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<th>Name of the Experiment</th>
<th>Page No</th>
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<td>6</td>
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<td>3.</td>
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<td>33</td>
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</table>
1. Verification of Kirchoff’s Law

Aim:

To verify the Kirchoff’s laws for the given network with the theoretical calculations.

Statement:

Kirchoff’s Current Law (KCL)

♦ Sum of all currents entering a node is zero.
♦ Sum of currents entering the node is equal to sum of currents leaving the node.

\[
\sum_{j=1}^{n} i_j(t) = 0
\]

Kirchoff’s Voltage Law (KVL)

♦ Sum of voltages around any loop in a circuit is zero.

\[
\Sigma V = V_1 + V_2 + \ldots + V_n = 0
\]

Apparatus required:
<table>
<thead>
<tr>
<th>S.No</th>
<th>Apparatus Required</th>
<th>Range</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Regulated Power Supply (RPS)</td>
<td>(0-30) V</td>
<td>1</td>
</tr>
<tr>
<td>2.</td>
<td>Ammeter (MC)</td>
<td>(0-100) mA</td>
<td>3</td>
</tr>
<tr>
<td>3.</td>
<td>Voltmeter (MC)</td>
<td>(0-10) V</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td><strong>Other items</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>Resistors</td>
<td>220Ω, 330Ω, 10kΩ, 22kΩ, 33kΩ</td>
<td>Each 1 no</td>
</tr>
<tr>
<td>2.</td>
<td>Bread Board</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>3.</td>
<td>Wires</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Kirchoff’s current law:**

*Circuit diagram:*

Let $R_1 = 220\Omega$; $R_2 = 330\Omega$

**Procedure:**
1. Connections are made as per the circuit diagram.
2. The total current is calculated theoretically \( (I_{th}) \).
3. The current through each branch is measured practically \( (I_1,I_2) \) and added to get the value \( I_{pr} \).
4. Verify KCL for each & every node presents in the given network.
5. Repeat the same procedure for different values of voltages.

**Observation:**

<table>
<thead>
<tr>
<th>V(volts)</th>
<th>( I_{th}(mA) )</th>
<th>( I_1(mA) )</th>
<th>( I_2(mA) )</th>
<th>( I_{pr}=I_1+I_2(mA) )</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Theoretical calculation**

\[
R_T = \frac{R_1}{|R_2|} = \frac{220\Omega}{|330\Omega|} = 132\Omega
\]

For \( V = 10V \)

\[
I_{th} = \frac{V}{R_T} = 75.8mA
\]

\[
I_1 = I * \frac{R_2}{(R_1+R_2)} = 45.5mA
\]

\[
I_2 = I * \frac{R_1}{(R_1+R_2)} = 30.3mA
\]

\[
I_{pr} = I_1 + I_2 = 45.5 + 30.0 = 75.8mA
\]

**Kirchoff’s voltage law:**
Circuit diagram:

Procedure:

1. Connections are made as per the circuit diagram.
2. The voltages \( V_1, V_2 \) and \( V_3 \) across each resistance is measured for different values of input voltage \( V \).
3. Add the voltages \( V_1, V_2 \) and \( V_3 \) and denote it as \( V_T \).
4. Verify KVL for the loop present in the given network (\( V_T = V \)).

Observation:

<table>
<thead>
<tr>
<th>( V ) (volts)</th>
<th>( V_1 ) (volts)</th>
<th>( V_2 ) (volts)</th>
<th>( V_3 ) (volts)</th>
<th>( V_T = V_1 + V_2 + V_3 )</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Theoretical Calculation
\[ V = V_1 + V_2 + V_3 \]
\[ V_1 = I \times R_1 \]
\[ V_2 = I \times R_2 \]
\[ V_3 = I \times R_3 \]

where \( I \) is the current in the loop = \( V / (R_1 + R_2 + R_3) \).

For \( V = 10V \)
\[ I = \frac{10}{(10+22+33) \times 10^3} = 0.154 \text{ mA} \]
\[ V_1 = 0.154 \times 10 = 1.54V \]
\[ V_2 = 0.154 \times 22 = 3.39V \]
\[ V_3 = 0.154 \times 33 = 5.08V \]

\[ V_1 + V_2 + V_3 = 10.01V \]

Result:

Using Kirchoff’s Laws the node currents and branch voltages are theoretically calculated & practically verified.
2. Verification of Superposition Theorem

Aim:

To verify the Superposition theorem for given circuit.

