ANSWERS - SECTION – A

1. Write the V-I relations of a Resistor.

$$\text{Voltage } V = IR$$

$$\text{Current } I = \frac{V}{R}$$

2. Write the V-I relations of an Inductor .

$$\text{Volatge } v\,(t) = L\,\frac{di(t)}{dt}$$

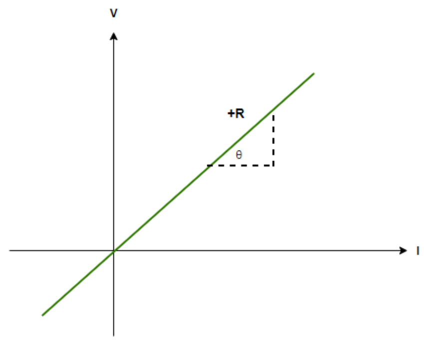
$$\text{Current } i\,(t) = \frac{1}{L}\int v\,(t)dt$$

3. Write the V-I relations of a Capacitor.

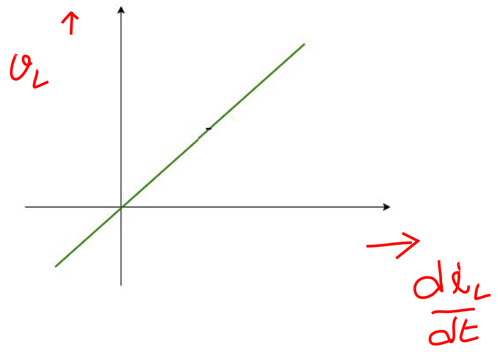
$$\text{Current } i\,(t) = C\,\frac{dv(t)}{dt}$$

$$\text{Volatge } v\,(t) = \frac{1}{C}\int i\,(t)dt$$

4. Sketch the V-I characteristics of a Resistor.

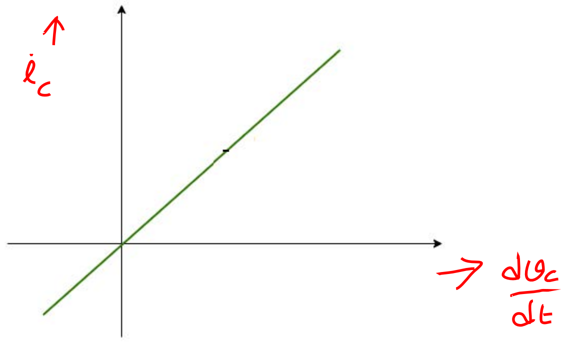


5.Sktech the V-I characteristics of an Inductor .



$$v_L = L\,\frac{di_L}{dt}$$

6.Sktech the V-I characteristics of a Capacitor.



$$i_c = C \frac{dv_c}{dt}$$

7. Identify the number of Branches in the circuit shown

No of branches=5

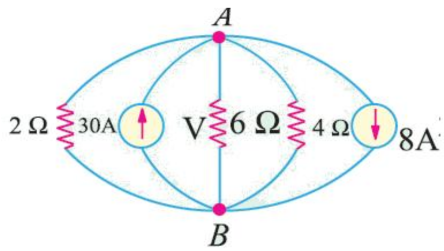


Fig.4

8. Identify the number of Nodes in the circuit shown?

No of nodes=5

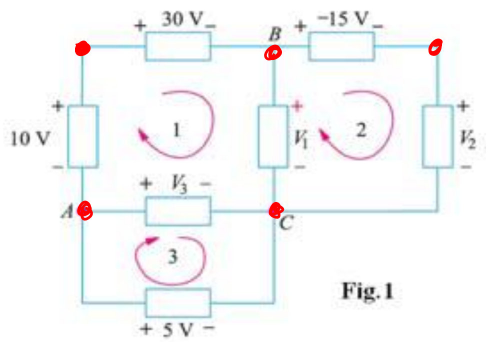
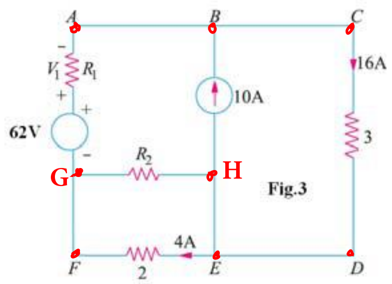


Fig.1

9.Identify the number of loops in the circuit shown?

No of loops=7



ABCDEFGA, ABHGA, GHEFG, BCDEHB,ABHEFGA,GHBCDEFG,GABCDEHG

10. Identify the number of Meshes in the circuit shown?

No of meshes=3

11.Mention the Form factor and Peak factor of the Sinusoidal signal.

$$Form\ Factor = \frac{RMS\ Value}{Average\ Value}$$

$$Peak\ Factor = \frac{Peak\ Value}{RMS\ Value}$$

For cosine wave $V_{rms} = \frac{V_m}{\sqrt{2}}, \ \ V_{avg} = \frac{2V_m}{\pi}$

Form Factor= $\frac{\frac{V_m}{\sqrt{2}}}{\frac{2V_m}{\pi}}$=1.11

Peak Factor=$\frac{V_m}{\frac{V_m}{\sqrt{2}}}$=1.414

12.Mention the Form factor and Peak factor of the Cosine signal.

For cosine wave $V_{rms} = \frac{V_m}{\sqrt{2}}, \ \ V_{avg} = \frac{2V_m}{\pi}$

Form Factor= $\frac{\frac{V_m}{\sqrt{2}}}{\frac{2V_m}{\pi}}$=1.11

Peak Factor=$\frac{V_m}{\frac{V_m}{\sqrt{2}}}$=1.414

13.Mention the Form factor and Peak factor of the Square wave signal.

For square wave $V_{rms} = V_m, \ \ V_{avg} = V_m$

Form Factor= $\frac{V_m}{V_m}$=1

Peak Factor=$\frac{V_m}{V_m}$=1

14.Mention the Form factor and Peak factor of the Triangular signal.

For triangular wave $V_{rms} = \frac{V_m}{\sqrt{3}}, \ \ V_{avg} = \frac{V_m}{2}$

Form Factor= $\frac{\frac{V_m}{\sqrt{3}}}{\frac{V_m}{2}}$=1.15

Peak Factor=$\frac{V_m}{\frac{V_m}{\sqrt{3}}}$=1.732

15.Define Impedance and Reactance.

Impedance is the total opposition that a circuit offers to the flow of alternating current (AC). It consists of both resistance (R) and reactance (X) and is represented as a complex number.

Reactance is the opposition to AC current caused by inductors (L) and capacitors (C). It does not cause power dissipation (unlike resistance) but affects the phase of the current.

16.Mention the value of power factor in a series resonance circuit at resonance frequency.

Power Factor=cos(θ)=cos(φ)

In a series resonance circuit, at resonance frequency R = Z, so the power factor is 1

17.Mention the value of power factor in a series resonance circuit below resonance frequency.

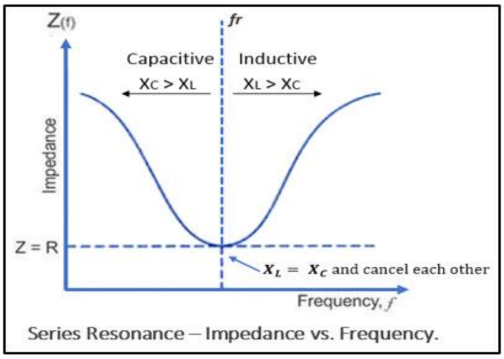
Power Factor Below Resonance Frequency = Leading (<1, Capacitive behavior).

18.Mention the value of power factor in a series resonance circuit above resonance frequency.

Power Factor Above Resonance Frequency = Lagging (<1, Inductive behavior).

19.Mention the impedance in a series resonance circuit below resonance frequency.

Below Resonance Frequency, Impedance is Z=R−j|X|, with a Capacitive Nature.



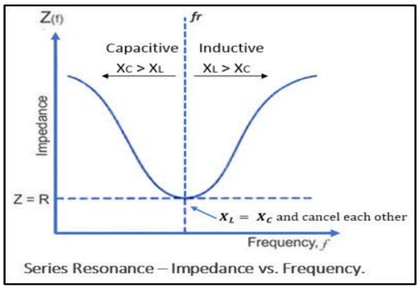
20.Mention the impedance in a series resonance circuit at resonance frequency.

At the **resonance frequency** in a series resonance circuit, the inductive and capacitive reactance's cancel each other out So the impedance reduces to only the resistance:

Z=R, This means the circuit behaves like a pure resistor at resonance.

21.Mention the impedance in a series resonance circuit above resonance frequency.

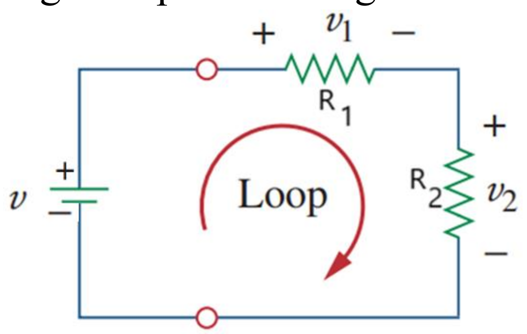
Above Resonance Frequency, Impedance is Z=R+j|X|, with an Inductive Nature.



