Section – A

1. (i). When converting from a Norton-equivalent circuit to a Thevenin equivalent circuit:

(a) R_N and R_{Th} have the same value (b) R_N will always be larger than R_{Th}

(c) I_N is short-circuited to find V_{TH} (d) V_{TH} is short-circuited

Ans: (a) R_N and R_{Th} have the same value

(ii). The resistance of an open circuit is

(a) approximately 0 Ω (b) infinitely high (c) very low (d) none of the above

Ans: (b) infinitely high

(iii). If a 10A I_1 and a 3A I_2 flow into point X, how much current must flow away from point X?

(a) 7A (b) 30A (c) 13A (d) this is impossible to determine

Ans: (c) 13A

(iv). To compare the phase angle between two waveforms, both must have

(a) the same amplitude (b) the same frequency (c) different frequencies (d) both a and b

Ans: (b) the same frequency

(v). For an ac waveform, the period, T refers to

(a) the number of complete cycles per second (b) the length of time required to complete one cycle (c) the time it takes for the waveform to reach its peak value (d) none of the above

Ans: (b) the length of time required to complete one cycle

(vi). A value of –j500Ω represents

(a) 500 Ω of inductive reactance (b) 500 Ω of capacitive reactance

(c) 500 Ω of resistance (d) 500 Ω of conductance

Ans: (b) 500 Ω of capacitive reactance

(vii). What is the resistance, R, of an ac circuit whose impedance, Z is $300\angle 53.13^\circ$ Ω ?

(a) 240 Ω (b) 180 Ω (c) 270 Ω (d) 60 Ω

Ans: (b) 180 Ω

(viii). The impedance of a parallel LC circuit at resonance is

(a) zero (b) maximum (c) minimum (d) equal to the r_s of the coil

Ans: (b) Maximum

(ix). When either L or C is increased, the resonant frequency of an LC circuit

(a) decreases (b) increases (c) doesn't change (d) this is impossible to determine

Ans: (a) decreases

(x). The impedance of the parallel *RLC* circuit is given by

(a). $\frac{1}{R} + \frac{1}{\omega L} + \omega C$ (b) $\left[\frac{1}{R^2} + \left(\omega C - \frac{1}{\omega L}\right)^2\right]^{-1/2}$ (c) $\frac{1}{R} + \left(\frac{1}{\omega L} - \frac{1}{\omega C}\right)$ (d) $\left[R^2 + \left(\omega L - \frac{1}{\omega c}\right)^2\right]^{-1/2}$

Ans: (b) $\left[\frac{1}{R^2} + \left(\omega C - \frac{1}{\omega L}\right)^2\right]^{-1/2}$

Section – B

2. Deduce the law of combination of resistors in series and in parallel.

Ans: i) Resistors in series: Consider two resistors connected in *series*, as shown in Fig. 1. It is clear that the same current I flows through both resistors. Suppose that the potential drop from point B to point A is V. This drop is the sum of the potential drops V_1 and V_2 across the two resistors R_1 and R_2, respectively. Thus, $V = V_1 + V_2$.

According to Ohm's law, the equivalent resistance R_{eq} between B and A is the ratio of the potential drop V across these points and the current I which flows between them. Thus,

$$R_{eq} = \frac{V}{I} = \frac{V_1 + V_2}{I} = \frac{V_1}{I} + \frac{V_2}{I} = R_1 + R_2$$

giving

$$R_{eq} = R_1 + R_2$$

The equivalent resistance of two or more resistors connected in series is the sum of the individual resistances.