Statement:

In a linear bilateral network containing more than one source, the current flowing through any branch is the algebraic sum of the current flowing through that branch when sources are considered one at a time and replacing the other source by their internal resistance.

Apparatus Required:

<table>
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<th>S.No</th>
<th>Apparatus Required</th>
<th>Range</th>
<th>Quantity</th>
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<td>Regulated Power Supply</td>
<td>(0-30) V</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>Ammeter (MC)</td>
<td>(0-10)mA</td>
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<tr>
<td></td>
<td><strong>Other items</strong></td>
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<tr>
<td>3</td>
<td>Resistors</td>
<td>10kΩ</td>
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<tr>
<td>4</td>
<td>Bread Board</td>
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<td>1</td>
</tr>
<tr>
<td>5</td>
<td>Wires</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Circuit Diagram:

Fig 1

Fig 2

Fig 3
Procedure:

1. Connect the circuit as per the circuit diagram (Fig 1).
2. Switch on the DC power supplies (10V and 5V) and note down the corresponding ammeter reading ($I_{pr}$).
3. Replace the second power supply (5V) by short circuit.
4. Switch on the power supply (10V) and note down the corresponding ammeter reading ($I_1$).
5. Connect the second power supply (5V) and replace the first power supply by short circuit.
6. Switch on the power supply (5V) and note down the corresponding ammeter reading ($I_2$).
7. Verify the following condition
   \[ I_{pr} = I_1 + I_2 \]
8. Calculate $I_1$, $I_2$ theoretically using mesh equations then find $I_{th} = I_1 + I_2$ and compare with the Practical value $I_{pr}$.

Observation:

<table>
<thead>
<tr>
<th>$I_1$ (mA)</th>
<th>$I_2$ (mA)</th>
<th>$I_{pr} = I_1 + I_2$ (mA)</th>
<th>$I_{th}$ (mA)</th>
</tr>
</thead>
</table>

Result

Superposition theorem for given circuit was verified.
3. Verification of Thevenin’s Theorem

Aim:
To practically verify the Thevenin’s theorem for the network with the theoretical calculations.

Statement:
Any two terminal network having a number of voltage sources & resistances can be replaced by a simple equivalent circuit consisting of single voltage source in series with a resistance, where the value of voltage source is equal to the open circuit voltage across the two terminals of the network, and resistance is equal to the equivalent resistance measured between the terminals with all energy source replaced by their internal resistance.
Apparatus Required:

<table>
<thead>
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<th>Quantity</th>
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</tr>
<tr>
<td>2</td>
<td>Voltmeter (MC)</td>
<td>(0-10) V</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>Resistors</td>
<td>220Ω</td>
<td>Each 1 no</td>
</tr>
<tr>
<td></td>
<td></td>
<td>330Ω, 1kΩ</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Bread Board</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>5</td>
<td>Wires</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Other items

Circuit diagram and Procedure:

I. Voltage Measurement

Let $R_1=220\Omega$ $R_2=330\Omega$ $R_L=1k\Omega$

1. Connect the circuit as per above diagram
2. Measure the voltage across the load using proper voltmeter
II. Thevenin’s Equivalent Voltage:

1. Remove the load resistance and connect the circuit as per above Diagram.
2. Measure the voltage across the output terminal using proper voltmeter.

![Thevenin's Equivalent Voltage Diagram]

III. Thevenin’s Equivalent Resistance:

1. Replace the voltage source by its internal resistance and open circuit the load.
2. Connect the circuit as per above diagram.
3. Using multimeter in resistance mode measure the resistance across the output terminal.
IV. Thevenin’s Circuit

1. Connect the supply $V_{th}$ and resistance $R_{th}$ in series as shown in the Circuit.
2. Connect the load resistance.
3. Switch the supply and measure the voltage drop across the load using voltmeter.