Section-B

1. State and explain Kirchoff's laws
    - **Kirchhoff's Voltage Law (KVL)** states that the total voltage around any closed loop in a circuit is zero.
    - The algebraic sum of voltages around each loop is zero.

$$\Sigma \text{ Voltage Drops} - \Sigma \text{ Voltage Rises} = 0$$



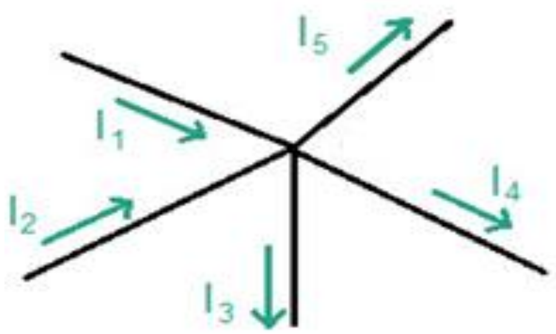
According to KVL:

$$\boxed{\sum V = 0}$$

$$-v + v_1 + v_2 = 0$$

   - **Kirchhoff's Current Law (KCL)** states that the total current entering a node in an electrical circuit is equal to the total current leaving the node.
   - The algebraic sum of currents entering a node is zero.

$$\Sigma \text{ Currents In} - \Sigma \text{ Currents Out} = 0$$



According to KCL:

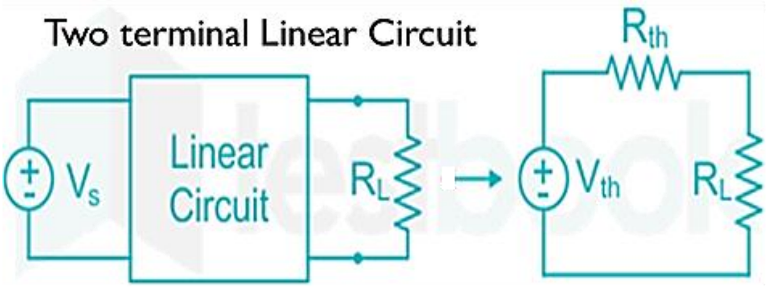
$$\boxed{\Sigma I = 0}$$

$$I_1 + I_2 - I_3 - I_4 - I_5 = 0$$

$$I_1 + I_2 = I_3 + I_4 + I_5$$

2. State and explain Maximum Power transfer theorem

The maximum power transfer theorem states that maximum power is transferred (delivered) from a source to a load when the load resistance (R_L) is equal to the Thevenin's equivalent resistance (R_{th}) of the source circuit.



Consider a Thevenin equivalent circuit consisting of a voltage source V_{th} with an internal resistance R_{th}, connected to a load resistance R_L .

Power delivered to the load is given by

$$P_L = I_L^2 R_L$$

$$= \frac{V_{th}^2}{(R_{th}+R_L)^2} R_L$$

To maximize power, differentiate P_L with respect to R_L and set it to zero

$$\frac{dP_L}{dR_L} = 0$$

Which leads to $R_{th}-R_L=0$

$$\therefore R_L = R_{th}$$

$$= \frac{V_{th}^2}{(R_{th}+R_{th})^2} R_{th}$$

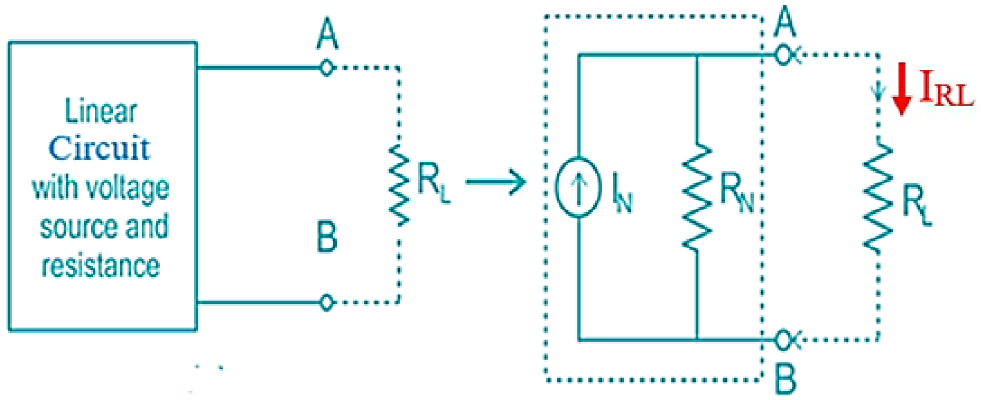
Maximum power delivered to the load is

$$P_{max} = \frac{{V_{th}}^2}{4R_L} = \frac{{V_{th}}^2}{4R_{th}}$$

3. State and explain Norton's theorem

Any two-terminal linear circuit having a number of voltage current sources and resistances can be replaced by a simple equivalent circuit consisting of a Norton current source (I_N) in parallel with a resistance (R_N).

Two terminal Linear Circuit



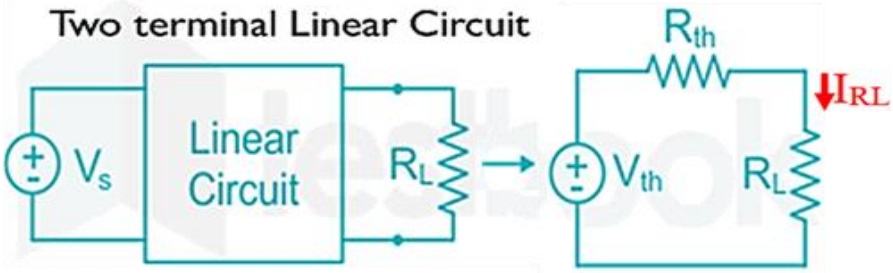
The equivalent **Norton current** I_N is the **short-circuit current** between the two terminals, and the **Norton resistance** R_N is the same as the Thevenin resistance R_{th} which is found by deactivating all independent sources and calculating the equivalent resistance seen from the terminals.

<u>Simple Steps/Procedure to analyze electric circuit through Norton's Theorem and determine I_N, R_N, and I_{RL}:</u>

1. Remove the load resistor (R_L) and replace it with a short circuit (I_{SC}=I_N).
2. Calculate the Norton current (I_N)-the current through the short circuit.
3. All voltage sources are replaced with short circuits, and all current sources are replaced with open circuits. Calculate the Norton resistance (R_N)-the total resistance between the open circuit connection points.
4. Now, Redraw the circuit with the Norton current source (I_N) in parallel with the Norton resistance (R_N). The load resistor (R_L) re-attaches between the two open points of the equivalent circuit. Now find the total current flowing through the load resistor by using $I_{RL} = I_N \frac{R_N}{(R_N + R_L)}$.

4. State and explain Thevenin's theorem

Any two-terminal linear circuit having a number of voltage current sources and resistances can be replaced by a simple equivalent circuit consisting of a single voltage source (V_{th}) in series with a resistance (R_{th}).

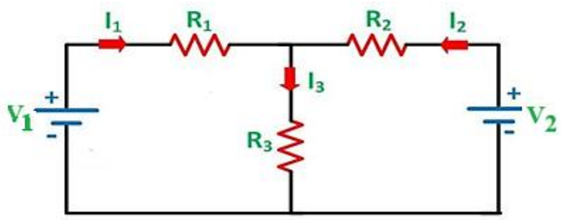


<u>Simple Steps/Procedure to analyze electric circuit through Thevenin's Theorem and determine V_{th}, R_{th}, and I_{RL}:</u>

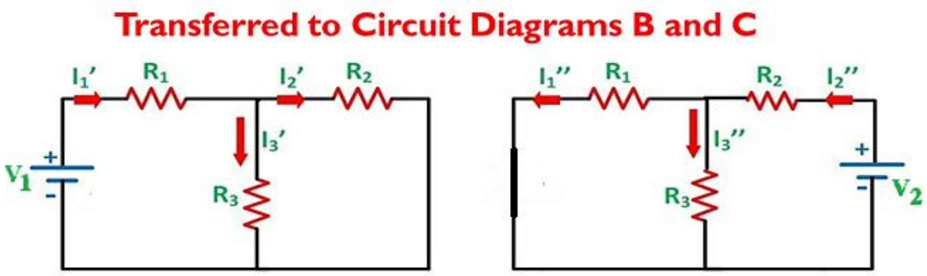
1. Open/remove the load resistor (R_L).
2. Calculate the Thevenin Voltage (V_{th}) (Open Circuit Voltage).
3. Open Current Sources and Short Voltage Sources. Calculate the Thevenin Resistance (R_{th}) (Open Circuit Resistance).
4. Now, Redraw the circuit with (V_{th}) in Step (2) as voltage Source and (R_{th}) in step (3) as a series resistance and connect the load resistor (R_L) which we had removed in Step (1). This is the Equivalent Thevenin Circuit. Now find the total current flowing through load resistor by using the Ohm's Law $I_{RL} = \frac{V_{th}}{(R_{th}+R_L)}$.