For *N* resistors connected in series, above Equation generalizes to $R_{eq} = \sum_{i=1}^{N} R_i$

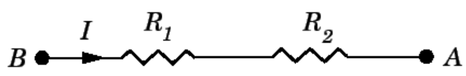


Fig. 1: *Two resistors connected in series*

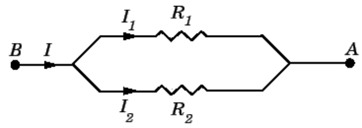


Fig. 2: *Two resistors connected in parallel*

ii) Resistors in parallel: Consider two resistors connected in *parallel*, as shown in Fig. 2. It is clear, from the figure, that the potential drop V across the two resistors is the same. In general, however, the currents I_1 and I_2 which flow through resistors R_1 and R_2, respectively, are different. According to Ohm's law, the equivalent resistance R_{eq} between B and A is the ratio of the potential drop V across these points and the current I which flows between them. This current must equal the sum of the currents I_1 and I_2 flowing through the two resistors, otherwise charge would build up at one or both of the junctions in the circuit.

Thus, $I = I_1 + I_2$

It follows that $\frac{1}{R_{eq}} = \frac{I}{V} = \frac{I_1+I_2}{V} = \frac{I_1}{V} + \frac{I_2}{V}$

giving

$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2}$$

Clearly, t*he reciprocal of the equivalent resistance of two resistances connected in parallel is the sum of the reciprocals of the individual resistances.*

For *N* resistors connected in parallel, above equation generalizes to $\frac{1}{R_{eq}} = \sum_{i=1}^{N} \frac{1}{R_i}$

3. State and explain Kirchhoff's law with suitable examples.

Ans: **Kirchhoff 's Current Law (KCL):** The algebraic sum of the currents entering and leaving any point in a circuit must equal zero. Or stated another way, *the algebraic sum of the currents into any point of the circuit must equal the algebraic sum of the currents out of that point.* An *algebraic sum* means combining positive and negative values. i.e.

$$\sum I = 0$$

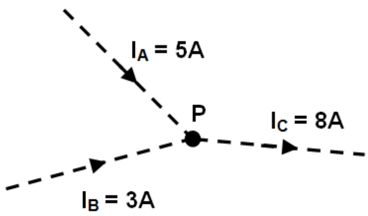


Fig.1

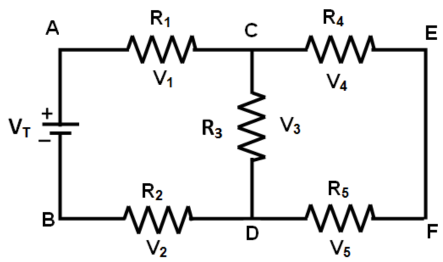


Fig. 2

Example, in Fig.1, we can write the currents as

$I_A + I_B - I_C = 0$

or

5 A + 3 A - 8 A = 0

Currents I_A and I_B are positive terms because these currents flow into P, but I_C , directed out, is negative.

Kirchhoff 's Voltage Law (KVL): The algebraic sum of the voltages around any closed path is zero. If you start from any point at one potential and come back to the same point and the same potential, the difference of potential must be zero. i.e.

$$\sum V = 0$$

Example: Figure 2 has three loops. The outside loop, starting from point A at the top, through CEFDB, and back to A, includes the voltage drops V_1, V_4, V_5 and V_2 and the source V_T.

The inside loop ACDBA includes V_1, V_3, V_2, and V_T. The other inside loop, CEFDC with V_4, V_5, and V_3, does not include the voltage source. Consider the voltage equation for the inside loop with V_T. In the clockwise direction starting from point A, the algebraic sum of the voltages is $V_1 + V_3 + V_2 - V_T = 0$

4. For a any network, loop equations are: $8i_1 - 3i_2 - 5i_3 = 5$, $-3i_1 + 7i_2 = -10$, and $-5i_1 + 11i_3 = -10$. Determine the value of i_1, i_2 and i_3.