**Observation:**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Theoretical value</th>
<th>Practical value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$R_{th}$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$V_{th}$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$V_{load}$</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Theoretical Calculation:**

$R_1 = 220 \, \Omega \quad R_2 = 330 \, \Omega \quad R_L = 1 \, K\Omega$

$I_T = \frac{V}{(R_1 + (R_2||R_L))} = 21.3 \, mA$

$I_L = I_T \times \frac{R_2}{R_2 + R_L} = 5.3 \, mA$

$V_L = I_L \times R_L = 5.3 \, V$

$V_{th} = \frac{V}{(R_2/(R_1+R_2))} = 6 \, V$

$R_{th} = \frac{R_1 \times R_2}{(R_1+R_2)} = 132 \, \Omega$

$I_L = \frac{V_{th}}{(R_{th} + R_L)} = 5.3 mA$

$V_L = I_L \times R_L = 5.3 \, V$
EXERCISE 1:

Circuit Diagram and Procedure:

Let $R_1=10\,\Omega$, $R_2=4.7\,\Omega$, $R_3=10\,\Omega$, $R_4=10\,\Omega$, $R_L=1\,\Omega$

I. Voltage Measurement

1. Connect the circuit as per above diagram.
2. Measure the voltage across the load using proper voltmeter.

II. Thevenin’s Equivalent Voltage:

1. Remove the load resistance and connect the circuit as per above diagram.
2. Measure the voltage across the output terminal using proper voltmeter.
III. Thevenin’s Equivalent Resistance:

1. Replace the voltage source by its internal resistance and open circuit the load.
2. Connect the circuit as per above diagram.
3. Using multimeter in resistance mode measure the resistance across the Output terminal.

IV. Thevenin’s Circuit

1. Connect the supply $V_{th}$ and resistance $R_{th}$ in series as shown in the circuit.
2. Connect the load resistance.
3. Switch the supply and measure the voltage drop across the load using voltmeter.
4. Verification of Maximum Power Transfer Theorem

Aim:

To verify the Maximum Power Transfer theorem for the network with the theoretical calculations.

Statement:

In a DC circuit the maximum power transferred from a source to the load resistance $R_L$ when the load resistance is made equal to the resistance of the network as viewed from the load terminal with load removed and all the sources replaced by their internal resistance $R_{TH}$.

Apparatus Required:

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<th>Quantity</th>
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</thead>
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<tr>
<td>1</td>
<td>Regulated Power Supply</td>
<td>(0-30) V</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>Voltmeter (MC)</td>
<td>(0-10) V</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>Resistors</td>
<td>100Ω, 470Ω, 330Ω</td>
<td>Each 1 no</td>
</tr>
<tr>
<td>4</td>
<td>Decode Resistance Box</td>
<td>(0-10) kΩ</td>
<td>1</td>
</tr>
<tr>
<td>5</td>
<td>Bread Board</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Wires</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Circuit Diagram:

Let $R_1 = 100\, \Omega$  $R_2 = 330\, \Omega$  $R_3 = 470\, \Omega$

Procedure

1. Remove the portion of the network through which maximum power has to be transferred.
2. Name those terminals as A&B.
3. Calculate $R_{th}$ by substituting all sources with their internal resistances looking back at the network.
4. Give the connection as per the circuit diagram.
5. By varying the DRB ($R_L$), for various values of $R_L$, measure the current through $R_L$.
6. Calculate the power delivered to $R_L$.
7. Plot the graph between $R_L$ & $P_L$.
8. Verify that the resistance ($R_L$) at $P_L$ (max) is equal to $R_{th}$.

Model Graph
Theoretical Verification:

\[ R_{th} = (100\Omega \parallel 470\Omega) + 330\Omega = 82.46 + 330 = 412.45\Omega \]

Equivalent voltage = \( \frac{10 \times 470}{570} \)
= 8.2456 V

Current through load resistance = \( \frac{8.24256}{412 + 412} \)
= 10mA

Power dissipated across the resistance = \( I^2 \times R_L = 100 \times 10^{-6} \times 412.45 = 41.4475\text{mWatts} \)

Result:
Using Maximum Power Transfer theorem, theoretically calculated values of \( R_L \) & \( P_L \) are verified with the practically measured values.
5. Verification of Norton’s Theorem

Aim:
To verify the Norton’s theorem for the network with the theoretical calculations.