5. State and explain Superposition theorem

The response in any two-terminal linear circuit with multiple independent sources is the sum of the individual responses, considering one source at a time while the other sources are non-operative.



Circuit Diagram A



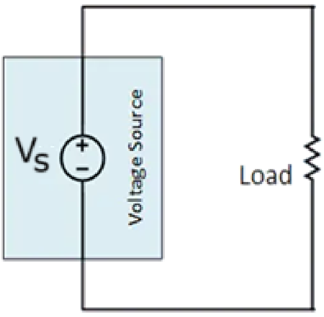
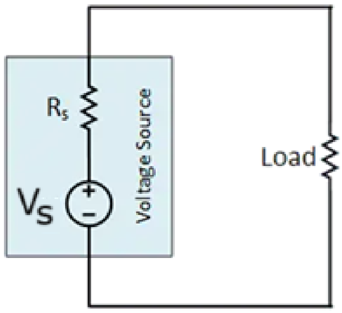
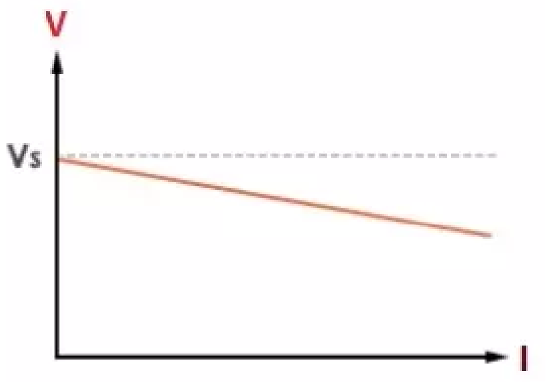
Circuit Diagram B

Circuit Diagram C

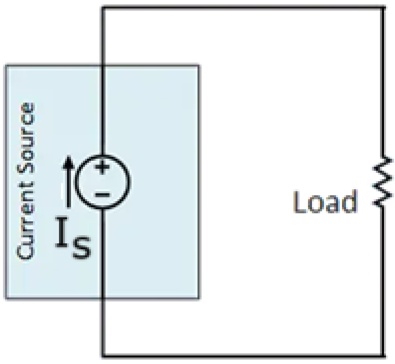
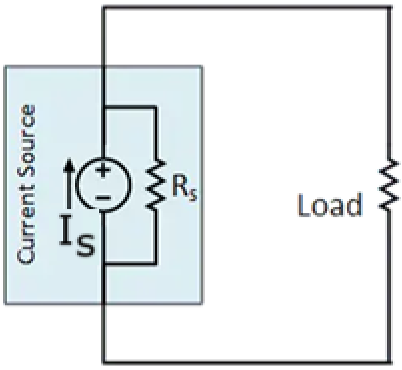
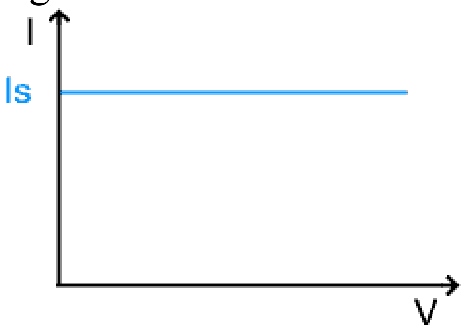
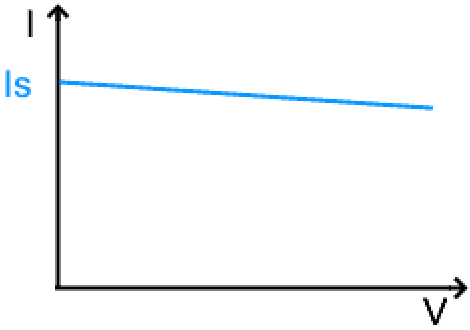
Steps of Applying Superposition Principle:

1. Deactivate all independent sources except one source. If the internal resistance of the sources is neglected then the deactivated voltage source is replaced with a "Short Circuit" (R= 0 Ω) and the deactivated current source is replaced with an open circuit (R = ∞) respectively then find the corresponding (V or I) due to that active source.
2. Repeat step (1) for each of the other independent sources.
3. Find the total contribution (V or I) by adding algebraically all the voltages or currents due to the independent sources.

6. List out difference between ideal and real voltage sources.

Ideal voltage sources	**Real voltage sources**
Ideal voltage sources are perfect models used for theoretical analysis. 	Real voltage sources have limitations due to internal resistance, leading to voltage drops and power losses in practical applications. 
Maintains a constant voltage regardless of load current. 	Provides voltage that decreases with increasing load due to internal resistance. 
Internal Resistance (R_S) is zero. causing no voltage drop.	Small but nonzero ($R_S > 0$) causing voltage drop.
Voltage remains constant under any load condition.	Voltage drops as current increases.
No internal power loss.	Some power is lost due to internal resistance ($P= I^2 R_S$).

7. List out difference between ideal and real current sources.

Ideal current sources	**Real current sources**
The ideal current source provides the same current to any load resistance and doesn't change its current by changing a load resistance. 	Ideal current source is connected in parallel with the internal resistance, and the current flowing through it depends on the load. 
Maintains a constant current regardless of load current. 	Provides current that decreases with increasing load due to internal resistance. 
Source resistance is infinite.	Source resistance is high.
Current remains constant under any load condition.	Current drops as voltage increases.
No internal power loss.	Some power is lost due to internal resistance ($P= I^2R_S$).

8. List out the differences between Mesh and Nodal Analysis.

Aspect	Mesh Analysis	Nodal Analysis
Basis	Based on Kirchhoff's Voltage Law (KVL).	Based on Kirchhoff's Current Law (KCL).
Unknown Variables	Solves for mesh currents (currents flowing in closed loops).	Solves for node voltages (voltages at circuit nodes).
Applicability	Best suited for circuits with many series elements and fewer current sources.	Best suited for circuits with many parallel elements and fewer voltage sources.
Complexity	Easier to use when the circuit has fewer meshes (loops).	Easier to use when the circuit has fewer nodes.
Equations	Equations are formed by applying KVL to each mesh.	Equations are formed by applying KCL at each node.
Preferred Use	Preferred for planar circuits (circuits that can be drawn on a plane without overlapping wires).	Preferred for both planar and non-planar circuits.

Key Points:

- Mesh analysis uses **KVL** and solves for **mesh currents**.
- Nodal analysis uses **KCL** and solves for **node voltages**.
- Mesh analysis is simpler for circuits with fewer loops, while nodal analysis is simpler for circuits with fewer nodes.

9. List out the steps followed in Mesh analysis.

a) Identify Meshes:
   - ➢ Identify all the independent closed loops (meshes) in the circuit. A mesh is a loop that does not contain any other loops within it.

b) Assign Mesh Currents:
   - ➢ Assign a current variable to each mesh. The direction of the current can be chosen arbitrarily (clockwise or counterclockwise).

c) Apply Kirchhoff's Voltage Law (KVL):
   - ➢ Write KVL equations for each mesh by summing the voltage drops and rises around the loop. For each mesh, the algebraic sum of voltages is set to zero.

d) Solve the Equations:
   - ➢ Solve the system of linear equations obtained from the KVL equations to find the mesh currents.

e) Determine Branch Currents:
   - ➢ Use the mesh currents to determine the currents in individual branches of the circuit. If a branch is shared by two meshes, the branch current is the algebraic sum or difference of the mesh currents.

10. List out the steps followed in Nodal analysis.

a) Identify Nodes:

- Identify all the principal nodes in the circuit. A node is a point where two or more circuit elements are connected.

b) Select a Reference Node:

- Choose one node as the reference node (usually the one with the most connections) and assign it a potential of zero volts.

c) Assign Node Voltages:

- Assign voltage variables to the remaining non-reference nodes. These voltages are measured with respect to the reference node.

d) Apply Kirchhoff's Current Law (KCL):

- Write KCL equations for each non-reference node by summing the currents leaving the node and setting the sum to zero. Express the currents in terms of the node voltages using Ohm's Law (I = V/R).

e) Solve the Equations:

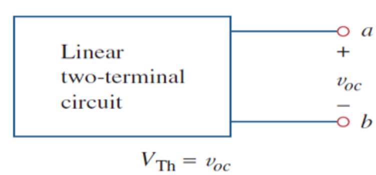
- Solve the system of linear equations obtained from the KCL equations to find the node voltages.

f) Determine Branch Currents and Voltages:

- Use the node voltages to determine the currents and voltages in individual branches of the circuit.

11. List out the steps followed to find Thevenin's theorem.

Statement: Thevenin’s theorem states that a linear two-terminal circuit can be replaced by an equivalent circuit consisting of a voltage source VTh in series with a resistor RTh, where VTh is the open-circuit voltage at the terminals and RTh is the input or equivalent resistance at the terminals when the independent sources are turned off.



