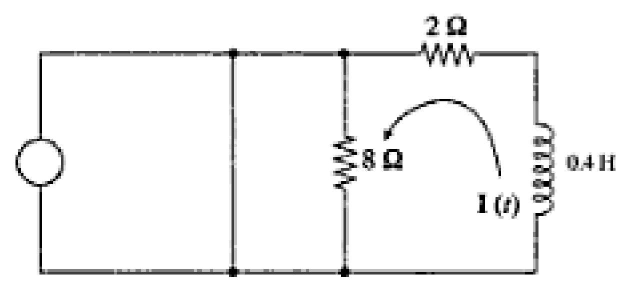
For R_{th}
$$-V + 3000\,I + 2000\left[\frac{V}{4000} + I\right] = 0$$
$$-V + 3000I + \frac{V}{2} + 2000\,I = 0$$
$$5000\,I = \frac{V}{2}$$
or $$\frac{V}{I} = 5000 \times 2$$
or $$R_{th} = \frac{V}{I} = 10000 = 10\text{ k}\Omega$$

29. (C) If $t < 0$



$$I_L(0^-) = I_L(0^+) = \frac{8 \times 2}{10} = 1{\cdot}6 \text{ amp.}$$

at $t \geq 0$



$$L\frac{dI(t)}{dt} + 2\,I(t) = 0$$
$$\frac{dI(t)}{dt} + \frac{20}{0{\cdot}4}\,I(t) = 0$$
$$\frac{dI(t)}{dt} + 5I(t) = 0$$
$$I{\cdot}F = e^{5t}$$
$$I(t).\,e^{5t} = \int 0{\cdot}e^{5t}\,dt + c$$
$$I(t) = ce^{-5t}$$
Given $$I(0^-) = I(0^+) = 1{\cdot}6 \text{ amp.}$$
$$c = 1{\cdot}6 \text{ amp.}$$
$$I(t) = 1{\cdot}6\,e^{-5t}$$
$$I(0{\cdot}15) = 1{\cdot}6e^{-5 \times 1{\cdot}5} = 0{\cdot}76 \text{ A}$$

30. (A) Deflection torque, $T_d = NIAB$

Given, $N = 100$, $I = 5 \text{ mA} = 5 \times 10^{-3}$ A

$$A = 100 \text{ mm} \times 10 \text{ mm} = 100 \times 10^{-6} \text{ m}^2$$

$$B = 2 \text{ mW/m}^2 = 2 \times 10^{-3} \text{ W/m}^2$$

Now, controlling torque, $T_c = k\theta$

where $\theta = 90° = \frac{90 \times \pi}{180} = \frac{\pi}{2}$ radian

Since, $T_d = T_c$ at Balanced condition

$$NIAB = k\theta$$

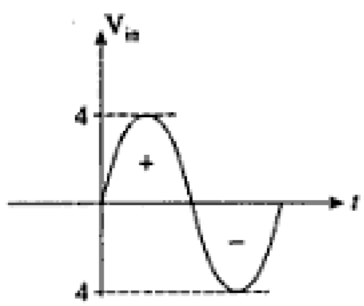
$$\text{or } k = \frac{NIAB}{\theta}$$

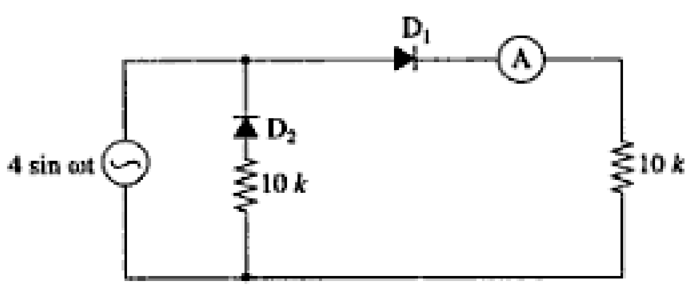
$$= \frac{100 \times 5 \times 10^{-3} \times 100 \times 10^{-6} \times 2 \times 10^{-3}}{\pi/2}$$

$$\text{or } k = \frac{10 \times 10^{-8}}{\pi/2} = \frac{2}{\pi} \times 10^{-7} \text{ N-m/rad}$$

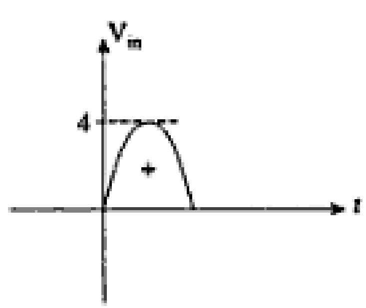
Thus, from the given options, alternative (A) is the most appropriate choice.

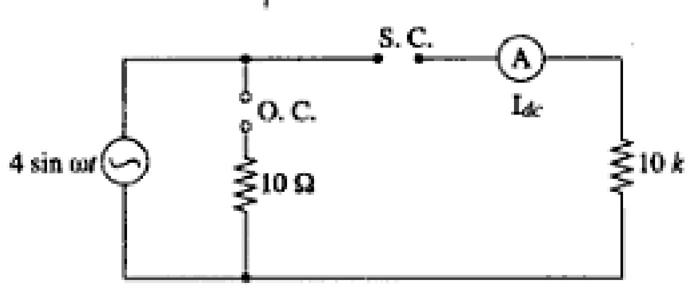
31. (A)



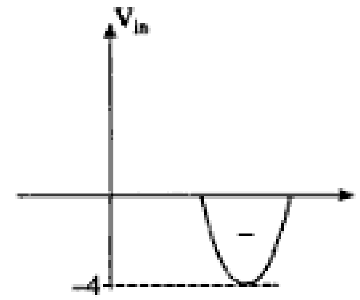


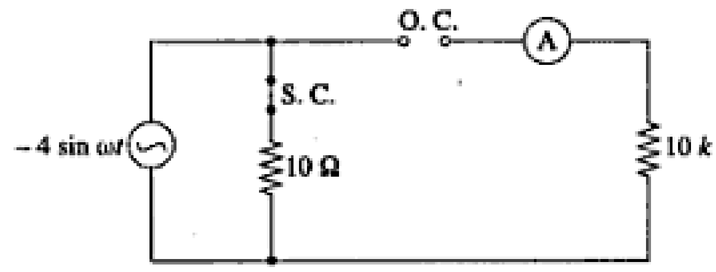
For upper half cycle D_1 conduct and D_2 not conduct as shown below—





Now for second half cycle D_2 conduct and D_2 not conduct as shown above—





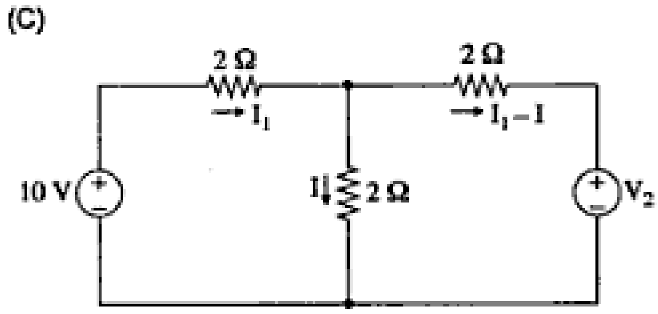
Then circuit is act as a half wave rectifier then

$$V_{dc} = \frac{V_0}{\pi} = \frac{4}{\pi} \text{ volt}$$

$$I_{dc} = \frac{V_{dc}}{R} = \frac{4}{10\pi} = \frac{0.4}{\pi} \text{ mA}$$

32. (C) 33. (A)

34. (C)



$$-10 + 2I_1 + 2I = 0$$

$$-10 + 2I_1 + 6 = 0$$

$$I_1 = \frac{4}{2} = 2 \text{ amp}$$

$$2(I_1 - I) + V_2 - 2 \times I = 0$$

$$2 \times 2 - 2 \times 3 + V_2 - 2 \times 3 = 0$$

or $V_2 = 8$ volt

35. (C) The shunt resistance, $R_{sh} = \frac{R_m}{m - 1}$

where, $m = \frac{I}{I_m} = \frac{1}{0.1} = 10$

Therefore, $R_{sh} = \frac{10}{10 - 1} = \frac{10}{9} \approx 1.1\Omega$

Hence alternative (C) is the correct choice.

36. (A)

$$V_D = 1\text{V}$$

$$I_D = 200\text{A}$$

$$\eta = 2$$

$$V_T = 25.7 \text{ mV}$$

$$I_S = ?$$

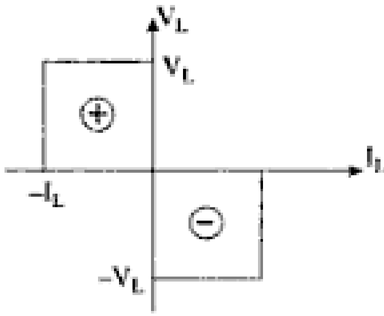
we have $I_D \approx I_S e^{\frac{V_D}{\eta V_T}}$

$$200 \approx I_S e^{\frac{1000}{2 \times 25.7}}$$

$$I_S = \frac{200}{e^{\frac{1000}{51.4}}} \approx 71.08 \ \mu\text{A}.$$

37. (D)

38. (D)

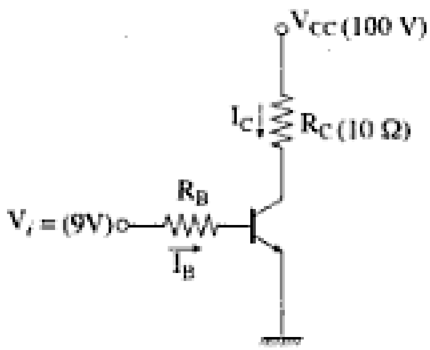


This is not a dc - dc converters.

39. (B)

40. (B)
- DC switch → MOSFET
- Regulated DC–DC → Boost converter
- AC to AC → Cyclo converter
- DC to AC → Inverter

41. (A)



Given
$$V_{CE\,(sat)} = 1{\cdot}0\text{V}$$
$$V_{BE\,(sat)} = 1{\cdot}5\text{V}$$
$$\beta = 9$$
$$\text{Overdrive factor} = 2{\cdot}5$$

Applying KVL

$$-100 + 10\,I_C + V_{CE\,(sat)} = 0$$
$$I_C = \frac{100 - V_{CE\,(sat)}}{10} = \frac{100-1}{10}$$
$$= \frac{99}{10} = 9{\cdot}9$$
$$I_B \geq \frac{I_C}{\beta}$$
$$\Rightarrow \quad I_B \geq \frac{9{\cdot}9}{9} = 1{\cdot}1 \text{ amp}$$

Then
$$R'_B = \frac{V_i - V_{BE\,(sat)}}{I_B} = \frac{9-1{\cdot}5}{1{\cdot}1} = \frac{7{\cdot}5}{1{\cdot}1}$$
$$R_B = \frac{R_B'}{\text{overdrive factor}}$$
$$= \frac{750}{11 \times 2{\cdot}5} = \frac{30}{11} = 2{\cdot}73\Omega$$

42. (C) $a \times b \times c = 5$ cm

$$f_c = ? \text{ for } TE_{101}$$
$$f_c = \frac{c}{2}\sqrt{\left(\frac{m}{a}\right)^2 + \left(\frac{n}{b}\right)^2 + \left(\frac{z}{c}\right)^2}$$
or
$$f_c = \frac{3 \times 10^8}{2}\sqrt{\left(\frac{1}{5}\right)^2 + \left(\frac{1}{5}\right)^2} \times 10^2$$
or
$$f_c = \frac{3}{2} \times 10^{10}\,\frac{\sqrt{2}}{5} = \frac{30\sqrt{2} \times 10^9}{2 \times 5} = 3\sqrt{2} \text{ GHz}$$

43. (C) When SCRs are in the conduction state, they can be turned off by applying reverse voltage across it.

44. (B) Given $\rho_1 = \rho_2$

(since wires made up of same material)

$$2D_1 = D_2$$
$$4L_1 = L_2$$
$$R_1 = \rho_1 \frac{L_1}{A_1}$$
$$R_2 = \rho_2 \frac{L_2}{A_2}$$
$$\frac{R_1}{R_2} = \frac{L_1 A_2}{L_2 A_1} = \frac{L_1}{4L_2} \times \frac{(2D_1)^2}{D_1^2} = 1$$
$$R_1 = R_2$$

Hence alternative (B) is the correct choice.

45. (A)
$$I = 1 \text{ A}$$
$$D = 1 \text{ m}$$
$$A = 1 \times 10^{-6} \text{ m}^2$$
$$L = 4\pi \times 10^{-7} \text{ H}$$

given current reduces to 0·99A after 1 year

$$\rho = ?$$
$$\rho = R \cdot \frac{A}{L} \qquad \text{...(i)}$$
$$V = L\frac{\Delta I}{\Delta T} = \frac{4\pi \times 10^{-7} \times [1 - 0{\cdot}99]}{1 \text{ year}}$$
$$1 \text{ year} = 365 \times 24 \times 60 \times 60$$
$$V = \frac{4\pi \times 10^{-7} \times 0{\cdot}01}{365 \times 24 \times 60 \times 60}$$
$$= 4\pi \times 10^{-7} \times 3{\cdot}17 \times 10^{-10}$$
$$V = 12{\cdot}68\pi \times 10^{-17} \text{ volt}$$
$$R = \frac{V}{I} = 12{\cdot}68\pi \times 10^{-17}\Omega$$
$$\rho = \frac{1268\pi \times 10^{-17} \times 1 \times 10^{-6}}{\pi D}$$
$$\rho = \frac{12{\cdot}68 \times 10^{-23}}{1} = 1{\cdot}268 \times 10^{-22}\ \Omega \text{ m}$$

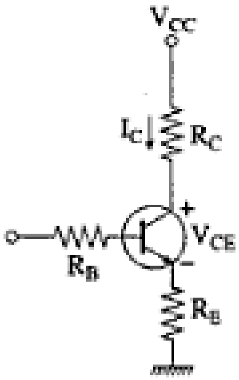
Hence alternative (A) is the correct choice.

46. (A) Applying KVL

$$-V_{CC} + R_C I_C + V_{CE} + I_C R_E = 0$$
$$(R_C + R_E)\,I_C + V_{CE} = V_{CC}$$
when $I_C = 1$ mA

and $V_{CE} = 1$ volt

$$(R_C + R_E) + 1 = V_{CC} \qquad \text{...(i)}$$



when $\quad V_{CE} = 11$ volt

$$(R_C + R_E)\, I_C + 11 = V_{CC} \quad \ldots\text{(ii)}$$

From equations (i) and (ii)

$$(R_C + R_E)\,[1 - I_C] = 10$$

$$(R_C + R_E) = \frac{10}{1 - I_C}$$

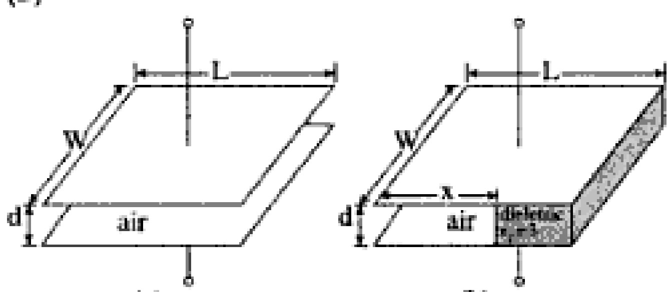
Here $(R_C + R_E)$ is passive element.
Therefore, it should be + ve

then $\quad 1 - I_C > 0$

$$I_C < 1$$

Hence only option (A) is correct.

47. (B)



(a) (b)

We know that $\quad C = E_0 \dfrac{A}{d}$

$$C_1 = \varepsilon_0 \frac{W.\,L}{d}$$

and $\quad C_2 = \left(\dfrac{3\varepsilon_0\, W\,(L - x)}{d}\right) + \varepsilon_0 \dfrac{W.\,x}{d}$

given $\quad C_2 = 2C_1$

$$\left(3\varepsilon_0 \frac{W\,(L - x)}{d} + \varepsilon_0 \frac{W.\,x}{d}\right) = 2\varepsilon_0 \frac{WL}{d}$$

$$3\,(L - x) + x = 2L$$

or $\quad 2L = x + 3L - 3x$

or $\quad 2x = L$

or $\quad x = \dfrac{L}{2}$

48. (A) $\quad R_H = 3{\cdot}6 \times 10^{-4}\ m^3C^{-1}$

$$\rho = 9 \times 10^{-3}\ \Omega m$$

$$\mu = \frac{R_H}{\rho} = \frac{3{\cdot}6 \times 10^{-4}}{9 \times 10^{-3}}$$

$$= 0{\cdot}4 \times 10^{-1} = 0{\cdot}04\ m^2V^{-1}s^{-1}$$

$$\eta = \frac{1}{R_H.\, e}$$

$$= \frac{1}{3{\cdot}6 \times 10^{-4} \times 1{\cdot}6 \times 10^{-19}}\ m^3$$

$$= 0{\cdot}173 \times 10^{19} \times 10^4$$

$$= 1{\cdot}73 \times 10^{22}\ m^{-3}$$

49. (A) Intrinsic concentration $= n_i$

Electron concentration $= n$

Electron mobility $= \mu_n$

Hole mobility $= \mu_p$

Conductivity $\sigma = (pe\mu_p + ne\mu_n) \quad \ldots$(i)

and $\quad p_n = n_i^2$

$$p = \frac{n_i^2}{n}$$

$$\sigma = ne\mu_n + \frac{n_i^2}{n} e\mu_p$$

For maximum $\quad \dfrac{d\sigma}{dn} = 0 = e\left[\mu_n - \dfrac{n_i^2\,\mu_p}{n^2}\right] = 0$

$$\mu_n - \frac{n_i^2}{n^2}\mu_p = 0$$

$$\boxed{n = n_i\sqrt{\frac{\mu_p}{\mu_n}}}$$

50. (C) $\quad E_{bg} = 1{\cdot}42$ eV

$$= 1{\cdot}42 \times 1{\cdot}6 \times 10^{-19}\ J$$

$$h = 6{\cdot}625 \times 10^{-34}$$

$$E_{bg} = \frac{hc}{\lambda}$$

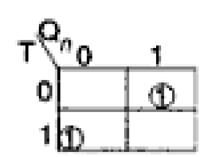
$$\lambda = \frac{hc}{E_{bg}} = \frac{6{\cdot}625 \times 10^{-34} \times 3 \times 10^8}{1{\cdot}42 \times 10^{-19} \times 1{\cdot}6}$$

$$\lambda = 0{\cdot}875\ \mu m$$

Section–II

1. (A) For TFF

T	Q_n	$Q(n + 1)$
0	0	0
0	1	1
1	0	1
1	1	0



$$\overline{T}Q_n + T\overline{Q}_n = Q.(n + 1)$$

2. (B) When the system encloses the point (– 1, j 0). Then intersection point of real axis is greater than 1 and hence

$$A > 1$$

$$\Rightarrow \quad \frac{1}{A} < 1$$

$$GM = 20\ \log_{10} \frac{1}{A}$$

$$GM < 0$$

3. (C) $\quad \dfrac{2d^2y\,(t)}{dt^2} + \dfrac{3dy\,(t)}{dt} + 4y\,(t) = r\,(t) + 2r\,(t - 1)$

Taking Laplace transform

$$2s^2Y\,(s) + 3sY\,(s) + 4Y\,(s) = R\,(s) + 2e^{-s}R(s)$$

$$\frac{Y\,(s)}{R\,(s)} = \frac{1 + 2e^{-s}}{2s^2 + 3s + 4}$$

4. (C) $x_{AM} = [1 + a_m \cos 2\pi f_a t] \cos 2\pi f_m t$
$\cos 2\pi f_c t$

modulating signal $= [1 + a_m \cos 2\pi f_a t] \cos 2\pi f_m t$

5. (D) $x_{FM} = A_C \cos 2\pi \left[f_c t + \int_0^t m(\tau)\, d\tau \right]$

6. (B) Condition for zero ISI

$$\sum_{n=-\infty}^{\infty} P\left(f - \frac{n}{T_b}\right) = T_b$$

7. (A) $X(f) = T \sin c\,(fT)\, e^{-j\pi fT}$

magnitude $|X(f)| = |T \sin c\,(fT)\, e^{-j\pi fT}|$
$= |T \sin c\,(fT)|$

8. (C) $f_c = 8$ kHz

$f_c \geq 2 f_m$

$\Rightarrow \quad f_m \leq \frac{f_c}{2}$

$f_m \leq 4$

9. (D) 10. (B) 11. (D)

12. (A) $F(A, B, C) = \pi(0, 2, 3)$

$F(A, B, C) = \sum(1, 4, 5, 6, 7)$

$F = \bar{B}C + A$

A \ BC	00	01	11	10
0		1		
1	1	1	1	1

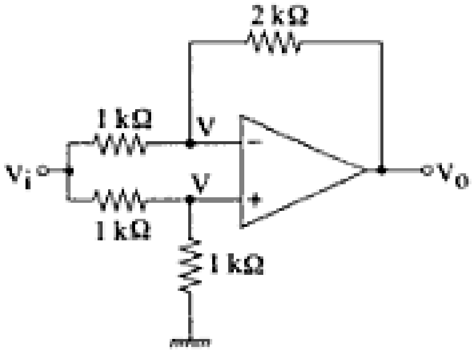
13. (A) No. of address line $= n$
for 2^n bit memory

Memory $=$ 8k byter
$= 2^3 \times 2^{10} = 2^{13-n}$
$n = 13$

14. (A)

15. (C) Binary no. $=$ 1101100
2′ comp $=$ 0010100
For BCD $=$ 00010100
$= 14$

16. (C)



$$\frac{V_i - V}{1} = \frac{V}{1}$$

$2V = V_i \quad \ldots(i)$

$$\frac{V_i - V}{1} = \frac{V - V_0}{2}$$

$\Rightarrow \quad 2V_i - 2V = V - V_0$

$2V_i = 3V - V_0$

$V_0 = 3V - 2V_i = \frac{3}{2}V_i - 2V_i = -\frac{V_i}{2}$

$\frac{V_0}{V_i} = -0{\cdot}5$

17. (C)

18. (D) Option (D) is correct answer.

$\overline{\bar{x} + \bar{y}} = \bar{\bar{x}} + \bar{\bar{y}} \neq \bar{x} + \bar{y}$

19. (B)

20. (D) CMOS has lowest power dissipation and highest noise margin.

21. (C) $s^4 + s^3 + 2s^2 + 2s + 3 = 0$

s^4	1	2	3
s^3	1	2	0
s^2	$0 = \epsilon$	3	0
s^1	$\lim_{\epsilon \to 0} \frac{2\epsilon - 3}{\epsilon} = -\infty$	0	0
s^0	3		

$$\lim_{\epsilon \to 0} \frac{2\epsilon - 3}{\epsilon} = -\infty$$

Here there two sign change in a row, hence atleast two roots present in RHP.

22. (D) $F(A, B, C) = \pi(0, 2, 4, 7)$

$F(A, B, C) = \sum(1, 3, 5, 7)$

For Max	I_0	I_1	I_2	I_3
$\bar{A}$	0	①	2	③
A	4	⑤	⑥	7
	0	1	A	$\bar{A}$

$(I_0, I_1, I_2, I_3, s_1, s_0) = (0, 1, A, \bar{A}, B, C)$

Hence alternative (D) is the correct choice.

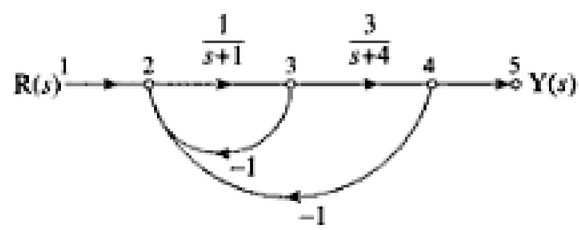
23. (A)
- $(CLK, \overline{CLR}, L, C) = (\uparrow, 1, 1, X)$
→ Means load inputs
- $(CLK, \overline{CLR}, L, C) = (\uparrow, 1, 0, 1)$
→ Means count next binary state
- $(CLK, \overline{CLR}, L, C) = (X, 0, X, X)$ → Clear outputs
- $(CLK, \overline{CLR}, L, C) = (X, 1, 0, 0)$ → No change

24. (D)

25. (A) Forward path 1 – 2 – 3 – 4 – 5

$$M_1 = \frac{3}{(s+1)(s+4)} \quad \Delta = 1$$

Loop $L_{11} = -\frac{1}{s+1}, \; L_{12} = \frac{-3}{(s+1)(s+4)}$



No non-touching loop

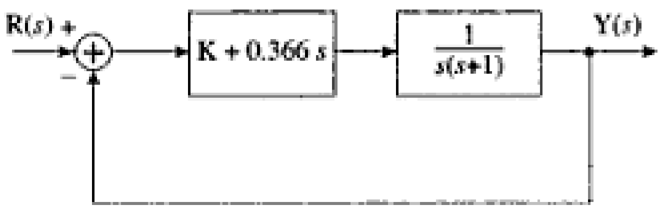
Gain $\quad M = \sum \frac{M4}{1-\sum(\text{loop})}$

$$M = \frac{\frac{3}{(s+1)(s+4)}}{1+\frac{1}{s+1}+\frac{3}{(s+1)(s+4)}}$$

$$M = \frac{3}{s^2+5s+4+s+4+3}$$

$$= \frac{3}{s^2+6s+11}$$

26. (C)



$$G = (K+0{\cdot}366s)\left(\frac{1}{s(s+1)}\right)$$

$$H(s) = 1$$

$$G(s)H(s) = \frac{K+0{\cdot}366s}{s(s+1)}$$

$$\angle\phi = -90+\tan^{-1}\frac{0{\cdot}366\omega}{K}-\tan^{-1}\omega$$

Given $\quad PM = 60° = 180+\angle\phi$

$$60 = 180-90+\tan^{-1}\frac{0{\cdot}366\omega}{K}-\tan^{-1}\omega$$

$$-30 = \tan^{-1}\frac{0{\cdot}366\omega}{K}-\tan^{-1}\omega$$

$$\tan^{-1}\omega-\tan^{-1}\frac{0{\cdot}366\omega}{K} = 30$$

$$\tan^{-1}\left[\frac{\omega-\frac{0{\cdot}366\omega}{K}}{1+\frac{\omega^2\,0{\cdot}366}{K}}\right] = 30$$

at $\quad \omega = 1$ rad/sec

$$\frac{1-\frac{0{\cdot}366\times 1}{K}}{1+\frac{0{\cdot}366}{K}} = \tan 30 = \frac{1}{\sqrt{3}}$$

$$\sqrt{3}-\frac{0{\cdot}366\sqrt{3}}{K} = 1+\frac{0{\cdot}366}{K}$$

$$\sqrt{3}-1 = \frac{0{\cdot}366\sqrt{3}+0{\cdot}366}{K}$$

$$K = \frac{0{\cdot}366\sqrt{3}+0{\cdot}366}{\sqrt{3}-1} = 1{\cdot}366$$

27. (A) Given no. of voice channels = 96

Sampling rate = 8 kHz

and encodes into 8 bits per sample

one synchronization bit per frame

Therefore, transmitted data rate

$$r = (96+1)\times 8\text{ kHz}\times 8\text{ bits per samples}$$

or $\quad r = 97\times 8\times 10^3\times 8$ bits/sec

or $\quad r = 6{\cdot}208\times 10^6$ bits/sec

or $\quad r = 6{\cdot}208$ mbps

Hence alternative (A) is the correct choice.

28. (D)

29. (B) In a uniform quantizer, the quantization noise is given by

$$\text{Quantization noise} = \frac{\Delta^2}{12} = \left(\frac{V_{PP}}{L}\right)^2\times\frac{1}{12}$$

or $\quad \text{Quantization noise} = \frac{V_{PP}^2}{(2^n)^2}\times\frac{1}{12}$

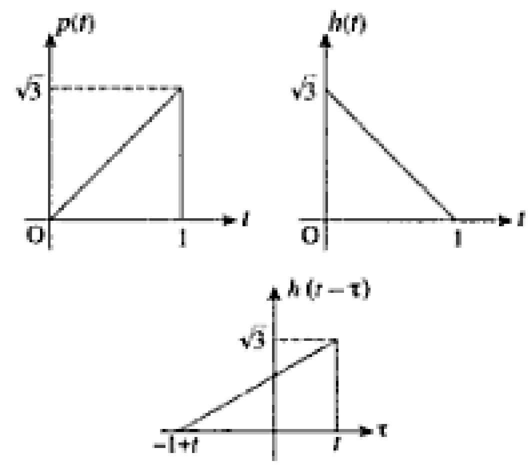
where, $\quad V_{PP}$ = Peak to peak voltage

L = No. of levels

n = No. of bits

Hence alternative (B) is the correct choice.

30. (A) For matched filter



$$h(t) = p(T-t)$$

$$T = 1\text{ sec (Given)}$$

$$h(t) = p(1-t)$$

$$y(t) = p(t) * h(t)$$

$$y(t) = \int_{-\infty}^{\infty} p(\tau).\,h(t-\tau)\,d\tau$$

$$y(t) = \int_0^t \sqrt{3}\tau\left[-\sqrt{3}(t-\tau)+1\right]d\tau$$

$$y(t) = \sqrt{3}\left[\int_0^t -\sqrt{3}t\,\tau\,d\tau+\int_0^t\sqrt{3}\,\tau^2\,d\tau+\int_0^t \tau d\tau\right]$$

$$y(t) = \sqrt{3}\left[-\frac{\sqrt{3}}{2}t^3+\frac{t^3}{\sqrt{3}}+\frac{t^2}{2}\right]$$

at $\quad t = 1$ sec

$$y(1) = \sqrt{3}\left[-\frac{\sqrt{3}}{2}+\frac{\sqrt{3}}{2}+\frac{1}{2}\right]$$

$$= \sqrt{3}\left[\frac{-\sqrt{3}+\sqrt{3}+1}{2}\right] = \frac{\sqrt{3}}{2}$$

31. (B) 32. (A) 33. (B)

34. (C) Effective aperture, $A_e = \frac{\lambda^2}{4\pi}D$

Given, $\quad f = 300$ MHz

$D = 2$

From relation, $\lambda = \frac{c}{f}$

$$\lambda = \frac{3 \times 10^8}{3 \times 10^6 \times 100} = 1$$

$$A_e = \frac{1}{4\pi} \times 2 = \frac{1}{2\pi} m^2$$

Hence alternative (C) is the correct choice.

35. (D)

36. (D) Arithmetic or logical operation can be directly performed with accumulator.

37. (B) dx = x * (i – 1)
 = 2 * (1 – 1) = 0
 sum = 0 + 0 = 0
 x = 2 * x = 2 * 2 = 4
 again for 2nd loop
 dx = 4 * (2 – 1) = 4
 sum = 0 + 4 = 4
 x = 2 * x = 2 * 4 = 8
 for 3rd loop
 dx = 8 * (3 – 1) = 16
 sum = 4 + 16 = 20
 x = 2 * 8 = 16
 sum > x
 break;
 printf ("%f", sum);
 end;
 The sum printed is 20.

38. (D) Complexity of selection sort $= \frac{n(n-1)}{2}$

Time to run 200 elements = 3 ms

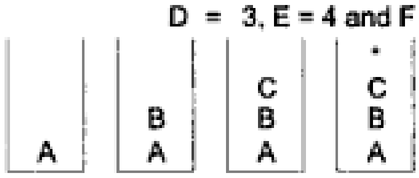
Time to run 1 element $= \frac{1 \times 3}{200}$

Time to run 4000 elements $= \frac{3 \times 4000}{200} = 60$ ms

Hence alternative (D) is the correct choice.

39. (A) This problem is related to stack ABC*/D – EF/+

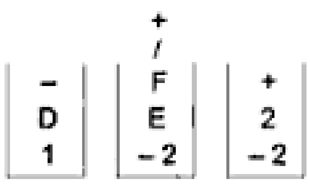
A = 6, B = 2, C = 3,
D = 3, E = 4 and F = 2



* performs on B and C

B * C = 6

$$\frac{A}{6} = \frac{6}{6} = 1$$



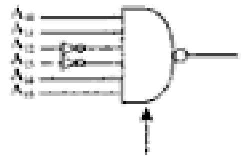
E/F = 2

= 0

Hence alternative (A) is the correct choice.

40. (A)

	A_{15}	A_{14}	A_{13}	A_{12}	A_{11}	A_{10}	A_9	A_8	A_7	A_6	A_5	A_4	A_3	A_2	A_1	} Starting Address
CCOO →	1	1	0	0	1	1	0	0	0	0	0	0	0	0	0	} Final Address
CFFF →	1	1	0	0	1	1	1	1	1	1	1	1	1	1	1	



6-input NAND gate

Hence the inputs to the NAND gate are $A_{10}A_{11}\overline{A}_{12}\overline{A}_{13}A_{14}A_{15}$.

41. (C)

- ALE → Address Batch Enable
- PSW → Program Status Word
- CMA → Complement Accumulator
- RLC → Rotate Accumulator Left

42. (D)

LXIB 2070H	←	loads the contents 70H in register C and 20 H in register B
MVI A, 8FH	←	stores the contents of 8FH in Accumulator
MVI C, 68H	←	stores the contents of 68FH in Accumulator
SUB C	←	subtracts the contents of register C from the contents of Accumulator*
ANI OFH	←	AND immediate the contents 0FH with the Accumulator**
STAX B	←	It copies data from the Accumulator into the register BC
HLT	←	End of the program

* 8 F H
 – 6 8 H
 2 7 H

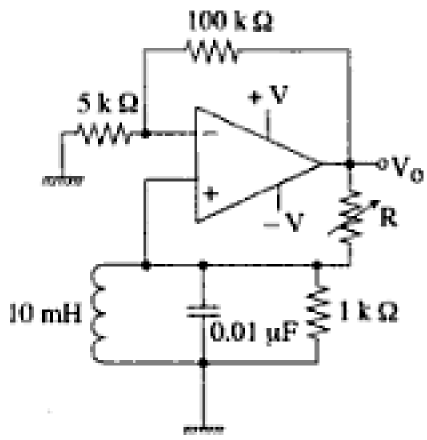
** 1 0 0 0 1 1 1 1 (8F H)
 0 0 0 0 1 1 1 1 (0F H)
AND → 0 0 0 0 1 1 1 1 (0F H)

Thus, the contents of memory location 2070H after the execution of the program will be 0F H.

43. (C) These are 8-Jump instructions in 8085, these are

S. No.	Name of Instruction	Meaning	No. of Machine cycles required
1.	JZ	Jump if the result is zero	3
2.	JNZ	Jump if the result is not zero	3
3.	JC	Jump if there is a carry	3
4.	JNC	Jump if there is no carry	3
5.	JP	Jump if result is plus	3
6.	JM	Jump is result is minus	3
7.	JPE	Jump is even parity	3
8.	JPO	Jump is odd parity	3
		Total	24

44. (D) The given circuit



As we know that

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

$$\omega = \frac{1}{\sqrt{LC}}$$

$$\omega = \frac{1}{\sqrt{10 \times 10^{-3} \times 0{\cdot}01 \times 10^{-6}}}$$

$$\omega = 10^5 \text{ rad/sec}$$

and $\frac{R}{R_1} = 2$

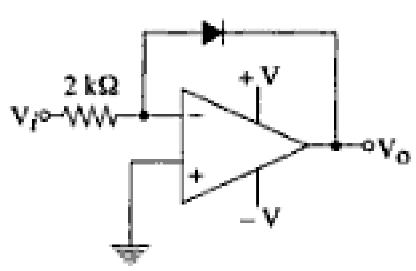
$\Rightarrow$ $R = 2R_1$, $R_1 = 5k$, $R = 10k$

45. (B) The given combinational circuit is 2 × 4 Decoder. (since it is given that a combinational circuit accepts a 2 bit binary number and outputs its square in binary).