Ans: For a network, Loop equations given by

$$8i_1 - 3i_2 - 5i_3 = 5$$
$$-3i_1 + 7i_2 = -10$$
$$-5i_1 + 11i_3 = -10$$

There are three equations and three unknowns, Using third-order determinants, we have

$$\begin{bmatrix} 8 & -3 & -5 \\ -3 & 7 & 0 \\ -5 & 0 & 11 \end{bmatrix} \begin{bmatrix} i_1 \\ i_2 \\ i_3 \end{bmatrix} = \begin{bmatrix} 5 \\ -10 \\ -10 \end{bmatrix}$$

$$i_1 = \frac{\begin{vmatrix} 5 & -3 & -5 \\ -10 & 7 & 0 \\ -10 & 0 & 11 \end{vmatrix}}{\begin{vmatrix} 8 & -3 & -5 \\ -3 & 7 & 0 \\ -5 & 0 & 11 \end{vmatrix}} = -\frac{50}{57}, \quad i_2 = \frac{\begin{vmatrix} 8 & 5 & -5 \\ -3 & -10 & 0 \\ -5 & -10 & 11 \end{vmatrix}}{\begin{vmatrix} 8 & -3 & -5 \\ -3 & 7 & 0 \\ -5 & 0 & 11 \end{vmatrix}} = -\frac{205}{114}, \quad i_3 = \frac{\begin{vmatrix} 5 & -3 & 5 \\ -10 & 7 & -10 \\ -10 & 0 & -10 \end{vmatrix}}{\begin{vmatrix} 8 & -3 & -5 \\ -3 & 7 & 0 \\ -5 & 0 & 11 \end{vmatrix}} = -\frac{445}{342}$$

$$i_1 = -0.88, \quad i_2 = -1.8, \quad i_3 = -1.30$$

5. Describe in details the conversion of T to delta sections.

Ans:

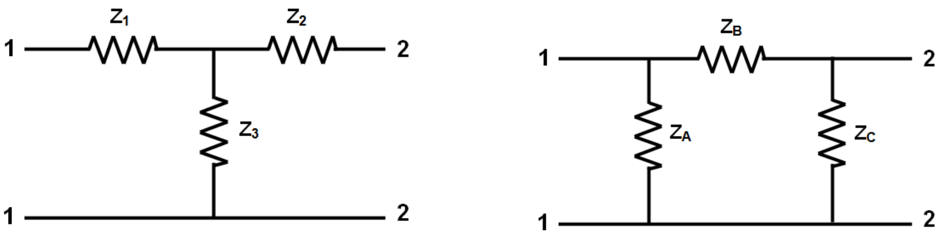


Fig. 1: T (tee) and delta (pi) network

Consider fig. 1, to find Z_{1OC}, Z_{2OC} and Z_{1SC} for both network (T and delta)

Impedance at 1,1, when terminal 2,2 open, $Z_{1OC} = Z_1 + Z_3 = \frac{Z_A(Z_B + Z_C)}{Z_A + Z_B + Z_C}$ -------(1)

Impedance at 2,2, when terminal 1,1 open, $Z_{2OC} = Z_2 + Z_3 = \frac{Z_C(Z_A + B)}{Z_A + Z_B + Z_C}$ -------(2)

Impedance at 1,1, when terminal 2,2 short circuit, $Z_{1SC} = Z_1 + \frac{Z_2 Z_3}{Z_2 + Z_3} = \frac{Z_A Z_B}{Z_A + Z_B}$ -------(3)

Subtracting eq.(3) form eq.(1) $\quad Z_3 - \frac{Z_2 Z_3}{Z_2 + Z_3} = \frac{Z_A^2 Z_C}{(Z_A + Z_B)(Z_A + Z_B + Z_C)}$ -------(4)

Multiply eq. (2) and eq. (4) $\quad Z_3^2 = \frac{Z_A^2 Z_C^2}{(Z_A + Z_B + Z_C)^2} \Longrightarrow Z_3 = \frac{Z_A Z_C}{Z_A + Z_B + Z_C}$ -------(5)

Using eq. (5) in eq. (1) and (2) $\quad Z_1 = \frac{Z_A Z_B}{Z_A + Z_B + Z_C}, \quad Z_2 = \frac{Z_B Z_C}{Z_A + Z_B + Z_C}$ -------(6)

Multiply eq. (2) and eq. (3) $\quad Z_1 Z_2 + Z_3 Z_2 + Z_1 Z_3 = \frac{Z_A Z_B Z_C}{Z_A + Z_B + Z_C}$ -------(7)