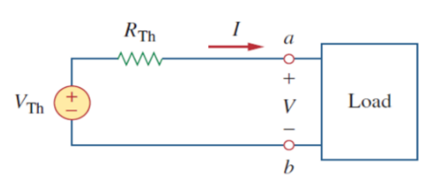
Step 1: Open the load resistor.

Step 2: Calculate the open circuit voltage. This is the Thevenin Voltage (V_{TH}).

Step 3: Open current sources and short voltage sources.

Step 4: Calculate the Open Circuit Resistance. This is the Thevenin Resistance (R_{TH}).

Step 5: Now, redraw the circuit with a series combination of open circuit Voltage (V_{TH}) calculated in Step (b), open circuit resistance (R_{TH}) calculated in step (d) with load resistor R_L which we had removed in Step (a). This is the equivalent Thevenin circuit of the linear electric network.



Step 6: Now find the Total current flowing through the load resistor by using the Ohm’s Law:

$$I_T = V_{TH} / (R_{TH} + R_L).$$

12. List out the steps followed to find Norton's theorem.

Statement: Norton's theorem states that any linear, bilateral electrical network with voltage and current sources and resistances can be replaced by an equivalent circuit consisting of a single current source in parallel with a single resistor. The current source is called the Norton equivalent current (I_N), and the resistor is called the Norton equivalent resistance (R_N).

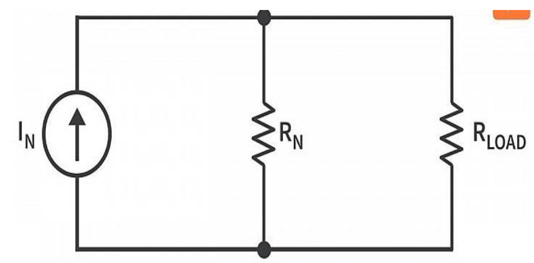
Step 1: Remove the load resistor and replace it with a short circuit.

Step 2: Calculate the Norton current—the current through the short circuit.

Step 3: All voltage sources are replaced with short circuits, and all current sources are replaced with open circuits.

Step 4: Calculate the Norton resistance —the total resistance between the open circuit connection points after all sources have been removed.

Step 5: Draw the Norton equivalent circuit, with the Norton current source in parallel with the Norton resistance. The load resistor re-attaches between the two open points of the equivalent circuit.



(13) $i_1 = 100 \sin(100t)$

$i_2 = 200 \cos(100t + 30^\circ)$

Find $i_1 + i_2$

Ans: $i_1 = 100 \sin(100t) = 100 \cos(100t - 90^\circ)$

$i_2 = 200 \cos(100t + 30^\circ)$

Phasor form $\begin{cases} i_1 = 100 \angle -90^\circ \end{cases}$; $i_2 = 200 \angle 30^\circ$

Rectangular form $\begin{cases} i_1 = 100\left[\cos(-90^\circ) + j\sin(-90^\circ)\right] = 100[-j] = -j100 \\ i_2 = 200\left[\cos 30^\circ + j\sin 30^\circ\right] = 173.2 + j100. \end{cases}$

$i_1 + i_2 = -j100 + 173.2 + j100 = 173.2 + j(0)$

$= 173.2 \angle 0^\circ$

$= 173.2 \cos(100t)$

(14) $\left.\begin{aligned} i_1 &= 100\cos(100t) \\ i_2 &= 200\sin(100t + 30^\circ). \end{aligned}\right\}$ Find $(i_1 - i_2)$

$i_1 = 100 \cos(100t)$

$i_2 = 200 \sin(100t + 30^\circ) = 200 \cos(100t + 30^\circ - 90^\circ) = 200 \cos(100t - 60^\circ)$

Phasor form $\begin{cases} i_1 = 100 \angle 0^\circ \\ i_2 = 200 \angle -60^\circ \end{cases}$

Rectangular form $\begin{cases} i_1 = 100 + j(0) \\ i_2 = 200\left[\cos(-60^\circ) + j\sin(-60^\circ)\right] \\ \quad = 100 - j173.2 \end{cases}$

$i_1 - i_2 = 100 - 100 + j173.2 = j173.2$

$= 173.2 \angle 90^\circ$

$= 173.2 \cos(100t + 90^\circ)$

(15) $i_1 = 100 \sin(100t)$, $i_2 = 200 \sin(100t + 30^\circ)$ } Find $i_1 * i_2$

$i_1 = 100 \sin(100t) = 100 \cos(100t - 90^\circ)$

$i_2 = 200 \sin(100t + 30^\circ) = 200 \cos(100t + 30^\circ - 90^\circ) = 200 \cos(100t - 60^\circ)$

Phasor form } $i_1 = 100 \angle -90^\circ$, $i_2 = 200 \angle -60^\circ$

$i_1 * i_2 = 100 \angle -90^\circ * 200 \angle -60^\circ = 20000 \angle -150^\circ$

$= 20000 \cos(100t - 150^\circ)$

(16) $i_1 = 100 \cos(100t)$, $i_2 = 200 \cos(100t + 30^\circ)$ } Find $i_1 \div i_2$

Phasor form { $i_1 = 100 \angle 0^\circ$, $i_2 = 200 \angle 30^\circ$

$$\frac{i_1}{i_2} = \frac{100 \angle 0^\circ}{200 \angle 30^\circ} = \frac{1}{2} \angle -30^\circ = 0.5 \angle -30^\circ$$

$= 0.5 \cos(100t - 30^\circ)$

(17) $i_1 = 100 \sin(100t)$, $i_2 = 200 \cos(100t + 30^\circ)$ } Find $(i_1 * i_2)^3$

$i_1 = 100 \sin(100t) = 100 \cos(100t - 90^\circ)$

$i_2 = 200 \cos(100t + 30^\circ)$

Phasor form { $i_1 = 100 \angle -90^\circ$, $i_2 = 200 \angle 30^\circ$

$i_1 * i_2 = 100 \angle -90^\circ * 200 \angle 30^\circ = 20000 \angle -60^\circ$

$(i_1 * i_2)^3 = (20000 \angle -60^\circ)^3 = 8 \times 10^{12} \angle -180^\circ$.

$= 8 \times 10^{12} \cos(100t - 180^\circ)$

18. Show that in pure resistor ac current and voltages are in same phase.

Consider the function $i(t)=I_m \sin\omega t = I_m \cos(\omega t - 90°)$

Phasor representation $I = I_m\angle -90°$

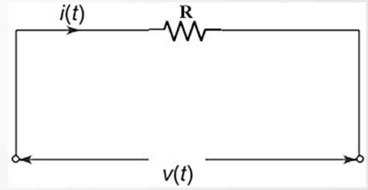
The voltage current relation in the case of a **resistor** is given by

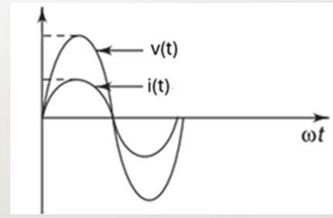
$v(t)= i(t)R = I_m R\cos(\omega t - 90°)$

Phasor representation $V = RI_m\angle -90°$

$$Z=\frac{V}{I} = \frac{RI_m\angle -90°}{I_m\angle -90°}$$

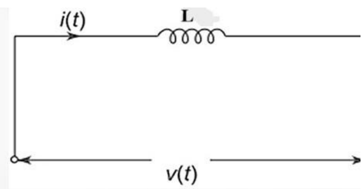
$$\boxed{\therefore Z=R}$$





Voltage wave form follows current wave form. Voltage and current phasor are in phase.

19. Show that in pure inductor ac current lags over voltage by 90° phase.



Consider the function $i(t)=I_m \sin\omega t = I_m \cos(\omega t - 90°)$

Phasor representation $I = I_m\angle -90°$

The voltage current relation in the case of an **inductor** is given by

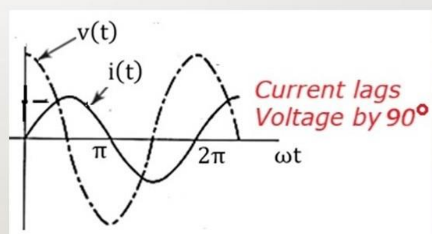
$$v(t)=L\frac{di(t)}{dt} = L\frac{d}{dt}(I_m\cos(\omega t - 90°)) = -L\omega I_m \sin(\omega t + 90°) = L\omega I_m\cos(\omega t - 90° + 90°)$$

Phasor representation $V = L\omega I_m\angle 0°$

$$Z=\frac{V}{I} = \frac{L\omega I_m\angle 0°}{I_m\angle -90°} = L\omega\angle +90° = j\omega L$$

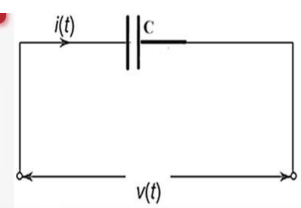
$$\boxed{\therefore Z= j\omega L = jX_L}$$

Where $X_L = \omega L$ and is called inductive reactance.