To design this circuit using a ROM the minimum size of ROM required is $2^k \times k$ where k is the number of inputs line and 2^k is the number of output lines.

Thus $2^2 \times 2$ *i.e.* 4 ×2 ROM is required.

46. (D) The given circuit



Given $I = I_s e^{\frac{V}{V_T}}$ where V is the output voltage

$$I = \frac{V_i}{2k\Omega}$$

where $V_i = 2V$ then $V_0 = V_{01}$

$$\frac{2V}{2k\Omega} = I_s e^{\frac{V_{01}}{V_T}} \quad \text{...(i)}$$

when $V_i = 4V$ then $V_0 = V_{02}$

Now, $$\frac{4V}{2k\Omega} = I_s e^{\frac{V_{02}}{V_T}} \quad \text{...(ii)}$$

From equations (ii) and (i)

$$\frac{e^{\frac{V_{02}}{V_T}}}{e^{\frac{V_{01}}{V_T}}} = 2$$

or $$e^{\frac{V_{02}-V_{01}}{V_T}} = 2$$

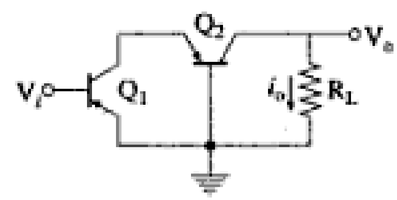
or $$\ln e^{\frac{V_{02}-V_{01}}{V_T}} = \ln 2$$

or $$\frac{V_{02}-V_{01}}{V_T} = \ln 2$$

or $$V_{02} = V_{01} + V_T \ln 2$$

Hence alternative (D) is the correct choice.

47. (A) The given circuit



from given circuit

$$g_{m_1} = \frac{I_c}{V_i}$$

or $$I_C = g_{m_1} V_i \quad \text{...(i)}$$

where g_{m_1} is the transconductance of transistor Q_1 and I_C is the collector current of the transistor Q_1. The transistor Q_2 in common base configuration.

Let the current gain of common base is α. Then

$$\alpha = \frac{I_0}{I_c}$$

or $$\alpha = \frac{I_0}{g_{m_1} V_i}$$

or $$\frac{I_0}{V_i} = \alpha\, g_{m_1}$$

or $$\frac{I_0}{V_i} = g_{m_1}$$

(since α = 1 For common Base configuration)

48. (C) Given $G(s)H(s) = \frac{K(s+4)}{s(s+1)}$

The C.E. is $1 + G(s)H(s) = 0$

or $$1 + \frac{K(s+4)}{s(s+1)} = 0$$

or $$K = \frac{-s(s+1)}{(s+4)}$$

or $$K = \frac{-(s^2+s)}{s+4}$$

or $$\frac{dk}{ds} = -\left[\frac{(s+4)(2s+1)-(s^2+s)\,1}{(s+4)^2}\right]$$

Breakaway points can be obtained by equating

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

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

or $$2s^2 + 8s + s + 4 - s^2 - s = 0$$

or $$s^2 + 8s + 4 = 0$$

After solving we get

$$s = -7{\cdot}46, -0{\cdot}54$$

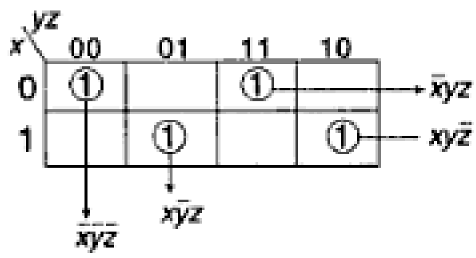
Hence alternative (C) is the correct choice.

49. (B)

50. (B) The given truth table

Input			Output
x	y	z	p
0	0	0	1
0	0	1	0
0	1	0	0
0	1	1	1
1	0	0	0
1	0	1	1
1	1	0	1
1	1	1	0

Now,



From k-map, the output p is given by

$$p = \bar{x}\,\bar{y}\,\bar{z} + \bar{x}yz + x\bar{y}z + xy\bar{z}$$

or $$p = \bar{x}\,(\bar{y}\,\bar{z} + yz) + x\,(\bar{y}z + y\bar{z})$$

or $$p = \bar{x}\,(y \oplus z) + x\,(y \oplus z)$$

or $$p = \overline{x \oplus y \oplus z}$$

Hence alternative (B) is the correct choice.

Section–III

1. (D) 2. (C) 3. (D) 4. (A) 5. (C) 6. (C) 7. (A)
8. (B) 9. (D) 10. (B) 11. (D) 12. (A) 13. (D) 14. (B)
15. (C) 16. (D) 17. (B) 18. (B) 19. (C) 20. (C)

Junior Telecom Officer Exam.
Solved Paper

JTO 2007

Section A

1. A house, served by a 220 V supply like, is protected by a 9 ampere fuse. The maximum number of 60 W bulbs in parallel that can be turned on is :
   (a) 11 (b) 33
   (c) 22 (d) 44

2. An n-channel JFET has I_{DSS} = 1 mA and V_P = – 5V. The maximum trans-conductance is :
   (a) g_{m_0} = 0·4 milli mho (b) g_{m_0} = 0·04 milli mho
   (c) g_{m_0} = 0·4 mho (d) g_{m_0} = 0·4 millimilli mho

3. The base to base resistance of an UJT is 6 k ohm when the emitter current is zero. If R_{B_1} = 3·6 k ohm, the intrinsic stand off ratio is :
   (a) n = 0·66 (b) n = 0·6
   (c) n = 6·0 (d) n = 3·6

4. A capacitor of 1 mF initially charged to 10 V is connected across an ideal inductor of 0·1 mH. The maximum current in the circuit is :
   (a) 0·5 A (b) 1 A
   (c) 31·62 A (d) 2 A

5. Silicon has a preference in IC technology because :
   (a) It is an indirect semiconductor
   (b) It is a covalent semiconductor
   (c) It is an elemental semiconductor
   (d) Of the availability of nature oxide SiO

6. Three equal resistances of magnitude 5 ohm each are connected in delta. The resistance between any two pair of terminals of the delta will be :
   (a) 5 ohm (b) 5/3 ohm
   (c) 10/3 ohm (d) 3/5 ohm

7. The R.M.S. value of a half wave rectified sinusoidal alternating current with peak value I_m is :
   (a) $I_m/1$ (b) $I_m/\sqrt{2}$
   (c) $I_m/2$ (d) $I_m\sqrt{3}$

8. For a series resonant circuit, at the half power points, which of the following is true ?
   (a) Current is half of the current at resonance
   (b) Resistance is equal to the resultant
   (c) The impedance is half the impedance at the resonance
   (d) None of the above

9. The loss less line of characteristic impedance 300 ohm is terminated in a pure resistance of 200 ohm. The value of the standing wave ratio is :
   (a) 1·5 (b) 0·67
   (c) 1·0 (d) 1·25

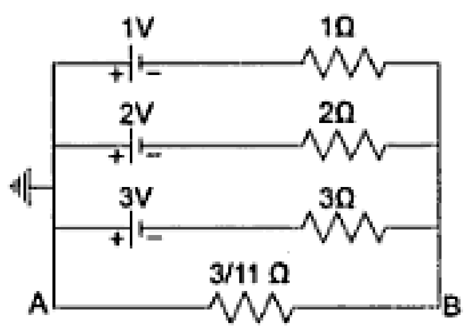
10. The transient current in lossless L–C circuit when excited from an AC source is .... sine wave.
    (a) Critically damped (b) Under damped
    (c) Over damped (d) Undamped

11. The values of L and C for a low pass filter with cut-off frequency of 2·5 kHz and operating with a terminated load resistance of 450 ohm are given by :
    (a) 57·3 μH; 0·283 μF (b) 28·66 μH; 0·14 μF
    (c) 114·64 μH; 0·566 μF (d) 50·23 μH; 0·632 μF

12. The driving point impedance with poles at ω = 0 (Zero) and ω = ∞ (infinity) must have the :
    (a) S term in the denominator and an excess term in the numerator
    (b) S term in the numerator and an excess term in the denominator
    (c) S term in the numerator and equal number of terms in the numerator and denominator
    (d) S term in the denominator and equal number of terms in the numerator and denominator

13. A transmission line is terminated at its characteristic impedance. The reflection coefficient is :
    (a) 1 (b) – 1
    (c) 0 (d) ∞

14. In the circuit shown below, the current through the 3/11 Ω resistance between terminals A and B is :



    (a) 4 amp (b) 1 amp
    (c) 2 amp (d) 5 amp

15. In a series RLC circuit operating below the resonant frequency, the current :
    (a) I leads V_S (b) I lags V_S
    (c) I is in phase with V_S (d) None of these

16. An antenna has maximum radiation intensity U_{max} = 10 watt/Sr and average radiation intensity U_{ave} = 4·5 watt/Sr.

If the efficiency of the antenna is given as η_r = 95%, the input power of the antenna is :

(a) 2·222 watt (b) 12·11 watt

(c) 55·55 watt (d) 59·52 watt

17. In an airport, a receiving antenna has a maximum dimension of 3 metre and operates at 100 MHz. An aircraft approaching the airport is 1/2 km away from the antenna. The aircraft is in the .... region of the antenna.

(a) far-field (b) near-field

(c) close-field (d) out-of-reach

18. A lossless transmission line with characteristic impedance 500 ohm is excited by a signal of voltage 10 $\angle 0°$ volts at 1·2 MHz. If the line is terminated by Z_L at a distance 1 km, the input impedances of the line for $Z_L = \infty$ (infinity) and $Z_L = 0$ (zero) in ohm, respectively are :

(a) $+j\infty, 0$ (b) $-j\infty, 0$

(c) $0, -j\infty$ (d) $0, +j\infty$

19. If the electric field of a plane wave is represented by $E = 10\hat{y}\cos(10^9 t + 30z)$ volt/m, assuming ε is the dielectric constant, the corresponding magnetic field H is :

(a) $-\hat{y}\,\varepsilon\,10^9/3\cos(10^9 t + 30z)$ amp/m

(b) $-\hat{x}\,\varepsilon\,10^9/3\cos(10^9 t + 30z)$ amp/m

(c) $-\hat{z}\,\varepsilon\,10^9/3\cos(10^9 t + 30z)$ amp/m

(d) $+\hat{x}\,\varepsilon\,10^9/3\cos(10^9 t + 30z)$ amp/m

20. A 50 Ohm lossless line connects a signal of 200 kHz to a load of 200 Ohm. If the load power is 100 mW, the value for voltage minimum V_{min} is :

(a) $(\sqrt{20})/4$ (b) $(\sqrt{10})/4$

(c) $(\sqrt{20})/2$ (d) $(\sqrt{10})/2$

21. Choose the correct statement :

(a) Digital multimeters are built using current measuring elements, while analog multimeters are built using voltage measuring units

(b) Digital multimeters are built using voltage measuring units, while analog multimeters are built using current measuring units

(c) Both digital and analog multimeters are built using voltage measuring units

(d) Both digital and analog multimeters are built using current measuring units

22. An analog voltmeter has a sensitivity of 10 kΩ/volt. The galvanometer used in constructing the instrument will produce a full scale deflection when the current passed through it is :

(a) 10 mA (b) 20 mA

(c) 50 mA (d) 100 μA

23. The input versus output characteristics of a digital-to-analog converter is given in the table above :

Input (bit string)	Output (in volts)
000	0·0
010	2·1
100	4·0
110	5·9

The converter is exhibiting :

(a) Offset error (b) Statistical error

(c) Linearity error (d) Hysteresis error

24. An optical fiber cable laid underground has developed a discontinuity at a distance d from the source end. The fault can be located using the instrument :

(a) Optical Spectrum Analyzer (OSA)

(b) Optical Time Domain Reflectometer (OTDR)

(c) Optical Power Meter (OPM)

(d) Laser Diffractometer (LD)

25. Two sinusoidal signals of the same frequency are displayed on a dual-trace oscilloscope. One complete cycle of each signal covers 6 cm of the horizontal scale and the starting point of the two signals are separated by 0·5 cm. The phase difference between the two signals in degrees is :

(a) 30 (b) 45

(c) 60 (d) 90

26. Transient signals can be observed using :

(a) Storage oscilloscope (b) Sampling oscilloscope

(c) Wave analyzer (d) Spectrum Analyzer

27. The trace on an oscilloscope continually moves to the right of the screen when :

(a) The sweep is triggered

(b) The sweep period is larger than the signal period

(c) The sweep period is smaller than the signal period

(d) There is no sweep

28. In a dual trace oscilloscope, the display appears segmented when :

(a) Low frequency signals are observed in alternate mode

(b) Low frequency signals are observed in Chop mode

(c) High frequency signals are observed in alternate mode

(d) High frequency signals are observed in Chop mode

29. To distinguish between signals having very close values, we need an instrument with :

(a) High accuracy (b) High resolution

(c) High sensitivity (d) High linearity

30. Match List-1 with List-2 and select the correct answer choice :

List 1 (Instruments)	List 2 (Measurement in which the instrument is used)
(A) Lock-in amplifier	1. Patient monitoring
(B) Sampling oscilloscope	2. Overcoming ground loop problem
(C) Isolation amplifier	3. Phase difference between two signals
(D) Strip-chart recorder	4. Signal recovery from noise
	5. Observing very high frequency signals

	(A)	(B)	(C)	(D)
(a)	1	3	5	3
(b)	2	1	3	4
(c)	4	5	2	1
(d)	3	4	1	2

31. A power diode has lightly doped n type substrate sandwiched between heavily doped p and n regions :
(a) To increase reverse breakdown voltage
(b) To reduce ohmic loss under forward bias
(c) To decrease switching time of the power diode
(d) To improve transient behaviour of the diode

32. An ideal thyristor is driving an R-L load of impedance Z. Input AC voltage is $V_S = V_m \sin \omega_m t$. If thyristor is fired at an input phase angle of 90°, what will be the output voltage and output current across R-L load at the instant of firing ?
(a) Output voltage is V_m and output current is V_m/Z
(b) Output voltage and output current are both zero
(c) Output voltage is zero and output current is delayed by an angle 90°
(d) Output voltage is V_m and output current is zero

33. In a regenerative braking, which of the following is generally true ?
(a) Back e.m.f. in the motor exceeds the applied voltage
(b) Back e.m.f. is less than the applied voltage
(c) Kinetic energy of the motor is dissipated in a resistance
(d) Kinetic energy of the motor is dissipated through free wheeling diode across the motor

34. A step-down chopper, fed from a 120 volt DC source, operates a DC motor, whose armature e.m.f. and armature resistance are 100 volt and 0·5 Ω respectively. With the magnitude control ratio 0·6, the quadrant of operation of DC motor is :
(a) First (b) Second
(c) Third (d) Fourth

35. For IGBT, which of the following statement is true ?
(a) Switching speed of IGBT is more than bipolar transistor
(b) IGBT is a current-controlled device
(c) ON-state collector-emitter voltage is less than that of bipolar junction transistor
(d) It combines voltage control features of MOSFET gate and high power capability of bipolar transistor

36. The semiconductor used for LEDs emitting in the visible range is :
(a) GaAs (b) GaAlAs
(c) GaInAs (d) GaAsP

37. The polar bonds, existing in III-V compound semiconductors, may be considered as equivalent to :
(a) 1 ionic bond and 3 covalent bonds
(b) 1 ionic bond and 4 covalent bonds
(c) 2 ionic bonds and 2 covalent bonds
(d) 2 ionic bonds and 4 covalent bonds

38. Which of the following pairs of crystal structures possesses the same atomic packing density ?
(a) Simple cubic and body centred cubic
(b) Body centred cubic and face centred cubic
(c) Face centred cubic and hexagonal close-packed
(d) Body centred cubic and hexagonal close-packed

39. The colour bands on a carbon composition resistor occur in the sequence—yellow, violet, yellow and silver. Its resistance is :
(a) 470 kΩ ± 47 kΩ (b) 470 kΩ ± 23·5%
(c) 47 kΩ ± 10% (d) 47 kΩ ± 5%

40. The real and imaginary dielectric constants ϵ_r^{I} and ϵ_r^{II} of 3 insulators at 1 kHz and 50°C are listed below

Material	ϵ_r^{I}	ϵ_r^{II}
Polycarbonate	2·47	0·003
PET	2·58	0·003
PEEK	2·24	0·003

At a given voltage, the lowest power dissipation per unit capacitance at 1 kHz can be obtained from :
(a) Polycarbonate
(b) PET
(c) PEEK
(d) Insufficient information to answer

41. A battery of 40 V and three capacitors of 1000 μF, 500 μF and 100 μF are all connected in (I) parallel and (II) series. The ratio of total charge stored in case I to that in case II is approximately :
(a) 3 : 64 (b) 64 : 3
(c) 13 : 160 (d) 160 : 13

42. The magnetic flux φ (in weber) linked with a coil at an instant of time t (in second) is given by $\phi(t) = 2t^2 - 20t + 40$. The induced e.m.f. in the coil at the instant t = 2 second is :
(a) 22 V (b) 20 V
(c) 12 V (d) 10 V

43. The speed of an audio cassette tape in a cassette player is 5 cm/sec. If the maximum frequency that needs to be recorded is 20 kHz, the minimum spatial wavelength on the tape is :

(a) 40 μm (b) 25 μm
(c) 4 μm (d) 2·5 μm

44. In a power transformer, the fundamental frequency of the hum arising due to magnetostriction is :

(a) Equal to the line frequency
(b) Double the line frequency
(c) 4 times the line frequency
(d) Not related to the line frequency

45. At a particular temperature and current density, the critical magnetic field for a Type I superconductor is B_C, and that for a Type II superconductor ranges from B_{C1} to B_{C2}. Keeping other parameters unaltered, both superconductors are now subjected to a magnetic field B that satisfies the conditions $B > B_C$ and $B_{C1} < B < B_{C2}$. Which of the following statements is then true ?

(a) Both Type I and Type II superconductors will switch to their normal conducting states
(b) Both Type I and Type II superconductors will maintain their superconducting states
(c) Type I superconductor will remain in superconducting state, while Type II superconductor will maintain a vortex state
(d) Type I superconductor will switch to the normal conducting state, while Type II superconductor will maintain a vortex state

46. Two free charges q and 4q are placed at a distance d apart. A third charge Q is placed between them at a distance x from charge q such that the system is in equilibrium. Then :

(a) $Q = \frac{4q}{9}, x = \frac{d}{3}$ (b) $Q = \frac{-4q}{9}, x = \frac{d}{4}$
(c) $Q = \frac{-4q}{9}, x = \frac{d}{3}$ (d) $Q = \frac{-4q}{9}, x = \frac{d}{4}$

47. In order to generate electron-hole pairs, the maximum wavelength of radiation for Silicon (Band gap = 1·1 eV) is :

(a) 1·88 μm (b) 1·68 μm
(c) 1·13 μm (d) 1·54 μm

48. Resistivity of a p-type specimen is 0·12 Ω-m, hole mobility is 0·048 $m^2V^{-1}s^{-1}$ (electron charge = 1.6×10^{-19} coulomb), and intrinsic concentration is 5.9×10^{10} cm^{-3}. Then, the electron concentration in the specimen is :

(a) 2.0×10^{11} cm^{-3} (b) 3.2×10^{5} cm^{-3}
(c) 2.0×10^{12} cm^{-3} (d) 2.0×10^{14} cm^{-3}

49. What is the change of barrier height of a p-n junction at 300 K when doping in n-side is increased by a factor of 1000 and doping in p-side remains unchanged ?

$$\left[300°K \left(\frac{kT}{q} = 0.026 \text{ V}\right)\right]$$

(a) 0·18 V (b) 1·8 V
(c) 0·018 V (d) 0·14 V

50. A BJT has α = 0·99, $I_B = I_B$ = 25 μA, and I_{CBO} = 200 nA. The collector current is :

(a) I_C = 2·5 mA (b) I_C = 1·5 mA
(c) I_C = 3·5 mA (d) I_C = 4·5 mA

Section B

Directions : Select the most appropriate answer from the four choices given below each of the questions 51 to 100.

51. Excitation table of a flip-flop is given below :

Q_n	Q_{n+1}	A	B
0	0	0	X
0	1	1	X
1	0	X	0
1	1	X	1

Characteristic equation of the flip-flop will be :

(a) $Q_{n+1} = A\overline{Q}_n + BQ_n$ (b) $Q_{n+1} = \overline{A}Q_n + BQ_n$
(c) $Q_{n+1} = A\overline{Q}_n + \overline{B}Q_n$ (d) $Q_{n+1} = \overline{A}Q_n + B\overline{Q}_n$

52. In a weighted-resistor digital-to-analog converter with 8-bit input, if the resistance corresponding to the MSB is 2k, what will be the resistance corresponding to the LSB ?

(a) 250 Ω (b) 512 kΩ
(c) 256 kΩ (d) 25·5 Ω

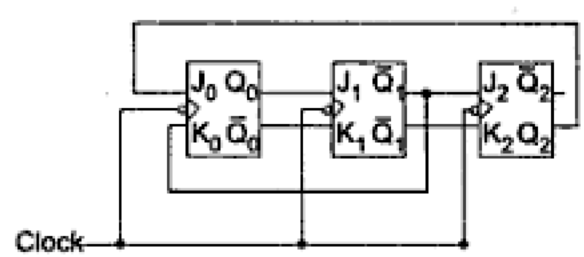
53. The angle (θ_k) of the asympototes of the root loci, where k = 0, 1, 2............n; n = (no. of poles N) – (no. of zeros Z), is given by :

(a) πk/n (b) (k + 1) 2π/n
(c) 2πk/n (d) (2k + 1) π/n

54. For a 2nd order feedback control system, the peak resonance magnitude should be $M_P \le 1.15$. Hence the damping ratio (ξ) is :

(a) 0·1 (b) 0·5
(c) 0·707 (d) 1

55. Modulus of the following counter is :



(a) 3 (b) 5
(c) 6 (d) 8

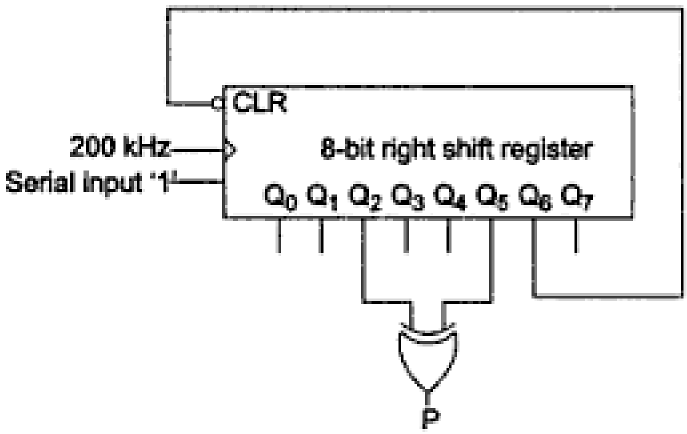
56. A ripple counter is to operate at a frequency of 10 MHz. If the propagation delay time of each flip-flop in the counter

is 10 ns and the strobing time is 50 ns, how many maximum stages can the counter have ?

(a) 10 (b) 5

(c) 2^{10} (d) 10^2

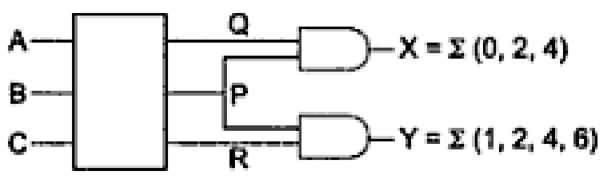
57. For the adjoining circuit, the waveform at P will be high during :



(a) (0–15) μs (b) (5–20) μs

(c) (10–25) μs (d) (15–30) μs

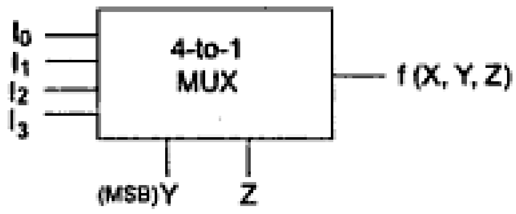
58. Given a combinational network with three inputs A, B and C, three intermediate outputs P, Q, and R, and two outputs $X = P \cdot Q = \Sigma (0, 2, 4)$ and $Y = P \cdot R = \Sigma (1, 2, 4, 6)$ as shown below, find the smallest function P (containing minimum number of minterms) that can produce the outputs X and Y :



(a) Σ (2, 4) (b) Σ (0, 1, 2, 4, 6)

(c) Σ (3, 5, 7) (d) Σ (1, 2, 6)

59. If a 4-to-1 MUX (shown below) realizes a three-variable function $f(X, Y, Z) = XY + X\overline{Z}$, then which of the following is correct ?



(a) $I_0 = X, I_1 = 0, I_2 = 1, I_3 = X$

(b) $I_0 = 0, I_1 = 1, I_2 = Y, I_3 = X$

(c) $I_0 = X, I_1 = 1, I_2 = 0, I_3 = X$

(d) $I_0 = X, I_1 = 0, I_2 = 1, I_3 = Z$

60. The characteristic equation for a closed loop system with forward gain K is $s^4 + 4s^3 + 8s^2 + 6s + K = 0$; the critical gain value K_c for stability should not exceed :

(a) 3·25 (b) 9·75

(c) 13·0 (d) 23·3

61. Two systems are defined by their state variable equations in time domain dx (t)/dt = Ax (t) + Bu (t) as follows. If the gain equations in this are as given below, which of the following choices is correct ?

$$A = \begin{bmatrix} -2 & 1 \\ 0 & -1 \end{bmatrix};\ B = \begin{bmatrix} 1 \\ 0 \end{bmatrix} \text{ .... Equation (1)}$$

$$A = \begin{bmatrix} 0 & 1 \\ -1 & 0 \end{bmatrix};\ B = \begin{bmatrix} 0 \\ 1 \end{bmatrix} \text{ .... Equation (2)}$$

(a) Both equations are uncontrollable

(b) Both equations are controllable

(c) Only equation (1) is controllable

(d) Only equation (2) is controllable

62. The loop transfer of a system is G(s) H(s) = 5/(s + 1) (2s + 1) (3s + 1) which has the phase crossover frequency f_c = 0·16 Hz. The gain margin (dB) of the system is :

(a) 6 (b) 4

(c) 2 (d) 0

63. For a 2nd order servo system, the damping ratio ξ = 0·5456 and undamped natural frequency is ω_n = 31·6 rad/sec. The per cent overshoot is :

(a) 7·07 (b) 10·2

(c) 14·10 (d) 21·21

64. For a system with derivative feedback, forward path transfer is G (s) = $1/(s^2 + s + 1)$ and feedback path transfer is H (s) = Ks. What is the value of K to obtain a critically-damped closed loop transient response :

(a) 0·5 (b) 0·707

(c) 1 (d) 1·414

65. A P-controller is used to adjust the outer level of a tank in a range of (0-10) m. The desired level is 5 m; the controller should fully close the valve, if level rises to 5·5 m, and it should fully open the valve, if level falls to 4·5 m. What should be the % P-band ?

(a) 1 (b) 5

(c) 7 (d) 10

66. In a radio transmitter, the frequency of the crystal oscillator will be stable for a long time if the quality factor of the crystal resonator is :

(a) > 100 (b) > 500

(c) > 1000 (d) > 20000

67. In an IF amplifier, the IF transformer is provided with tapping to :

(a) Increase the voltage gain

(b) Increase the bandwidth of the resonance circuit

(c) Increase the impedance offered by the resonance circuit to the following cascaded amplifier

(d) Increase the quality factor of the resonance circuit

68. Consider the waveform V (t) = (1 + μ cos ω_m t). Show that, if the demodulated wave is to follow the envelope of V (t), it is required that at any time t_0 :

(a) RC ≤ ω_m (μ sin $\omega_m t_0$) / (1 + μ cos $\omega_m t_0$)

(b) (1/RC) ≥ ω_m (μ sin $\omega_m t_0$) / (1 + μ cos $\omega_m t_0$)

(c) RC ≤ 1 / (μ ω_m)

(d) RC is very large

69. QPSK system is superior to BPSK system because :
(a) Its bandwidth is higher than that of BPSK system
(b) Interchannel interference in QPSK system is less than that in BPSK system
(c) Bandwidth of QPSK system is half of the bandwidth of BPSK system
(d) In QPSK system inter-symbol interference is improved

70. A radio receiver is placed at one corner of a table and again placed at some other corner of the same table. Loudspeaker output is changed because :
(a) Image interference is reduced
(b) Adjacent channel interference is increased
(c) Of fading
(d) Line of sight propagation is not utilized

71. In time-division multiple access system, a traffic system on the receiver side must receive the traffic burst addressed to it. For this :
(a) Transmitting frame acquisition is required
(b) Proper synchronization of the timing of transmit frame is required
(c) Frame efficiency should be higher
(d) Synchronization is necessary to overcome the perturbations of the satellite

72. Earth coverage dish antenna is used in satellite system. It is characterized by the fact that :
(a) It is a narrow beam antenna
(b) It is a parabolic antenna
(c) It is sharply focused within a small area of the surface of the earth
(d) It is a wide angle antenna which covers a large area of the surface of the earth

73. In a Klystron amplifier, the RF voltage produces :
(a) Amplitude modulation (b) Frequency modulation
(c) Phase modulation (d) Velocity modulation

74. For the proper operation of MASER at a frequency of 10 GHz, the material used is :
(a) Al_2O_3 with slight doping of chromium
(b) TiO_2 with slight doping of iron
(c) TiO_2 with slight doping of chromium
(d) Al_2O_3 with slight doping of iron

75. A rectangular wave-guide is 4·2 cm by 1·85 cm. The cut-off frequency of the dominant mode through this wave-guide is :
(a) 3·57 GHz (b) 3·75 GHz
(c) 3·70 MHz (d) 3·57 MHz

76. For an antenna to be frequency-independent, it should expand or contract in proportion to the :
(a) Gain (b) Directivity
(c) Wavelength (d) Impedance

77. Suppose that data items, numbered 1, 2, 3, 4, 5 and 6 come in the input stream in this order. By using a queue, which of the following rearrangement can be obtained in the output order ?
(a) 1 2 6 4 5 3 (b) 2 4 3 6 5 1
(c) 4 2 1 3 5 6 (d) 1 2 3 4 5 6

78. We are told that the integers between 1 and 1000 are arranged in a binary search tree with '<' as the ordering relation. Below are four lists of vertices encountered as we search for the number 363. Which list cannot be produced by this search through a binary search tree ?
(a) 924, 220, 911, 244, 898, 248, 363
(b) 2, 252, 401, 398, 330, 344, 397, 363
(c) 925, 202, 911, 240, 912, 245, 363
(d) 2, 399, 387, 219, 266, 382, 381, 278, 363

79. The number of 1's in the binary representation of $13*16^3 + 11*16 + 2$ is :
(a) 8 (b) 7
(c) 9 (d) 12

80. A disk has 500 bytes/sector, 100 sectors/track, 20 heads and 1000 cylinders. Total capacity of the disk is :
(a) 1 GB (b) 100 MB
(c) 10 MB (d) 10 GB

81. Suppose that the same clock signal is used to increment the microprogram counter and to load the control register. Which of the following assertion(s) is(are) true ?
I. Microinstruction execution time is at least two clock periods.
II. Microinstruction execution time can be overlapped with fetching the next microinstruction.
III. Unconditional branch microinstructions must necessarily take longer than other types.
(a) I only (b) II only
(c) I and III (d) II and III

82. Some system architects do not find Rich instruction repertoire to be cost-effective because it :
(a) Results in large increase in program size
(b) Results in complex structure of microcode
(c) Has been observed that an average compiler does not employ more than a limited subset of available instructions
(d) Results in complex decoding of op code filed resulting in longer execution time

83. A stack machine pushes operands on a stack and evaluates binary operators by a pcs (*i.e.,* pop/compute/store) where the top two operands are popped, computation is performed and the result is pushed onto stack. Evaluation of an expression (x*y) + (u*v) by Reverse Polish notation in a stack machine needs :
(a) 4 push and 3 pcs instructions
(b) 6 push and 1 pcs instructions
(c) 4 push and 1 pcs instructions
(d) 5 push and 2 pcs instructions

84. A dot matrix printer takes 3 μ sec. to print a character, and 1 μ sec for a space between two consecutive

characters. If it prints 100 characters per line, its printing speed specifications in characters per second (cps) and time to print a line of characters are respectively :

(a) 100 cps and 400 μ sec

(b) 2500 cps and 0·04 μ sec

(c) 250 cps and 40 μ sec

(d) 250 cps and 0·4 μ sec

85. Consider the following program segment with 8085 microprocessor :

```
LXI H    3600 H
MOV      A, M
HLT
```

The MOV instruction involves :

(a) Indirect addressing (b) Immediate addressing

(c) Implicit addressing (d) Direct addressing

86. To establish a communication between 8085 microprocessor and 8255 Programmable Peripheral Interface chip, the status of the chip select input would be :

(a) TRISTATE (b) HIGH

(c) LOW (d) DON'T CARE

87. Which flag does not change by the execution of the instruction DCR B in 8085 microprocessor ?

(a) Parity (b) Carry

(c) Zero (d) Sign

88. Let the content of the memory location 3501H be 72H. Now consider the following program with 8085 microprocessor :

```
LDA    3501H
CMA
STA    3502H
HLT
```

The content of the memory location 3502H after execution of the program will be :

(a) 27H (b) D8H

(c) 8DH (d) 72H

89. Given the program segment below, how many times will the instruction LP : JNZ REP be executed ?

```
        MVI H, 02H
        MVI L, 05H
REP :   DCR L
LP :    JNZ REP
        DCR H
        JNZ REP
        ............
```

(a) 10 (b) 260

(c) 510 (d) 7

90. What addressing mode is used in the instruction RET ?

(a) Direct (b) Immediate

(c) Implicit (d) Register-indirect

91. A one-byte instruction is executed in the 8085 microprocessor by the following steps :

((SP) – 1) ← (PCH)

((SP) – 2) ← (PCL)

(SP) ← ((SP) – 2)

(PC) ← 0008H

The corresponding instruction is :

(a) JMP 0008H (b) PUSH PSW

(c) CALL 0008H (d) RST 1

92. The zero flag of 8085 microprocessor is to be set, keeping the content of the accumulator unchanged. Which instruction is to be used ?