Divide eq. (7) by eq. (5) and eq.(6), we get

$$Z_A = \frac{Z_1 Z_2 + Z_3 Z_2 + Z_1 Z_3}{Z_2}, \quad Z_B = \frac{Z_1 Z_2 + Z_3 Z_2 + Z_1 Z_3}{Z_3}, \quad Z_C = \frac{Z_1 Z_2 + Z_3 Z_2 + Z_1 Z_3}{Z_1} \qquad \text{-------(8)}$$

Equation (8) shows conversion between T to delta network.

6. The voltage across a resistor is V = 100 $sin\, 377t$. Find the sinusoidal expression for the current if the resistor is 10Ω. Sketch the curves for V and I.

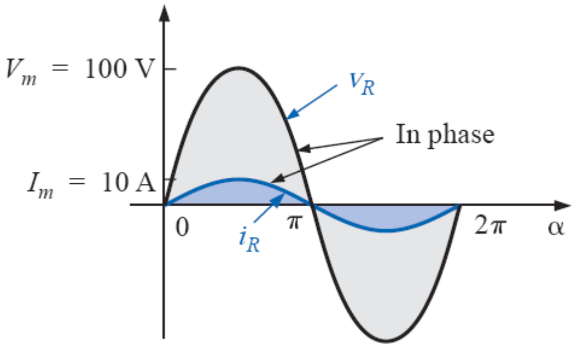
Ans:

$$I_m = \frac{V_m}{R} = \frac{100V}{10\Omega} = 10\,A$$

(v and i are in phase), resulting in

$$i = 10\, sin\, 377t$$

The curves are sketched in Fig.

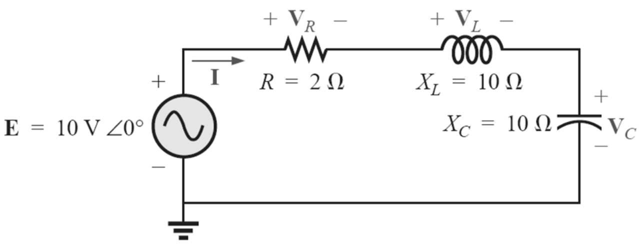


7. What is the difference between the series and parallel resonant circuits?

Ans: Difference between the series and parallel resonant circuits

Series Resonance	**Parallel Resonance**
Resonance frequency, $f_r = \frac{1}{2\pi\sqrt{LC}}$	Resonance frequency, $f_r = \frac{1}{2\pi}\sqrt{\frac{1}{LC} - \frac{R^2}{L^2}}$
Current maximum at f_r	Current minimum at f_r
Impedance (Z) minimum at f_r	Impedance Z maximum at f_r
Total impedance Z = R	Total impedance $Z = \frac{L}{CR}$
Circuit capacitive below f_r, but inductive above f_r	Circuit inductive below f_r, but capacitive above f_r
Voltage drops at L and C are equal and opposite phase	Current in L and C equal and opposite phase
This is acceptor circuit	This is rejecter circuit

8. For the series resonant circuit of given Fig., find **I**, $\mathbf{V}_R$, $\mathbf{V}_L$, and $\mathbf{V}_C$ at resonance.



Ans: Total impedance in series resonance circuit is

$$Z_T = R + jX_L - JX_C = 2\Omega$$

Current in circuit is

$$I = \frac{E}{Z_T} = \frac{10\,V\angle 0^\circ}{2\,\Omega} = 5\,A\angle 0^\circ$$

Voltage drop at resistance

$$V_R = E = 10\,V\angle 0^\circ$$

Voltage drop at inductance

$$V_L = (I\angle 0^\circ)(X_L\angle 90^\circ) = 50\,V\angle 90^\circ$$

Voltage drop at capacitance

$$V_C = (I\angle 0^\circ)(X_C\angle -90^\circ) = 50\,V\angle -90^\circ$$