The current lags behind the voltage by 90°.

20. Show that in pure capacitor ac current lags over voltage by 90° phase.



Consider the function $i(t)=I_m \sin\omega t = I_m \cos(\omega t - 90°)$

Phasor representation $I = I_m\angle -90°$

The voltage current relation in the case of an **capacitor** is given by

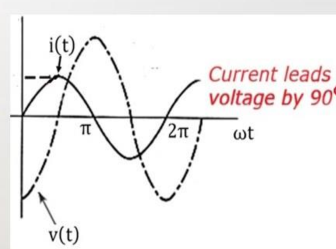
$$v(t)=\frac{1}{C}\int i(t)dt = \frac{I_m}{C}\int \cos(\omega t - 90°)dt = \frac{I_m}{\omega C}\sin(\omega t - 90°) = \frac{I_m}{\omega C}(\cos\omega t - 90° - 90°)$$

Phasor representation $V = \frac{I_m}{\omega C}\angle -180°$

$$Z=\frac{V}{I} = \frac{I_m\angle -180°}{\omega C I_m\angle -90°} = \frac{1}{\omega C}\angle -90° = \frac{-j}{\omega C}$$

$$\boxed{\therefore Z= \frac{-j}{\omega C} = -jX_C}$$

Where $X_C = \frac{1}{\omega C}$ and is called capacitive reactance.



The current leads the voltage by 90°.

SECTION-C

1.A 50μF capacitor is connected across a 230V, 50Hz supply. Calculate (a) the reactance offered by the capacitor (b) the maximum current (c) the r.m.s. value of the current drawn by the capacitor (d) the maximum energy stored in the capactitor and (e) plot the current and voltage waveforms.

given that $C = 50\mu F$, $f = 50Hz$ $\therefore \omega = 2\pi f = 100\pi$ and

$V_m = 230\sqrt{2}\,V$

Capacitive reactance $X_C = \frac{1}{\omega C} = \frac{1}{100\pi \times 50\times10^{-6}} = 63.66\Omega$

The capacitive reactance is $-jX_C = -j63.66 = 63.66\angle{-90^\circ}$

The maximum current $I_m = \frac{V_m}{|X_C|} = \frac{230\sqrt{2}}{63.66} = 5.109A$

The rms value of the current $= \frac{I_m}{\sqrt{2}} = 0.707\times5.109 = 3.613.$

The maximum energy stored $E = \frac{1}{2}CV_m^2 = \frac{1}{2}\times50\times10^{-6}(230\sqrt{2})^2$

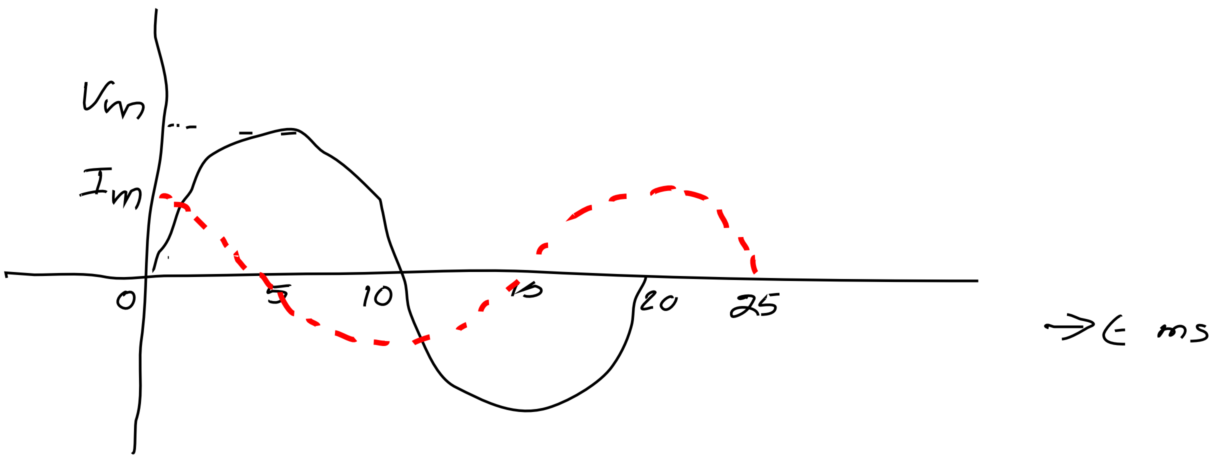
$= 2.645$ Joules

Here $v = 230\sqrt{2}\sin100\pi t$

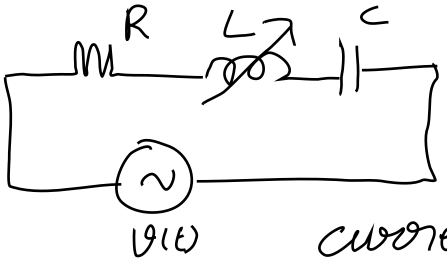
$V = 230\sqrt{2}\angle{-90^\circ}$; $I = \frac{230\sqrt{2}\angle{-90^\circ}}{63.66\angle{-90^\circ}} = 5.109\angle{0^\circ}$

$\therefore i = 5.109\cos100\pi t = 5.109\sin(100\pi t + 90^\circ)$

Here $f = 50Hz$ $\therefore T = \frac{1}{50} = 20ms$



2.For a series R-L-C circuit the inductor is variable. Source voltage is 283sin100πt. Maximum current obtainable by varying the inductance is 0.314 A and the voltage across the capacitor then is 300V. Find the circuit element values, resonance frequency, Q-factor and bandwidth of the circuit.



Here $v(t) = 283\sin 100\pi t$ V

$\omega = 100\pi$.

Since 'L' varied at one instant current is maximum means, the circuit is in resonance and the resonance frequency $\omega_0 = \omega$

$\Rightarrow \omega_0 = 100\pi \Rightarrow f_0 = \frac{100}{2\pi} = 50Hz$

at resonance current is maximum

$I = I_0 = \frac{V_m}{|Z|}$. Here $Z = R + JX$

where $X = 0 \Rightarrow X_L = X_C$

$\therefore I_0 = \frac{V_m}{R} = \frac{283}{R} \Rightarrow R = \frac{283}{0.314} = 901.27\Omega$

at resonance $|JX_L| = |-JX_C|$

and $|V_L| = |V_C| = 300$

but $|V_L| = |JX_L I_0| = \omega_0 L I_0 = 300$

$\therefore L = \frac{300}{\omega_0 I_0} = \frac{300}{100\pi \times 0.314} = 3.041$ H

but $|V_C| = |-JX_C I_0| = \frac{I_0}{\omega_0 C} = 300$

$\Rightarrow C = \frac{I_0}{300\omega_0} = \frac{0.314}{300 \times 100\pi} = 3.332\,\mu F$

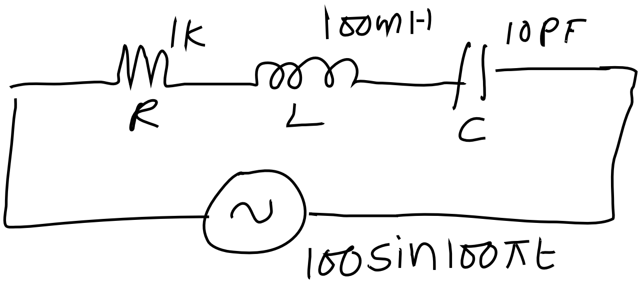
The Q-factor $= \frac{\omega_0 L}{R} = \frac{1}{\omega_0 RC} = \frac{1}{R}\sqrt{\frac{L}{C}} = 1.06$

Bandwidth $\Delta f = \frac{R}{2\pi L} = 47.17Hz$

or $\Delta f = \frac{f_0}{Q} = \frac{50}{1.06} = 47.17Hz$

10μF

3.A series circuit with R = 1kΩ, L = 100 mH and C = 10μF is supplied with 100V,50 Hz. Determine the impedance, current, power factor, resonance frequency, Q-factor and bandwidth of the circuit.