(a) MOV A, A (b) ANI 00H

(c) XRA A (d) CMP A

93. In class-A power amplifier, the collector dissipation is maximum when :

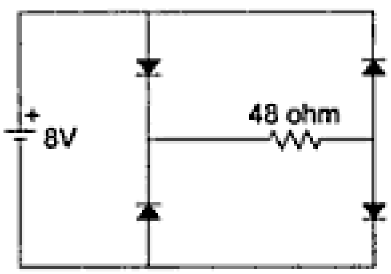
(a) No signal is present

(b) Signal swing is maximum

(c) Signal swing is (1/1·414) of its maximum

(d) None of the above

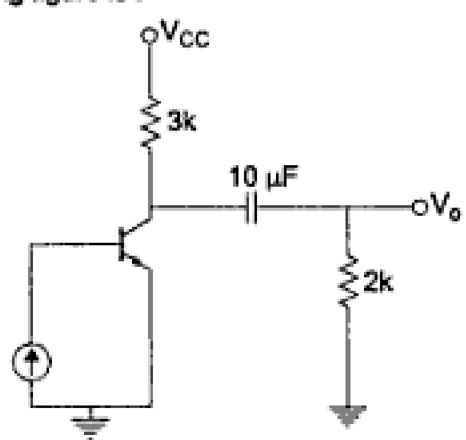
94. If cut-in voltage and forward resistance of each diode (in the adjoining figure) are 0·7 V and 1 ohm respectively, the current through the 48 ohm resistor is :



(a) 132 mA (b) 160 mA

(c) 0 mA (d) (1/6) A

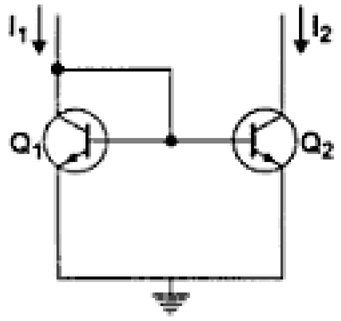
95. The lower cut-off frequency of the transistor stage in the adjoining figure is :



(a) 7·95 Hz (b) 13·25 Hz

(c) 5·30 Hz (d) 3·18 Hz

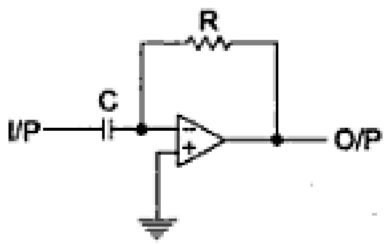
96. In the adjoining current mirror circuit, if Q_1 and Q_2 are identical and base currents are not neglected, then which of the following is true ?



(a) $I_2 = I_1$ (b) $I_2 = \beta I_1$

(c) $I_2 = \{\beta / (\beta + 2)\} I_1$ (d) $I_2 = \{(\beta + 2) / \beta\} I_1$

97. If rectangular input is applied to the adjoining curcuit, it produces :



(a) Square output (b) Spike output

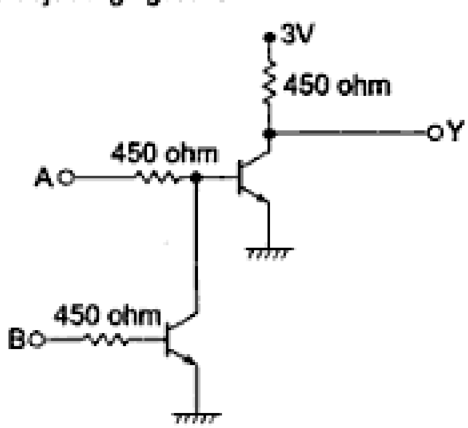
(c) Sinusoidal output (d) None of these

98. In an oscillator, if amplifier gain (A) without feedback is $(1 + R_F / R_1)$ and gain (β) of the feedback network is $1 / \{3 + j(\omega RC - 1 / \omega RC)\}$ then which of the following is true ?

(a) $R_F \leq 2R_1$ (b) $R_F \geq R_1$

(c) $|\beta| = 3$ (d) $|\beta| = 1/3$

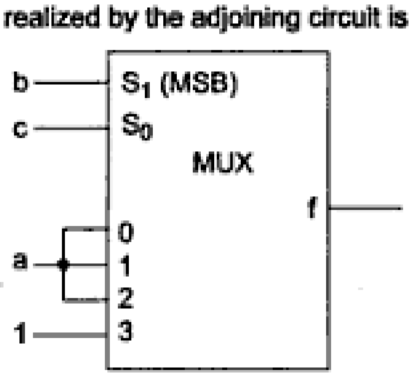
99. Logic expression for Y in terms of logical variables A and B in the adjoining figure is :



(a) $\overline{A} + B$ (b) $A + \overline{B}$

(c) $A + B$ (d) $\overline{A} + \overline{B}$

100. The logic realized by the adjoining circuit is :



(a) f (a, b, c) = a + bc (b) f (a, b, c) = ab + c

(c) f (a, b, c) = ac + b (d) f (a, b, c) = a (b + c)

Section C

Directions : Select the most appropriate answer from the four choices given below each of the questions 101 to 120.

101. Choose the word that is most nearly similar or opposite in meaning to the word SKITTISH :

(a) Frisky (b) Inquiring

(c) Tractable (d) Vain

102. Choose the lettered pair of words whose relationship is most like the relationship OFFHAND : PREMEDITATION :

(a) Upright : integrity (b) Aboveboard : guile

(c) Underline : foundation (d) Cutthroat : competition

103. Out of the following Indian Test Cricketers who was not awarded the Wisden Cricketer of the Year :

(a) Polly R. Umrigar (b) M. Amarnath

(c) V. V. S. Laxman (d) B. S. Chandrasekhar

104. A style of painting which produces effects by use of colour rather than details of form is termed as :

(a) Dadaism (b) Impressionism

(c) Cubism (d) Absurdism

105. If a person publishes his/her writings using the name of somebody else as the author, he/she is said to have used a :

(a) Pseudonym (b) Pen name

(c) Acronym (d) Naum-De-Plume

106. The prime target for exploration of extra-terrestrial life is in the :

(a) Moon-the satellite of Earth

(b) Titan-a satellite of Saturn

(c) Desdemona-a satellite of Uranus

(d) None of these

107. Tribology is the scientific study of :

(a) Alloys having three alloying elements

(b) Tribes

(c) Frictional properties between metallic surfaces moving in relation to each other

(d) Human habitation

108. The highest layer of atmosphere from the Earth is :

(a) Mesosphere (b) Stratosphere

(c) Troposphere (d) Ionosphere

109. The permanent Secretariat of SAARC is located in :

(a) New Delhi (b) Kathmandu

(c) Lahore (d) Colombo

110. The Indian state which touches the boundaries of maximum number of other Indian states is :

(a) U. P. (b) Jharkhand

(c) M. P. (d) Orissa

111. Who said of all the art forms, cinema is the most important ?
(a) A. Hitch cock (b) J. F. Kennedy
(c) A. Hitler (d) V. I. Lenin

112. In NTP' 99, TRAI stands for :
(a) Transatlantic Railways Authority Incorporated
(b) Telecommunications regulatory authority of India
(c) Telephone Relay access integration
(d) Tourism and Resort Association of India

113. The busiest airport in India is in :
(a) Bangalore (b) Mumbai
(c) Chennai (d) Delhi

114. Photocopying machines are now known as Xerox machines because they were popularized by :
(a) Their founder T. Xerox (b) A Company named
(c) The method Xerox (d) Xerox brothers

115. In an adult, the heart weighs about :
(a) 100 gm (b) 1 kg
(c) 300 gm (d) 5 kg

116. Which telephone number will always be engaged when you dial it ?
(a) Airline booking (b) Fault booking
(c) Railway information (d) Your own number

117. 'Bills' critics in the Technology world .... that many of observations he has made during more than five years of his research in mexico have been reported as .... in popular magazines rather than as carefully documented research articles in technical journals.
(a) Charge .... anecdotes
(b) Apologize .... fabrications
(c) Intimate .... hypotheses
(d) Appioud .... rumours

118. "When those who he had injured accused him of being a ...., he retorted, curtly that he had never seen a quack".
(a) Likertine (b) Charlatan
(c) Reprobate (d) Sycophant

119. "Professor Ray knows a great deal in terms of the condition of the situation" :
(a) The above sentence is correct
(b) Professor Ray knows a great deal about the situation
(c) Professor Ray knows a great deal on the condition of the situation
(d) Professor Ray knows a lot about the condition of the situation

120. Choose the word that is most nearly opposite in meaning to the word PROLIX :
(a) Stupid (b) Indifferent
(c) Livid (d) Pithy

ANSWERS WITH HINTS

Section A

1. (b) Given, $V = 220\text{ V}$

$P = 60\text{ W}$

$I_{max} = 9\text{ A}$

Let the n bulbs are connected in parallel.

Let the current offered by one bulb

From, $P = VI$

$$I = \frac{P}{V} = \frac{60\text{ W}}{220\text{ V}}$$

$$= 0.2727\text{ A}$$

$\therefore$ $I \times n = 9$

or $$n = \frac{9}{I} = \frac{9}{0.2727}$$

$$= 33.0033 \approx 33$$

2. (a) Given, $I_{DSS} = 1\text{ mA}$

$V_P = -5V$

$g_{m_o} = ?$

We know that $g_m = g_{m_o}\left(1 - \frac{V_{GS}}{V_P}\right)$

Where, g_{m_o} = Maximum transconductance and it is given by $g_{m_o} = \frac{-2 I_{DSS}}{V_P} = \frac{-2 \times 1 \times 10^{-3}}{-5}$

$= 0.4$ milli mho

3. (b) Intrinsic stand-off ratio

$$n = \frac{R_{B_1}}{R_{BB'}} = \frac{3.6\text{ k}\Omega}{6\text{ k}\Omega} = 0.6$$

4. (c) Energy in capacitor is given by

$$= \frac{1}{2}CV^2 \quad ...(i)$$

where, C = Capacitance, V = Voltage

and energy and inductor in given by

$$= \frac{1}{2}LI^2 \quad ...(ii)$$

where, L = Inductance, I = Current

From equation (i) and (ii)

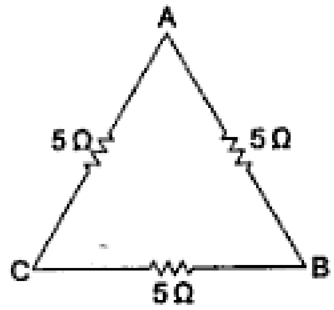
$$\frac{1}{2}CV^2 = \frac{1}{2}LI^2$$

or $$I = \sqrt{\frac{CV^2}{L}} = \sqrt{\frac{1 \times 10^{-3} \times 100}{0.1 \times 10^{-3}}}$$

$$= \sqrt{1000} = 31.62\text{ A}$$

5. (d) Silicon has a preference in IC technology because of the availability of nature oxide SiO.

6. (c) Given



$$R_{AB} = R_{BC} = R_{CA}$$
$$= 5 \,//\, (5+5) = \frac{5 \times 10}{5 + 10}$$
$$= \frac{10}{3}\ \Omega$$

7. (c) $I_{rms} = \frac{I_m}{2}$ (For H.W.R. where I_m is the peak value of alternating current)

8. (d) None of the above are true.

9. (b) Given, $Z_L = 200\ \Omega$ & $Z_0 = 300\ \Omega$

S.W.R. (standing wave ratio)

$$= \frac{1+\Gamma}{1-\Gamma}$$

where, Γ = Reflection coefficient and given as

$$\Gamma = \frac{Z_0 + Z_L}{Z_0 + Z_L} = \frac{300 - 200}{300 + 200}$$
$$= \frac{1}{5} = 0{\cdot}2$$

Now, $\text{S.W.R.} = \frac{1 + 0{\cdot}2}{1 - 0{\cdot}2} = \frac{1{\cdot}2}{0{\cdot}8}$
$$= \frac{2}{3} = 0{\cdot}67$$

10. (d) The transient current in lossless L-C circuit when excited from an AC source is undamped sine wave, since the L-C circuit is lossless.

11. (b) Given, $f_H = 2{\cdot}5$ kHz, $R = 450\ \Omega$, C = ? and L = ?

We know that cut-off frequency in the case of Low Pass Filter (LPF) is given by

$$f_H = \frac{1}{2\pi RC} = 2{\cdot}5 \times 10^3 \text{ Hz}$$

or
$$C = \frac{1}{2 \times 3{\cdot}14 \times 450 \times 2{\cdot}5 \times 10^3}$$
$$= 0{\cdot}141\ \mu F$$

and from relation

$$f = \frac{1}{2\pi\sqrt{LC}}$$
$$2{\cdot}5 \times 10^3 = \frac{1}{2\pi\sqrt{L \times 0{\cdot}141 \times 10^{-6}}}$$

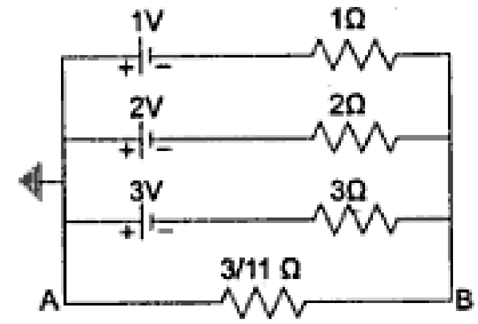
or $L = 28{\cdot}66$ mH

12. (a) Due to pole at $\omega = 0$, there will be s term in the denominator and due to pole at $\omega = \infty$, there will be an excess term in the numerator. Hence alternative (a) is the correct choice.

13. (c) Given, $Z_L = Z_0$, where Z_0 is the characteristic impedance. The reflection coefficient, Γ is given by

$$\Gamma = \frac{Z_L - Z_0}{Z_L + Z_0} = \frac{Z_0 - Z_0}{Z_0 + Z_0} = 0$$

14. (c) The given circuit



Using Milliman theorem

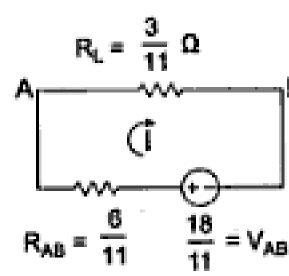
$$V_{AB} = \frac{\frac{V_1}{R_1} + \frac{V_2}{R_2} + \frac{V_3}{R_3}}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}}$$

$$V_{AB} = \frac{\frac{1}{1} + \frac{2}{2} + \frac{3}{3}}{\frac{1}{1} + \frac{1}{2} + \frac{1}{3}} = \frac{18}{11}$$

$$\frac{1}{R_{AB}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

$$\frac{1}{R_{AB}} = \frac{1}{1} + \frac{1}{2} + \frac{1}{3}$$

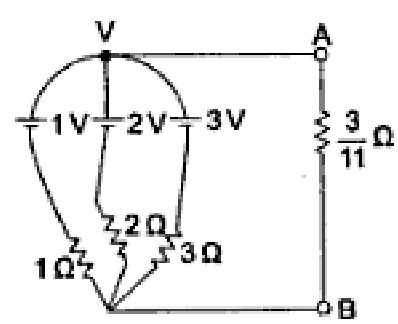
$$R_{AB} = \frac{6}{11}$$



$$I = \frac{V_{AB}}{R_{AB} + R_L} = \frac{18/11}{\frac{6}{11} + \frac{3}{11}}$$
$$= 2 \text{ amp.}$$

Alternative Method :

Let the node voltage is V



Applying KCL at node

$$\frac{V-1}{1}+\frac{V-2}{2}+\frac{V-3}{3}+\frac{V-0}{3/11}=0$$

or $$V = \frac{6}{11}$$

and $$I = \frac{V}{R_L}=\frac{6}{11}\times\frac{11}{3}$$

$$= 2 \text{ amp.}$$

15. (a) In a series RLC circuit operating below the resonant frequency, the current I leads voltage V because when operating frequency is less than the resonant frequency the net reactance is capacitive and the current I leads voltage V, indicating the power factor to be leading. This continues as long as the operating frequency is less than the resonant frequency *i.e.* $f < f_r$. Where f_r is the resonant frequency.

16. (d) We know that radiated power is given by

$$P_r = 4\pi U_{av}$$

where, P_r = Radiated power

U_{av} = Average radiation intensity

and from relation

$$\eta = \frac{P_r}{P_i}$$

or $$P_i = \frac{P_r}{\eta}=\frac{4\pi U_{av}}{\eta}$$

$$= \frac{4\times 3{\cdot}14\times 4{\cdot}5}{0{\cdot}95} = 59{\cdot}52 \text{ watt.}$$

Hence alternative (d) is the correct choice.

17. (a) Given $D = 3$ m

$f = 100 \text{ MH}_2 = 100\times 10^6$ Hz

$d = \frac{1}{2}$ km = 500 m

Now, $$\frac{2D^2}{\lambda} = \frac{2D^2}{C/f}$$

$$= \frac{2\times 3^2}{\frac{3\times 10^8}{100\times 10^6}} = 6 \text{ m}$$

Given, $d = 500$ m

since $$d > \frac{2D^2}{\lambda}$$

Therefore, aircraft is in the far region of the antenna.

18. (b)

19. (d) Poynting vector,

$$\vec{P} = \vec{E}\times\vec{H}$$

Since given that wave is propagating in z-direction and electric field $\vec{E}$ is in + y direction. Here the magnetic field must be in + x direction. Hence alternative (d) is the correct choice.

20. (a) Given, $Z_0 = 50\ \Omega$

$Z_L = 200\ \Omega$

$P_L = 100$ mW

$V_{min} = ?$

we know that

$$P_L = \frac{V_{max}{}^2}{Z_L}$$

or $$V_{max} = \sqrt{P_L Z_L}$$

$$= \sqrt{100\times 10^{-3}\times 200} = \sqrt{20}$$

and Standing Wave Ratio (SWR)

$$= \frac{Z_L}{Z_0} = \frac{200}{50} = 4$$

Also Standing Wave Ratio (SWR)

$$\frac{V_{max}}{V_{min}} = \frac{\sqrt{20}}{V_{min}}$$

or $$V_{min} = \frac{\sqrt{20}}{4}$$

Hence alternative (a) is the correct choice.

21. (b) Digital multimeters are built using voltage measuring units, while analog multimeters are built using current measuring units.

22. (d) Current required for full scale deflection.

$$I_{fs} = \frac{1}{S_v}$$

where, S_v = sensitivity of voltmeter

$$= \frac{1}{10\times 10^3} = 100\ \mu A$$

23. (a)

24. (b) An optical fiber cable laid underground has developed a discontinuity at a distance d from the source end. The fault can be located using the instrument called Optical Time Domain Reflectometer (OTDR).

25. (a) Phase difference

$$= \frac{2\pi}{\lambda}\times \text{Path difference}$$

$$= \frac{2\pi}{6 \text{ cm}}\times 0{\cdot}5 \text{ cm}$$

$$= \frac{\pi}{6} = 30^\circ$$

26. (a) Transient signals can be observed using storage oscilloscope.

27. (c) The trace on an oscilloscope continually moves to the right of the screen when the sweep period is smaller than the signal period.

28. (d) In a dual trace oscilloscope, the display appears segmented when high frequency signals are observed in chop mode.

29. (b) To distinguish between signals having very close values, we need an instrument with high resolution.

30. (c) • Lock-in amplifier → Signal recovery from noise
• Sampling oscilloscope → Observing very high freqeuncy signals
• Isolation amplifier → Overcoming ground loop problem
• Strip chart recorder → Patient monitoring.

31. (d) A power diode has lightly doped n-type substrate sandwiched between heavily doped p and n regions to improve transient behaviour of the diode.

32. (d)

33. (a) In a regenerative braking, back e.m.f. in the motor exceeds the applied voltage.

34. (a)

35. (d) IGBT (Insulator Gate Bipolar Transistor) combines the voltage control features of MOSFET gate and high power capability of bipolar transistor.

36. (d) The semiconductor material used for LEDs emitting in the visible range is GaAsP.

37. (a) The polar bonds, existing in III-V compound semiconductors as equivalent to 1 ionic bond and 3 covalent bonds.

38. (c) Face Centred Cubic (FCC) and Hexagonal Closed Packed (HCP) pairs of crystal structures possesses the same atomic paking density.

39. (c)

40. (b) For lowest power dissipation, loss tangent should be lowest

Here loss tangent,

$$\tan\delta = \frac{\varepsilon_r''}{\varepsilon_r'} = \frac{0{\cdot}003}{2{\cdot}58} \quad \text{(will be lowest)}$$

Hence alternative (b) is the correct choice.

41. (d) Given, $V = 40$ volt

$$C_1 = 1000\ \mu F,\ C_2 = 500\ \mu F,\ C_3 = 100\ \mu F$$

When they are connected in parallel

$$C_{eq(p)} = C_1 + C_2 + C_3 = 1000 + 500 + 100 = 1600\ \mu F$$

when they are connected in series

$$\frac{1}{C_{eq(s)}} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$$

$$= \frac{1}{1000} + \frac{1}{500} + \frac{1}{100}$$

$$\text{or} \quad C_{eq(s)} = \frac{1000}{13}$$

Ratio of total charge stored

$$\frac{Q_P}{Q_S} = \frac{C_{eq(p)} \cdot V}{C_{eq(s)} V} = \frac{1600/40}{\frac{1000}{13} \times \frac{1}{40}} = \frac{16 \times 13}{10} = \frac{104}{5}$$

Hence alternative (d) is the correct choice.

42. (c) Induced e.m.f. is given by

$$E_{induced} = -\frac{N\,d\phi}{dt}$$

$$\text{or} \quad E_{induced} = -\frac{d\phi}{dt} \quad \text{(Assume N = 1)}$$

$$\text{or} \quad E_{induced} = \frac{-d}{dt}(2t^2 - 20t + 40)$$

$$= -4t + 20$$

$$\text{at} \quad t = 2 \text{ sec}$$

$$E_{induced} = -4 \times 2 + 20 = 12 \text{ V}$$

Hence alternative (c) is the correct choice.

43. (d) Given speed = 5 cm/sec = 5×10^{-2} m/sec,

$f_{max} = 20$ kHz

Minimum spatial wavelength of the tape

$$\lambda = \frac{\text{Speed}}{\text{Maximum frequency}}$$

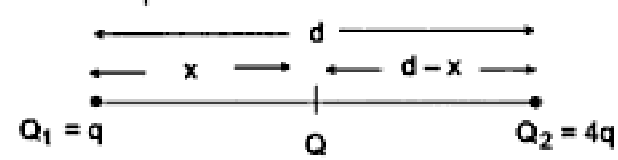
$$\text{or} \quad \lambda = \frac{5 \times 10^{-2}}{20 \times 10^3} = 2{\cdot}5 \times 10^{-6}$$

$$= 2{\cdot}5\ \mu m$$

44. (b) In a power transformer, the fundamental frequency of the hum arising due to magnetostriction is double the line frequency.

45. (d)

46. (a) Given the charges are $Q_1 = q$, $Q_2 = 4q$ are placed at a distance d apart



At equilibrium

$$\frac{1}{4\pi\varepsilon_0} \cdot \frac{Q_1 Q}{x^2} = \frac{1}{4\pi\varepsilon_0} \cdot \frac{Q_2 Q}{(d-x)^2}$$

$$\text{or} \quad \frac{1}{4\pi\varepsilon_0} \cdot \frac{9\,Q}{x^2} = \frac{1}{4\pi\varepsilon_0} \frac{4q\,Q}{(d-x)^2}$$

$$\text{or} \quad (d-x)^2 = 4x^2$$

$$\text{or} \quad d - x = \pm 2x$$

$$\text{or} \quad x = \frac{d}{3}$$

$$\text{or} \quad x = -\frac{d}{3}$$

Neglect the negative sign

$$x = \frac{d}{3}$$

$$\text{and} \quad Q = \frac{4q}{9}$$

Hence alternative (a) is the correct choice.

47. (c) Given $E_g = 1{\cdot}1$ eV

$$\lambda = ?$$

We know that,

$$E = h\nu = \frac{hc}{\lambda}$$

$$\text{or} \quad \lambda_{max} = \frac{hc}{E_g}$$

or $$\lambda_{max} = \frac{6 \cdot 6 \times 10^{-34} \times 3 \times 10^8}{1 \cdot 1 \times 1 \cdot 6 \times 10^{-19}}$$

$$= \frac{6 \cdot 6 \times 3 \times 10^{-7}}{1 \cdot 1 \times 1 \cdot 6} = \frac{18}{1 \cdot 6} \times 10^{-7}$$

or $$\lambda_{max} = 1 \cdot 125\ \mu m \approx 1 \cdot 13\ \mu m$$

Hence alternative (c) is the correct choice.

48. (b) Given, $\rho_p = 0 \cdot 12\ \Omega\text{-m}$

$$\mu_p = 0 \cdot 048\ m^2/V\text{-s}$$

$$\eta_i = 5 \cdot 9 \times 10^{10}/cm^3$$

We know that

$$\sigma_p = \frac{1}{\rho_p} = p\, q\, \mu_p$$

or $$p = \frac{1}{\sigma_p\, q\, \mu_p}$$

$$= \frac{1}{0 \cdot 12 \times 1 \cdot 6 \times 10^{-19} \times 0 \cdot 048}$$

or $$p = 1 \cdot 085 \times 10^{21}/m^3$$

or $$p = 1 \cdot 085 \times 10^{15}/cm^3$$

$\therefore$ $$p = N_A \text{ (In p-type semiconductor)}$$

Now, the concentration of minority charge carriers *i.e.* electrons in p-type semiconductor will be

$$n_p \approx \frac{n_i^2}{N_A} = \frac{(5 \cdot 9 \times 10^{10})^2}{1 \cdot 085 \times 10^{15}}$$

$$= 3 \cdot 2 \times 10^5/cm^3$$

or $$n_p = 3 \cdot 2 \times 10^5\ cm^{-3}$$

Hence alternative (b) is the correct choice.

49. (a) Change of barrier height

$$V_0 = \frac{kT}{q} \ln \frac{N_A N_D}{n_i^2}$$

Given that doping in n-side is increased by a factor of 1000 and doping in p-side remains unchanged it means

$$V_0 = \frac{kT}{q} \ln 1000 = 0 \cdot 026 \ln 1000$$

$$= 0 \cdot 026 \times 6 \cdot 908$$

or $$V_0 = 0 \cdot 1796 \approx 0 \cdot 18\ V$$

Hence alternative (a) is the correct choice.

50. (a) Given $\alpha = 0 \cdot 99$ then $\beta = \frac{\alpha}{1 - \alpha} = \frac{0 \cdot 99}{1 - 0 \cdot 99} = 99$

$$I_B = 25\ \mu A$$

$$I_{CBO} = 200\ nA$$

$$I_C = ?$$

from relation, $$I_C = \beta I_B + (1 + \beta) I_{CBO}$$

or $$I_C = 99 \times 25\ \mu A + (1 + 99)\ 200\ nA$$

or $$I_C = 2495\ \mu A \approx 2 \cdot 5\ mA$$

Section B

51. (c)

Q_n	Q_{n+1}	A	B
0	0	0	X
0	1	1	X
1	0	X	0
1	1	X	1

The given excitation table is of J-K Flip-Flop.

The characteristic table of J-K Flip Flop is shown below :

J	K	Q_n	Q_{n+1}
0	0	0	0
0	0	1	1
0	1	0	0
0	1	1	0
1	0	0	1
1	0	1	1
1	1	0	1
1	1	1	0

K-map for Q_{n+1} in terms of JK and Q_n

where (J = A and K = B)

Q_n \ JK	00	01	11	10
0	(0)	(2)	(6) 1	(4) 1
1	(1) 1	(3)	(7)	(5) 1

$$Q_{n+1} = T \overline{Q}_n + \overline{K} Q_n$$

or $$Q_{n+1} = A \overline{Q}_n + \overline{B} Q_n$$

Hence alternative (c) is the correct choice.

52. (c) Resistance corresponding to LSB

$$R_{LSB} = R_{MSB} \times 2^{n-1}$$

where, $$n = \text{number of bits}$$

$$R_{MSB} = 2\ k\Omega$$

Now, $$R_{LSB} = 2\ k\Omega \times 2^{8-1}$$

$$= 2\ k\Omega \times 2^7 = 256\ k\Omega$$

Hence alternative (c) is the correct choice.

53. (d) The angle of asymptotes of the root loci,

$$\theta_K = \frac{(2k + 1)\pi}{(\text{No. of poles} - \text{No. of Zeros})}$$

or $$\theta_K = \frac{(2k + 1)\pi}{P - Z}$$

or $$\theta_K = \frac{(2k + 1)\pi}{n}$$

54. (b) We know that maximum overshoot is given by

$$M_P = e^{\frac{-\xi\pi}{\sqrt{1 - \xi^2}}}$$

where, M_P = Maximum overshoot

ξ = Damping ratio

or $$0{\cdot}15 = e^{\frac{-\xi\pi}{\sqrt{1-\xi^2}}}$$

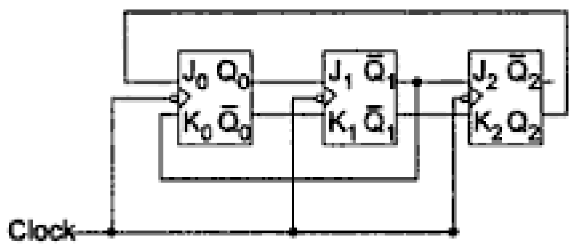
or $$\frac{1{\cdot}897}{\pi} = \frac{\xi}{\sqrt{1-\xi^2}}$$

or $$0{\cdot}604 = \frac{\xi}{\sqrt{1-\xi^2}}$$

or $$\xi = 0{\cdot}50$$

Hence alternative (b) is the correct choice.

55. (c) Since here complement output is feedback to the input, therefore, the given circuit represents Johnson counter



with 6 states because circuit uses 3 flip flops. Hence the given circuit represents modulo – 6 counter.

56. (b) We know that in the case of ripple counter, the following condition must be satisfied

$$t_s + n\, t_{pd} \le T$$

or $$t_s + n\, t_{pd} \le \frac{1}{f}$$

where, t_s = Strobing time

t_{pd} = Propagation delay to one Flip Flop

n = No. of Flip Flop connected in cascade

T = Time period of the operating clock

f = Frequency of the clock

Given, t_s = 50 ns

t_{pd} = 10 ns

f = 10 MHz

n = ?

Now, $n \times 10 \text{ ns} + 50 \text{ ns} \le \frac{1}{10 \text{ MHz}}$

or $$n \times 10 \times 10^{-9} + 50 \times 10^{-19} \le 100 \times 10^{-9}$$

or $$n \times 10 \times 10^{-9} \le 50 \times 10^{-9}$$

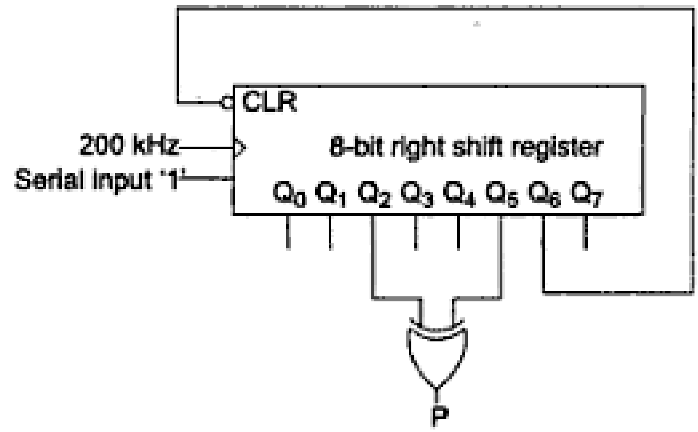
or $$n \le \frac{50 \times 10^{-9}}{10 \times 10^{-9}}$$

or $$n \le 5$$

or $$n = 5$$

Hence 5 maximum stages the counter have.

57. (c) Given input clock frequency = 200 kHz



Time period of '1' clock

$$= \frac{1}{200 \times 10^3} = 5 \times 10^{-6} = 5\ \mu s$$

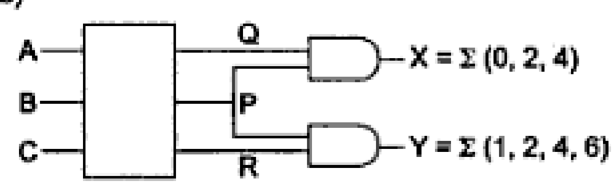
It means after 5 μs transition will take place in 8-bit right shift register.

Given that output P of X-OR gate is connected to output Q_2 and Q_5.

It means output of the P will be high when Q_2 and Q_5 are complementary outputs. Assume that initially all the Flip-Flop of shift register are reset. After two clock pulse (i.e. after $2 \times 5\ \mu s = 10\ \mu s$) output of Q_2 will be high and Q_5 will be low, we get output high at P. And this will continue upto 5 clock pulses.

Hence the waveform will high during (10 – 25) μs.

58. (b)



Given, $X = PQ = \Sigma\,(0, 2, 4)$

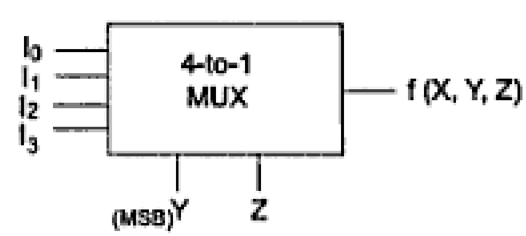
$Y = PR = \Sigma\,(1, 2, 4, 6)$

P should contain each function of X as well as Y

Therefore, $P = \Sigma\,(0, 1, 2, 4, 6)$

Hence alternative (b) is the correct choice.

59. (a)



Writing output expression of 4X1 MUX, we get

$$f(X, Y, Z) = I_0 \bar{Y}\,\bar{Z} + I_1 \bar{Y} Z + I_2 Y \bar{Z} + I_3 Y Z \quad \text{...(i)}$$

Given

$$f(X, Y, Z) = XY + X\bar{Z} \quad \text{...(ii)}$$

Rewriting equation (i)

$$f(X, Y, Z) = (I_2 \bar{Z} + I_3 Z)\, Y + \bar{Z}\,(I_0 \bar{Y} + I_2 Y) \quad \text{...(iii)}$$

Comparing equations (ii) and (iii), we get

$$l_2 = l_3 = X, l_0 = X \text{ and } l_1 \text{ may be 0 or 1}$$

Hence alternative (a) is the correct choice.

60. (b) The given characteristic equation

$$s^4 + 4s^3 + 8s^2 + 6s + K = 0$$

Routh's array of the given characteristic equation

s^4	1	8	K
s^3	4	6	
s^2	$\frac{32-6}{4} = \frac{13}{2}$	K	
s^1	$\frac{\frac{78}{2} - 4K}{13/2}$		
s^0	K		

For the system to be stable

$$\frac{\frac{78}{2} - 4K}{\frac{13}{2}} \geq 0$$

or $$\frac{78}{2} - 4K \geq 0$$

or $$\frac{78}{2} \geq 4K$$

or $$K \leq \frac{78}{8}$$

or $$K \leq 9.75$$

Therefore, for critical gain K should not exceed 9·75.

Hence alternative (b) is the correct choice.

61. (d) For system to be controllable

$$Q_C = [B : AB : A^2 B \,.........] \neq 0$$

Given, $A = \begin{bmatrix} -2 & 1 \\ 0 & -1 \end{bmatrix}; B = \begin{bmatrix} 1 \\ 0 \end{bmatrix} \rightarrow$ Equation (1)

$A = \begin{bmatrix} 0 & 1 \\ -1 & 0 \end{bmatrix}; B = \begin{bmatrix} 0 \\ 1 \end{bmatrix} \rightarrow$ Equation (2)

From equation (1)

$$[AB] = \begin{bmatrix} -2 & 1 \\ 0 & -1 \end{bmatrix} \begin{bmatrix} 1 \\ 0 \end{bmatrix} = \begin{bmatrix} -2 \\ 0 \end{bmatrix}$$

and $$Q_C = \begin{bmatrix} 1 & -2 \\ 6 & 0 \end{bmatrix} = 0$$

i.e. $Q_C = 0$

So, equation (1) is uncontrollable

Now, from equation (2)

$$[AB] = \begin{bmatrix} 0 & 1 \\ -1 & 0 \end{bmatrix} \begin{bmatrix} 0 \\ 1 \end{bmatrix} = \begin{bmatrix} 1 \\ 0 \end{bmatrix}$$

and $$Q_C = \begin{bmatrix} 0 & 1 \\ 1 & 0 \end{bmatrix} = -1$$

i.e. $Q_C \neq 0$

So, equation (2) is controllable.

Hence alternative (d) is the correct choice.