Statement:
Any two terminal linear networks with current source, voltage source and resistances can be replaced by an equivalent circuit consisting of a current source in parallel with a resistance. The value of current source is the short circuit between the two terminals of the network and resistance is equal to the equivalent resistance measured between the terminals with all energy source replaced by their internal resistance.

Apparatus Required:

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<td>1</td>
</tr>
<tr>
<td>2</td>
<td>Voltmeter (MC)</td>
<td>(0-10) V</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>Resistors</td>
<td>220Ω, 330Ω, 1kΩ</td>
<td>Each 1 no</td>
</tr>
<tr>
<td>4</td>
<td>Bread Board</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>5</td>
<td>Wires</td>
<td></td>
<td>1</td>
</tr>
</tbody>
</table>
Circuit diagram and Procedure:

I. Current Measurement

Let $R_1 = 220\,\Omega$  $R_2 = 330\,\Omega$  $R_L = 1\,K\Omega$

1. Connect the circuit as per above diagram.
2. Measure the current through the load using proper ammeter.

II. Norton’s Current:

1. Short circuit the load resistance and connect the circuit as per above diagram.
2. Measure the short circuit current using proper ammeter.

III. Norton’s Equivalent Resistance:
1. Replace the source by its internal resistance and open circuit the load.
2. Connect the circuit as per above diagram.
3. Using multimeter in resistance mode measure the resistance across the output terminal.

IV. Norton’s Circuit

1. Connect the source $I_{\text{NOR}}$ and resistance $R_{\text{th}}$ in parallel as shown in the circuit.
2. Connect the load resistance.
3. Switch on the supply and measure the current across the load using ammeter.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Theoretical value</th>
<th>Practical value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$R_{\text{th}}$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$I_L$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$V_L$</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Observation:

Theoretical calculation:

- $I_1 = \frac{V}{R_1+(R_2||R_L)} = 20\text{mA}$
- $I_L = I_T \times \frac{R_2}{R_2+R_L} = 4.9\text{mA}$
- $V_L = I_L \times R_L = 4.9\text{V}$
- $I_N = \frac{V}{R_1} = 45.5\text{mA}$
- $R_N = R_{\text{th}} = R_1||R_2 = 132\Omega$
- $I_L = I_N \times \frac{R_N}{R_N+R_L} = 4.54\text{mA}$
- $V_L = I_L \times R_L = 4.54\text{V}$

Result:

Norton’s theorem was verified for the given network both theoretically & practically.
EXERCISE:

I. Current Measurement:

1. Connect the circuit as per above diagram.
2. Measure the current through the load using proper ammeter.

![Circuit diagram for current measurement]

II. Norton’s Equivalent Current:

1. Short circuit the load resistance and connect the circuit as per above diagram.
2. Measure the short circuit current using proper ammeter.

![Circuit diagram for Norton's equivalent current]

III. Norton’s Equivalent Resistance:

1) Replace the source by its internal resistance and open circuit the load.
2) Connect the circuit as per above diagram.
3) Using multimeter in resistance mode measure the resistance across the output terminal.
IV. Norton’s Circuit

1. Connect the source $I_{nor}$ and resistance $R_{th}$ in parallel as shown in the circuit
2. Connect the load resistance
3. Switch on the supply and measure the current across the load using ammeter

Observation

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Theoretical value</th>
<th>Practical value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$R_{th}$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$I_L$</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
6. Time Domain Transient Response of RL circuit

Aim:

(a) To study the transient response of RL circuit.
(b) To determine the time constant of the circuit theoretically and practically.

Theory:

When a RL circuit is suddenly energized or de-energized a transient phenomenon which dies out as the circuit approaches its steady state. This is because of the way in which inductor store energy and resistor dissipate it. The exact nature of the transient depends on R and L as well as how they are connected in the circuit. The time constant $\tau$ represent the time for the system to make significant change in charge $V$ or current $I$.