Here $JX_L = J\omega L$

$= J\,100\pi \times 100 \times 10^{-3}$

$= J10\pi\ \Omega = 10\pi\angle 90^\circ$

$$-JX_C = \frac{-J}{\omega C} = \frac{-J}{100\pi \times 10 \times 10^{-6}} = -J\,318.31\,\Omega$$

The impedance $Z = R + JX_L - JX_C = 1000 + j10\pi - J318.31$

$= 1000 - J286.9\ \Omega = 1040\angle -16^\circ$

at resonance $Z = R = 1000\Omega$

current $I_0 = \frac{V_m}{R} = \frac{100}{1000} = 0.1\,A$

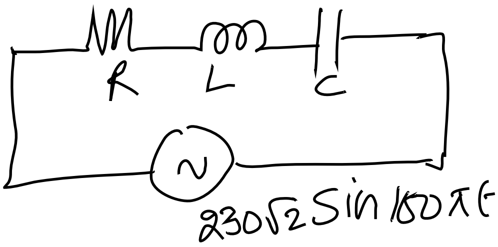
Power factor $PF = \cos 0^\circ = 1$

resonance frequency $f_0 = \frac{1}{2\pi\sqrt{LC}} = 159.15\,Hz$

Q-factor $= \frac{\omega_0 L}{R} = \frac{2\pi \times 159.15 \times 100 \times 10^{-3}}{1000} \simeq 0.1$

Bandwidth $\Delta f = \frac{R}{2\pi L} = 1591.5\,Hz = \frac{f_0}{Q}$

4.A series circuit with R = 100Ω, L = 10 mH and C = 10μF is supplied with 230V,50 Hz. Determine the impedance, current, power factor resonance frequency, Q-factor and bandwidth of the circuit.



$$jX_L = j\omega L = j\,100\pi \times 10 \times 10^{-3}$$

$$= j\pi\,\Omega = \pi\angle 90^\circ\,\Omega$$

$$-jX_C = \frac{-j}{\omega C} = \frac{-j}{100\pi \times 10 \times 10^{-6}}$$

$$= -j\,318.3\,\Omega = 318.3\angle -90^\circ\,\Omega$$

$$\therefore Z = R + jX$$

$$= 100 + j3.14 - j318.3 = 100 - j315.17 = 330.65\angle -72.4^\circ$$

The impedance at resonance $Z = R$ $\because X = 0$

$\therefore$ $Z = 100\Omega$; current $I_0 = \frac{V_m}{|Z|} = \frac{230\sqrt{2}}{100} = 3.253A$

power factor $= \cos 0^\circ = 1$

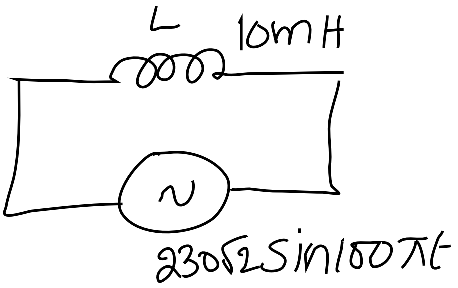
$$f_0 = \frac{1}{2\pi\sqrt{LC}} = \frac{1}{2\pi\sqrt{10\times10^{-3}\times10\times10^{-6}}} = 503.3\,Hz$$

$$\text{Q-factor }(Q) = \frac{\omega_0 L}{R} = \frac{2\pi f_0 L}{R} = \frac{2\pi\times503.3\times10\times10^{-3}}{100}$$

$$= 0.316$$

$$\text{Bandwidth } \Delta f = \frac{R}{2\pi L} = \frac{f_0}{Q} = \frac{100}{2\pi\times10\times10^{-3}} = 1591.5\ Hz$$

5. A 10mH inductor is connected across a 230V, 50Hz supply. Calculate (a) the reactance offered by the inductor (b) the maximum current and (c) the rms value of the current drawn by the inductor (d) the maximum energy stored in the inductor and (e) plot the current and voltage waveform.



The reactance JX_L

$$= J\omega L$$
$$= J\,100\pi \times 10 \times 10^{-3}$$
$$= J\pi\,\Omega = \pi \angle 90^\circ$$

$$v = 230\sqrt{2}\sin 100\pi t$$

$\therefore V = 230\sqrt{2}\angle -90^\circ$ Hence current $I_m = \dfrac{V}{JX_L}$

$$= \frac{230\sqrt{2}\angle -90^\circ}{\pi \angle 90^\circ} = 103.54\angle -180^\circ \text{ A}$$

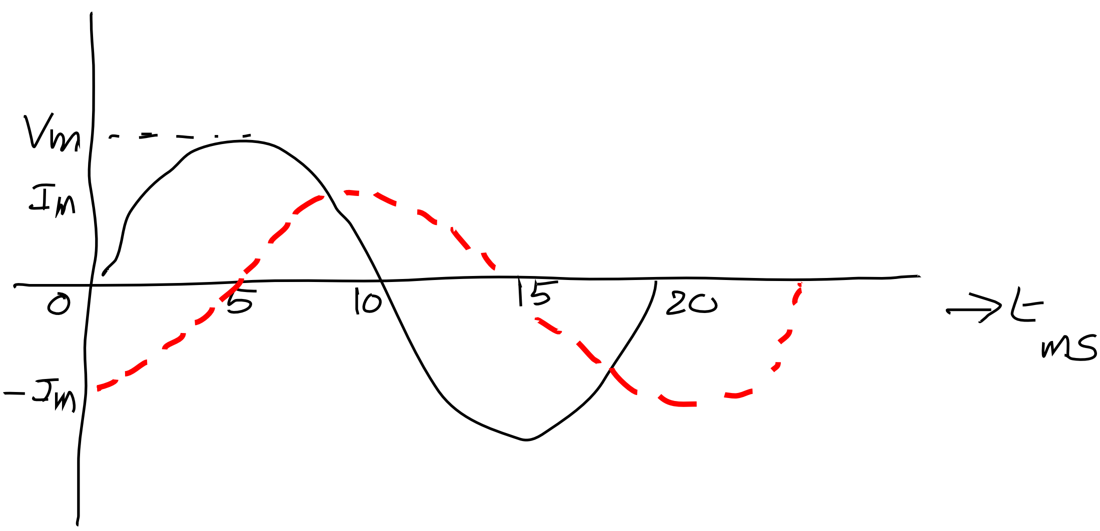
i.e $i = 103.54\sin(100\pi t - 90^\circ)$

The rms current $= \dfrac{I_m}{\sqrt{2}} = 103.54 \times 0.707 = 73.21$ A

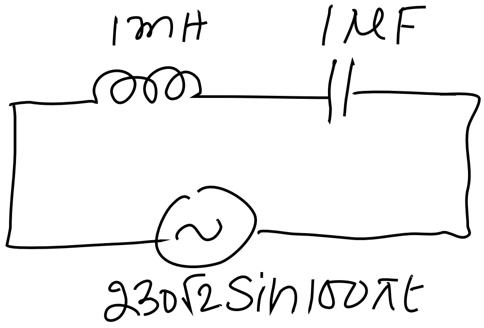
The maximum Energy stored in the inductor

is $E = \frac{1}{2} L I_m^2 = \frac{1}{2} \times 10 \times 10^{-3} \times 103.54^2$

$$= 53.60 \text{ Joules}$$



6. A 1mH inductor and a 1μFcapacitor are connected in series with a 230V, 50Hz supply. Calculate (a) the reactance offered by the inductor (b) the maximum current and (c) the rms value of the current drawn by the inductor (d) the maximum energy stored in the inductor and (e) plot the current and voltage waveform.



Here $\omega = 100\pi$

$v = 230\sqrt{2}\sin 100\pi t$

$V = 230\sqrt{2}\angle -90^\circ$

inductive reactance $jX_L = j\omega L = j100\pi \times 1 \times 10^{-3}$

$= j0.314\ \Omega = 0.314\angle 90^\circ$

capacitive reactance $-jX_C = \frac{-j}{\omega C} = \frac{-j}{100\pi \times 10^{-6}}$

$= -j3183\ \Omega = 3183\angle -90^\circ\ \Omega$

Now $Z = jX_L + jX_C = j0.314 - j3183$

$= -j3182.7\ \Omega = 3182.7\angle -90^\circ\ \Omega$

Hence current $= \frac{V}{Z} = \frac{230\sqrt{2}\angle -90^\circ}{3182.7\angle -90^\circ} = 102\angle 0^\circ$ mA

Hence $i = 102\sin(100\pi t + 90^\circ)$ mA

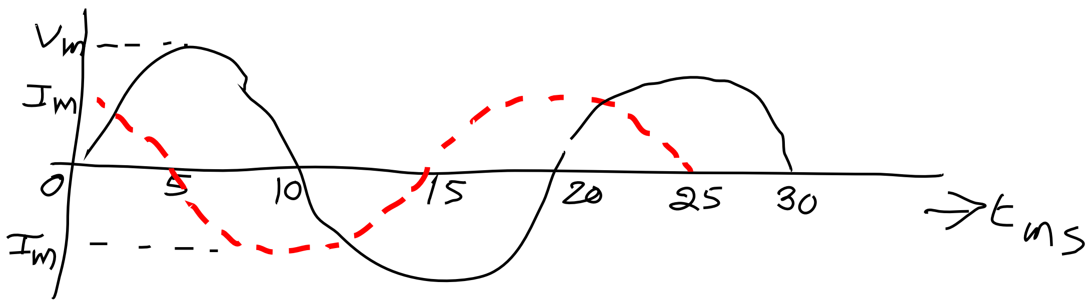
maximum current in the inductor = 102 mA

rms current = $102 \times 0.707 = 72.3$

maximum energy stored in the inductor is

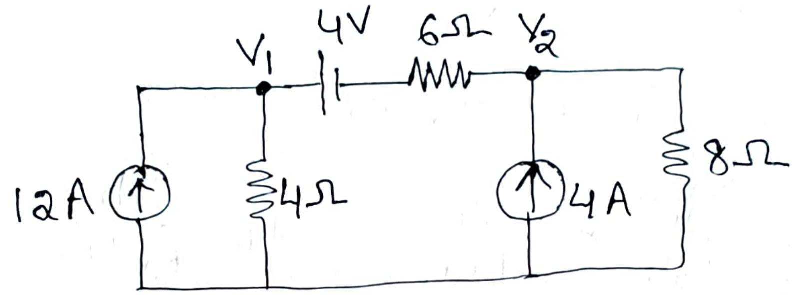
$E = \frac{1}{2} L I_m^2 = \frac{1}{2} \times 10^{-3} (102 \times 10^{-3})^2$