62. (a) We know that Gain Margin (G.M.) is given by

$$\text{G.M.} = \frac{1}{|G(j\omega) H(j\omega)|_{\text{at } \omega = \omega_c}}$$

given $$G(s) H(s) = \frac{5}{(s+1)(2s-1)(3s+1)}$$

or $$G(j\omega) H(j\omega) = \frac{5}{(j\omega + 1)(2j\omega + 1)(3j\omega + 1)}$$

or $$GM = \frac{|(j2\pi \times 0.16 + 1)(2j2\pi \times 0.16 + 1)(3j2\pi \times 0.16 + 1)|}{5}$$

or $$GM = \frac{10.117}{5} = 2.0234$$

$$\text{GM in dB} = 20 \log 2.0234 = 6.12 \text{ dB}$$

Hence alternative (a) is the correct choice.

63. (c) Given, $\xi = 0.54\,56$

$$\omega_n = 31.6 \text{ rad/sec}$$

$$\% M_P = ?$$

We know that per cent overshoot is given by

$$\% M_P = 100\, e^{\frac{-\xi M}{\sqrt{1-\xi^2}}}$$

or $$\% M_P = 100\, e^{\frac{-0.5456 \times 3.14}{\sqrt{1-(0.5456)^2}}}$$

or $$\% M_P = 13.2\%$$

Hence alternative (c) is the correct choice.

64. (c) Given $$G(s) = \frac{1}{(s^2 + s + 1)}$$

$$H(s) = Ks$$

Now,

$$\frac{G(s)}{1 + G(s) H(s)} = \frac{1}{s^2 + (K+1)s + 1} \qquad ...(i)$$

The standard equation

$$\frac{G(s)}{1 + G(s) H(s)} = \frac{\omega_n}{s^2 + 2\xi\omega_n s + \omega_n^2} \qquad ...(ii)$$

On comparing equation (i) and (ii), we get

$$\omega_n = 1$$

$$2\xi \omega_n = (K+1)$$

At critically damped

$$\xi = 1$$

So, $$2 \times 1 \times 1 = K + 1$$

or $$K = 2 - 1 = 1$$

Hence alternative (c) is the correct choice.

65. (d)

66. (c) In a radio transmitter, the frequency of the crystal oscillator will be stable for a long time if the quality factor of the crystal resonator is > 1000.

67. (a) In an IF amplifier, the IF transformer is provided with tapping to increase the voltage gain.

68. (b) In Envelop detector the demodulated wave will follow the envelop of m (t) *i.e.* modulating signal if charging time constant (R_SC) is very-very low and discharging time constant (R_LC) is very-very high.

Given, $V(t) = (1 + \mu \cos \omega_m t)$

so, $\frac{V(t)}{RC} \geq \frac{dV(t)}{dt}$

and $\frac{dV(t)}{dt} = -\mu\, \omega_m \sin \omega_m t$

at $t = t_0$

$$\frac{1 + \mu \cos \omega_m t_0}{RC} \geq -\mu\, \omega_m \sin \omega_m t$$

or $$\left|\frac{1}{RC}\right| \geq \frac{\omega_m\, \mu \sin \omega_m t_0}{1 + \mu \cos \omega_m t_0}$$

Hence alternative (b) is the correct choice.

69. (c) QPSK system is superior to BPSK system because bandwidth of QPSK system is half of the bandwidth of BPSK system.

70. (a) A radio receiver is placed at one corner of a table and again placed at some other corner of the same table. Loudspeaker output is changed because of fading. Since fading introduce fluctuation in signal strength at a receiver due to interference between two waves which left the same source but arrived at the destination by different paths.

71. (b) In time-division multiple access system, a traffic system on the receiver side must receive the traffic burst addressed to it. For this frame efficiency should be higher.

72. (c)

73. (d) In a Klystron amplifier, the RF voltage produces velocity modulation.

74. (b) For the proper operation of MASER at a frequency of 10 GHz, the material used is TiO_2 with slight doping of iron.

75. (a) Given a = 4·2 cm

Cut-off wavelength for dominant mode,

$$\lambda_C = 2a = 2 \times 4{\cdot}2 = 8{\cdot}4 \text{ cm}$$

Cut-off frequency, $f_c = \frac{c}{\lambda_c} = \frac{3 \times 10^8 \text{ m/s}}{8{\cdot}4 \times 10^{-2} \text{ m}} = 3{\cdot}57 \text{ GHz}$

Hence alternative (a) is the correct choice.

76. (d) For an antenna to be frequency independent, it should expand or contract in proportion to the impedance.

77. (d) 78. (c)

79. (b) The given number

$$= 13 * 16^3 + 11 * 16 + 2$$

80. (a) Total capacity of the disk

$$= 500 \times 100 \times 20 \times 1000$$
$$= 1 \times 10^9 = 1 \text{ GB}$$

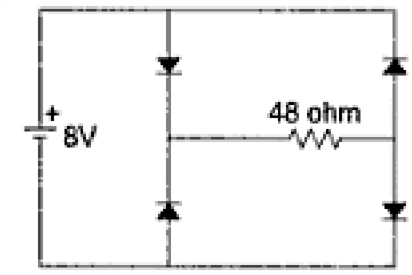
81. (d) 82. (a) 83. (a) 84. (d) 85. (d)

86. (c) 87. (b) 88. (c) 89. (a) 90. (d)

91. (c) 92. (d)

93. (a) In class A power amplifier, the collector dissipation is maximum when no signal is present.

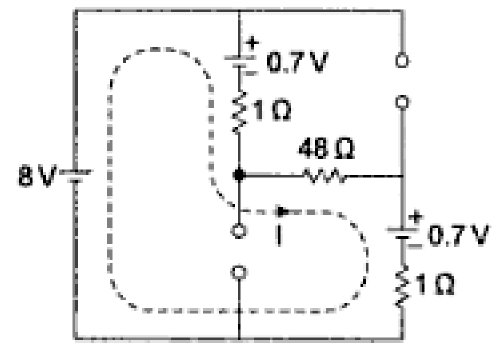
94. (a) The given circuit



Given $V_r = 0{\cdot}7$,

$r_f = 1\ \Omega$

The equivalent circuit can be redrawn as



The current through 48 Ω resistor

$$I = \frac{8 - 0{\cdot}7 - 0{\cdot}7}{48 + 1 + 1}$$
$$= \frac{6{\cdot}6}{50} = 132 \text{ mA}$$

95. (c) Given, $C_1 = 1\ \mu F, R_1 = 3\ k\Omega$

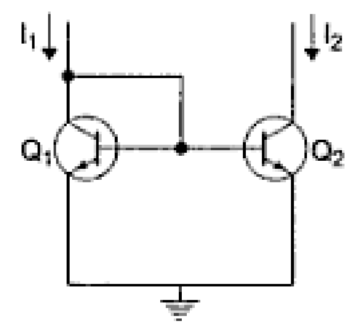
Lower cut-off frequency

$$f_L = \frac{1}{2\pi R_1 C_1}$$

or $$f_L = \frac{1}{2\pi \times 3 \times 10^3 \times 10 \times 10^{-6}}$$

or $f_L = 5{\cdot}30$ Hz

96. (c) The given circuit



Since both the transistors are identical.

Therefore collector currents and base currents are same.

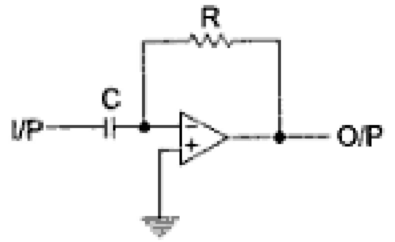
So, $$I_1 = I_2 + \frac{2I_2}{\beta}$$

or $$I_1 = I_2\left(\frac{\beta + 2}{\beta}\right)$$

or $$I_2 = I_1\left(\frac{\beta}{\beta + 2}\right)$$

Hence alternative (c) is the correct choice.

97. (b) The given circuit represents High Pass Filter (HPF)



and H. P. F. acts as a differentiator.

So, if rectangular input is applied, it will produce spike output.

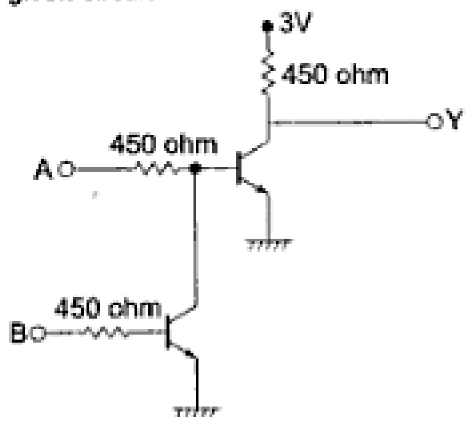
98. (d) ∴ $AB \geq 1$

and $A > 3$

For phase shift oscillator

So, $|\beta| = \frac{1}{3}$

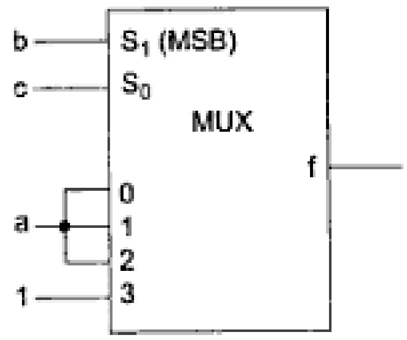
99. (d) The given circuit



The given circuit represent 2 input NAND gate

i.e. $Y = \overline{AB} = \overline{A} + \overline{B}$

100. (a) The given circuit



$$f(a, b, c) = \bar{b}\,\bar{c}\,a + \bar{b}\,c\,a + b\,\bar{c}\,a + bc$$

$$= \bar{b}\,a + b\,\bar{c}\,a + bc$$

$$= a(\bar{b} + b\,\bar{c}) + bc$$

$$= a + bc$$

Hence alternative (a) is the correct choice.

101. (a) 102. (b) 103. (a) 104. (b) 105. (b)

106. (b) 107. (c) 108. (d) 109. (b) 110. (a)

111. (d)

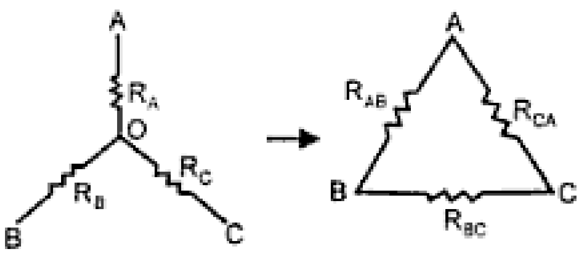
112. (b) New Telecom Policy (NTP 99) has defined Cellular Mobile Telephone Services provider by Telecommunication Regulatory Authority of India.

113. (b) 114. (b) 115. (c) 116. (d) 117. (b)

118. (c) 119. (b) 120. (d)

NETWORK AND SYSTEMS

- **Kirchhoff Voltage Law (KVL)** is a consequence of the law of conservation of energy, voltage being the energy (or work) per unit charge.
- **Kirchhoff Current Law (KCL)** is the consequence of conservation of charge. Since the algebraic summation of the charge must be zero, the time derivative of this summation must also equal to zero.
- **Star to Delta Transformation**



$$R_{AB} = \frac{R_A R_B + R_B R_C + R_C R_A}{R_C}$$

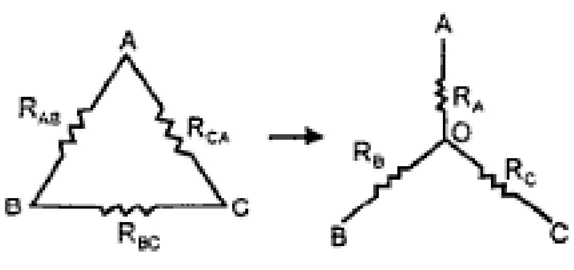
or $$R_{AB} = R_A + R_B + \frac{R_A R_B}{R_C}$$

Similarly,

$$R_{BC} = \frac{R_B R_C + R_C R_A + R_A R_B}{R_A}$$

and $$R_{CA} = \frac{R_C R_A + R_A R_B + R_B R_C}{R_B}$$

- **Delta to Star Transformation**



$$R_A = \frac{R_{AB} \times R_{AC}}{R_{AB} + R_{BC} + R_{CA}}$$

Similarly, $$R_B = \frac{R_{AB} \times R_{BC}}{R_{AB} + R_{BC} + R_{CA}}$$

and $$R_C = \frac{R_{AC} \times R_{BC}}{R_{AB} + R_{BC} + R_{CA}}$$

- Resistance of a wire depends on its material and its size. It is given by

$$\boxed{R = \frac{\rho l}{A}}$$

Where, ρ = Resistivity of a material in Ω cm

l = Length of the wire, and

A = Area of cross-section of wire.

- **Self inductance (L)** is the property of conductor (or coil) by virtue of which it opposes any change in direction or magnitude of current flowing through itself. It is given by

$$L = \frac{N\phi}{I} \text{ henry}$$

Where, N = No. of turns in the coil

ϕ = Flux set by current I.

- Also, $$\boxed{L = \frac{\mu_0 \mu_r N^2 A}{l} \text{ henry}}$$
- Current through inductor is given by

$$i(t) = \frac{1}{L}\int_{-\infty}^{t} V\,dt \text{ or } \frac{1}{L}\int_{-\infty}^{t} V\,dt + i(0) \text{ amp}$$

- Voltage across inductor is given by

$$V = L\frac{di}{dt} = N\frac{d\phi}{dt} \text{ volt.}$$

- Power, $P = VI = LI\frac{di}{dt}$ watt.
- When n inductors are connected in series the equivalent inductance is

$$L_{eq} = L_1 + L_2 + L_3 + \ldots + L_n$$

- When n inductors are connected in parallel the equivalent inductance,

$$\frac{1}{L_{eq}} = \frac{1}{L_1} + \frac{1}{L_2} + \frac{1}{L_3} + \ldots + \frac{1}{L_n}.$$

- Relation between the mutual inductance and two coils with inductance L_1 and L_2 is given by relation.

$$\boxed{M = k\sqrt{L_1 L_2}} \qquad \text{where } 0 \le k \le 1$$

where k = coefficient of coupling. It is a measure of amount of linking flux produced by one coil, w.r.t. other coil.

- **Capacitance** is the property of material by virtue of which it opposes the variation in potential between the two sides

$$\boxed{C = \frac{q}{V}}$$

where, q = charge, V = potential.

- $$\boxed{C = \frac{\varepsilon_0 \varepsilon_r A}{d}}.$$

where C = Capacitance is proportional to the dielectric and area of the plates, and is inversely proportional to the distance between the plates.

$\varepsilon_0 = 8.86 \times 10^{-12}$ F/m

ε_r = Relative permittivity

A = Area of the plate

d = Spacing between two plates.

- Current through the capacitor is

$$\boxed{i = C\frac{dv}{dt} \text{ amp.}}$$

- Voltage across the capacitor is

$$V = \frac{1}{C}\int_{-\infty}^{t} i(t)\,dt \text{ or } \frac{1}{C}\int_{-\infty}^{t} i(t)\,dt + V_C(0)$$

where $V_C(0)$ = initial voltage on capacitor.

- When n capacitances are connected in series, the equivalent capacitance is given by

$$\boxed{\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \dots + \frac{1}{C_n}}$$

- When n capacitances are connected in parallel, the equivalent capacitance is give by

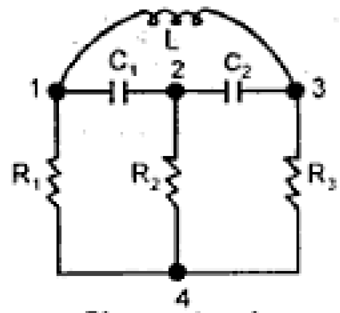
$$\boxed{C_{eq} = C_1 + C_2 + C_3 + \dots + C_n}$$

- **Some conservation laws are given below**
  (a) The conservation of charge
  $q_1 = q_2$ and $C_1 V_1 = C_2 V_2$; $i \neq \infty$
  (b) The conservation of flux linkage
  $\psi_1 = \psi_2$ and $L_1 i_1 = L_2 i_2$; $v \neq \infty$
  (c) The conservation of momentum
  $P_1 = P_2$ and $m_1 v_1 = m_2 v_2$; $F \neq \infty$

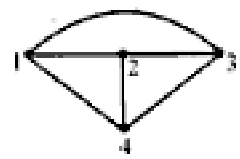
- **Mutual Inductance (M)**
It is the ability of one coil to produce an induced voltage in a nearby coil by electromagnetic induction, when the current being changed in the first coil, the action is *vice-versa*. It is measured in terms of the coefficient of mutual induction.

- **Network topology** is only concern with the geometrical structure of the network.

- A graph of any Network can be drawn by placing all the nodes which are points of intersection of more than two branches. Consider a network given beolw :



Given network



Graph of the given network

- If there exists a path between every pairs of nodes of a graph, then the graph is said to be a **connected graph.**

- There are at least two branches in a circuit.

- Rank of graph = n – 1, where n = no. of nodes or vertices.

- A subgraph is a subset of the branches and nodes of a graph. The subgraph is said to be proper if it consists of strictly have branches and nodes less than all the branches and nodes of the graph.

- Any tree contains n – 1 branches where n is the number of nodes or vertices. The branches in a tree called twig the branches other then the twing is called link (also called cords).

Fig. : Simple graph and Tree

In the above figure branches 3, 2, 5 are **called twig** while the branches 1, 4, 6 **called link.**

- **Properties of Trees**
  (i) In a tree, there exist one and only one path between any pair of nodes.
  (ii) Every connected graph has at least one tree.
  (iii) All the links of a tree together constitute the complement of the corresponding tree is called co-tree.
  (iv) Each tree has (n – 1) branches.
  (v) The rank of tree is (n – 1). This is also the rank of a graph to which the tree belongs *i.e.*, both tree and graph has some rank. Where n is the number of nodes in a graph.
  (vi) No. of possible trees of a graph = dct $[[A][A^T]]$ where A is the reduced incidence matrix.

- If the total number of branches and nodes in a connected graph are b and n respectively, then the number of links *l* is given by

$$\boxed{l = b - n + 1}$$

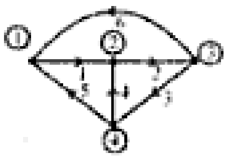
Incidence Matrix

- Tells information about the branches connected at which nodes and what the orientations relative to nodes. It is denoted by A_a.
- The matrix obtained from Incidence Matrix (A_a) by eliminating one of the rows is called the **reduced incidence matrix** denoted by A. It is of order $(n-1)^{th} \times b$

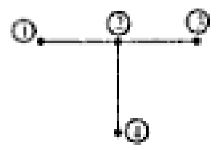
  where n = No. of nodes

  b = Branches.
- **Properties of Complete Incidence Matrix :**
  (i) Sum of entries in any column is zero.
  (ii) The determinant of the the complete incidence matrix of a closed loop is zero.
- **Fundamental circuit or tie set matrix** can be obtained by taking one link and other twigs at a time. The number of fundamental circuit depends upon the number of link.

  Consider a graph given below and select a tree.

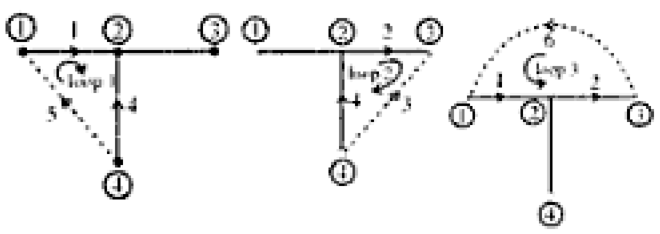


Given graph



Corresponding tree

- The fundamental circuit can be drawn as :



In matrix form :

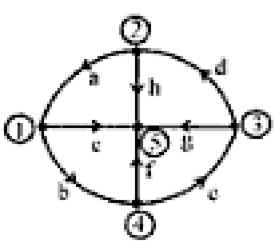
fundamental circuit	Branches 1	2	3	4	5	6
5	1	0	0	–1	1	0
3	0	1	1	1	0	0
6	1	1	0	0	0	1

- **Cut-set matrix** is formed by taking one twig and all other link. The set of branches which is cut by the closed line forms a cut set.

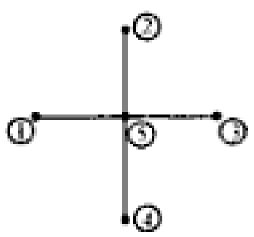
  Number of cut-sets = Number of twig = n – 1

  where n = No. of nodes in a graph.

  Consider a graph having 5 nodes shown below :



Given graph



Corresponding tree

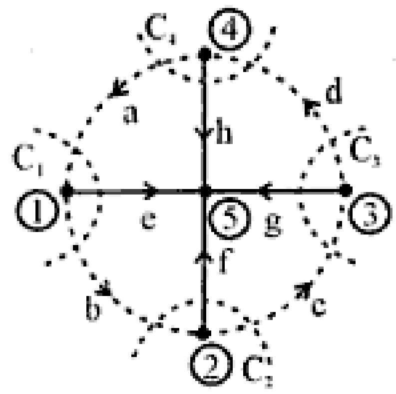
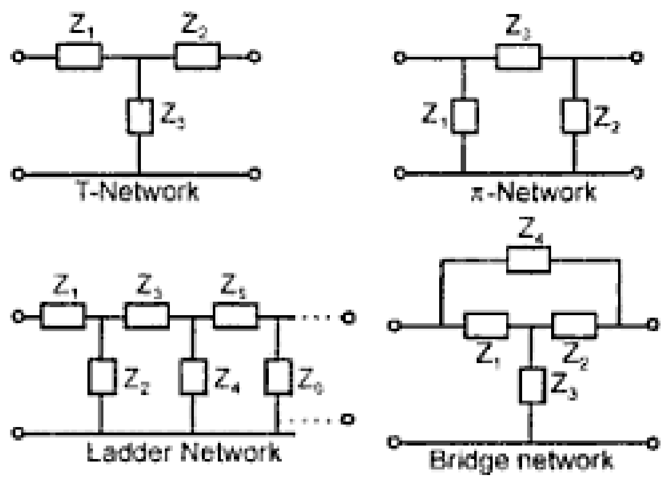


Fig. : Formation of cut-set

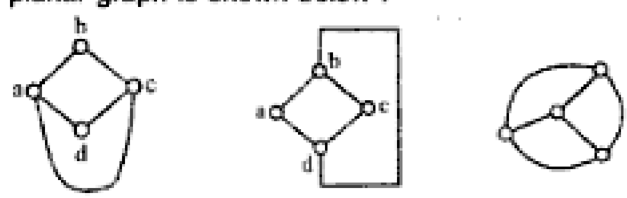
- Since in the given graph there are 5 nodes, so 5 – 1 = 4 cut-sets are possible. One things should be kept in mind that the orientation of a cut-set is decided by the defining branch of the tree.

  Line four cut sets for the above choice of the tree are (a, c, b) ; (b, f, c) ; (c, g, d) ; (d, h, a) and each cut set defines a cut-set row vector. The cut-set (a, e, b), for example, defines the following cut-set row vector.
- **Network shown below :**

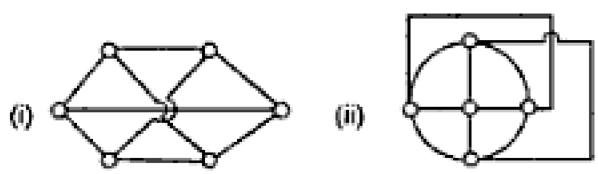


Note : These network are said to be *grounded* or *unbalanced network.*

- **Planar graph** if it is possible to draw a graph on sheet of paper without crossing the lines than such types of the graph are said to be planar graph. Some of the planar graph is shown below :



- **Non-planar graph :** in graph is drawn with crossing lines then it is called non-planar graph. Fig. shows the non-planar graph.

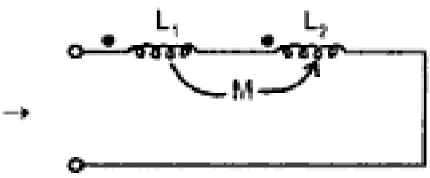


non-planar graph non-planar graph

- **Dot notation :** Dot on the coils indicate the polarity of voltages induced in the coils. These also indicate whether the fluxes produced by the coils will be additive or opposing.

(i) When coils are joined in series with fluxes additive, the equivalent inductance is

$L_{eq} = L_1 + L_2 + 2M$

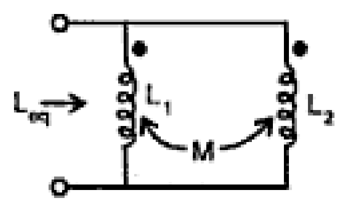


$L_{eq} = L_1 + L_2 - 2M$ (for opposing fluxes) →

(ii) For parallel connected inductance

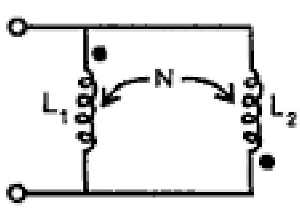
(a) **For additive fluxes :**

$$L_{eq} = \frac{L_1 L_2 - M^2}{L_1 + L_2 - 2M}$$



(b) **For opposing fluxes : replace M by – M**

$$L_{eq} = \frac{L_1 L_2 - M^2}{L_1 + L_2 + 2M}$$



- For better understanding the concept of the dot notation we must know the types of *Coupling*.

Types of Coupling :

(i) **Electrical Coupling :** Two coils are connected by a wire, so that physical connection exists.

(ii) **Magnetic Coupling :** Two coils are magnetically coupled but physically isolated, so called *transformer coupling*.

(i) **Magnetic Coupling :** Consider two inductors with self inductances L_1 and L_2, mutual inductance M, and coefficient of coupling k and dots are shown in fig. applying KVL to both side we get

$M = K\sqrt{L_1 L_2}$

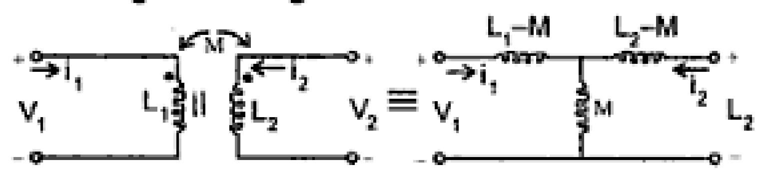
where, $0 \le K \le 1$

$$V_1(t) = L_1 \frac{di_1(t)}{dt} + M \frac{di_2(t)}{dt} + R_1 i_1(t),$$

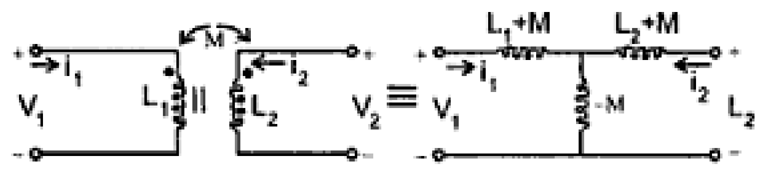
and $L_2 \frac{di_2(t)}{dt} + M \frac{di_1(t)}{dt} + R_2 i_2(t) = 0$

A transformer replaced by its T-equivalent :

Magnetic adding :

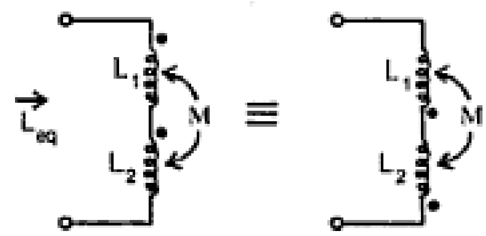


Magnetic opposition :

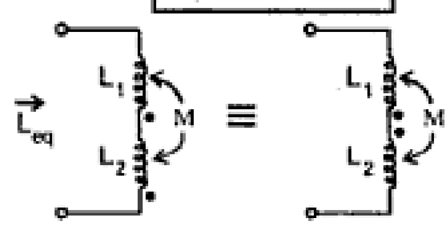


(ii) Electrical Coupling :

Case (I) : When Coupled inductors in series :

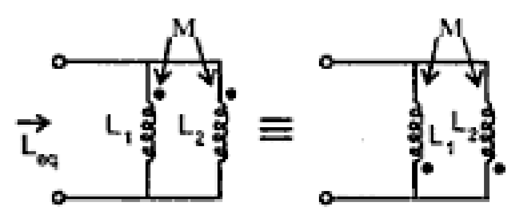


$L_{eq} = L_1 + L_2 + 2M$

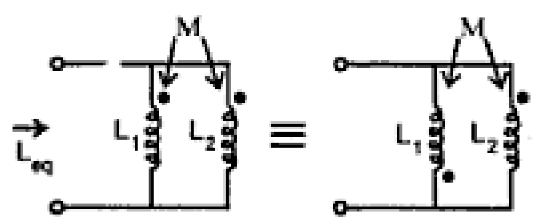


$L_{eq} = L_1 + L_2 - 2M$

Coupled inductors in parallel :

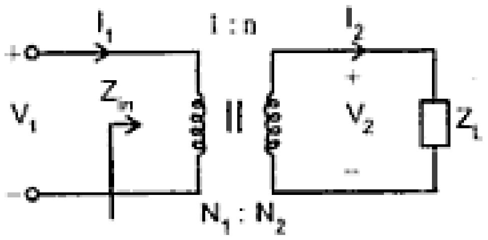


$$L_{eq} = \frac{L_1 L_2 - M^2}{L_1 + L_2 - 2M}$$



$$L_{eq} = \frac{L_1 L_2 - M^2}{L_1 + L_2 + 2M}$$

Transformer as an impedance matching device :



$$\frac{V_2}{V_1} = \frac{N_2}{N_1} = n = \frac{I_1}{I_2}$$

and $$Z_{in} = \frac{Z_L}{n^2}$$

Phasors and Phasor Diagrams :

- Phasor is a directed line segment, whose magnitude is the maximum value of the cosine function and angle is the initial phase of the cosine function.
- Phasor can be treated as complex number. When the circuit is analyzed using phasors, it is said to be in the frequency domain.
- There are three equivalent notations for a phasor.

  Polar form $V = V_m \angle\theta$

  Rectangular form $V = V_m (\cos\theta + j\sin\theta)$

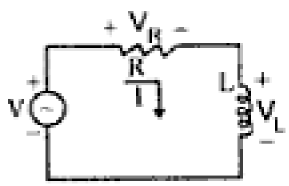
  Exponential form $V = V_m e^{j\theta}$
- The cosine function can be written from the given Phasor.

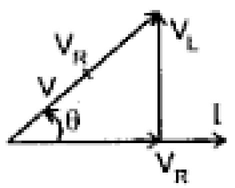
$$\begin{aligned} V(t) &= R_e [V e^{j\omega t}] \\ &= R_e [V_m e^{j\theta} . e^{j\omega t}] \\ &= R_e [V_m e^{j(\omega t+\theta)}] \\ V(t) &= V_m \cos(\omega t + \theta). \end{aligned}$$

- Both polar and exponential forms are used for the multiplication or division of two phasors, whereas rectangular form is used for additon and subtraction of two Phasors.

Phasor Diagrams :

- **RL Series Circuit :**



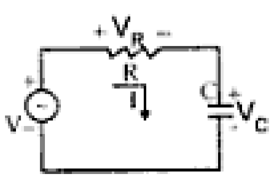


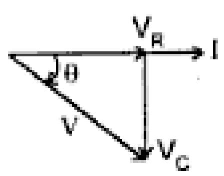
$$V = \sqrt{V_R^2 + V_L^2}$$

$\theta = \tan^{-1} (V_L/V_R)$

Power factor = cos θ (lagging)

- **RC Series Circuit :**



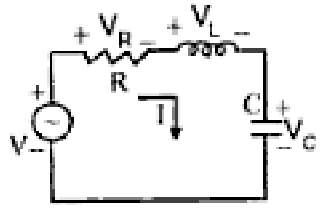


$$V = \sqrt{V_R^2 + V_C^2}$$

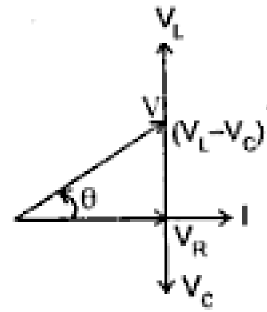
$\theta = \tan^{-1} (V_C/V_R)$

Power factor = cos θ (leading)

- **RLC Series Circuit :**



For $V_L > V_C$:

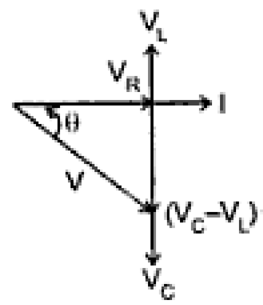


$$V = \sqrt{V_R^2 + (V_L - V_C)^2}$$

$\theta = \tan^{-1} [(V_L - V_C)/(V_R)]$

Power factor = cos θ lagging

For $V_C > V_L$:

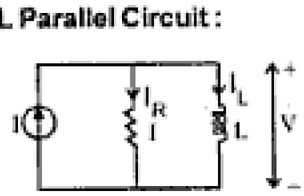


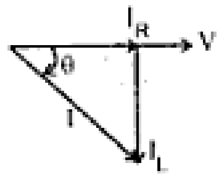
$$V = \sqrt{V_R^2 + (V_C - V_L)^2}$$

$\theta = \tan^{-1} [(V_C - V_L)/(V_R)]$

Power factor = cos θ (leading)

- **RL Parallel Circuit :**



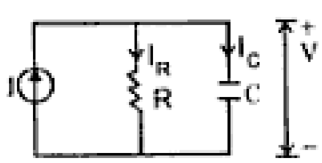


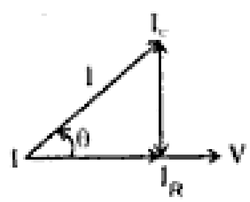
$$I = \sqrt{I_R^2 + I_L^2}$$

$\theta = \tan^{-1} (I_L/I_R)$

Power factor = cos θ (lagging)

- **RC Parallel Circuit :**



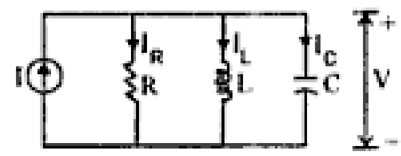


$$I = \sqrt{I_R^2 + I_C^2}$$

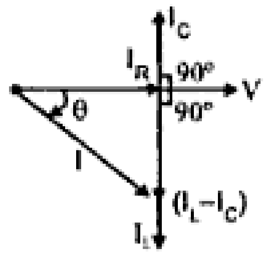
$\theta = \tan^{-1} (I_C/I_R)$

Power factor = cos θ (leading)

- **RLC Parallel Circuit :**



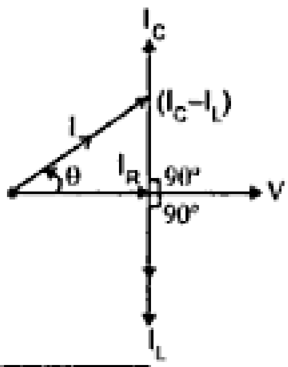
For $I_L > I_C$:



$$I = \sqrt{I_R^2 + (I_L - I_C)^2} \quad \theta = \tan^{-1}\frac{(I_L - I_C)}{I_R}$$

Power factor = cos θ **(lagging)**

For $I_C > I_L$:



$$I = \sqrt{I_R^2 + (I_C - I_L)^2}, \ \theta = \tan^{-1}\frac{(I_C - I_L)}{I_R}$$

Power factor = cos θ **(leading).**

Note : (i) Power factor is said to be leading if current leads voltage, and lagging if current lags voltage.