Apparatus Required:

<table>
<thead>
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<th>S.No</th>
<th>Apparatus Required</th>
<th>Range</th>
<th>Quantity</th>
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<td>1</td>
</tr>
<tr>
<td>2.</td>
<td>CRO</td>
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<td>1</td>
</tr>
<tr>
<td>3.</td>
<td>Resistance</td>
<td>100 Ohms</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>Decade Inductance Box</td>
<td>(0-1)H</td>
<td>1</td>
</tr>
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<td>5</td>
<td>Breadboard</td>
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</tr>
<tr>
<td>6</td>
<td>Wires</td>
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<td></td>
</tr>
</tbody>
</table>

Circuit Diagram:
Procedure:

1. Connections are given as per the circuit diagram and set the input voltage as 2V.
2. Calculate the time constant theoretically \( \tau = \frac{L}{R} \).
3. Choose the frequency such that \( \frac{1}{2f} > 2\tau \) i.e., \( f < \frac{1}{4\tau} \).
4. Select square wave mode in function generator and set frequency lesser than the calculated frequency.
5. Connect the CRO probe across the resistor and observe the waveform.
6. Find the time taken to reach 63.2% of the final value \( \tau_{pr} \) and compare it with the time constant calculated in step 2.

Theoretical Calculation:

Let \( R = 100\Omega \) \( L = 50mH \)

Time constant \( \tau = \frac{L}{R} = 0.5\text{msec}. \)

Input frequency \( f < \frac{10^3}{4*0.5} = f < 500 \text{ Hz}. \)

Observation:

From the output waveform, for the 63% of maximum voltage find the time period \( \tau_{pr} \).

Model Graph:

\[
\begin{align*}
V_{R}(V) & \\
V_{ss} & \\
63\% & \\
\tau & \text{Time} \\
\end{align*}
\]

where, \( V_{ss} = \text{Steady State Voltage} \)

Result:

Transient response of RL circuit was studied and the time constant was calculated both theoretically and practically.
7. Time Domain Transient Response of RC circuit

Aim:
(c) To study the transient response of RC circuit
(d) To determine the time constant of the circuit theoretically and practically.

Theory:
When a RC circuit is suddenly energized or de-energized a transient phenomenon which dies out as the circuit approaches its steady state. This is because of the way in which capacitor store energy and resistor dissipate it. The exact nature of the transient depends on R and C as well as how they are connected in the circuit. The time constant \( \tau \) represent the time for the system to make significant change in charge V or current I whenever a capacitor is charging or discharging.

Apparatus Required:

<table>
<thead>
<tr>
<th>S.No</th>
<th>Apparatus Required</th>
<th>Range</th>
<th>Quantity</th>
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<tr>
<td>2.</td>
<td>CRO</td>
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<td>1</td>
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<tr>
<td>3.</td>
<td>Resistance</td>
<td>100 Ohms</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>Capacitor</td>
<td>0.1(\mu)f</td>
<td>1</td>
</tr>
<tr>
<td>5</td>
<td>Breadboard</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>6</td>
<td>Wires</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Circuit Diagram:
Procedure:

1. Connections are given as per the circuit diagram and set the input voltage as 2V.
2. Calculate the time constant theoretically \( \tau = R \times C \).
3. Choose the frequency such that \( 1/(2f) > 2\tau \) i.e., \( f < 1 / (4f) \).
4. Select square wave mode in function generator and set frequency lesser than the calculate frequency.
5. Connect the CRO probe across the resistor and observe the waveform.
6. Find the time taken to reach 36.8% of the final value \( \tau_{pr} \) and compare it with the time constant calculated in step 2.

Theoretical Calculation:

Let \( R=100 \Omega \) \( C = 0.1 \ \mu\text{f} \)

Time constant \( \tau = R \times C = 10^{-5} \text{ s} = 0.1 \ \mu\text{s} \).

Input frequency \( f < 1 / (4 \times 10^{-5}) = f < 25000 \text{ Hz} \).

Observation:

From the output waveform, for the 36.8% of maximum voltage find the time period \( \tau_{pr} \).

Model Graph:

![Model Graph](image)

where, \( V_{ss} = \text{Steady State Voltage} \)

Result

Transient response of RC circuit was studied and the time constant was calculated both theoretically and practically.
8. Parallel RLC Resonance Circuits

Aim:

To Study and plot the curve of Resonance for a parallel resonance circuits.