$= 5.202\ \mu$ Joules

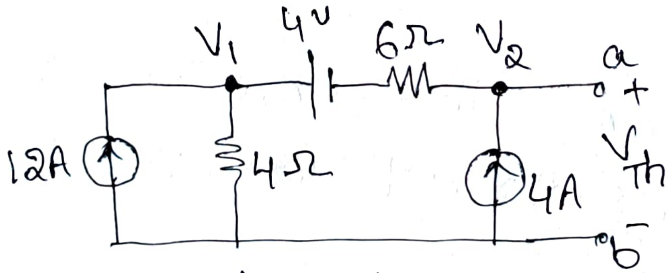


section-C

7. Using thevenin's theorem, find the current flowing through the 8Ω resistor of the network shown.



Sol:- (i) To find V_{Th}: Remove $R_L = 8\Omega$



$V_{Th} = V_2$

By nodal analysis,

At node-1 : $\frac{V_1}{4} + \frac{V_1 - 4 - V_2}{6} = 12$

$3V_1 + 2V_1 - 8 - 2V_2 = 144$

$5V_1 - 2V_2 = 152 \rightarrow (1)$

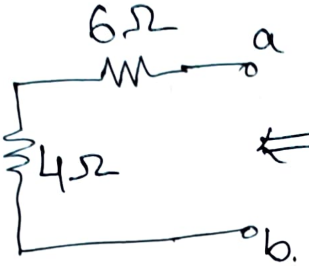
At node-2 : $\frac{V_2 + 4 - V_1}{6} = 4$

$-V_1 + V_2 = 20 \rightarrow (2)$

Solving eq- (1) & (2), we get

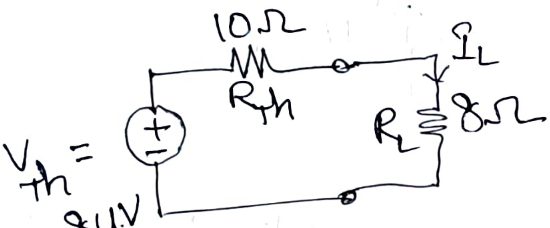
$\boxed{V_1 = 64V \qquad V_{Th} = V_2 = 84V}$

ii) To find R_{th}:



$\Leftarrow R_{th} = 6+4 = 10\Omega.$

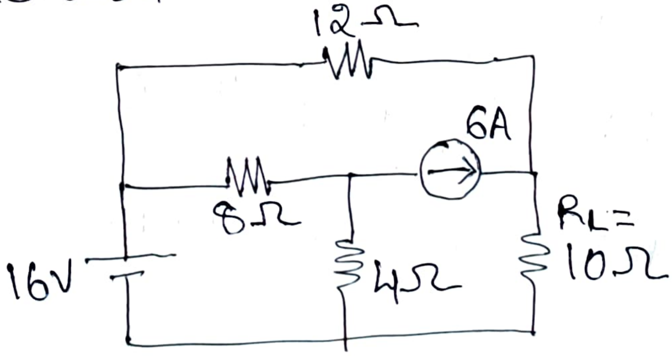
(iii) To find current in 8Ω resistor:



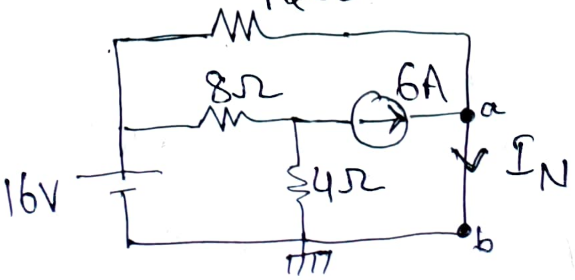
$$I_L = \frac{V_{th}}{R_{th}+R_L} = \frac{84}{18}$$

$$\boxed{I_L = 4.67\,A}$$

(8) Using Norton's theorem, find the current flowing through 10Ω resistor in the network shown.



Sol:- (i) To find short circuit current I_N,



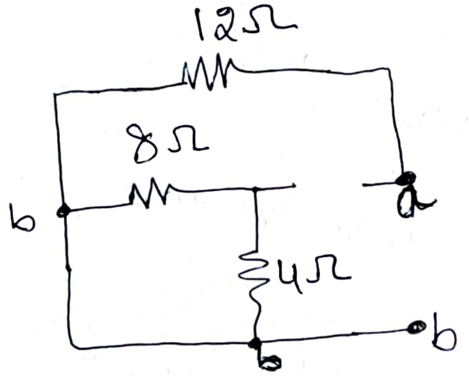
current through 12Ω is

$$I_{12\Omega} = \frac{16}{12} = 1.33A$$

By KCL at node-a,

$$I_N = 6 + I_{12\Omega} = 6 + 1.33 = \underline{\underline{7.33A.}}$$

(ii) To find R_N:

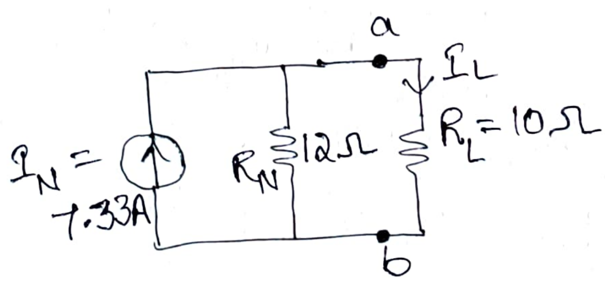


R_N = Resistance between node-a and node-b.

$$\boxed{R_N = 12\Omega}$$

[∵ (8+4) is parallel with short circuit]

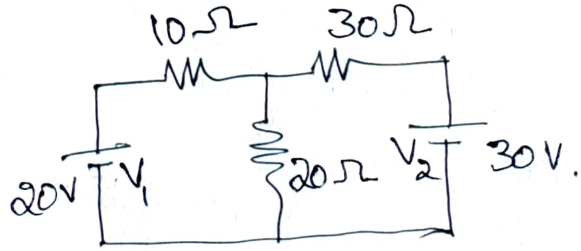
(iii) To find current in 10Ω resistor:



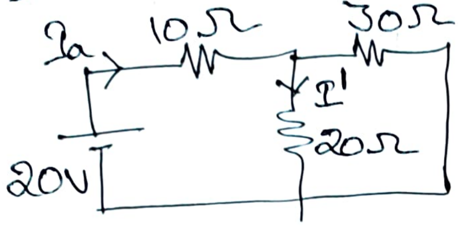
$$I_L = I_N \times \frac{R_N}{R_N + R_L}$$

$$\boxed{I_L = 7.33 \times \frac{12}{22} = 4A}$$

(9) Using superposition theorem, find the current flowing through the 20Ω resistor of the network shown.



sol:- (i) with only 20V source in the network,



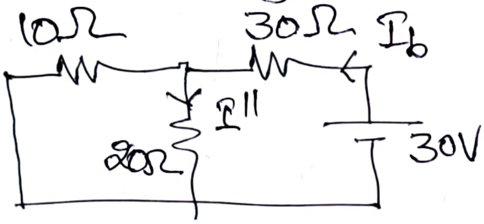
$$I_a = \frac{20}{10+\frac{20\times 30}{20+30}} = \frac{20\times 50}{1100}$$

$$I_a = \frac{10}{11} = 0.91A.$$

then

$$I' = I_a \times \frac{30}{30+20} = 0.55A.$$

(ii) with only 30V source in the network,



$$I_b = \frac{30}{30+\frac{10\times 20}{10+20}} = 0.82A$$

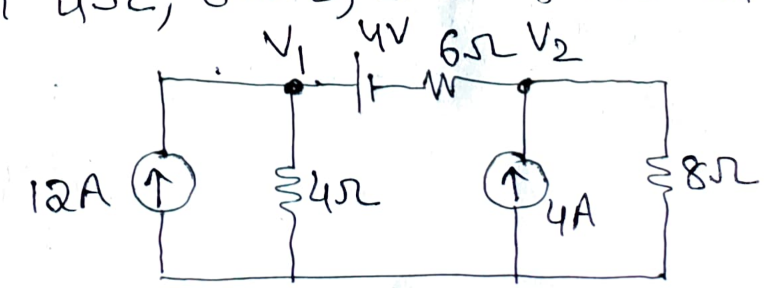
then

$$I'' = I_b \times \frac{10}{10+20} = 0.27A$$

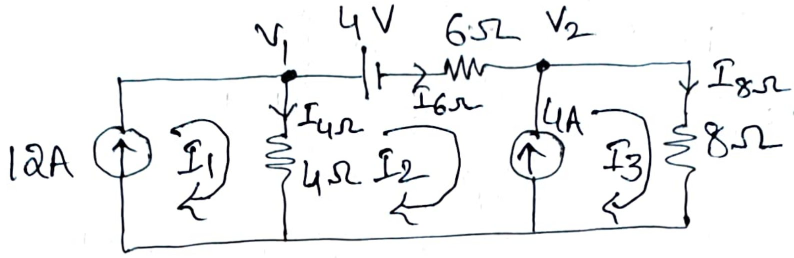
(iii) By superposition theorem, the current flowing through 20Ω resistor is

$$I = I' + I'' = 0.55 + 0.27 = 0.82A$$

(10) Using mesh analysis, determine the currents in 4Ω, 6Ω & 8Ω of the network shown.