(ii) $P_{av} = I_{rms}^2 R = \frac{V_{rms}^2}{R} = R_e [I V^*] = R_e [I V^*]$

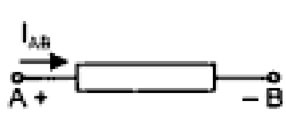
$= V_{rms} I_{rms} \cos\theta$ watt called **active power.**

(iii) $Q = I_{mg}[V I^*] = I_{mg}[I V^*] = V_{rms} I_{rms} \sin\theta$ watt called **reactive power.**

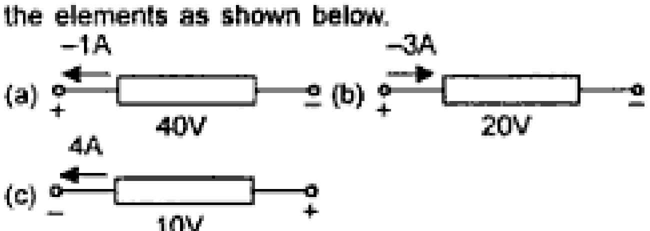
(iv) $S = \sqrt{P_{av} + Q^2} = V_{rms} \cdot I_{rms}$ V-amp (volt ampere) is called the **apparent power.**

Rule for Calculating Absorbed Power

The power absorbed by any circuit element as shown below with terminals labelled A and B is equal to the voltage drop from A to B multiplied by the current through the element from A to B, *i.e.* $P = V_{AB} \cdot I_{AB}$.



Example : Compute the power absorbed by each of the elements as shown below.



Solution : (a) P = –40 × (–1) = 40W.
(b) P = 20 × (– 3) = – 60 W. (c) P = 10 × 4 = 40 W.

Principle of Conservation of Power :

The sum of powers absorbed by all elements in a circuit is zero at any instant of time. Equivalently, the sum of absorbed powers equals the sum of the generated powers at each instant of time.

Transients :

- Transients in the system is due to the presence of energy storing elements of opposite kinds, like inductor and capacitor.
- Inductor will store the energy in magnetic field whereas capacitor will store the energy in electric field.
- If the system consists of only resistors in it, then there are no transients in the system.
- The presence of inductor or capacitor or both will oppose any change in their state or their behaviour for the sudden changes in the outside world.
- Transients are inevitable for d.c. excitations.
- Transient effects are negligible for d.c. excitations.
- Transient free response is possible only for the a.c. excitations, but this will depend on the type of the excitation, frequency and phase of the excitation and also on the circuit elements.
- The network with both the energy storing elements will always produce transients in the system even for a.c. excitations.
- When the independent source is connected to the network for a long time, then the network is said to be in steady state.
- In steady state the energy stored in the inductor and capacitor is maximum and constant.

$$V_L = \frac{L\, di_L}{dt} \Rightarrow V_L = 0$$

Since 'i_L' is constant. So the inductor will act like a short circuit in steady state.

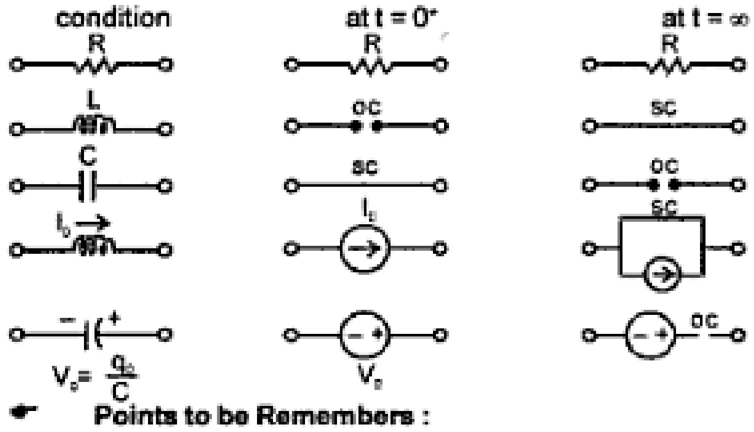
- Similarly $i_C = C\frac{dV_C}{dt} \Rightarrow i_C = 0$

Since 'V_C' is constant. So the capacitor will act like an open circuit in steady state :

- In steady state the nature of the circuit is always resistive for d.c.
- Since the energies stored in the capacitor and inductor, cannot change instantaneously, so the capacitor voltage and inductor current cannot change instantaneously.
- For impulse excitation both the inductor current and capacitor voltage can change instantaneously.

- **Elements and their equivalent circuit at t = 0⁺ and t = ∞.**

Element and initial condition	Equivalent circuit at $t = 0^+$	Equivalent circuit at $t = \infty$



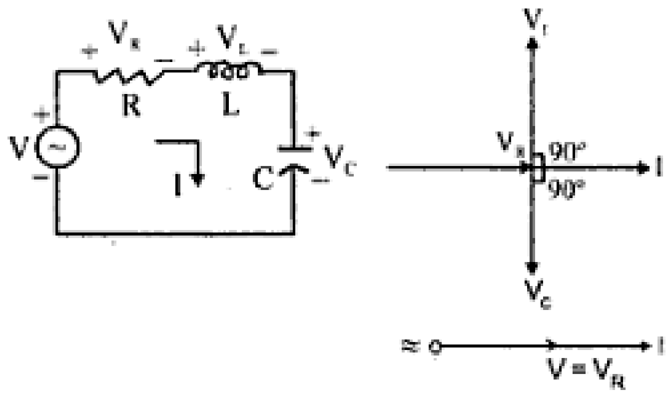
- **Points to be Remembers :**

(i) $V_C(0^-) = V_C(0^+)$ (ii) $i_L(0^-) = i_L(0^+)$
(iii) $u(-t) \rightarrow$ exist for $t < 0$.

THE CONCEPT OF RESONANCE

- Resonance is the phenomenon involved in the production of sinusoidal oscillations.
- These oscillations are due to the continuous exchange of energy between the inductor and capacitor.
- At one frequency, called **resonance frequency (f_r)** the exchange of energy is independent of type of the source and the power factor of the circuit is unity and the nature of the circuit is purely resistive.

● **RLC Series Circuit :**



- **At Resonance :**

$$|V_L| = |V_C| \Rightarrow X_L = X_C \Rightarrow \omega_0 = \frac{1}{\sqrt{LC}}$$

$\therefore \quad V = V_R = IR$

$\therefore \quad I = (V/R)$

$V_L = QV\angle 90°$

$V_C = QV\angle -90°$

Where, $Q = \frac{\omega_0 L}{R} = \frac{1}{\omega_0 CR} = \frac{1}{R}\sqrt{\frac{L}{C}}$

and Q = quality factor of the series RLC circuit.

Bandwidth of the circuit at resonance B.W. = (f_0/Q)

$\therefore \quad f_2 - f_1 = (f_0/Q)$ and $\sqrt{f_1 f_2} = f_0$

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

$Q = \omega_0 L/R$

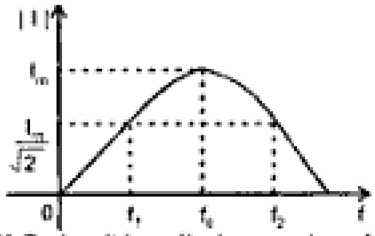
f_1 = lower cut-off frequency

f_2 = upper cut-off frequency

Note : Quality factor can also be defined in other way

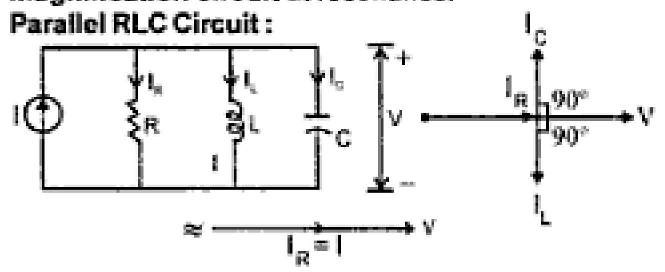
$$Q = 2\pi\left[\frac{\text{Maximum energy stored in L or C in one cycle}}{\text{Energy dissipated per cycle in resistor}}\right]$$

- Frequency response of the series RLC circuit :

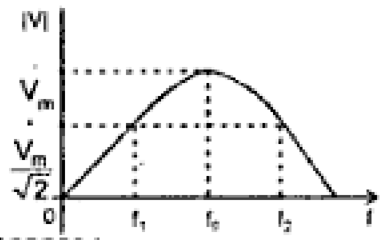


- Series RLC circuit is called **acceptor circuit or voltage magnification circuit** at resonance.

● **Parallel RLC Circuit :**



- **Frequency Response of the Parallel RLC Circuit**



- **At Resonance :**

$|I_L| = |I_C|$

$\therefore \quad I = I_R = V/R$

$I_L = QI\angle -90°$, $I_C = QI\angle 90°$

Where, $Q = (R/\omega_0 L) = \omega_0 CR = R\sqrt{C/L}$

= quality factor for the parallel RLC circuit.

Bandwidth of the circuit at resonance.

B.W. = (f_0/Q) Where, $f_0 = \frac{1}{2\pi\sqrt{LC}}$

$f_2 - f_1 = (f_0/Q)$, $Q = (R/\omega_0 L)$

- Parallel RLC circuit at resonance is called rejecter circuit or current magnification circuit.

Note : It may be always remember that quality factor $Q = \frac{\omega_0 L}{R}$ for series RLC circuit while $Q = \frac{R}{\omega_0 L}$ for parallel RLC circuit.

- **Selectivity** may be defined as the reciprocal of the quality factor. Higher value of the quality factor means lower selectivity. In other words higher degree of sharpness.

i.e. $\boxed{\text{Selectivity} = \frac{1}{Q}}$ and $\sqrt{f_1 f_2} = f_0$

Where, f_1 = Lower cut-off frequency

f_2 = Upper cut-off frequency

Comparison between Series and Parallel Resonance

S. No.	Parameters	Series circuit (R-L-C)	Parallel circuit (R-L-C)
1.	Impedance at resonance	Minimum	Maximum
2.	Current at resonance	Maximum =V/R	Minimum = V/(L/CR)
3.	Effective impedance	R	L/CR
4.	Power factor at resonance	Unity	Unity
5.	Resonant frequency	$\frac{1}{2\pi\sqrt{LC}}$	$\frac{1}{2\pi}\sqrt{\left(\frac{1}{LC}-\frac{R^2}{L^2}\right)}$
6.	It magnifies	Voltage	Current
7.	Magnification is	$\frac{\omega L}{R}$	$\frac{\omega L}{R}$

- The energy absorbed by the network from time t_1 to t_2 is

$$W = \int_{t_1}^{t_2} V(t) \cdot i(t)\, dt \text{ joule.}$$

- The rate at which energy is being absorbed is the power given by

$$P = \frac{dW}{dt} = V(t)\ i(t) \text{ watt.}$$

Note : A positive P indicates a flow of energy into the network, negative P out of network. The direction of flow may change with time, of course and will depend only on the sign of power *i.e.* P.

- The energy absorbed by the network-from time t_1 to t_2 is

$$W_L = \int_{t_1}^{t_2} L \frac{di}{dt}\, i\, dt = \int_{i_1}^{i_2} Li\, di = \frac{1}{2} L (i_2^2 - i_1^2) \text{ joule.}$$

where i_1 and i_2 are the currents at t_1 and t_2.

- Energy stored in the case of capacitor is given by

$$W_C = \int_{t_1}^{t_2} C \frac{dV}{dt} . V\, dt = \int_{V_1}^{V_2} CV\, dV = \frac{1}{2} C (V_2^2 - V_1^2) \text{ J}$$

where V_1 and V_2 are the voltages at t_1 and t_2.

- **The effective value or root-mean-square** values of a periodic current i(t) is defined as the constant value of current which will produce the same power in a resistor as is produced on the average by the periodic current. The power in a resistor due to a constant current I is

$$\boxed{P = I^2R}$$

- In the sinusoidal steady state, the average power in the resistor is given by

$$\boxed{P_{av} = \frac{1}{2} I_m^2 R = \frac{V_m^2}{2R}}$$

- Workdone or energy liberated can be expressed as

$$\boxed{W = Pt = VIt = \frac{V^2}{R} t = I^2Rt \text{ joule}}$$

- The rate at which electric energy is transferred into other forms of energy is called electric power 'P'.

$$\boxed{P = VI = I^2R = \frac{V^2}{R} \text{ watt}}$$

- **kWh** : The unit of electricity consumed in factories and in houses. It is calculated on the basis of electric energy.
- 1 kWh or 1 unit is the quantity of electric-energy which dissipated in 1 hour in a circuit when the electric power in the circuit is 1 kilo watt

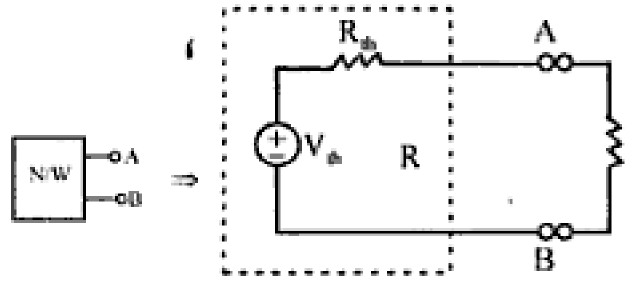
1 unit = 1 kWh = 1000 × 3600 watt-sec

or 1 unit = 3.6×10^6 joule.

- **Network Theorems :**

Thevenin's theorem : It is applied in finding the current, voltage and power in a particular element of a multi-element network with active dependent and independent sources.

Statement : According to Thevenin theorem any two terminal linear network can be replace by a voltage generator V_{th} (equivalent to open circuit voltage) in series with an Thevenin resistance R_{th}, (obtained by looking into the open circuit terminals and replacing the sources by their internal impedances).



R_{th} → Thevenin's equivalent resistance

V_{th} → Thevenin's voltage = $V_{OC} = V_{AB}$.

Note : Under different situation different cases arises to solve for R_{th} or Z_{th}.

Case I : *When circuit consisting only independent source*

In this case $V_{th} = V_{OC}$

Z_{th} = Impedance seen from the open terminal by replacing all source with their internal impedance *i.e.* all independent voltage sources are S.C. and independent current sources O.C.

Case II : *When circuit consisting dependent and independent source*

Method 1 :

$$Z_{th} = \frac{V_{OC}}{I_{SC}}$$

where V_{OC} = Open circuited voltage between the terminals concerned.

I_{SC} = Short circuit current through given terminal.

Method 2 :

$$Z_{th} = \frac{V_{dc}}{I_{dc}}$$

where V_{dc} = Assume an imaginary source having any value like 10 V, 20 V or any other value and connected across given terminals by replacing all other independent sources of network by their internal impedances.

I_{dc} = current supplied by V_{dc} to network.

Case III : *Circuit consisting only dependent sources :*

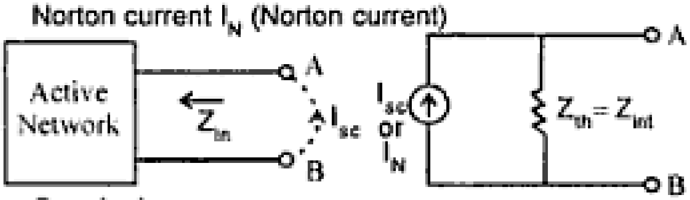
$$Z_{th} = \frac{V_{dc}}{I_{dc}}$$

The circuit with dependent sources cannot exist in isolation, they must be part of some big network consisting of some independent source also.

Note : For the circuit consisting with dependent source only, Thevenin voltage is zero but there can be Thevenin impedance of network seen across the given terminal.

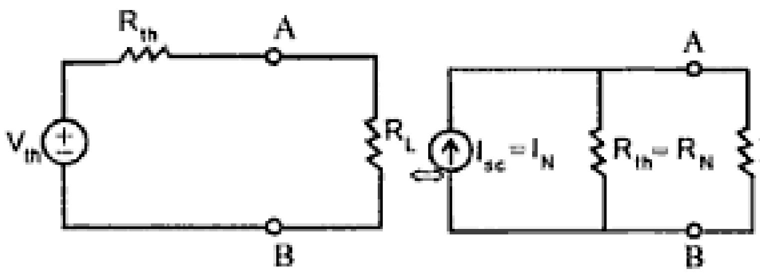
Norton's Theorem :

Any two terminal linear bilateral network containing active and passive elements can be replaced by an equivalent current source in parallel to an equivalent impedance. Current source is equal to short circuited current through the given terminals and equivalent impedance is the impedance seen across the terminals by replacing all the sources with their internal impedance. I_{sc} (Short circuit current) is also called Norton current I_N (Norton current)



Conclusion :

The current that flows by short circuiting the terminals of a Thevenin circuits is the Norton current. So a Thevenin circuit can be converted into a Norton circuit or *vice-versa* by replacing the Thevenin voltage with series resistance to a Norton current with parallel resistance. So we can transform a voltage source into a current source.



This is a case of source transformation.

Notes :

(i) Thevenin and Norton equivalents are valid only for linear circuits.

(ii) Thevenin and Norton theorems are applicable to passive as well as active networks.

Superposition Theorem

According to the superposition theorem if a number of energy sources (*i.e.* voltage and current) are acting together in a bilateral network then resultant voltage/current in any branch is the algebraic sum of voltage/current due to individual sources by replacing them with their internal impedances.

Notes :

(i) Superposition theorem is applicable to linear circuit (*i.e.* R, L and C) only.

(ii) The presence of dependent source make the network active, so this makes an active network.

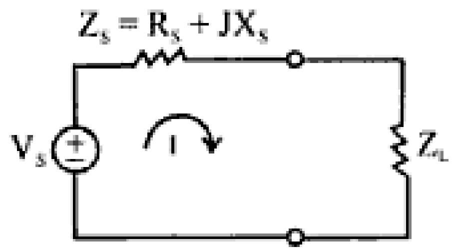
(iii) Therefore, the superposition theorem is applicable to passive as well as active networks with linear dependent sources.

(iv) Superposition theorem cannot be applied directly to computation of power as power is a square of V or I.

(v) It is also applicable for circuit having initial condition.

Maximum Power Transfer Theorem

According to maximum power transfer theorem a generator with an internal impedance of $R_S + JX_S$ will delivers maximum power to the load impedance Z_L, if and only if Z_L = conjugate of internal impedance *i.e.* $Z_L = R_S - JX_S$.



$$Z_S = R_S + JX_S$$
$$Z_L = R_L + JX_L$$

$$I = \frac{V_S}{Z_S + Z_L} = \frac{V_S}{(R_S + R_L) + J(X_S + X_L)}$$

Power, $P = I^2R_L$

$$P = \frac{V_S^2 \cdot R_L}{(R_S + R_L)^2 + (X_S + X_L)^2}$$

For maximum or minimum values of power, put

$$\frac{\partial P}{\partial X_S} = 0$$

$$\frac{\partial P}{\partial X_S} = -\frac{2(V_S^2) \cdot R_L (X_L + X_S)}{[(R_S + R_L)^2 + (X_S + X_L)^2]^2} = 0$$

$$-2V_S^2 R_L X_L = 2V_S^2 R_L X_S$$

or $\boxed{X_S = -X_L}$

so, $$P = \frac{V_S^2 R_L}{(R_S + R_L)^2}$$

Differentiating P, w.r.t. R_L and equating to 0 for maximum

$$\frac{\partial P}{\partial R_L} = \frac{V_S^2 (R_L + R_S)^2 - 2V_S^2 R_L (R_L + R_S)}{(R_S + R_L)^4} = 0$$

$\therefore$ $\boxed{R_L = R_S}$

$$\boxed{\textbf{Maximum power output } P_{max} = \frac{V_S^2}{4R_L}}$$

Notes :

(i) At maximum power output, 50% of the power delivered by the generator to its internal resistance and 50% in the load so maximum efficiency is 50%.

(ii) Maximum power transfer theorem is applicable to linear passive as well as active networks.

Tellegan's Theorem :

This theorem states that the algebraic sum of power consumed and delivered by each branch of a network is always zero.

$$\sum_{k=1}^{n} V_k i_k = 0$$

n = No. of branches of network

V_k = Voltage across k_{th} branch

i_k = Current in k_{th} branch.

Notes :

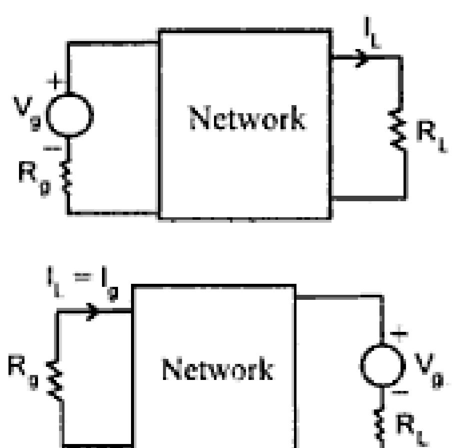
(i) The physical interpretation of Tellegen's theorem is the conservation of power. As per the theorem, the sum of powers delivered to or absorbed by all branches of a given lumped network is equal to 0, *i.e.* the power delivered by the active elements of a network is completely absorbed by the passive elements at each instant of time.

(ii) Tellegen's theorem depends on KCL and KVL but not on the type of the elements.

(iii) Tellegen theorem can be applied to any network linear or non-linear, active or passive, time variant or time-invariant.

- **Reciprocity Theorem :**

This theorem states that any sources of emf E, located at one point in a network composed of linear bilateral circuit element produces a current I at the second point in the Network, the same source of emf, E acting at the second point will produce the same current I at the first point.



V_g of a voltage source in one part of the network driving a current I_L in another part remains the same if the source V_g and I_L are interchanged.

Notes :

(i) Reciprocity theorem is applicable for single voltage source or single current source.

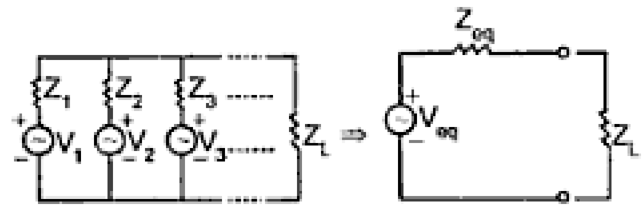
(ii) The initial conditions are assumed to be zero in reciprocity theorem.

(iii) There should not be any extra dependent or independent sources in network, *i.e.*, network with controlled sources are called non-reciprocal networks.

(iv) Reciprocity theorem is applicable to only linear passive bilateral networks.

Milliman's Theorem :

- According to this theorem if number of voltage sources V_1, V_2, V_3 ...... V_n having internal impedances Z_1, Z_2, Z_3, ... Z_n are connected in parallel supplying a common load Z_L, this arrangement can be replaced by a single voltage source V_{eq} in series with an impedance Z_{eq} as shown :



$$V_{eq} = \frac{V_1 Y_1 + V_2 Y_2 + V_3 Y_3 + \dots V_n Y_n}{Y_1 + Y_2 + Y_3 + \dots Y_n}$$

$$V_{eq} = \frac{\sum_{k=1}^{n} Y_k V_k}{\sum_{k=1}^{n} Y_k} \quad \text{and} \quad Z_{eq} = \sum_{k=1}^{n} \frac{1}{Y_k}$$

- **Relationship of Parameters :**

Parameter	Basic Relationship	V - I Relationship	Energy
$R, G = \frac{1}{R}$	V = IR	i = GV and V = iR	$= \int_{-\infty}^{t} Vi\,dt$
C	$C = \frac{Q}{V}$	$V = \frac{1}{C}\int_{-\infty}^{t} i\,dt$ i = C dV/dt	$= \frac{1}{2} CV^2$
L	$\phi = Li$	$V = L\frac{di}{dt}$ $i = \frac{1}{L}\int_{-\infty}^{t} V\,dt$	$= \frac{1}{2} Li^2$

- **Passive Network :**

A network containing circuit elements without any energy sources.

- **Active Network :**

A network containing energy sources together with other circuit elements.

- **Lumped Network :**

Lumped network are those in which we can separate resistors, capacitors and inductors physically.

- **Distributed Network :**

A circuit in which the voltage and current are functions of time and position is called a distributed parameter circuit. While a circuit in which the voltage and current are functions of time only is called **lumped parameter** circuit. In distributed network, resistors, capacitors and inductors cannot be electrically separated and isolated as separate elements. For example, transmission line.

- **Linear Element :**

  A circuit element is said to be linear if the relation between current and voltage involves a constant coefficient, *e.g.*

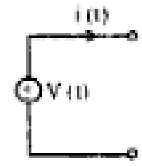
  $$V = IR\ ;\ V = L\frac{di}{dt},\ \ V = \frac{1}{C}\int i\,dt.$$

- A linear Network is one in which principle of superposition (*i.e.* linearity) holds. A non-linear network is one which is not linear.

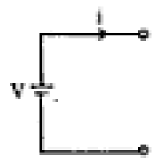
- **Energy Sources**

  (i) **Voltage source :** For ideal voltage source internal resistance = 0 Ω.

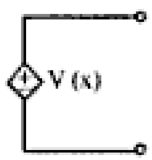
  (a) Ideal voltage source



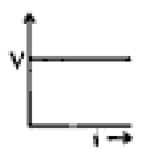
  (b) Ideal independent voltage source



  (c) Dependent voltage source

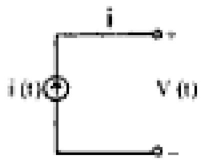


  (d) V – i characteristics of ideal voltage source.

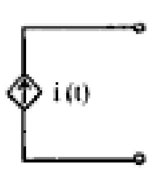


  (ii) **Current sources :** For ideal current source internal resistance = ∞

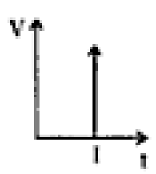
  (a) Ideal current source



  (b) Dependent current source



  (c) V – i characteristic of ideal current source.



  (iii) **Practical voltage source :**

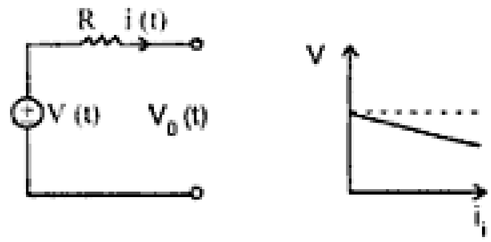


Fig. : Practical voltage source and V – i characteristic

  (iv) **Practical current source :**

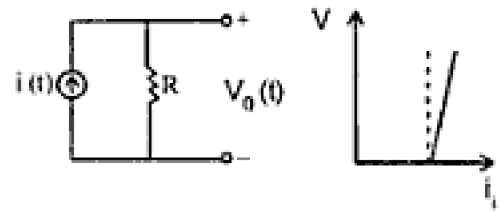
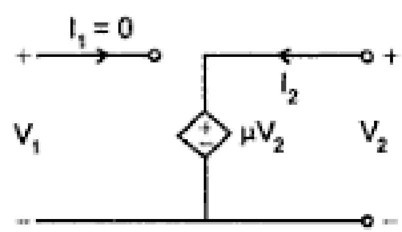


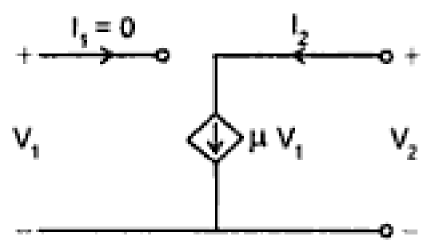
Fig. : Practical current source and V – i characteristic

- **Dependent Energy Source :**

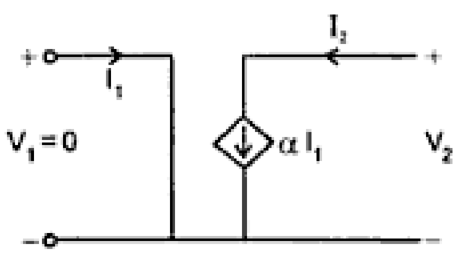
  (i) Voltage dependent voltage source (VCVS)



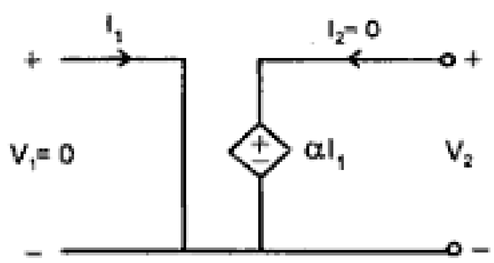
  (ii) Voltage dependent current source (VCCS)



  (iii) Current dependent current source (CCCS)

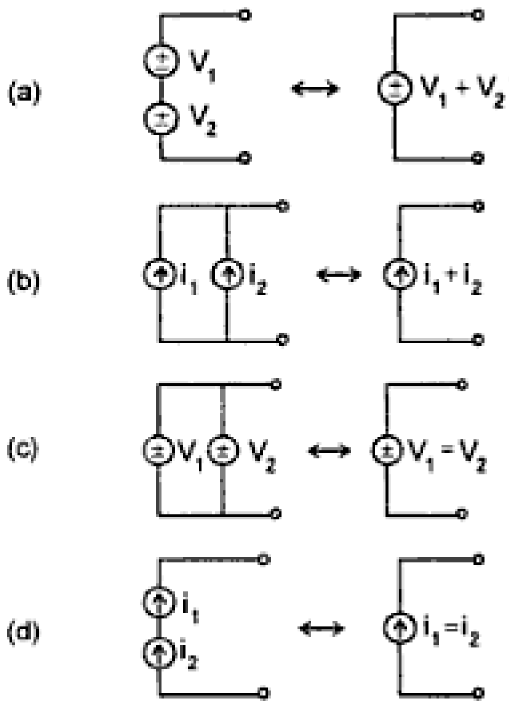


  (iv) Current dependent voltage source (CCVS)

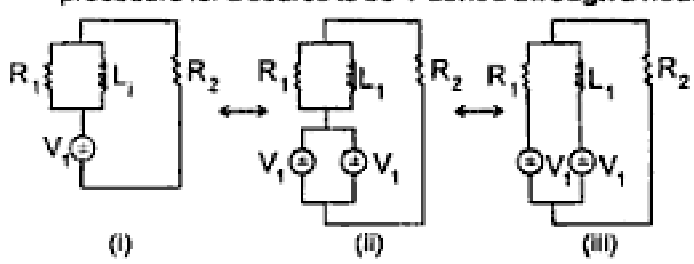


- **Source Transformations :**

  If may be always remember that voltage source cannot be connected in parallel unless the two sources have identical voltages, and similarly, the current sources cannot be connected in series unless identical. The paralleling of generators with non-similar voltage waveforms, results in heavy currents and equipment can damage.



- Three equivalent networks shows below illustrating a procedure for a source to be **'Pushed through a node'**.



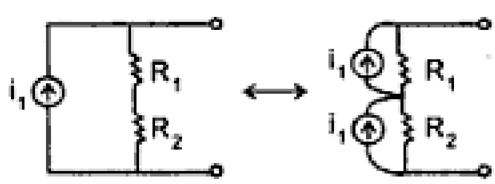
- 

Fig. : Two equivalent network

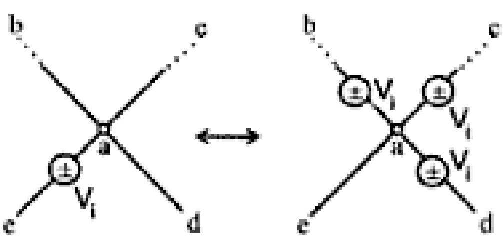
- 

Fig. : Two equivalent network

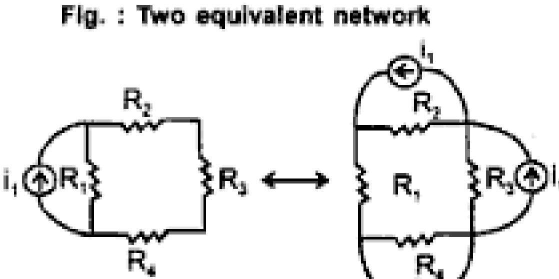
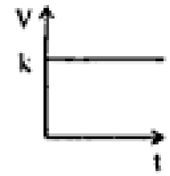
- 

Fig. : Two equivalent network

- **Standard Input Signals :**

(i) **Step function :**
The most widely used input is the step function in testing dynamic behaviour.



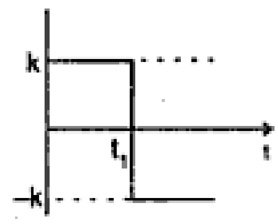
representation of a step function is

$$V(t) = \begin{cases} k ; & t \geq 0 \\ 0 ; & t < 0 \end{cases}$$

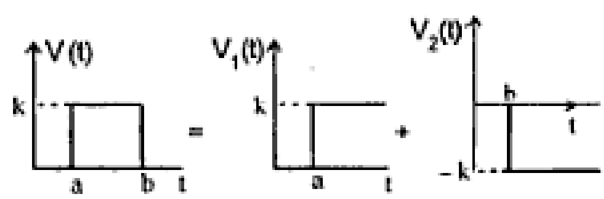
If k is Assigned a value of 1, it is a unit step function

$$u(t) = \begin{cases} 1 ; & t \geq 0 \\ 0 ; & t < 0 \end{cases}$$

(ii) **Rectangular input pulse function :**
A modification of the step function is the rectangular pulse function.



(iii) **Gate function :**
It is the time difference or delayed of two step function.



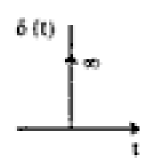
Where, $V(t) = V_1(t) + V_2(t)$

$V(t) = ku(t-a) - ku(t-b)$

Also V_1 (t) and V_2 (t) are called the time delayed version of step function.

(iv) **Unit impulse function :**
An impulse is a unit step of extremely large magnitude and infinitesimal duration. If we go on reducing the width of the pulse keeping the area constant, the pulse height will increase as duration becomes shorter so that $t \to 0$, magnitude $\to \infty$
Mathematically impulse function defined as :

$$\delta(t) = \begin{cases} 1 ; & t = 0 \\ 0 ; & t \neq 0 \end{cases}$$



$$\delta(t-a) = \begin{cases} 1 ; & t = a \\ 0 ; & t \neq a \end{cases}$$

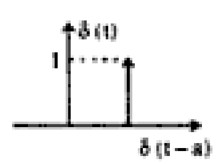


Fig. : Delayed Impulse δ (t – a)

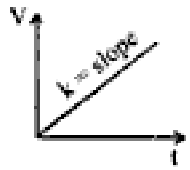
Properties of impulse function :

(a) $\int_{-\infty}^{\infty} \delta(t)\, dt = 1$

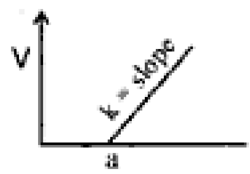
(b) $\int_{-\infty}^{\infty} x(t)\, \delta(t)\, dt = x(0)$

(v) **Ramp function :**
Ramp function defined as

$$V(t) = \begin{cases} kt\, u(t)\,; & t \geq 0 \\ 0\,; & t < 0 \end{cases}$$



the value of the function V(t) rises uniformly at a constant rate k called the slope of the ramp function.
Unit ramp is the integral of the unit step, conversely unit step is the derivative of the unit ramp.
Figure given below called the time delayed ramp function



$V(t) = k(t - a)\, u(t - a).$

Average and Effective Values (or r.m.s. value) :
The figures shown below are some periodic waveforms

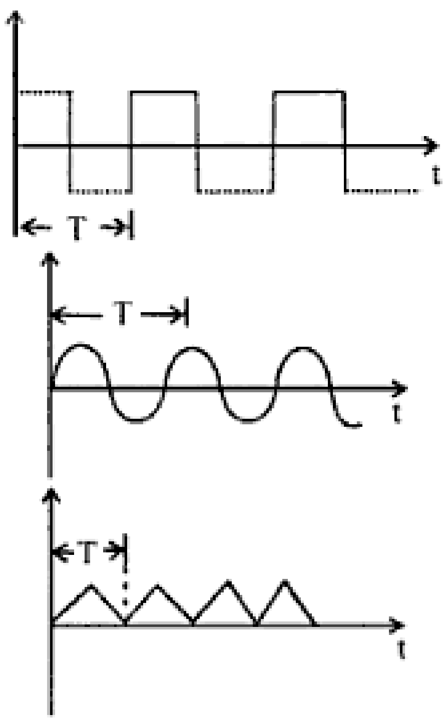


Fig. : Periodic waveforms

(i) **Average value :**
The general periodic function y (t) with period T has an average value Y_{av} is given by

$$\boxed{Y_{av} = \frac{1}{T}\int_0^T y(t)\, dt}$$

(ii) **R.M.S. or effective value :**
The general function y (t), with, period T has an effective value Y_{rms} given by

$$Y_{rms} = \sqrt{\frac{1}{T}\int_0^T \overline{y^2(t)}\, dt}$$

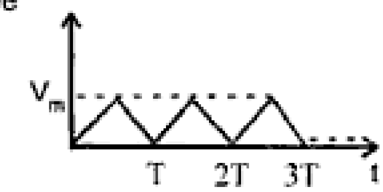
(iii) **Voltmeter** and a **ammeter** always reads a rms value.