Theory:

An ac circuit is said to be in resonance when the applied voltage and the resulting current are in phase. In an RLC circuits at resonance, \( Z = R \) \& \( X_L = X_C \) where \( X_L \) is inductive reactance and \( X_C \) is capacitive reactance.

The frequency at which the voltage in RLC circuit is maximum is known as resonant frequency \( (f_o) \). At \( f_o \), \( I_C \) and \( I_L \) are equal in magnitude and opposite in phase.

Apparatus required:

<table>
<thead>
<tr>
<th>S.No</th>
<th>Apparatus Required</th>
<th>Range</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Signal Generator</td>
<td>(0-1) MHz</td>
<td>1</td>
</tr>
<tr>
<td>2.</td>
<td>Ammeter (MC)</td>
<td>(0-10) mA</td>
<td>3</td>
</tr>
<tr>
<td>3.</td>
<td>Voltmeter (MC)</td>
<td>(0-10) V</td>
<td>1</td>
</tr>
</tbody>
</table>

Other items:

<table>
<thead>
<tr>
<th>S.No</th>
<th>Apparatus Required</th>
<th>Range</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Resistors</td>
<td>1KΩ, 1μF</td>
<td>2</td>
</tr>
<tr>
<td>2.</td>
<td>Capacitor</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>3.</td>
<td>Bread Board</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>4.</td>
<td>Decade Inductance Box</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>5.</td>
<td>Wires</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Procedure:

1. Connect the circuit as per the circuit diagram.
2. Set input voltage, \( V_i \) (5 or 10 v) using signal generator and vary the frequency from (0-1) MHz in regular steps.
3. Note down the corresponding output voltage and current.
4. Plot the graph: \( V \), \( I_C \) & \( I_L \) Vs frequencies.
To Measure the Resonance Frequency

1. Plot the graph: Voltage Vs Frequencies
2. Draw a vertical line, from the maximum current reading to the X-axis. That is the resonant frequency $f_0$.

Circuit Diagram:

MODEL GRAPHS:
**Observation:**

\[ V_{in} = 5 \text{ V} \]

<table>
<thead>
<tr>
<th>Frequency (KHz)</th>
<th>Voltage ( V_r ) (volts)</th>
<th>Current (mA)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>100KHz</td>
<td>1</td>
<td>( I_L )</td>
<td>( I_C )</td>
</tr>
<tr>
<td>200KHz</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>300KHz</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1MHz</td>
<td>4</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Theoretical Calculation:**

\[ f_r = \frac{1}{2\pi\sqrt{LC}} \text{ Hertz} \]

where,

- \( f_r \) = Resonant frequency
- \( L \) = Inductance
- \( C \) = Capacitance

**Result**

Thus the resonance curve for parallel resonance is plotted and verified the resonant frequency.
9. Series RLC Resonance Circuits

Aim:

To Study and plot the curve of Resonance for a Series resonance circuits.

Theory:

An ac circuit is said to be in resonance when the applied voltage and the resulting current are in phase. In an RLC circuits at resonance, \( Z = R \) & \( X_L = X_C \) where \( X_L \) is inductive reactance and \( X_C \) is capacitive reactance.

The frequency at which the voltage in RLC circuit is maximum is known as resonant frequency \( (f_o) \). At \( f_o \), \( I_C \) and \( I_L \) are equal in magnitude and opposite in phase.

Apparatus Required:

<table>
<thead>
<tr>
<th>S.No</th>
<th>Apparatus Required</th>
<th>Range</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Signal Generator</td>
<td>(0-1) MHz</td>
<td>1</td>
</tr>
<tr>
<td>2.</td>
<td>Ammeter (MC)</td>
<td>(0-10) mA</td>
<td>1</td>
</tr>
<tr>
<td>3.</td>
<td>Voltmeter (MC)</td>
<td>(0-10) V</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td><strong>Other items</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>Resistors</td>
<td>1 KΩ</td>
<td>1</td>
</tr>
<tr>
<td>2.</td>
<td>Capacitor</td>
<td>1 μF</td>
<td>1</td>
</tr>
<tr>
<td>3.</td>
<td>Bread Board</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>4.</td>
<td>Decade Inductance Box</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>5.</td>
<td>Wires</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Procedure:

1. Connect the circuit as per the circuit diagram.
2. Set input voltage, \( V_i \) (5 or 10 v) using signal generator and vary the frequency from (0-1)MHz in regular steps.
3. Note down the corresponding output voltage and current.
4. Plot the graph: \( I \), \( V_C \) & \( V_L \) Vs frequencies.
To Measure the Resonance Frequency:

1. Plot the graph: Current Vs Frequencies
2. Draw a vertical line, from the maximum current reading to the X-axis. That is the resonant frequency $f_0$.