Sol:- Let the mesh currents are I_1, I_2 and I_3 as shown



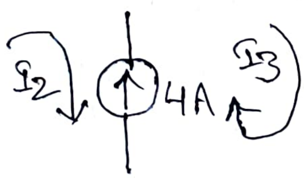
From mesh-1 : $I_1 = 12A$.

from mesh-2 & 3 form a super mesh, then

$$4(I_2 - I_1) + 4 + 6I_2 + 8I_3 = 0$$

$$10I_2 + 8I_3 = 44 \rightarrow (1) \quad [\because I_1 = 12]$$

From 4A current source branch,



$$-I_2 + I_3 = 4 \rightarrow (2)$$

solving eq-(1) & (2), we get

$$I_2 = 0.67A \quad \text{and} \quad I_3 = 4.67A.$$

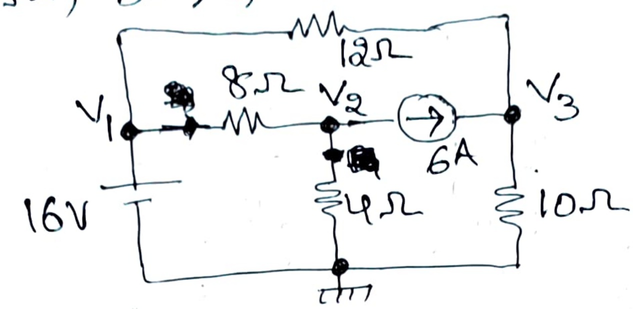
Now,

$$I_{4Ω} = I_1 - I_2 = 12 - 0.67 = \underline{\underline{11.33A}}.$$

$$I_{6Ω} = I_2 = \underline{\underline{0.67A}}$$

$$I_{8Ω} = I_3 = \underline{\underline{4.67A}}.$$

(11) using nodal analysis, determine the currents in 4Ω, 8Ω, $\overset{10\Omega}{\&}$ 12Ω in the network shown.



$\underline{\text{sol:-}}$ Let V_1, V_2 and V_3 are the node voltages at node-1, 2, & 3, respectively, w.r.t ground.

From node-1: $\boxed{V_1 = 16\text{ V.}}$

From node-2, by KCL:

$$\frac{V_2 - V_1}{8} + \frac{V_2}{4} + 6 = 0.$$

$$-V_1 + 3V_2 = -48 \rightarrow (1) \quad \therefore \boxed{V_2 = -10.67\text{ V.}}$$

From node-3, by KCL

$$\frac{V_3 - 16}{12} + \frac{V_3}{10} = 6 \Rightarrow 11V_3 = \cancel{280}\ 440$$

$$\therefore \cancel{V_3 = 25.45\text{ V}} \qquad \boxed{V_3 = 40\text{V}}$$

Then,

$$I_{8\Omega} = \frac{V_1 - V_2}{8} = 3.33\text{A.}$$

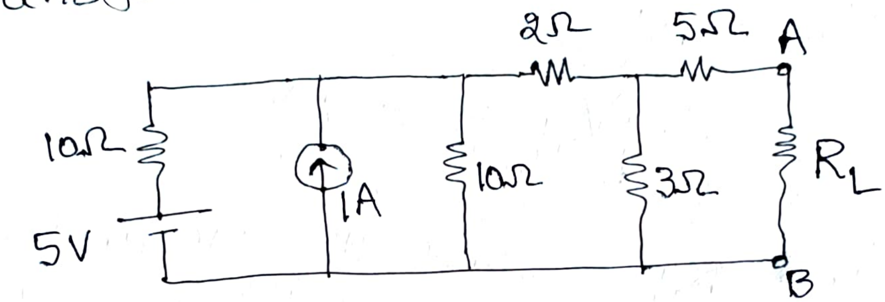
$$I_{4\Omega} = \frac{V_2}{4} = -2.67\text{A}$$

$$I_{10\Omega} = \frac{V_3}{10} = \cancel{2.545\text{ A}} = 4\text{A}$$

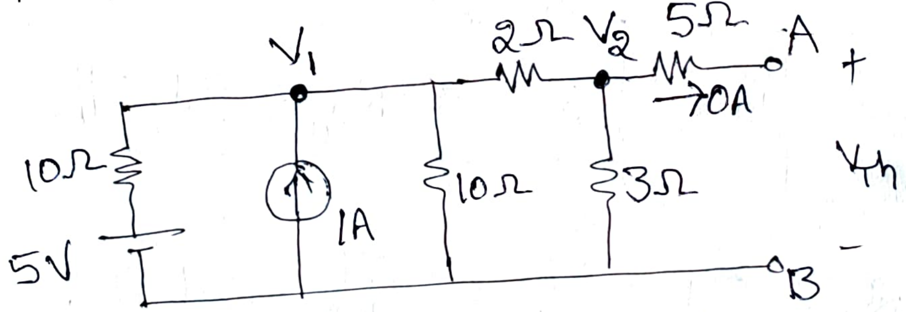
$$I_{12\Omega} = \frac{V_3 - V_1}{12} = \frac{24}{12} = \cancel{0.788\text{A}}.$$

$$I_{12\Omega} = 2\text{A}.$$

(12) In the circuit shown, (a) obtain the condition for maximum power transfer to the load R_L. (b) Hence determine the maximum power transferred.



Sol:- (i) To find thevenin's voltage across the terminals A–B:



By nodal analysis; at node-1,

$$\frac{V_1-5}{10}+\frac{V_1}{10}+\frac{V_1-V_2}{2}=1$$

$$7V_1-5V_2=15 \rightarrow (1)$$

at node-2:

$$\frac{V_2-V_1}{2}+\frac{V_2}{3}=0 \Rightarrow -3V_1+5V_2=0 \rightarrow (2)$$

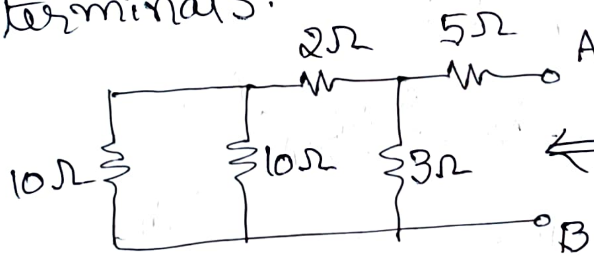
solving eq-(1) & (2), we get

$V_1 = 3.75V$ and $V_2 = 2.25V$.

As no current flow through 5Ω when load terminals are open, the thevenin's voltage V_{Th} across A-B terminals is equal to V_2 only.

$$\therefore \boxed{V_{Th} = 2.25V}$$

(ii) To find R_{Th}, short the 5V and open the 1A sources and calculate R_{Th} between load terminals.

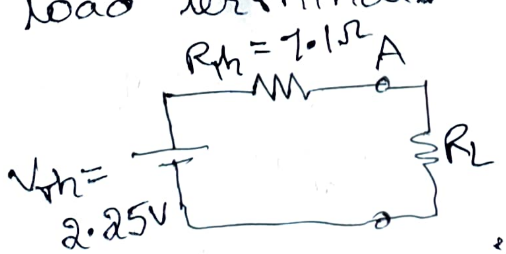


$$\Leftarrow R_{Th} = 5 + [3 \| (2 + (10 \| 10))]$$

$$R_{Th} = 5 + \frac{3 \times 7}{3+7} = \frac{71}{10} = 7.1\Omega.$$

$$\boxed{R_{Th} = 7.1\Omega}$$

(iii) the thevenin's equivalent circuit across load terminals is



According to maximum Power transfer theorem, for max. power transfer is possible when $R_L = R_{Th}$.

$$\therefore \boxed{R_L = 7.1\Omega}$$

(iv) The value of max. power transferred to the load $P_{L,max}$ is,

$$P_{L,max} = \frac{V_{Th}^2}{4R_{Th}} = \frac{(2.25)^2}{4 \times 7.1}$$

$$\boxed{P_{L,max} = 0.18\,W.}$$