Notes :

(i) RMS value of a function $V_m \sin \omega t$ and $V_m \cos \omega t$ is $\frac{V_m}{\sqrt{2}}$.

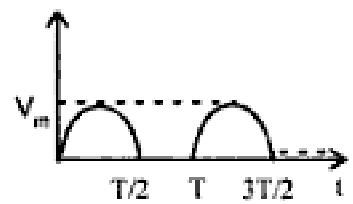
(ii) RMS value of a square wave is always equals to the peak value.

(iii) For wave



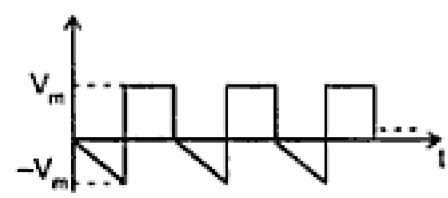
$$\begin{cases} V_{rms} = \dfrac{V_m}{\sqrt{3}} \\ V_{av} = \dfrac{V_m}{2} \end{cases}$$

(iv) For wave



$$\left.\begin{aligned} V_{rms} &= \frac{V_m}{\sqrt{2}} \text{ for F.W.R.} \\ V_{av} &= \frac{2V_m}{\pi} \text{ for F.W.R.} \end{aligned}\right\} \quad \begin{cases} V_{rms} = \dfrac{V_m}{2} & \text{for H.W.R.} \\ V_{av} = \dfrac{V_m}{\pi} & \text{for H.W.R.} \end{cases}$$

(v) RMS value of combined waveform like



can be calculated as :

$$V_{rms} = \frac{1}{\sqrt{2}}\left[\sqrt{\begin{pmatrix}\text{RMS value} \\ \text{of first waveform}\end{pmatrix}^2 + \begin{pmatrix}\text{RMS value} \\ \text{of second waveform}\end{pmatrix}^2}\right]$$

(vi) RMS value for several sine and cosine terms like :
$Y(t) = a_0 + (a_1 \cos \omega t + a_2 \cos 2\omega t + \ldots\ldots) + (b_1 \sin \omega t + b_2 \sin 2\omega t + \ldots\ldots)$
then effective or rms value for this waveform is given as

$$Y_{rms} = \sqrt{a_0^2 + \frac{1}{2}(a_1^2 + a_2^2 + \ldots.) + \frac{1}{2}(b_1^2 + b_2^2 + \ldots)}$$

(vii) Waveforms with half wave symmetry, *i.e.*

$f(t) = -f\left(t + \frac{T}{2}\right)$ have an average value of zero.

- **Form Factor :**

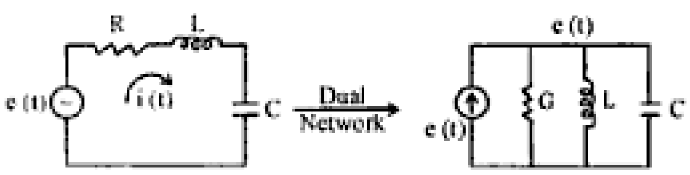
  Form factor may be defined as the ratio of rms value to the average value *i.e.*

$$\text{Form factor} = \frac{V_{rms}}{V_{av}} = \frac{\sqrt{\frac{1}{T}\int_0^T y(t)^2\, dt}}{\frac{1}{T}\int_0^T y(t)\, dt}$$

- **Construction of a Dual Network :**

  Before discussing the construction of a dual network one things must be clear about the element and their dual element.

Element	Dual element
Resistance	Conductance
Capacitance	Inductance
Inductance	Capacitance
Series branch	Parallel branch
Voltage source	Current .source
Charge	Flux linkage
Mesh	Node
Link	Twig.



Network **Dual Network**

Applying KVL

$$e(t) = i(t)R + L\frac{di(t)}{dt} + \frac{1}{C}\int i(t)\, dt$$

$$i(t) = G\,e(t) + C\frac{de(t)}{dt} + \frac{1}{L}\int e(t)\, dt$$

- **Laplace Transform Analysis and Circuit Transients :**

  Laplace transform is exceptionally important tool that is used extensively in electric circuit analysis. It is an operation associating a time function f (t), defined in the interval $0 \le t \le \infty$, with a function F (s) in the complex frequency plane or s-plane. The complex frequency variable (s-operator) is given by $s = \sigma + j\omega$ where σ is real quantity and ω is imaginary quantity. And one sided Laplace transform of a function f (t) is obtained by multiplying f (t) by e^{-st} and integrating the product between the limits of zero and infinity, that is

$$L[f(t)] = \int_0^{\infty} f(t)\, e^{-st}\, dt = F(s)$$

- F (s) is called the Laplace transform of f (t). The function f (t) and F (s) constitute a Laplace transform pair.

- For the two side Laplace transformation, the limits on the integration are from $-\infty$ to ∞.

  There are one integral in box is an improper integral, it exists only under certain conditions. The condition for a function f (t) to be Laplace transformable is given by

$$\int_0^{\infty} |f(t)|\, e^{-\sigma_0 t} < \infty$$

  for positive values of σ_0.

- **Basic Laplace Transform Properties :**

Property	Time domain	Frequency domain
Linearity	$a_1 f_1(t) + a_2 f_2(t)$	$a_1 F_1(s) + a_2 F_2(s)$
Integration property	$\int_0^t f(t)\, dt$	$\frac{F(s)}{s}$
Differentiation property	$\frac{df(t)}{dt}$	$sF(s) - f(0)$
	$\frac{d^2 f(t)}{dt}$	$s^2F(s) - s\,f(0) - f'(0)$
	$\frac{d^3 f(t)}{dt^3}$	$s^3F(s) - s^2 f(0) - sf'(0)$ $f''(0)$

- **In general the differentiation property for the nth derivative is given by the relation**

$$L[f^n(t)] = L\left[\frac{d^n f(t)}{dt^n}\right]$$
$$= s^n F(s) - s^{n-1} f(0) - s^{n-2} f'(0) \ldots\ldots - f^{n-1}(0)$$

- **The Laplace transform of the nth integral of a function.**

  $L[f^{-n}(t)]$ = nth indefinite integral of f (t), that is the nth integral of f (t) between the limits $-\infty$ and t

$$L[f^{-n}(t)] = \frac{1}{s^n} F(s) + \frac{1}{s^{n-1}} f^{-1}(0) + \frac{1}{s^{n-2}} f^{-2}(0) + \ldots + \frac{1}{s} f^{-n}(0)$$

- **Laplace transform of the nth definite integral is given by**

$$L\left[\int_0^t \int_0^t \ldots \int_0^t f(t)\, dt \ldots dt\right] = \frac{L[f(t)]}{s^n}$$

- **Complex frequency differentiation**

$$F^n(s) = \frac{d^n F(s)}{ds^n} = L[(-t)^n f(t)], \quad n = 1, 2, 3, \ldots$$

- **Complex frequency (s domain) integration.**

If $\frac{1}{t}$ f (t) is Laplace transformable, then

$$L\left[\frac{1}{t} f(t)\right] = \int_s^\infty F(s)\, ds$$

where F(s) is the Laplace transform of f (t)

In general $L \frac{f(t)}{t^n} = \int_s^\infty ds \ldots \int_s^\infty F(s)\, ds$

n integrals.

- **Time-shift property :**

If the original time function is shifted to the right by a units of time, its Laplace transform is equal to the original Laplace transform multiplied by e^{-as}.

i.e.

$$L[f(t-a)] = e^{-as} \int_0^\infty f(\tau)\, e^{-s\tau}\, d\tau = e^{-as} F(s)$$

- **Complex frequency shift property :**

If L f (t) = F (s) and a is real or complex number then

$$L[e^{-at} f(t)] = F(s+a)$$

Note : Multiplication by e^{-at} in the time domain is equivalent to translation by 'a' in the s domain.

- **Scaling :**

Scaling by the factor 'a' in the time domain corresponds to scaling 's' by the factor $\frac{1}{a}$.

$$L[f(at)] = \frac{1}{a} F\left(\frac{s}{a}\right)$$

Example : Find the Laplace transform of $\frac{1}{t}$ sin t and determine the value of $\int_0^\infty \frac{\sin t}{t}\, dt$.

Solution :

$$L \sin t = \frac{1}{1+s^2}$$

$$L \frac{\sin t}{t} = \int_s^\infty \frac{1}{1+s^2}\, ds = \left[\tan^{-1} s\right]_s^\infty$$

$$= \frac{\pi}{2} - \tan^{-1} s = \tan^{-1} \frac{1}{s}.$$

Also $L \frac{\sin t}{t} = \int_0^\infty \frac{\sin t}{t} e^{-st}\, dt = \tan^{-1} \frac{1}{s}$

if $s \to 0$ $\int_0^\infty \frac{\sin t}{t}\, dt = \frac{\pi}{2}$

- **Initial and Final Value Theorem :**

The initial value theorem states that if f(t) and its derivative f' (t) are Laplace transformable, then the initial value f (0) of the function f (t) is given by

$$f(0) = \lim_{t \to 0} f(t) = \lim_{s \to \infty} sF(s)$$

- The final value theorem states that if the function f (t) and its derivative f'(t) are Laplace transformable then the final value f (∞) of the function f (t) is given by

$$f(\infty) = \lim_{t \to \infty} f(t) = \lim_{s \to 0} sF(s)$$

Notes :

(i) Final value theorem is applicable for the stable system only. If there is any poles on the imaginary axis then final value theorem is not applicable.

(ii) Final value theorem is useful where the transform solution of problem is available and needed information is about the final or steady state value.

- **Some Laplace Transform Pairs :**

Function = f (t)	F (s) = Laplace transform
δ (t) (unit impulse function)	1
u (t)	1/s
r (t) = tu (t)	$1/s^2$
t^n u (t)	$\frac{n!}{s^{n+1}}$
$e^{-\alpha t}$ u (t)	$\frac{1}{s+\alpha}$
(sin ωt) u (t)	$\frac{\omega}{s^2+\omega^2}$
(cos ωt) u (t)	$\frac{s}{s^2+\omega^2}$
[(sinh λt)] u (t)	$\left[\frac{\lambda}{s^2-\lambda^2}\right]$
(cosh λt) u (t)	$\left(\frac{s}{s^2-\lambda^2}\right)$
($e^{-at} t^n$) u (t)	$\frac{n!}{(s+a)^{n+1}}$
t sin ωt	$\frac{2\omega s}{(s^2+\omega^2)^2}$
t cos ωt	$\frac{s^2-\omega^2}{(s^2+\omega^2)^2}$
(t sin ωt) u (t)	$\frac{2\omega s}{(s^2+\omega^2)^2}$

Note : We follow the following steps in solving problems of first order RL and RC circuits.

Step 1 : We consider a steady state before the switch changes its position at $t = 0$. *i.e.*, for $t = 0^-$, we apply the steady state conditions.

Note for step 1 :

(a) D.C. circuit are in a 'steady state' since the current and voltages do not change in time we also use the term steady state to describe currents and voltages that display repetitive temporal waveform. Thus systems in which the currents and voltages can be described by constant amplitude constant frequency sinusoidal functions are also considered to be in a steady state.

And the term 'transient' refers to the behaviour of the voltage or current when it is in transition between one state to another.

(b) At steady state capacitor behaves as open circuit.

$$i_c = C\frac{dV_c}{dt} \text{ for steady state}$$

$$\text{time} \to \infty$$

$\therefore i_c \to 0$ hence open circuit.

and inductor behaves as short circuit.

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

for steady state $t \to \infty$

$\therefore V_L = 0$, hence short circuit.

Step 2 : Then for the changed position of switch we again consider the steady state conditions

In step '1' : We will calculate the value f (0^-).

where f (0^-) can be i_L (0^-) (current through inductor) or V_c (0^-) (Voltage through capacitor).

In step '2' : We will calculate the value f (∞)

where f (∞) can again be described as i_L (∞) and V_c (∞)

At any time 't' the response can be described as

$$f(t) = f(\infty) - \{f(\infty) - f(0^-)\}\, e^{-t/\tau}$$

where f (t) can be current through inductor and voltage through capacitor at any time 't' and $\tau \to$ time constant

Note : For RC, circuit, time constant,

$$\boxed{\tau = R_{eq} \cdot C}$$

where $R_{eq} \to$ resistance seen across terminals of capacitor by replacing all sources with their internal resistances.

Note : For RL circuit, time constant,

$$\boxed{\tau = \frac{L}{R_{eq}}}$$

$R_{eq} \to$ resistance seen across terminals of inductor by replacing all sources with their internal resistance.

Conclusion :

During solving switching *i.e.* ON/OFF based problem, remember general equation for voltage and current

$$i(t) = \{i(0) - i(\infty)\}\, e^{-\frac{t}{\tau}} + i(\infty)$$

and $$V_C(t) = \{V_C(0) - V_C(\infty)\}\, e^{-\frac{t}{\tau}} + V_C(\infty)$$

where, i (0) = initial condition

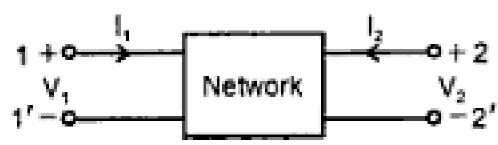
i (∞) = final condition

τ = time constant

Network Function :

(i) **Driving-point Impedance :**

The impedance or admittance found at a given port is called a driving-point impedance (or admittance)



Note : Immittance is a combination of impedance and admittance.

$$Z_{11}(s) = \frac{V_1(s)}{I_1(s)} \text{ (called driving-point impedance at port 1)}$$

$$Z_{22}(s) = \frac{V_2(s)}{I_2(s)} \text{ (called driving-point impedance at port 2)}$$

$$Y_{11}(s) = \frac{I_1(s)}{V_1(s)} \text{ (called driving-point admittance at port 1)}$$

$$Y_{22}(s) = \frac{I_2(s)}{V_2(s)} \text{ (called driving-point admittance at port 2)}$$

(ii) **Transfer function** is used to describe networks which have at least two ports, In general, the transfer function relates the transform of a quantity at one port to the transform of another quantity at another port.

(a) Voltage transfer function

$$G_{21}(s) = \frac{V_2(s)}{V_1(s)}$$

$$G_{12}(s) = \frac{V_1(s)}{V_2(s)}$$

(b) Current transfer function

$$\alpha_{21} = \frac{I_2(s)}{I_1(s)}$$

$$\alpha_{12} = \frac{I_1(s)}{I_2(s)}$$

- **Consider a network function :**

$$H(s) = \frac{a_0 s^n + a_1 s^{n-1} + ... + a_n}{b_0 s^m + b_1 s^{m-1} + ... + b_m}$$

$$= \frac{(a_0/b_0)[(s - Z_1)(s - Z_2)(s - Z_3)....(s - Z_n)]}{[(s - P_1)(s - P_2).....(s - P_m)]}$$

$$= \frac{P(s)}{Q(s)}$$

- **Properties of driving point impedance and admittance functions or necessary conditions for driving point impedance and admittance functions :**

(i) All coefficient of P (s) and Q (s) must be positive and real.

(ii) Complex and imaginary poles and zeros must be conjugate

i.e. $F(s) = \frac{(s + 1)}{(s + 3)(s + 1 - j)}$

is not a driving point impedance function.

(iii) (a) Real part of all poles and zeros must not be positive.

(b) If poles and zeros are imaginary they must be simple (non-repeated).

(iv) There should not be any missing power of 's' between highest and lowest power in numerator and denominator except either all even or odd powers are missing.

(v) The degree of P (s) and Q (s) can at most differ by 1.

(vi) Lowest powers of s in numerator and denominator can differ at most by '1'.

- **Necessary conditions for transfer function :-**

(i) The coefficients in the polynomials P (s) and Q (s) of H (s) = P (s) / Q (s) must be real and those for Q (s) must be positive.

(ii) Poles and zeros which are complex and imaginary must be conjugate.

(iii) The real part of the poles must be either negative or zero, if poles are imaginary, then they must be simple (non-repeated) but zeros can have positive real part also.

(iv) There should not be any missing power of s between lowest and highest power of s in denominator except all odd or all even powers are missing. Numerator can have *i.e.*, (P (s)) can have missing terms of s and some of the coefficients may be negative.

(v) The degree of P(s) may be as small as zero independent of the degree of Q(s).

(vi) (a) For G_{12} and α_{12}, the maximum degree of P(s) is the degree of Q(s).

(b) For Z_{12} and Y_{12}, the maximum degree of P (s) is the degree of Q (s) plus one.

Notes :

(i) Transfer function is the ratio of Laplace transform (L.T.) of the O/P to the L.T. of the input, with all initial condition set to zero.

(ii) The transfer function may be impedance Z(s), admittance Y(s), voltage and current gain G(s) and α (s) respectively.

(iii) The transfer function also indicates the steady state response to sinusoidal inputs. If s is to set to zero, G(0), the dc gain of system is obtained.

- **Two-Port Parameters :**

Brief summary of two port parameters

S.No.	Name	Expression in terms of V and I	Matrix form	Basic equation involved
1.	Z-parameter (open-circuit Impedance)	V_1, V_2 and I_1, I_2	$\begin{bmatrix} V_1 \\ V_2 \end{bmatrix} = \begin{bmatrix} I_1 \\ I_2 \end{bmatrix} \begin{bmatrix} Z_{11} & Z_{12} \\ Z_{21} & Z_{22} \end{bmatrix}$	$V_1 = Z_{11} I_1 + Z_{12} I_2$ $V_2 = Z_{21} I_1 + Z_{22} I_2$
2.	Y-parameter (short-circuit admittance)	I_1, I_2 and V_1, V_2	$\begin{bmatrix} I_1 \\ I_2 \end{bmatrix} = \begin{bmatrix} V_1 \\ V_2 \end{bmatrix} \begin{bmatrix} Y_{11} & Y_{12} \\ Y_{21} & Y_{22} \end{bmatrix}$	$I_1 = V_1 Y_{11} + V_2 Y_{12}$ $I_2 = V_1 Y_{21} + V_2 Y_{22}$
3.	T-parameter (Transmission parameter)	V_1, I_1 and V_2, I_2	$\begin{bmatrix} V_1 \\ I_1 \end{bmatrix} = \begin{bmatrix} V_2 \\ -I_2 \end{bmatrix} \begin{bmatrix} A & B \\ C & D \end{bmatrix}$	$V_1 = AV_2 - I_2B$ $I_1 = CV_2 - I_2D$
4.	Inverse-transmission parameter	V_2, I_2 and V_1, I_1	$\begin{bmatrix} V_2 \\ I_2 \end{bmatrix} = \begin{bmatrix} V_1 \\ -I_1 \end{bmatrix} \begin{bmatrix} A' & B' \\ C' & D' \end{bmatrix}$	$V_2 = A_1V_1 - B_1I_1$ $I_2 = C_1 V_1 - D_1 I_1$
5.	h-parameter (Hybrid parameter)	V_1, I_2 and I_1, V_2	$\begin{bmatrix} V_1 \\ I_2 \end{bmatrix} = \begin{bmatrix} I_1 \\ V_2 \end{bmatrix} \begin{bmatrix} h_{11} & h_{12} \\ h_{21} & h_{22} \end{bmatrix}$	$V_1 = h_{11} I_1 + h_{12} V_2$ $I_2 = h_{21} I_1 + h_{22} V_2$
6.	Inverse-hybrid parameter	I_1, V_2 and V_1, I_2	$\begin{bmatrix} I_1 \\ V_2 \end{bmatrix} = \begin{bmatrix} V_1 \\ I_2 \end{bmatrix} \begin{bmatrix} g_{11} & g_{12} \\ g_{21} & g_{22} \end{bmatrix}$	$I_1 = g_{11} V_1 + g_{12} I_2$ $V_2 = g_{21} V_1 + g_{22} I_2$

- **Condition of Reciprocity and Symmetry :**

(i) **Reciprocal Network :**
Network must be reciprocal when ratio of response at port 2 to the excitation at port 1 is same as ratio of response at port 1 to the excitation at port 2 then Network is called reciprocal

$$\Rightarrow \boxed{\left.\frac{V_2}{I_1}\right|_{I_2=0} = \left.\frac{V_1}{I_2}\right|_{I_1=0}}$$

given $\boxed{Z_{21} = Z_{12}}$

(ii) **Symmetric Network :**
Network is said to be symmetrical if the ratio of current and voltage at some (one) port is same as ratio of current and voltage at other port *i.e.*

$$\boxed{\left.\frac{V_1}{I_1}\right|_{I_2=0} = \left.\frac{V_2}{I_2}\right|_{I_1=0}}$$

$$\Rightarrow \boxed{Z_{11} = Z_{22}}$$

- **Parameter Relationship :**

S. No.	parameter	Condition of Symmetry	Condtion of Reciprocity
1.	Z-parameter	$Z_{11} = Z_{22}$	$Z_{12} = Z_{21}$
2.	Y-parameter	$Y_{11} = Y_{22}$	$Y_{12} = Y_{21}$
3.	h-parameter	$\Delta h = 1$	$h_{12} = -h_{21}$
4.	Inverse h-parameter	$\Delta g = 1$	$g_{12} = -g_{21}$
5.	Transmission parameter	$A = D$	$AD - BC = 1$

Notes :

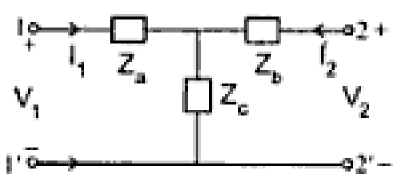
(i) When two ports are connected in parallel it is easier to find Y-parameter.

(ii) When two ports are connected in series it is easier to find Z-parameter.

(iii) When two ports are connected in cascaded it is easier to find A, B, C, D paramter.

- **Some short-cuts to solve two-port network based problems :**

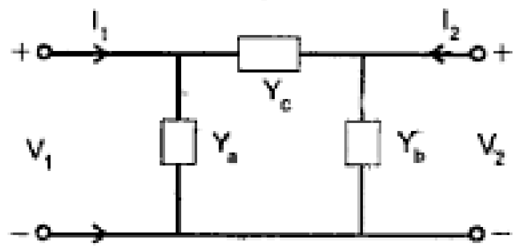
(i) If the given two port like



then remember

$$Z_{11} = Z_a + Z_c$$
$$Z_{22} = Z_b + Z_c$$
$$Z_{12} = Z_{21} = Z_c$$

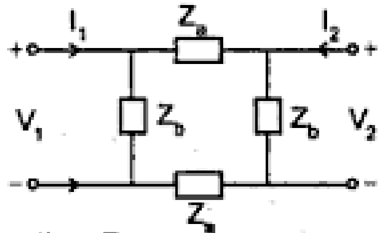
(ii) If the given two-port like



then remember

$$Y_{11} = Y_a + Y_c$$
$$Y_{22} = Y_b + Y_c$$
$$Y_{12} = Y_{21} = -Y_c$$

(iii) If the given two port like

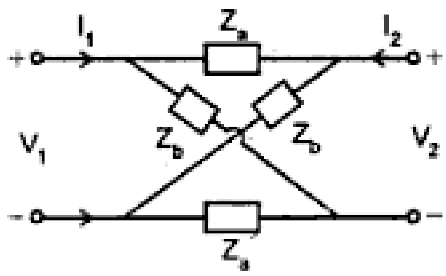


then Remember :

$$Z_{11} = Z_{22} = \frac{Z_b}{2}\left(\frac{Z_b + 2Z_a}{Z_a + Z_b}\right)$$

$$Z_{21} = Z_{12} = \frac{Z_b^2}{2\,(Z_a + Z_b)}$$

(iv) If the given two-port Network like



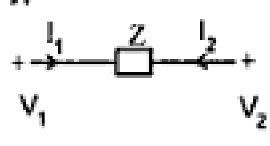
then remember

$$Z_{11} = Z_{22} = \frac{Z_a + Z_b}{2}$$

$$Z_{12} = Z_{21} = \frac{Z_b - Z_a}{2}$$

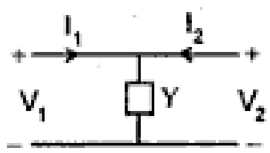
Some typical circuit **their ABCD parameters**

(i)



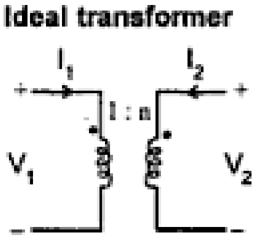
$$\begin{bmatrix} A & B \\ C & D \end{bmatrix} = \begin{bmatrix} 1 & Z \\ 0 & 1 \end{bmatrix}$$

(ii)



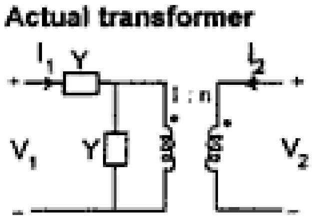
$$\begin{bmatrix} A & B \\ C & D \end{bmatrix} = \begin{bmatrix} 1 & 0 \\ Y & 1 \end{bmatrix}$$

(iii) **Ideal transformer**



$$\begin{bmatrix} A & B \\ C & D \end{bmatrix} = \begin{bmatrix} n & 1 \\ 0 & \frac{1}{n} \end{bmatrix}$$

(iv) **Actual transformer**



$$\begin{bmatrix} A & B \\ C & D \end{bmatrix} = \begin{bmatrix} 1 & Z \\ 0 & 1 \end{bmatrix}\begin{bmatrix} 1 & 0 \\ Y & 1 \end{bmatrix}\begin{bmatrix} n & 1 \\ 0 & \frac{1}{n} \end{bmatrix}$$

$$= \begin{bmatrix} n\,(1 + YZ) & \frac{Z}{n}YZ + 1 \\ nY & \frac{1}{n} + Y \end{bmatrix}$$

Notes :

(i) ABCD parameters always follow the condition $AD - BC = 1$.

(ii) In ABCD parameter I_2 leaving or entering the output terminal does not affects the parameters.

(iii) In case of transformer 1 : n or n : 1 current direction will not affects ABCD parameters.

- **Conversion of parameters :**

(i) Z to Y

$$Y_{11} = \frac{Z_{22}}{\Delta Z},\quad Y_{12} = \frac{Z_{12}}{\Delta Z}$$

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

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

(ii) Y to Z

$$Z_{11} = \frac{Y_{22}}{\Delta Y} \qquad Z_{22} = \frac{Y_{11}}{\Delta Y}$$

$$Z_{12} = \frac{-Y_{12}}{\Delta Y} \qquad Z_{21} = \frac{-Y_{21}}{\Delta Y}$$

where $\Delta Y = Y_{22}\,Y_{11} - Y_{12}\,Y_{21}$

(iii) Z to h

$$h_{11} = \frac{\Delta Z}{Z_{22}} \qquad h_{22} = \frac{1}{Z_{22}}$$

$$h_{12} = \frac{Z_{12}}{Z_{22}} \qquad h_{21} = \frac{-Z_{21}}{Z_{22}}$$

- **Image Impedance :**

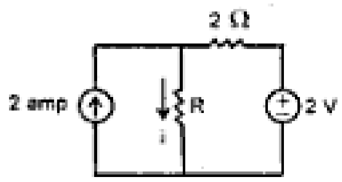
$$Z_{I_1} = \sqrt{\frac{AB}{CD}},\ Z_{I_2} = \sqrt{\frac{BD}{AC}}$$

where Z_{I_1} = input impedance of the filter
= generator impedance.
Z_{I_2} = output impedance of the filter
= antenna impedance for symmetric Network, *i.e.*, A = D.

i.e. $Z_{I_1} = Z_{I_2} = \sqrt{\frac{B}{C}}$

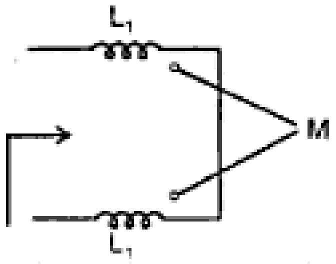
PROBLEMS

1. Given the current through R is i = 1 amp. The value of R is–



(a) 0 (b) 2
(c) 4 (d) 8

2. The equivalent inductance of the network is–



(a) $L_1 + L_2 - 2M$ (b) $L_1 + L_2 + 2M$
(c) $L_1 + L_2 - M$ (d) $L_1 + L_2$

3. The network element and V–L characteristics are shown in fig. (a) and (b). The element is–

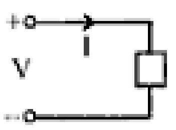


Fig. (a)

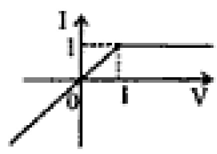
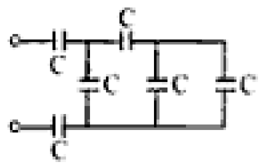


Fig. (b)

(a) Non-linear, active and bilateral
(b) Linear, passive and bilateral.
(c) Non-linear, passive and non-bilateral
(d) Non-linear, active and non-bilateral.

4. The equivalent capacitance for the network shown in the fig. is–



(a) C/4 (b) $\frac{5C}{13}$
(c) 5C/2 (d) 3C

5. Twelve 1Ω resistors are used as edge to form a cube. The resistance between two diagonally opposite corners of the cube is–

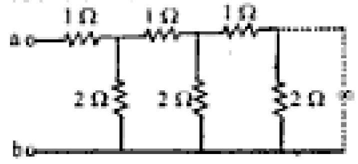
(a) $\frac{5}{6}$ Ω (b) $\frac{6}{5}$ Ω
(c) 1 Ω (d) None of these

6. Twelve 1H inductors are used as edge to form a cube. The inductance between two diagonally opposite corners of cube is–

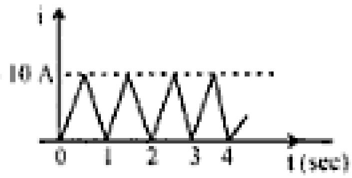
(a) $\frac{5}{6}$ H (b) $\frac{10}{6}$ H
(c) 2 H (d) $\frac{3}{2}$ H

7. The Nodal method of circuit analysis is based on–
(a) KVL and Ohm's law
(b) KCL and Ohm's law.
(c) KCL and KVL
(d) KCL, KVL and Ohm's law

8. The equivalent resistance as seen between the terminals (a, b) is–
(a) 2 Ω
(b) 4 Ω
(c) 1 Ω
(d) Not possible

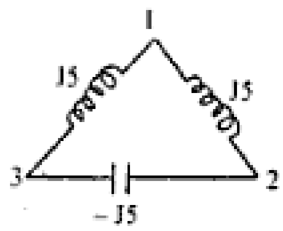


9. The current having the waveform shown in figure is flowing in a resistance of 10 Ω. The average power is–

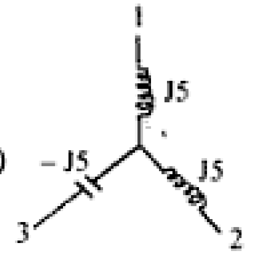


(a) 1000 watt
(b) 1000/2 watt
(c) 1000/3 watt (d) 1000/4 watt

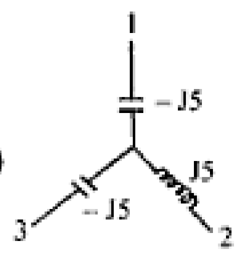
10. Which one of the following networks is the Y equivalent of Δ circuit shown in figure ?



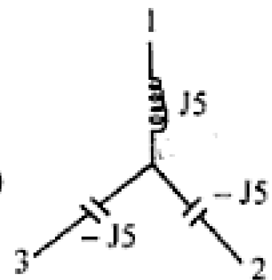
(a)



(b)

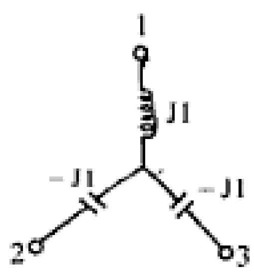


(c)

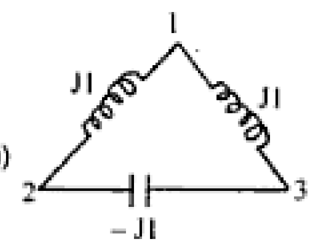


(d) None of these

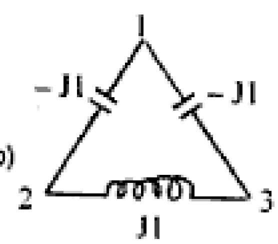
11. Which of the following networks in the Δ equivalent of the circuit shown in figure ?



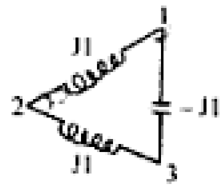
(a)



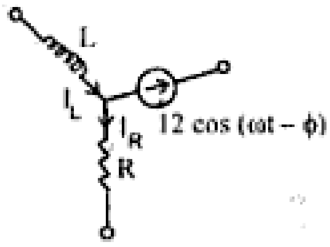
(b)



(c) 

(d) 

12. The network shown, if $i_R = (4\,e^{-3t} + 5\,e^{-4t})$ amp and $i_L(0) = 1$ amp, then ϕ would be equal to–



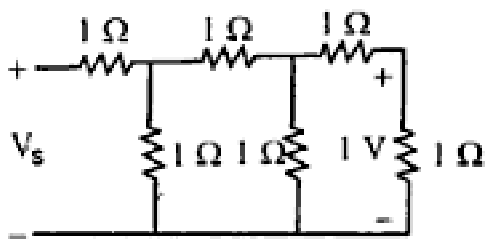
(a) $\frac{\pi}{2}$

(b) $\frac{\pi}{3}$

(c) $\frac{2\pi}{3}$

(d) 2π

13. For the circuit shown in figure, the voltage V_s will be



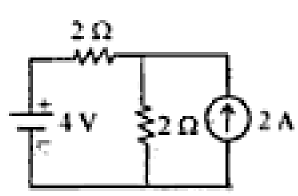
(a) 12 V (b) 8 V
(c) 4 V (d) 13 V

14. An ideal voltage source and ideal current source are connected in parallel this circuit has–
(a) a Norton equivalent but not Thevenin equivalent.
(b) a Thevenin equivalent but not Norton equivalent.
(c) Both the Thevenin and Norton equivalent.
(d) Neither Thevenin nor Norton equivalent.

15. Reciprocity theorem is valid for–
(a) All linear networks
(b) All active elements.
(c) All linear and passive networks
(d) All linear, passive and bilateral networks.

16. The superposition theorem is valid for–
(a) All linear networks
(b) Linear and symmetrical network
(c) Only linear networks having no dependent sources.
(d) Linear as well as non-linear networks.