Circuit Diagram:

MODEL GRAPHS:

![Model Graphs Image]
Observation:

<table>
<thead>
<tr>
<th>Frequency (KHz)</th>
<th>Voltage (volts)</th>
<th>Current I(mA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>100KHz</td>
<td>Vr</td>
<td>Vc</td>
</tr>
<tr>
<td>200KHz</td>
<td></td>
<td></td>
</tr>
<tr>
<td>300KHz</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1MHz</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Theoretical Calculation:

\[ f_r = \frac{1}{2\pi\sqrt{LC}} \text{ Hertz} \]

where,

- \( f_r \) = Resonant frequency
- \( L \) = Inductance
- \( C \) = Capacitance

Result:

Thus the resonance curve for series resonance is plotted and the resonant frequency is calculated theoretically and practically.
10. POWER FACTOR MEASUREMENT

Aim

To measure the real power, reactive power, power factor and impedance of the given RL and RC circuits.

Theory:

- **Impedance** is the total measure of opposition to electric current and is the complex (vector) sum of (“real”) resistance and (“imaginary”) reactance.
- **Power** is defined as the rate of flow of energy past a given point.
- In alternating current circuits, energy storage elements such as inductors and capacitors cause periodic reversals of energy flow. The portion of power flow averaged over a complete cycle of the AC waveform that results in net transfer of energy in one direction is known as **real power**.
- The portion of power flow due to stored energy which returns to the source in each cycle is known as **reactive power**.
- The ratio between real power and apparent power in a circuit is called the **power factor**. Where the waveforms are purely sinusoidal, the power factor is the cosine of the phase angle (φ) between the current and voltage sinusoid waveforms.

**Apparatus Required:**

<table>
<thead>
<tr>
<th>Apparatus</th>
<th>Range</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Function Generator</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Resistor</td>
<td>1K</td>
<td>2</td>
</tr>
<tr>
<td>Inductor</td>
<td>100mH</td>
<td>1</td>
</tr>
<tr>
<td>Capacitor</td>
<td>0.001μF</td>
<td>1</td>
</tr>
<tr>
<td>Multimeter</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Bread Board</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>CRO</td>
<td></td>
<td>1</td>
</tr>
</tbody>
</table>
R-C CIRCUIT:

R-L CIRCUIT:

R-L-C CIRCUIT:
PROCEDURE

1. Give the connections as per the circuit diagram.
2. Connect the CRO probe at point A to get voltage waveform and at B to get the current waveform.
3. Adjust vertical deflection of each channel such that the waveform fills the whole screen.
4. Adjust the sweep rate and the horizontal position control until one half cycle of the waveform spans 9 divisions on the scope’s scale.
5. Since one half cycle covers 9 divisions, it means each major division on the scope represents 20°.
6. Since each major division consists of 5 smaller divisions, each smaller division represents 20/5 = 4°.
7. Phase difference between two waveforms is determined by simply counting the number of small divisions between corresponding points on the 2 waveforms.
8. Phase Angle $\phi = \text{(no.of divisions)} \ast \left(\frac{\text{degree}}{\text{divisions}}\right)$.
9. Power Factor is given by $\cos \phi$.

FORMULAS:

1. Real Power $(P) = V \ast I \cos \phi$
2. Reactive Power $(Q) = V \ast I \sin \phi$
3. Power Factor $(P.F) = \cos \phi = \frac{R}{Z}$
4. Impedance $(Z) = \frac{R}{\cos \phi}$

RESULT:

Thus the real power, reactive power, power factor and impedance of the given RLC circuit have been measured.