EXPERIMENT 2:- Verification of Superposition theorem and Thevenin’s theorem

Objectives: Analysis and verification of Thevenin’s theorem and superposition theorem

Materials and Equipments Required:

1. Digital multi-meter
2. Power supply (GPC-3020D)
3. Resistors 1 KΩ (1/4 W) [1], 4.7 KΩ (1/4 W) [1], 470 Ω [1], 10 KΩ [1], 47 KΩ [1]
4. Breadboard.

Theory:

Thevenin’s theorem: In circuit theory, Thevenin's theorem for linear electrical networks states that any combination of voltage sources, current sources and resistors with two terminals is electrically equivalent to a single voltage source \( E_{th} \) and a single series resistor \( R \). The Thevenin voltage \( E_{th} \) used in thevenin's theorem is an ideal voltage source equal to the open circuit voltage at the terminals whereas the thevenin resistance \( r \) used in Thevenin's Theorem is the resistance measured at terminals AB with all voltage sources replaced by short circuits and all current sources replaced by open circuits.

Superposition theorem: The superposition theorem for electrical circuits states that the response (Voltage or Current) in any branch of a bilateral linear circuit having more than one independent source equals the algebraic sum of the responses caused by each independent source acting alone, while all other independent sources are replaced by their internal impedances. To ascertain the contribution of each individual source, all of the other sources first must be "turned off" (set to zero) by:

- Replacing all other independent voltage sources with a short circuit (thereby eliminating difference of potential. i.e. \( V=0 \), internal impedance of ideal voltage source is ZERO (short circuit)).
- Replacing all other independent current sources with an open circuit (thereby eliminating current. i.e. \( I=0 \), internal impedance of ideal current source is infinite (open circuit)).
- This procedure is followed for each source in turn, and then the resultant responses are added to determine the true operation of the circuit. The resultant circuit operation is the superposition of the various voltage and current sources.
Procedure:

i) **Thevenin Theorem**
- Connect the circuit as shown in figure 1 on the breadboard.
- Measure the voltage across AB (i.e. p.d. across load resistor).
- Remove load resistor (for first case it is 4.7KΩ).
- Measure the open circuit voltage across AB with the help of multimeter (Placing positive terminal of multimeter at A and negative at B).
- Measure the Thevenin’s resistance with the help of multimeter (with short circuiting voltage sources and open circuiting current sources (if any) (Alternatively you can measure the short circuit current through load).
- Connect the circuit as shown in figure 2; replacing \( E_{TH} \) and \( R_{TH} \) are open circuit voltage and Thevenin resistance respectively, as measured in third step.
- Connect the load and measure the voltage across load with the help of voltmeter.
- REPEAT above steps for different load resistor.

Circuit Diagram:

![Figure 1](image1)

![Figure 2](image2)

**NOTE:** You now need only one voltage source, but you will probably need to use a combination of resistors in series to obtain \( R_{eq} \). Similarly the resistor value may not be exact as specified

ii) **Superposition theorem**
- Connect the circuit as shown in figure 1 on the breadboard.
- Set the value of voltage supply 1 to 0 V and supply 2 to 7 V and measure the potential difference across A and B. Also measure the current through load of 4.7KΩ.
- Set the value of voltage supply 2 to 0 V and supply 1 to 10 V and measure the potential difference across A and B. Also measure the current through load of 4.7KΩ.
- Now set the value of voltage supply 1 to 7 V and supply 2 to 10V and measure the potential difference across A and B and current through load of 4.7KΩ.
- REPEAT above steps for different load resistor.
Observations:

1. Measurement and Calculation of Thevenin circuit parameters

<table>
<thead>
<tr>
<th>S.N.</th>
<th>$V_{OC}$</th>
<th>$R_{TH}$</th>
<th>$V_{OC}$ (From calculation)</th>
<th>$R_{TH}$ (From calculation)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

2. Verification of Thevenin’s theorem

<table>
<thead>
<tr>
<th>S.N</th>
<th>$R_{LOAD}$</th>
<th>$V_{AB}$ from circuit of figure 1</th>
<th>$V_{AB}$ from Thevenin equivalent circuit</th>
<th>$I_L$ from circuit of figure 1</th>
<th>$I_L$ from Thevenin equivalent circuit</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4.7 KΩ</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>10 KΩ</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>47 KΩ</td>
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</table>

➢ Do these measurements taken from Thevenin equivalent circuit agree with the measurements from the original circuit?

3. Verification of Superposition theorem

<table>
<thead>
<tr>
<th>S.N</th>
<th>$R_{LOAD}$</th>
<th>$V_1=V_{AB}$ ($V_{Source1}=0V$)</th>
<th>$V_2=V_{AB}$ ($V_{Source2}=0V$)</th>
<th>$V_{AB}=V_1+V_2$</th>
<th>$I_1$ when ($V_{Source1}=0V$)</th>
<th>$I_2$ when ($V_{Source2}=0V$)</th>
<th>$I=I_1+I_2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
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</tbody>
</table>

➢ Do these measurements taken from Superposition theorem and thevenin theorem agree with the measurements from the original circuit? Original value is to be tabulated in table 2.
Conclusions and Inference:

Exercises:

i) Discuss the relationship of terminal voltage with increase in load resistance.

ii) Calculate the value of thevenin equivalent circuit in paper and compare with the experimental results.

iii) Calculate and compare the total power supplied by sources in the original circuit and thevenin circuit from experimental data.