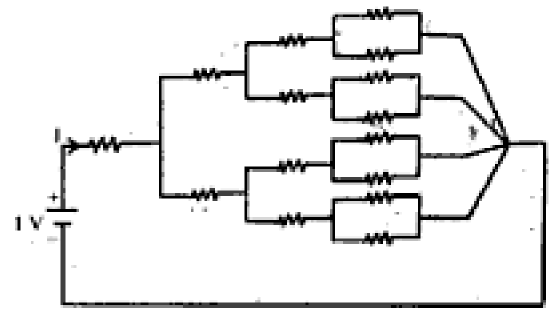
17. The total power consumed in the circuit shown in figure is–



(a) 6 W (b) 8 W
(c) 9 W (d) 12 W

18. Substitution theorem applies to–
(a) linear networks
(b) non-linear networks
(c) linear time-invariant networks
(d) any network

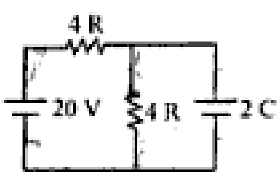
19. All the resistances in the fig. are 1 Ω each. The value of I will be– **(GATE 1992)**



(a) $\frac{1}{15}$ A (b) $\frac{2}{15}$ A

(c) $\frac{4}{15}$ A (d) $\frac{8}{15}$ A

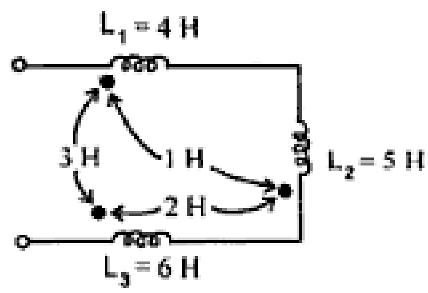
20. The time constant of the network shown in the fig. is–



(a) 4RC
(b) 3RC
(c) 2RC
(d) $\frac{2RC}{3}$

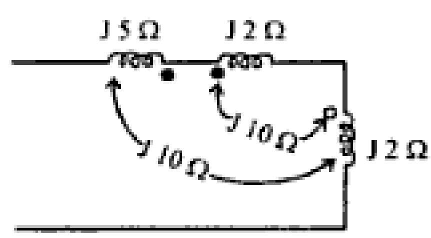
21. The energy stored in the magnetic field at a solenoid 30 cm long and 3 cm diameter wound with 1000 turns of wire carrying a current of 10A, is– **(GATE 1996)**
(a) 0.015 joule (b) 0.15 joule
(c) 0.5 joule (d) 1.15 joule

22. The effective inductance of the circuit across the terminal AB in the figure shown below, is–



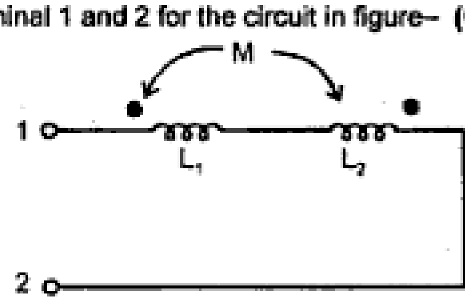
(a) 9 H (b) 21 H
(c) 11 H (d) 6 H

23. Impedance Z as shown in figure– **(GATE 2005)**



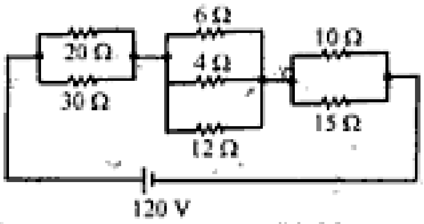
(a) J 29 Ω (b) J 9 Ω
(c) J 19 Ω (d) J 39 Ω

24. The equivalent inductance measured between the terminal 1 and 2 for the circuit in figure– **(GATE 2004)**



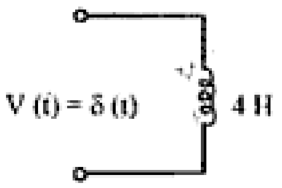
(a) $L_1 + L_2 + M$ (b) $L_1 + L_2 - M$
(c) $L_1 + L_2 + 2M$ (d) $L_1 + L_2 - 2M$

25. In the figure below, the current of 1 ampere flows through the resistance of–



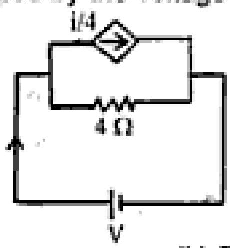
(a) 4 Ω (b) 20 Ω
(c) 30 Ω (d) 12 Ω

26. When a unit impulse voltage is applied to an inductor of 4 H, the energy supplied by the source is–



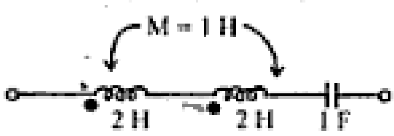
(a) ∞ (b) 5 J
(c) $\frac{1}{8}$ J (d) $\frac{1}{2}$ J

27. In the network shown in the figure, the effective resistance forced by the voltage source is–



(a) 4 Ω (b) 3 Ω
(c) 2 Ω (d) 1 Ω

28. The resonant frequency of the given series is–



(a) $\frac{1}{2\pi\sqrt{3}}$ Hz (b) $\frac{1}{4\pi\sqrt{3}}$ Hz
(c) $\frac{1}{4\pi\sqrt{2}}$ Hz (d) $\frac{1}{2\pi\sqrt{2}}$ Hz

29. Given two coupled inductors L_1 and L_2, their mutual Inductance M satisfies– **(GATE 2001)**

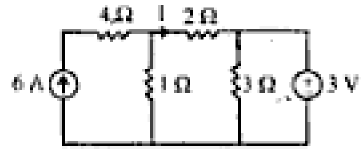
(a) $M = \sqrt{L_1^2 + L_2^2}$ (b) $M > \frac{L_1 + L_2}{2}$
(c) $M > \sqrt{L_1 L_2}$ (d) $M \le \sqrt{L_1 L_2}$

30. Two Incandescent light bulbs of 40 W and 60 W rating are connected in series across the supply voltage, V then– **(GATE 2001)**

(a) the bulbs together consume 100 W
(b) the bulbs together consume 50 W
(c) the 60 W bulb glows brighter.
(d) the 40 W bulb glows brighter.

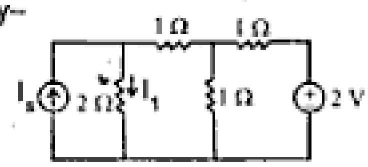
31. A network contains linear resistors and ideal voltage sources. If values of all the resistors are doubled, then the voltage across the resistor is–
(a) halved
(b) doubled
(c) increased by four times
(d) not changed

32. The current I as marked in the figure is–



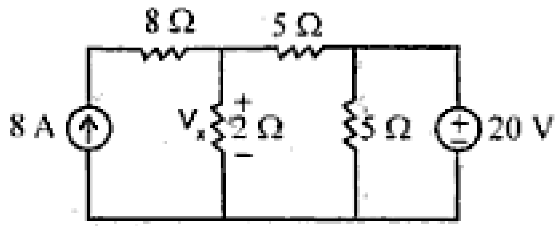
(a) 3 A (b) 2 A
(c) 1 A (d) 0 A

33. In the circuit $V_2 = 2$ V and $I_1 = 2$ amp. The value of I_s is given by–



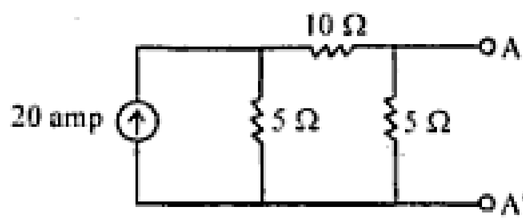
(a) 2 (b) 4
(c) 5 (d) 6

34. The voltage marked V_x is given by–



(a) $\frac{60}{7}$ V (b) $\frac{120}{7}$ V
(c) $\frac{40}{7}$ V (d) None of these.

35. The Thevenin equivalent across AA′ is given by–



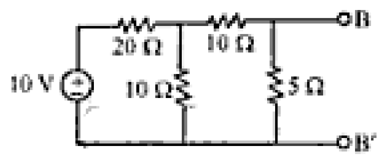
(a) $V_{th} = 5$ V, $R_{th} = \frac{15}{2}$ Ω

(b) $V_{th} = 15$ V, $R_{th} = \frac{15}{4}$ Ω

(c) $V_{th} = 25$ V, $R_{th} = \frac{15}{4}$ Ω

(d) None of these

36. The Norton equivalent across BB′ is given by–



(a) $R_N = \frac{50}{26}$ Ω, $I_{sc} = \frac{2}{5}$ amp

(b) $R_N = \frac{50}{13}\ \Omega, I_{sc} = \frac{1}{5}$ amp

(c) $R_N = \frac{50}{13}\ \Omega, I_{sc} = \frac{2}{5}$ amp

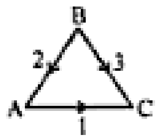
(d) None of the above

37. A connected graph has 'b' number of branches and 'n' number of nodes. Its ranks is–

(a) b (b) n

(c) b – 1 (d) n – 1

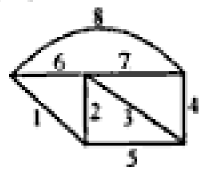
38. For the given graph the incidence matrix 'A' is given by–



(a) $\begin{bmatrix} -1 & -1 & 0 \\ 0 & 1 & 1 \\ -1 & 0 & -1 \end{bmatrix}$ (b) $\begin{bmatrix} 1 & 0 & -1 \\ 1 & 1 & 0 \\ 0 & -1 & 1 \end{bmatrix}$

(c) $\begin{bmatrix} 1 & -1 & 0 \\ 0 & 1 & 1 \\ -1 & 0 & -1 \end{bmatrix}$ (d) None of these

39. For the given graph, match List I with List II–



	List I		List II
(A)	1, 2, 3, 4	(1)	Twigs
(B)	4, 5,6, 7	(2)	Links
(C)	1, 2, 3, 4	(3)	Fundamental cutset
(D)	1, 4, 5, 6, 7	(4)	Fundamental loop

Codes :

	A	B	C	D
(a)	3	1	2	4
(b)	2	3	1	4
(c)	3	2	1	4
(d)	1	2	3	4

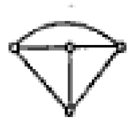
40. For a given network, the number of independent mesh equations (m) and the number of independent node equations (n) are related as follows–

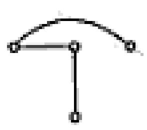
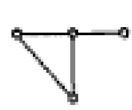
(a) m > n always (b) m < n always

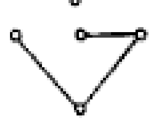
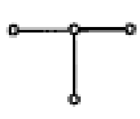
(c) m = n always

(d) m ≥ or < n depending upon the form of the network.

41. Consider the network graph shown in figure. Which one of the following is 'not' a tree of this graph ? **(GATE 2004)**



(a)  (b) 

(c)  (d) 

42. A planar graph has 4 nodes and 5 branches the number of meshes in dual graph is–

(a) 5 (b) 4

(c) 3 (d) 2

43. The graph of a network has six branches with three tree branches. The minimum number of equations required for the solution of the network is–

(a) 2 (b) 3

(c) 4 (d) 5

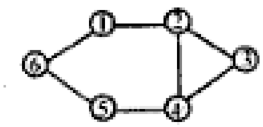
44. For the graph shown below. Find the minimum number of branches that may be added to make the resulting structure non planar–

(a) 2

(b) 3

(c) 4

(d) None of these

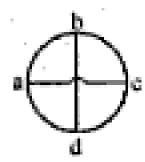


45. For the above figure what is the maximum number of branches you may add before the resulting structure becomes nonplanar ?

(a) 4 (b) 5

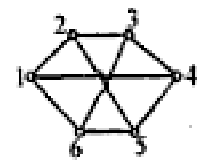
(c) 6 (d) None of these

46. For the given graphs shown below which one is non-planar graph ?



(i)

(ii)

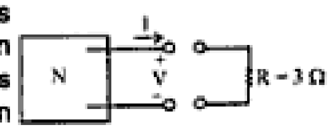


(iii)

(a) (i) only (b) (i) and (ii)

(c) (ii) only (d) (iii) only

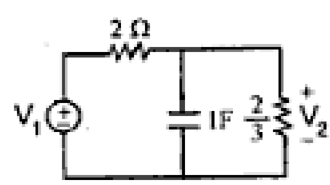
47. The V-I relation for network is $V = 5 - 2I$, when $R = 3\ \Omega$ is connected as shown the value of I is given by–



(a) 5 (b) $\frac{5}{3}$

(c) – 1 (d) 1

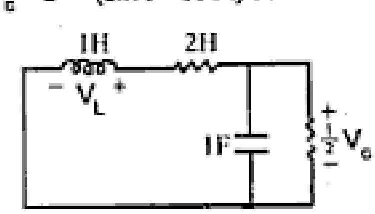
48. Given $V_2 = 1 - e^{-2t}$, the value of V_1 is given by–



(a) $3 + e^{-2t}$ (b) $1 + 3e^{-2t}$

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

49. Given $V_c = e^{-2t}(\sin t + \cos t)$ the value of V_L is given by–



(a) $-e^{-2t}\sin t + 3e^{-2t}\cos t$

(b) $-e^{-2t}\sin t + e^{-2t}\cos t$

(c) $e^{-2t}\sin t - 3e^{-2t}\cos t$

(d) $5e^{-2t}(\sin t - \cos t)$

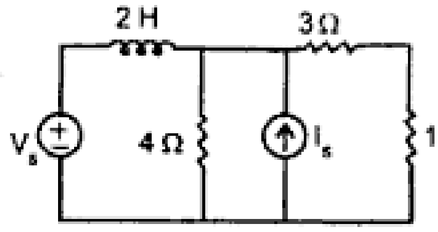
50. The natural frequency S_n of the given circuit is–

(a) 1

(b) – 1

(c) $-\frac{1}{2}$

(d) 2



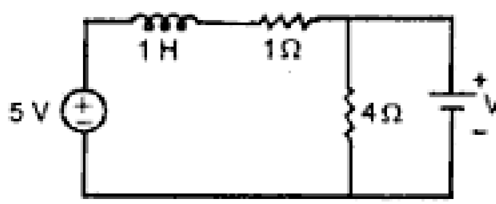
51. Steady state is reached for the circuit. V_C as marked in the circuit is–

(a) 0

(b) 4

(c) 5

(d) $\frac{10}{3}$



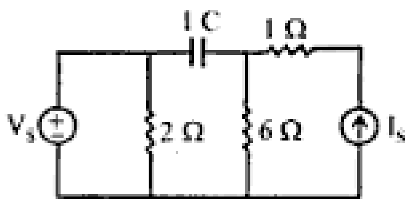
52. The natural frequency of the circuit is given by–

(a) – 6

(b) – 8

(c) $\frac{15}{2}$

(d) – 10



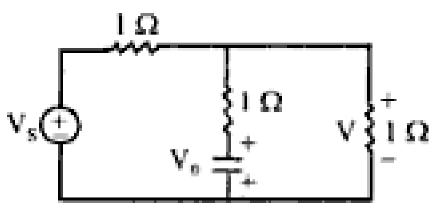
53. Initial voltage on capacitor V_0 as marked $|V_0| = 5$ volts. $V_s = 8\ u\ (t)$, where u (t) is the unit step. The voltage marked V at $t = 0^+$ is given by–

(a) 1 V

(b) – 1 V

(c) $\frac{13}{3}$ V

(d) $-\frac{13}{3}$ V

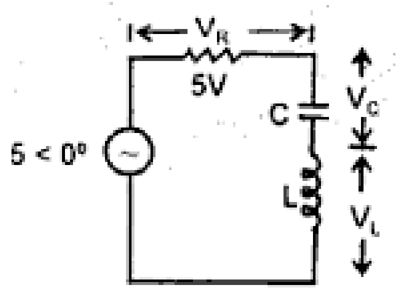


54. A voltage waveform $V(t) = 12\ t^2$ is applied across 1 H inductor for $t \geq 0$, with initial current through it being zero the current through the inductor for $t \geq 0$ is given by– **(GATE 2003)**

(a) 12 t (b) 24 t

(c) $12\ t^3$ (d) $4\ t^3$

55. In the circuit of the given figure, the magnitude of V_L and V_C are twice that of V_R. The inductance of the coil is– **(GATE 2003)**



(a) 2.14 mH (b) 5.30 H

(c) 31.8 mH (d) 1.32 H

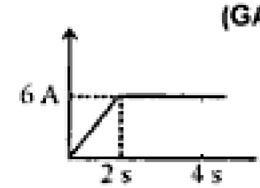
56. Figure shows the waveform of the current passing through an inductor of resistance 1 Ω and Inductance 2H. The energy absorbed by the inductor in the first four seconds is– **(GATE 2003)**

(a) 144 J

(b) 98 J

(c) 132 J

(d) 168 J



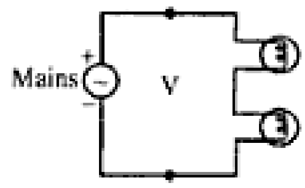
57. The incandescent bulbs respectively as P_1 and P_2 for operation at a specified main voltage are connected in series across the mains as shown in the figure, then the total power supplied by the mains to the two bulbs–

(a) $\frac{P_1 P_2}{P_1 + P_2}$

(b) $\sqrt{P_1^2 + P_2^2}$

(c) $(P_1 + P_2)$

(d) $\sqrt{P_1 \times P_2}$



58. If the number of branches in a network is B, the number of nodes is N and the number of dependent loop is L, then the number of independent node equations will be–

(a) N + L – 1 (b) B – 1

(c) N – 1 (d) B – N

59. A connected network of N > 2 nodes has at most one branch directly connecting any pair of nodes. The graph of the network– **(GATE 2001)**

(a) must have at least N branches for one or more closed paths to exist.

(b) can have an unlimited number of branches.

(c) can only have at most N branches.

(d) can have minimum number of branches not decided by N.

60. A network has 7 nodes and 5 independent loops. The number of branches in the network is–

(a) 13 (b) 12

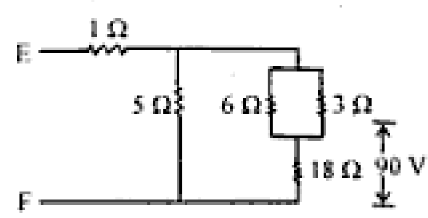
(c) 11 (d) 10

61. The number of independent loops for a network with n nodes and b branch is–

(a) n – 1 (b) b – n

(c) b – n + 1 (d) Independent of the number of nodes

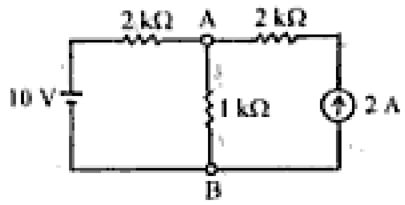
62. In the figure below, the voltage across the 18 ohm resistor is 90 volts. What is the total voltage across the combined circuit at terminal E and F ?



(a) 125 V (b) 16 V

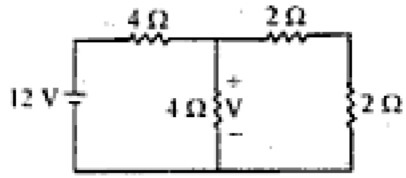
(c) 24 V (d) 40 V

63. The voltage across the 1 kΩ resistor between A and B of the network shown in the given figure is–



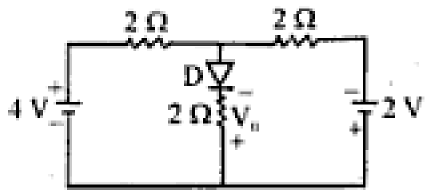
(a) 12 V
(b) $\frac{34}{3}$ V
(c) 10 V
(d) $\frac{26}{3}$ V

64. The voltage V in the given figure is–



(a) 2 V
(b) $\frac{4}{3}$ V
(c) 4 V
(d) 8 V

65. For the circuit shown below in the figure, the voltage V_0 is–



(a) 2 V
(b) 1 V
(c) – 1 V
(d) None of these

66. For V (s) = $\frac{(s+2)}{s(s+1)}$, the initial and final values of V (t) will be respectively–
(a) 1 and 1
(b) 2 and 1
(c) 2 and 2
(d) 1 and 2

67. The Laplace transform of $(t^2 - 2t)\,u(t-1)$ is–

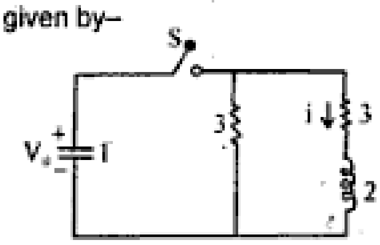
(a) $\frac{2}{s^3}e^{-s} - \frac{2}{s^2}e^{-s}$
(b) $\frac{2}{s^3}e^{-s} - \frac{2}{s^2}e^{-s}$
(c) $\frac{2}{s^3}e^{-2s} - \frac{1}{s}e^{-s}$
(d) None of these

68. The impulse response of an R-L circuit is a–
(a) rising exponential function
(b) decaying exponential function
(c) step function
(d) parabolic function

69. If the unit step response of a network is $(1 - e^{-\alpha t})$, then its unit impulse response will be–

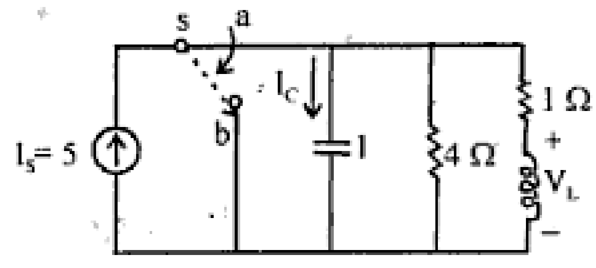
(a) $\alpha e^{-\alpha t}$
(b) $\frac{1}{\alpha}e^{-t/\alpha}$
(c) $\frac{1}{\alpha e^{-t/\alpha}}$
(d) $(1-\alpha)e^{-\alpha t}$

70. S is open, $V_0 = 6$ V, i = 0. S is closed at t = 0, the values of i and $\frac{di}{dt}$ at t = 0^+ are given by–



(a) 0, 6
(b) 2, 0
(c) 1, 3
(d) 0, 3

71. S is in position (a) for a long time. S moved to position (b) at t = 0^-. At t = 0^+, the values of I_C and V_L are–

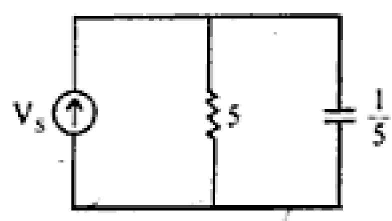


(a) – 5, 0
(b) 5, 0
(c) 0, 4
(d) – 2, 3

72. Given H (s) = $\frac{X}{Y} = \frac{s+1}{s^2+s+1}$. x (t) = cos t ∠0°. The phasor Y is given by–

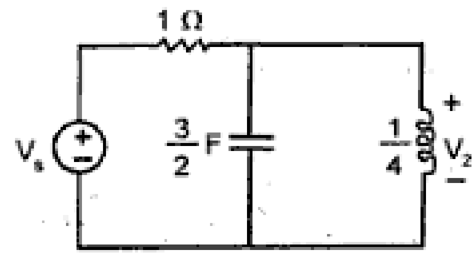
(a) $\sqrt{2}\,\angle 45°$
(b) $\frac{1}{\sqrt{2}}\,\angle 45°$
(c) $1\,\angle 0°$
(d) $\frac{\sqrt{2}}{\sqrt{5}}\,\angle\tan^{-1}1 - \angle\tan^{-1}2$

73. In the figure V_s = 10 cos t = 10 ∠0°. The current drawn from V_s is given by the phasor–



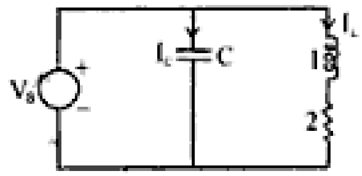
(a) $\frac{2}{\sqrt{5}}\,\angle -45°$
(b) $2\sqrt{2}\,\angle 45°$
(c) $2\,\angle 0°$
(d) $2\,\angle 90°$

74. Given V_2 = 2 cos 2t = 2 ∠0°, the value of V_s is given by–



(a) $3\,\angle 0°$
(b) $\sqrt{29}\,\angle\tan^{-1}2.5$
(c) $\sqrt{104}\,\angle\tan^{-1}5$
(d) $2\sqrt{2}\,\angle 45°$

75. In the circuit V_s = cos 2t. The value of C is chosen so that I from V_s is in phase with V_s. Then I_c leads I_L by an angle given by–



(a) 45°　　(b) 90°
(c) 135°　　(d) 0°

76. $P_{complex}$ = 200 + J 150 from a source V_s = 200 cos ωt. The impedance across V_s is given by–
(a) 16 + J 12　　(b) 128 + J 96
(c) 64 + J 48　　(d) 32 + J 24

77. A source V_s = 100 cos ωt is connected to an impedance which drawn a power P_{av} = 200 watts at power factor 0.8 lagging. The current drawn from the source is I = I_m cos (ωt + θ). The value of I_m and θ are given by–
(a) 5 and $-\cos^{-1} 0.8$　　(b) 5 and $-\cos^{-1} 0.8$
(c) $\frac{5}{\sqrt{2}}$ and $\cos^{-1} 0.8$　　(d) 5 and 0

78. A source V_s = 200 cos ωt delivers power to a load at power factor 0.8 lagging. The reactive power is 300 VAR. The P_{av} is given by–
(a) 200 watts　　(b) 225 watts
(c) 400 watts　　(d) 300 watts

79. The dimension of LC is–
(a) zero　　(b) $\left(\frac{\text{volt}}{\text{ampere}}\right)^2$
(c) $(\text{second})^{-2}$　　(d) $(\text{second})^2$

80. In fig. (a) the values i_L, V_c as shown have initial values $i_L(0^-) = 1$ and $V_c(0^-) = 2$ fig. (b) is the equivalent circuit in the s-domain. The values of V_1 and V_2 are–

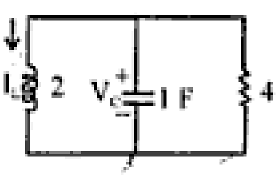


Fig. (a)

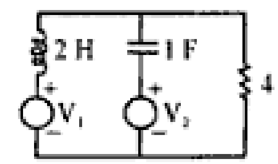


Fig. (b)

(a) + 2 and $\frac{2}{5}$　　(b) – 2 and $\frac{2}{5}$
(c) $\frac{2}{5}$ and 2　　(d) 1 and 2

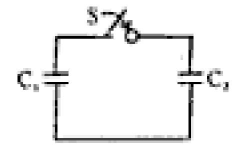
81. The total impedance of the circuit shown is–

(a) 20 Ω
(b) (20 + J 10) Ω
(c) (20 – J 10) Ω
(d) (20 + J 5) Ω

82. A voltage has a value of V = 180 cos (ωt + 12°) and current – i = 2.5 cos (ωt + 5°) the power factor of the circuit is–
(a) 0.978　　(b) 0.996
(c) 0.993 lead　　(d) 0.993 lag

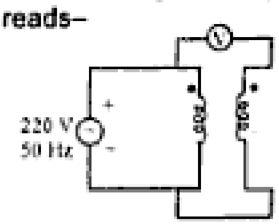
83. A long uniform coil of inductance 2L and associated resistance 2R ohms is physically cut into two exact halves which are rewound in parallel. The resistance and inductance of the combination are–
(a) R and L　　(b) 2R and 2L
(c) $\frac{R}{2}$ and $\frac{L}{2}$　　(d) $\frac{R}{4}$ and $\frac{L}{4}$

84. The capacitor C_1 in the circuit shown has a voltage of 20 V across it before the switch S is closed at time t = 0. C_1 = 2 μF and C_2 = 3 μF. The voltage across C_2 after S is closed is–



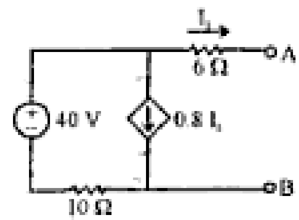
(a) 8 V
(b) 10 V
(c) 12 V
(d) 15 V

85. The voltmeter in the shown circuit is ideal. The transformer has identical windings with perfect coupling. The voltmeter reads–



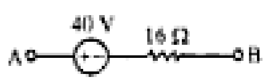
(a) 110 V
(b) 220 V
(c) 440 V
(d) 0 V

86. The Thevenin equivalent of the following network between A and B is–



(a)

(b)


(c)

(d)


87. The Laplace transforms of the functions t, u (t) and u (t) sin t are respectively–
(a) $\frac{1}{s}, \frac{s}{s^2+1}$　　(b) $\frac{1}{s}, \frac{1}{s^2+1}$
(c) $\frac{1}{s^2}, \frac{1}{s^2+1}$　　(d) $s, \frac{5}{s^2+1}$

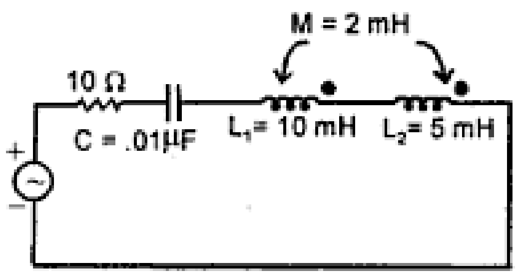
88. The Laplace transform of a function f (t) u (t), where f (t) is periodic with period T, is A(s) times the L.T. of its first period. Then–
(a) A(s) = s　　(b) $A(s) = \frac{1}{1 - e^{-Ts}}$
(c) $A(s) = \frac{1}{1 + e^{-Ts}}$　　(d) $A(s) = e^{Ts}$

89. If the L.T. of the voltage across a capacitor of value 1/2 F is $V_1(s) = \frac{s+1}{s^3 + s^2 + s + 1}$ then value of the current through the capacitor at $t = 0^+$ is–

(a) 0 A (b) 2 A

(c) $\frac{1}{2}$ A (d) 1 A

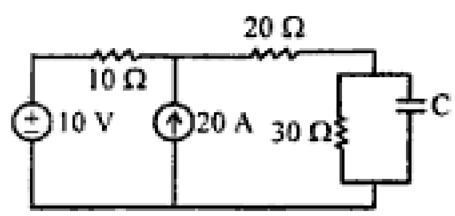
90. The resonant frequency of the circuit–



(a) $\frac{10^5}{2\pi\sqrt{1.9}}$ Hz (b) $\frac{10^5}{2\pi\sqrt{1.1}}$ Hz

(c) $\frac{10^4}{2\pi\sqrt{1.9}}$ Hz (d) $\frac{10^4}{2\pi\sqrt{1.1}}$ Hz

91. The time constant of the circuit–



(a) $\frac{60}{5}$ C (b) 15 C

(c) 25 C (d) None of these

92. Maximum power form a source having internal resistance R_i is delivered to a resistive load R_L if–

(a) $R_i = R_L$ (b) $R_i > R_L$

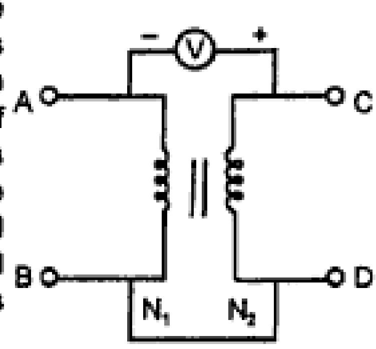
(c) $R_i < R_L$ (d) $R_i = R_L^2$

93. A capacitor is charged by a square wave current source, the voltage across the capacitor is–

(a) a square wave (b) a triangular wave

(c) a step function (d) zero

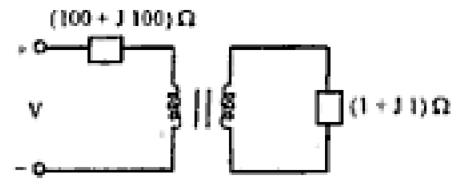
94. A single phase transformer is connected as shown in fig. when a voltage of 100 V (rms) was applied across AB, the voltmeter connected across AC measured 100 V (rms). The turns ratio $N_1 : N_2$ is–



(a) 1 : 1 (b) 1 : 2

(c) 2 : 1 (d) 4 : 1

95. In the figure the transformer is ideal with adjustable turns ratio $\frac{N_2}{N_1}$. The turns ratio $\frac{N_2}{N_1}$ for maximum power transfer to the load is–



(a) 1 : 1 (b) 100 : 1

(c) 1 : 100 (d) 1000 : 1

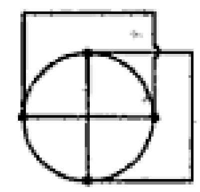
96. The number of branches and nodes in the graph are–

(a) 5, 10

(b) 10, 5

(c) 10, 10

(d) 6, 10



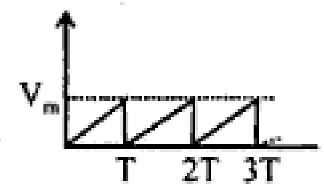
97. Find the rms value of the wave show below–

(a) $\frac{V_m}{\sqrt{3}}$

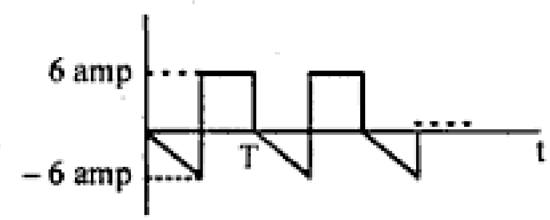
(b) $\frac{2V_m}{\sqrt{3}}$

(c) $\frac{V_m}{\sqrt{2}}$

(d) $\frac{V_m}{2}$



98. Calculate the rms value of the given wave–



(a) $2\sqrt{6}$ A (b) $6\sqrt{2}$ A

(c) $\sqrt{\frac{4}{3}}$ A (d) 1.5 A

99. Calculate the rms value of the given wave–

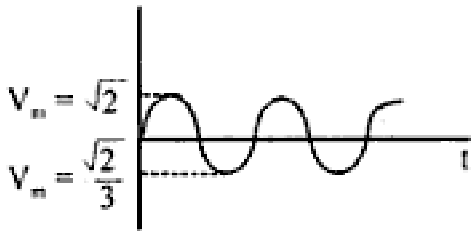
(a) $\sqrt{\frac{15}{10}}$ A

(b) $\sqrt{\frac{5}{12}}$ A

(c) $\sqrt{\frac{15}{9}}$ A

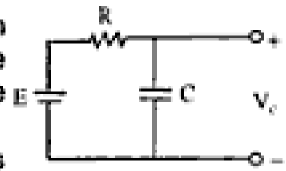
(d) $\sqrt{\frac{12}{15}}$ A

100. The r.m.s. value for the given wave is given by–



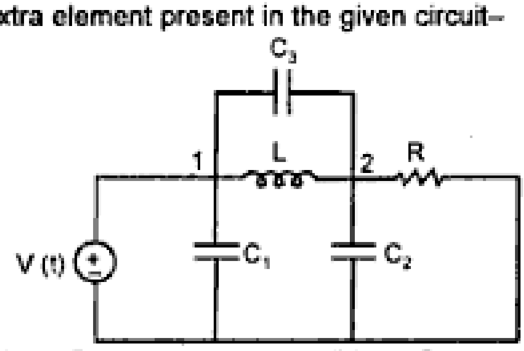
(a) $\sqrt{10/18}$ (b) $\sqrt{2}$
(c) $\sqrt{12/18}$ (d) None of these

101. For the figure given below which of these sets of E, R and C value will ensure that the state equation $\frac{dV_C}{dt} = 1.25 V_C + 2$ is valid–



(a) 2 V, 1 Ω, 1.25 F (b) 1.6 V, 0.8 Ω, 1 F
(c) 1.6 V, 1Ω, 0.8 F (d) 2 V, 1.25 Ω, 1 F

102. Extra element present in the given circuit–



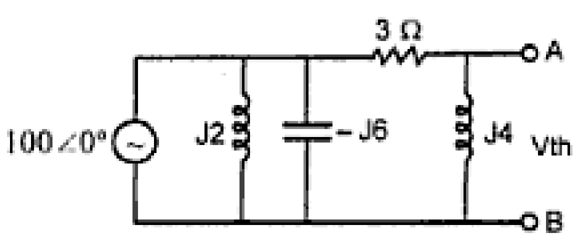
(a) C_1 (b) C_2
(c) C_3 (d) R

103. Given T.F. $H(s) = \frac{s+2}{s^2+s+4}$, under steady state condition, the sinusoidal input and output are respectively–

x (t) = cos 2t
y (t) = cos (2t + ϕ), then angle ϕ of will be

(a) 45° (b) 0°
(c) – 45° (d) – 90°

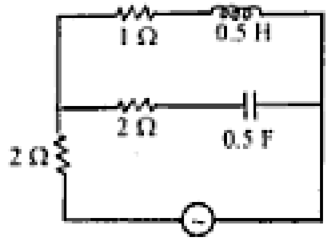
104. The Thevenin equivalent voltage V_m appearing between the terminals A and B of the network shown is given by–



(a) J 16 (3 – J 4) (b) J 16 (J 3 + 4)
(c) J 6 (3 + J 4) (d) J 6 (3 – J 4)

105. For a given voltage four heating coils will produce max. heat when connected in–
(a) All in parallel
(b) All in series
(c) With two parallel pairs in series
(d) One pair in parallel with other two in series

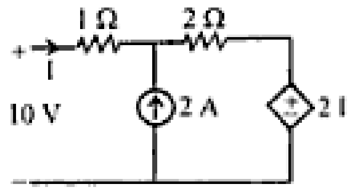
106. The complex power in the circuit shown below will be–



10 sin (2t – 40°) volt

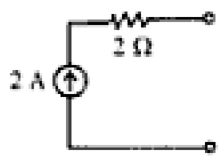
(a) 16.5 ∠– 6.3° (b) 16.5 ∠6.3°
(c) 33 ∠– 6.3° (d) 33 ∠+ 6.3°

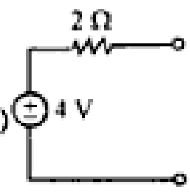
107. The current I in the circuit will given by–

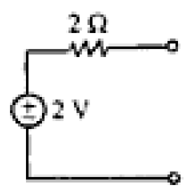


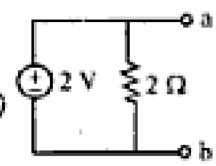
(a) 5 amp (b) 1.2 amp
(c) 2.4 amp (d) 0.6 amp

108. The Thevenin equivalent of the given at terminal a – b will be–



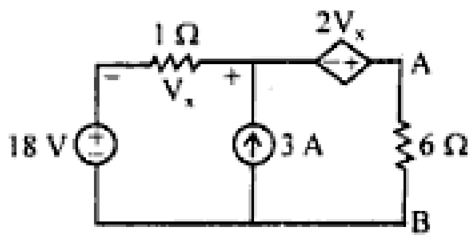
(a) 

(b) 

(c) 

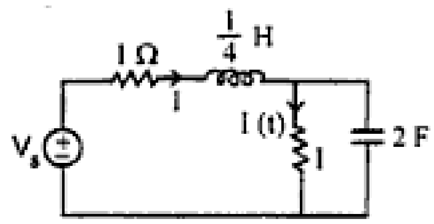
(d) Not feasible

109. Find the Thevenin voltage and resistance for the network shown below across the terminal A.B–



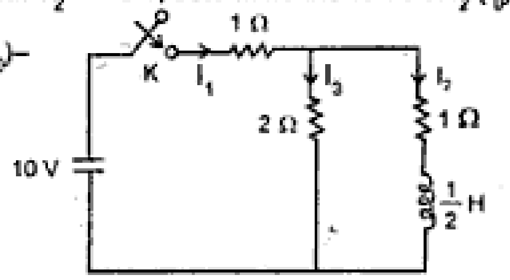
(a) 27 V, 3 Ω (b) 18 V, 3 Ω
(c) 27 V, 1 Ω (d) 18 V, 8 Ω

110. The voltage of the source *i.e.* V_s, if $i(t) = -20 e^{-2t}$



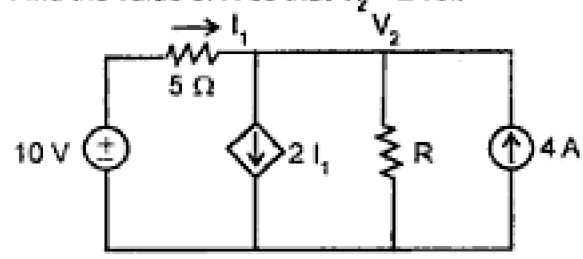
(a) $10 e^{-2t}$ (b) $10 e^{2t}$
(c) $20 e^{-2t}$ (d) $20 e^{2t}$

111. For fig. at time t_0 after the switch K was closed, it is found that $V_2 = +5$ V, determine the value of $i_2(t_0)$ and $\frac{d}{dt} i_2(t_0)$–



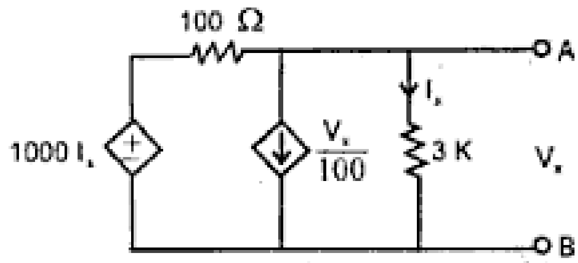
(a) 2.5 amp, 5 amp/see (b) 2.5 amp, 2.5 amp/sec
(c) 5 amp, 2.5 amp/sec (d) 5 amp, 5 amp/sec

112. Find the value of R so that $V_2 = 2$ volt–



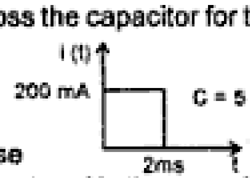
(a) $\frac{6}{5}$ Ω (b) $\frac{5}{6}$ Ω
(c) 2 Ω (d) 5 Ω

113. Find the Thevenin voltage and resistance for the given circuit shown below–



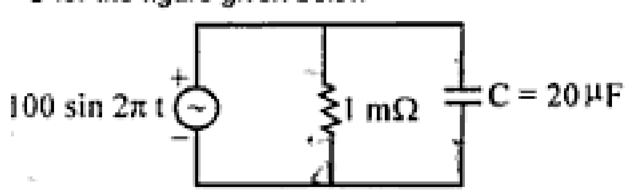
(a) $R_{th} = 58.82$ Ω, $V_{th} = 117.64$ V
(b) $R_{th} = 117.64$ Ω, $V_{th} = 58.82$ V
(c) $R_{th} = 58.82$ Ω, $V_{th} = 58.82$ V
(d) $R_{th} = 117.64$ Ω, $V_{th} = 117.64$ V

114. What will be output voltage across the capacitor for the given input shown below ?



(a) 8 V (b) 12 V
(c) 10 V (d) None of these

115. Determine the maximum energy stored in the capacitor C for the figure given below–

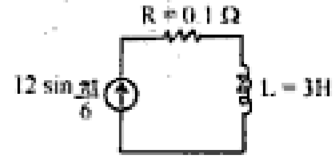


(a) 1 joule (b) 10 joule
(c) 0.1 joule (d) .001 joule

116. What will be the power dissipated in R in above question ?
(a) 2.5×10^{-3} joule (b) 25×10^{-3} joule
(c) $.25 \times 10^{-3}$ joule (d) None of these

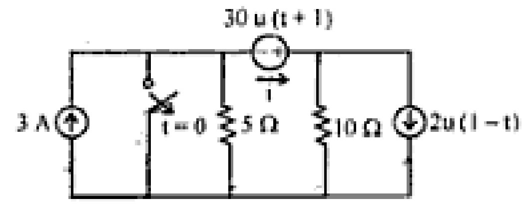
117. The percentage of power loss in the question 115–
(a) 5% (b) 2.5%
(c) 10% (d) 20%

118. The maximum energy in the given circuit will be–



(a) 14.4 joule
(b) 126 joule
(c) 216 joule
(d) None of these

Directions–Fig. shows the statement for Q. 119-122.



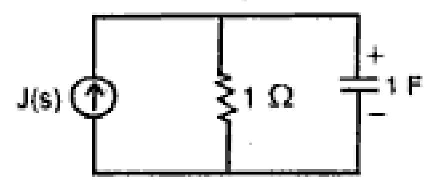
119. Find the current i at time t = – 2 see–
(a) 2 amp. (b) – 2 amp
(c) 1 amp (d) None of these

120. Current i at t = – 0.5 sec will be–
(a) $\frac{50}{15}$ amp (b) $\frac{50}{20}$ amp
(c) 5 amp (d) 3 amp

121. Current i at t = 0.5 sec will be–
(a) 5 amp (b) $\frac{5}{3}$ amp
(c) 3 amp (d) $\frac{3}{5}$ amp

122. Current i at time t = 4 sec will be–
(a) 5 amp (b) 3 amp
(c) – 3 amp (d) 5 amp

123. The initial voltage on the capacitor is V (0) = 2 V, J (s) = 4 (t). cos t find V (t) for t > 0–



(a) $V(t) = \frac{1}{\sqrt{2}} \cos(t - 45^0) + \frac{3}{2} e^{-t}$

(b) $V(t) = \sqrt{2} \cos(t - 45^0) + \frac{3}{2} e^{+t}$

(c) $V(t) = \cos(t - 45^0) + \frac{1}{2} e^{-2t}$

(d) $V(t) = \cos(t + 45^0) + \frac{3}{2} e^{-2t}$

124. The Laplace transform of the given function–

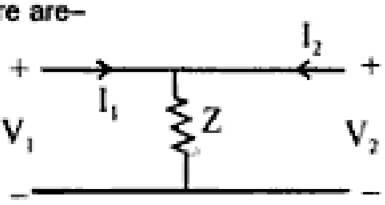
$$f(t) = \begin{cases} t, & t \geq 4 \text{ sec} \\ 0, & \text{otherwise} \end{cases}$$ will be–

(a) $\frac{e^{-4s}}{s^2}$ (b) $\frac{e^{-4(s+1)}}{s^2}$

(c) $\frac{e^{-4s}}{s}$ (d) $e^{-4s}\left\{\frac{4s+1}{s^2}\right\}$

(a) 10/12 (b) 12/10
(c) 1/2 (d) 2/3

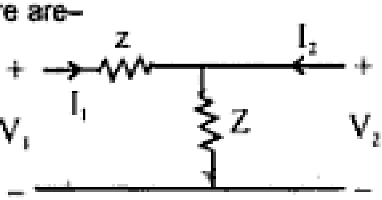
196. The ABCD parameters of the 2-port network, shown in the figure are–



(a) $\begin{bmatrix} 1 & 0 \\ \frac{1}{Z} & 1 \end{bmatrix}$ (b) $\begin{bmatrix} 1 & Z \\ 0 & 1 \end{bmatrix}$

(c) $\begin{bmatrix} 2 & 0 \\ \frac{2}{Z} & \frac{1}{Z} \end{bmatrix}$ (d) $\begin{bmatrix} \frac{1}{Z} & 0 \\ \frac{2}{Z} & 2 \end{bmatrix}$

197. The ABCD parameters of the 2-port network shown in the figure are–



(a) $\begin{bmatrix} 0 & Z \\ 1 & 2 \end{bmatrix}$ (b) $\begin{bmatrix} 2 & Z \\ \frac{1}{Z} & 1 \end{bmatrix}$

(c) $\begin{bmatrix} 1 & \frac{1}{Z} \\ Z & 2 \end{bmatrix}$ (d) $\begin{bmatrix} 2 & 0 \\ \frac{1}{Z} & \frac{1}{Z} \end{bmatrix}$

198. For a two-port network the three parameters A, B and C are given by–

$$A = x_1,\ B = x_2,\ C = \frac{-1}{x_2}$$

then D is equal to under the network to be reciprocal–

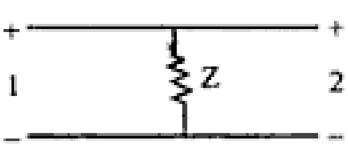
(a) $\frac{1}{x_1}$ (b) 0

(c) $\frac{2}{x_1}$ (d) $\frac{2}{x_1}$

199. If the ABCD parameters of–

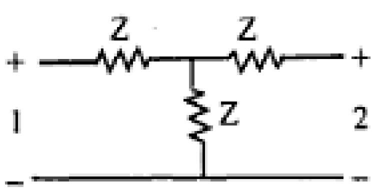
are $\begin{bmatrix} 1 & 2Z \\ 0 & 1 \end{bmatrix}$

and of



are $\begin{bmatrix} 1 & 0 \\ \frac{1}{Z} & 1 \end{bmatrix}$

then the ABCD parametrs of 1–



(a) $\begin{bmatrix} 2 & 3Z \\ \frac{1}{Z} & Z \end{bmatrix}$ (b) $\begin{bmatrix} 3 & 5Z \\ \frac{1}{Z} & 3 \end{bmatrix}$

(c) $\begin{bmatrix} 2 & 1 \\ 1 & 1 \end{bmatrix}$ (d) $\begin{bmatrix} 3 & 2Z \\ \frac{1}{Z} & 1 \end{bmatrix}$

200. The 2-port network of fig. (1) has Y-parameter $\begin{bmatrix} Y_{11} & Y_{12} \\ Y_{21} & Y_{22} \end{bmatrix}$. The network is excited as shown in fig. (2). If $I_X = I_Y$, the current I drawn from the source would be–

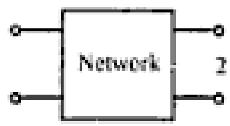


Fig. (1)

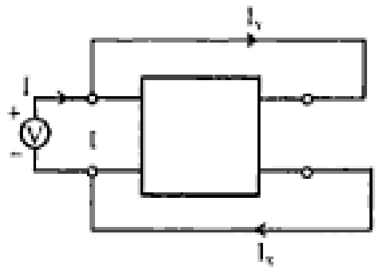
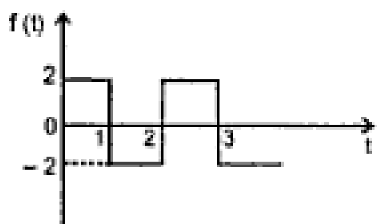


Fig. (2)

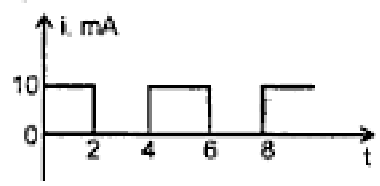
(a) $V(Y_{11} + Y_{12} + Y_{21} + Y_{22})$
(b) $V(Y_{11} + Y_{22})$
(c) $V(Y_{11})$
(d) $V(Y_{11} + Y_{22} + Y_{12} - Y_{21})$

201. D.C. component of the waveforms shown below is–



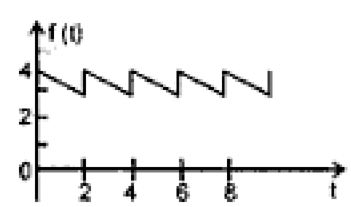
(a) 2 (b) 1
(c) 0.5 (d) 0

202. D.C. component of the waveform shown below is–



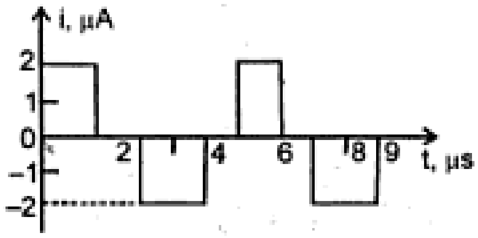
(a) 0 (b) 2.5 mA
(c) 5 mA (d) 10 mA

203. D.C. component of the waveform shown below is–



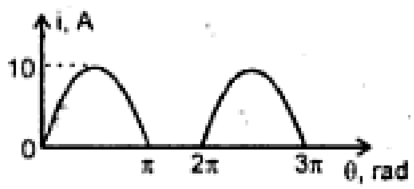
(a) 0.5 V (b) 1.5 V
(c) 2.5 V (d) 3.5 V

204. D.C. component of the waveform shown below is–



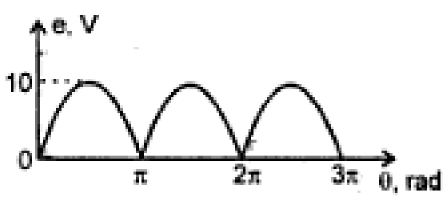
(a) 0.4 μA (b) –0.4 μA
(c) 0.8 μA (d) 0.8 μA

205. D.C. component of the waveform shown below is–



(a) 0.5 A (b) 1.38 A
(c) 3.18 A (d) 6.36 A

206. D.C. component of the waveform shown below is–

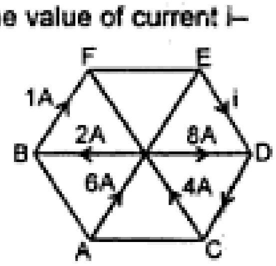


(a) 1.372 A (b) 6.36 A
(c) 0.318 A (d) 0.159 A

207. If 120 C of charge passes through an electric conduction in 30 sec, the current in the conductor is–
(a) 0.5 A (b) 2 A
(c) 8 A (d) 4 A

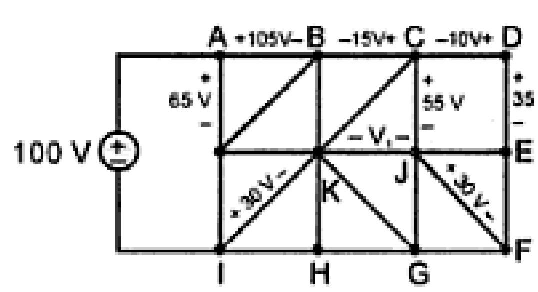
208. The energy required to move 50 coulomb through 3 V is–
(a) 125 mJ (b) 150 J
(c) 400 J (d) 2.78 J

209. Calculate the value of current i–



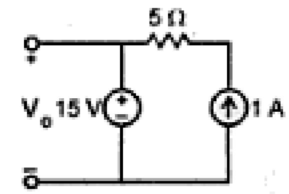
(a) 5 A (b) 2 A
(c) 3 A (d) 8 A

210. The each branch of circuit graph shown below represent a circuit element. The value of voltage V_1 is–



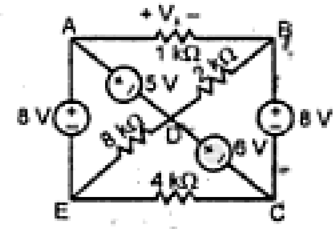
(a) – 30 V (b) 25 V
(c) – 20 V (d) 15 V

211. Find V_0 for the circuit given below–



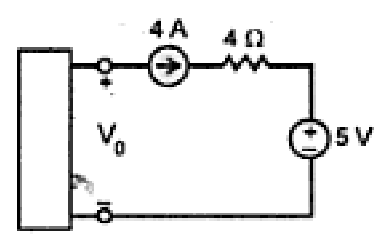
(a) 10 V (b) 15 V
(c) 20 V (d) None of these

212. Calculate the value of V_R for the circuit given below–



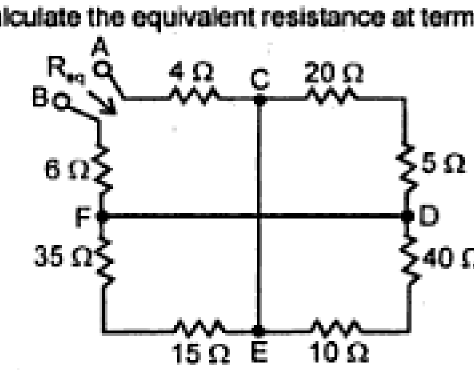
(a) 3 V (b) 19 V
(c) – 9 V (d) – 19 V

213. The voltage V_0 shown below is always equal to–



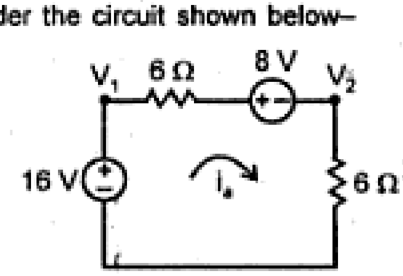
(a) 11 V (b) 8 V
(c) 21 V (d) None of these

214. Calculate the equivalent resistance at terminal A and B–



(a) 100 Ω (b) 22.5 Ω
(c) 60 Ω (d) 28.75 Ω

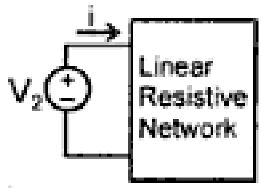
215. Consider the circuit shown below–



The voltage V_1 and V_2 are related as–

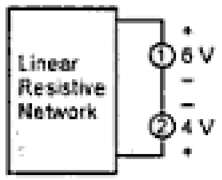
(a) $V_1 = 6i_a - 8 + V_2$ (b) $V_1 = 6i_a + 8 + V_2$
(c) $V_1 = -6i_a + 8 + V_2$ (d) $V_1 = -6i - 8 + V_2$

216. If a resistor of 10 Ω is placed in parallel with voltage source in the circuit shown below, the current i will be–



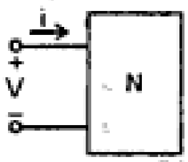
(a) increased (b) decreased
(c) constant (d) It is not possible to say

217. Two elements are connected in series as shown below element-1 supplies 36 W of power. Element-2–



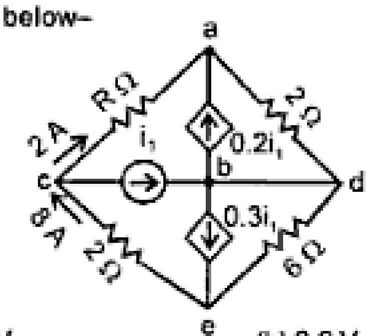
(a) supplies 24 W (b) absorbs 24 W
(c) supplies 32 W (d) absorb 32 W

218. Let $i(t) = 3te^{-100t}$ A and $V(t) = 0.6(0.01 - t)e^{-100t}$ V for the network of fig. shown below. The power being absorbed by the network element at t = 5 ms is–



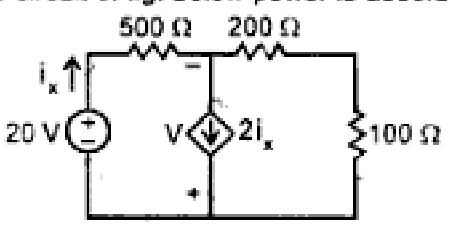
(a) 18.4 μW (b) 9.2 μW
(c) 16.6 μW (d) 8.3 μW

219. Calculate the voltage between terminal ab for figure shown below–



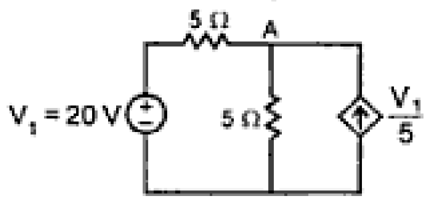
(a) 2.4 V (b) 2.6 V
(c) – 2.6 V (d) – 2.4 V

220. In the circuit of fig. below power is absorbed by–



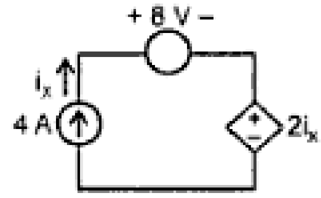
(a) dependent source of 6 W
(b) dependent source of 60 W
(c) independent source of 6 W
(d) independent source of 60 W

221. The dependent source in fig. shown below–



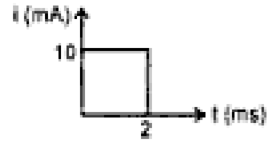
(a) delivers 80 W (b) delivers 40 W
(c) absorbs 40 W (d) absorbs 80 W

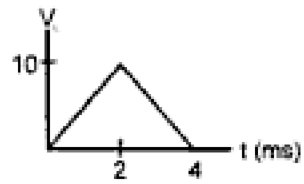
222. In the circuit of fig. shown below dependent source–

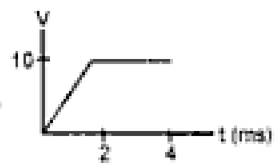


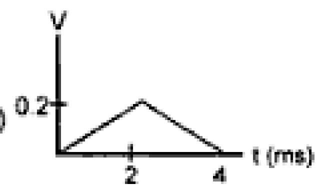
(a) supplies 16 W (b) absorbs 16 W
(c) supplies 32 W (d) absorbs 32 W

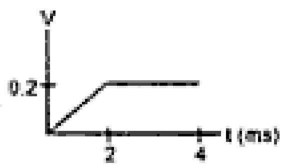
223. The current in a 100 μF capacitor is shown below. If capacitor is initially uncharged, then the waveform for the voltage across it is–



(a)


(b)


(c)


(d)


224. The incidence matrix of a graph is as given below–

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

The number of possible tree are–
(a) 40 (b) 70
(c) 50 (d) 240

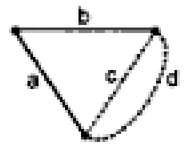
225. The incidence matrix of a graph is as given below–

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

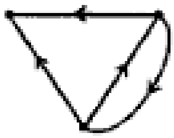
The number of possible tree are–
(a) 11 (b) 14
(c) 16 (d) 8

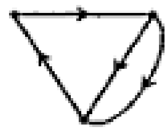
226. The f-cut set matrix of a graph shown in fig. with respect to chosen tree is as given below–

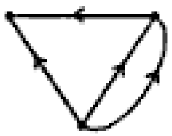
$$Q_f = \begin{bmatrix} 0 & 1 & -1 & -1 \\ 1 & 0 & -1 & -1 \end{bmatrix}$$

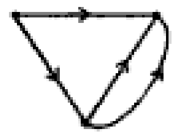


The oriented graph of the network is–

(a) 

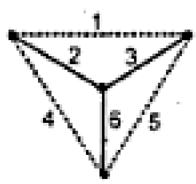
(b) 

(c) 

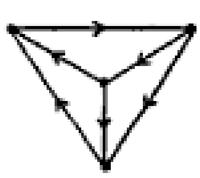
(d) 

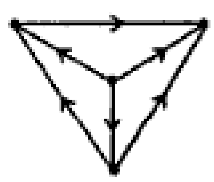
227. The f-cut set matrix of a graph shown below with respect to chosen tree is as given below :

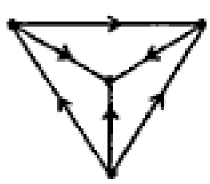
$$Q_F = \begin{bmatrix} -1 & 1 & 0 & 1 & 0 & 0 \\ -1 & 0 & 1 & 0 & 1 & 0 \\ 0 & 0 & 0 & -1 & 1 & 1 \end{bmatrix}$$

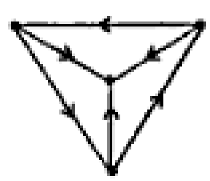


The oriented graph of the network is–

(a) 

(b) 

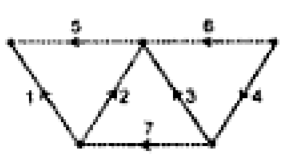
(c) 

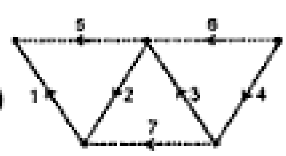
(d) 

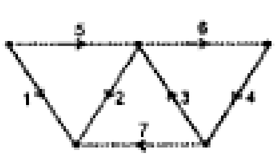
228. The f-cut set matrix of a graph is given as :

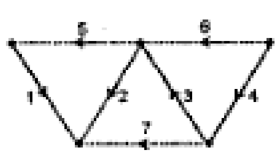
$$Q_F = \begin{bmatrix} 1 & 0 & 0 & 0 & -1 & 0 & 0 \\ 0 & 1 & 0 & 0 & 1 & 0 & 1 \\ 0 & 0 & 1 & 0 & 0 & 1 & 1 \\ 0 & 0 & 0 & 1 & 0 & 1 & 0 \end{bmatrix}$$

The oriented graph of the network is–

(a) 

(b) 

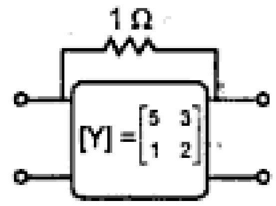
(c) 

(d) 

229. The Y-parameters of a 2-port network are :

$$[Y] = \begin{bmatrix} 5 & 3 \\ 1 & 2 \end{bmatrix} S$$

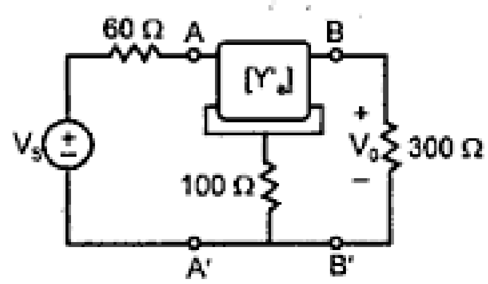
A resistor of I ohm is connected across as shown below. The new Y-parameter would be–



(a) $\begin{bmatrix} 6 & 4 \\ 2 & 3 \end{bmatrix} S$ (b) $\begin{bmatrix} 6 & 2 \\ 0 & 3 \end{bmatrix} S$

(c) $\begin{bmatrix} 5 & 4 \\ 2 & 2 \end{bmatrix} S$ (d) $\begin{bmatrix} 4 & 4 \\ 2 & 1 \end{bmatrix} S$

230. For the 2-port as given below $[Y_a] = \begin{bmatrix} 2 & 0 \\ 0 & 10 \end{bmatrix}$ mS



The value $\frac{V_0}{V_s}$ is–

(a) $\frac{3}{3.2}$ (b) $\frac{1}{16}$

(c) $\frac{2}{33}$ (d) $\frac{1}{17}$

231. The T-parameters of a 2-port network are $[T] = \begin{bmatrix} 2 & 1 \\ 1 & 1 \end{bmatrix}$.

If such two 2-port network are cascaded, the Z-parameter for the cascaded network is–

(a) $\begin{bmatrix} 2 & -2 \\ -\frac{1}{2} & 1 \end{bmatrix}$ (b) $\begin{bmatrix} \frac{5}{3} & -\frac{1}{3} \\ -\frac{1}{3} & \frac{2}{3} \end{bmatrix}$

(c) $\begin{bmatrix} \frac{5}{3} & \frac{1}{3} \\ \frac{1}{3} & \frac{2}{3} \end{bmatrix}$ (d) $\begin{bmatrix} 2 & 2 \\ \frac{1}{2} & 1 \end{bmatrix}$

ANSWERS WITH EXPLANATORY NOTES

1. (c) Apply superpositon theorem :

Case I. Taken current source, circuit becomes as given in fig. (1)

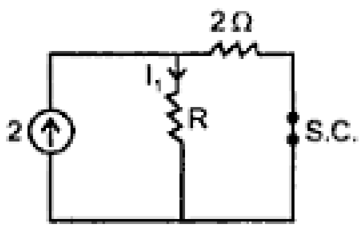


Fig. (1)

Let the current

flowing in R is I_1

$$I_1 = 2 \times \frac{2}{2+R}$$

$$= \frac{4}{2+R} \qquad \text{.......(i)}$$

Case II. Taken voltage source, circuit becomes as given in fig. (2)

Let the current flowing in R is I_2

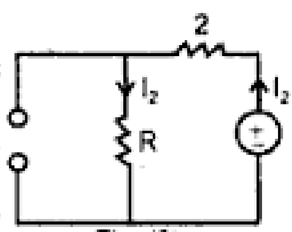


Fig. (2)

$$I_2 = \frac{2}{2+R} \qquad \text{.......(ii)}$$

Since current in both the cases flowing in the same direction, so net current

$$i = I_1 + I_2$$

$$1 = \frac{4}{2+R} + \frac{2}{2+R} \; (i = 1 \text{ given})$$

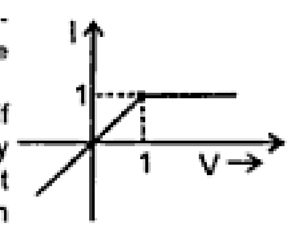
$$2 + R = 6$$

$$R = 6 - 2 = 4\,\Omega$$

2. (a) Since in one inductor current is leaving to dot and in other inductor current is entering to dot. So

$$L_{eq} = L_1 + L_2 - 2M$$

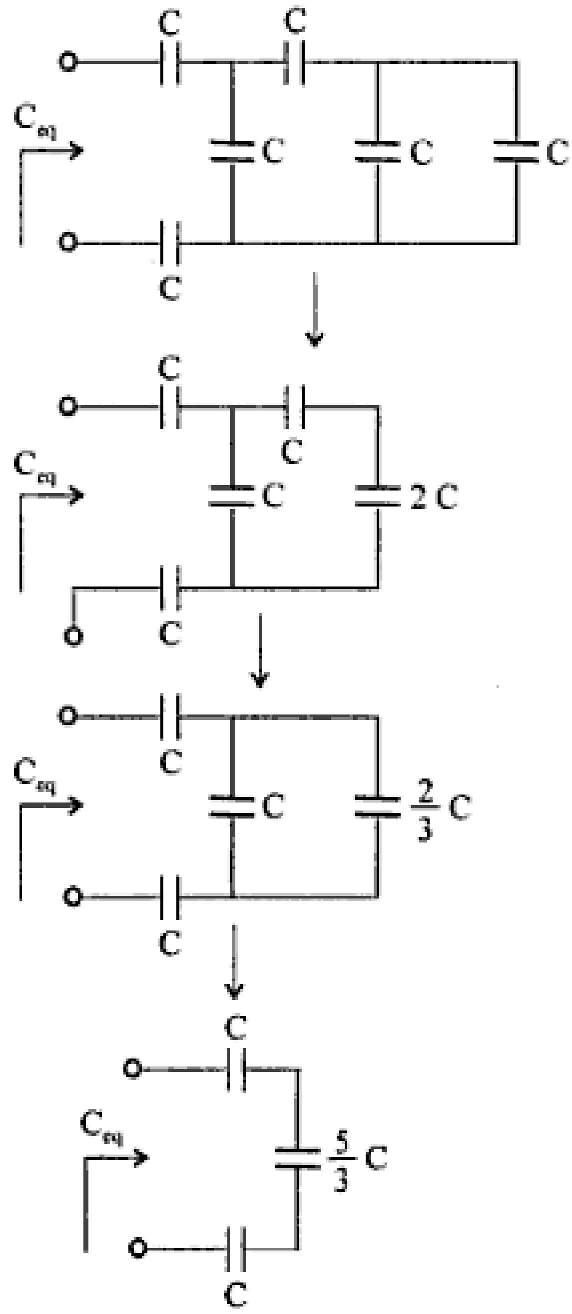
3. (d) The given figure is non-linear because after 1 volt the output becomes constant.



Any element will be passive if the ratio V/I is positive any time, so the given output shown that the element in Passive.

Element will be bilateral if and only if the magnitude (*i.e.* V, or I) is same in both the direction. Here the given element is non-bilateral.

4. (b) Circuit for equivalent capacitance by applying the concept of series parallel combination of the capacitance



$$\frac{1}{C_{eq}} = \frac{1}{C} + \frac{1}{C} + \frac{1}{\frac{5C}{3}}$$

$$= \frac{1}{C} + \frac{1}{C} + \frac{3}{5C} = \frac{1}{C}\left[\frac{5+5+3}{5}\right]$$

or $\quad C_{eq} = \dfrac{5C}{13}$

5. (a) Suppose value of resistances be RΩ each. Applying KVL by selecting any path between A and B.