Exp.No.: 4 **Reg.No.: 21BAI1604**

Name : Dhruv Karmokar **Date : 22/10/2021**

Thevenin's and Maximum power transfer theorem

(Loud Speaker Application)

Aim:

To design a simplified equivalent circuit in analyzing the power systems and other circuits where the load resistor is subject to change in order to determine the voltage across it and current through it using Thevenin's theorem. To design the circuit for maximizing, the power transferred from the amplifier to the loudspeaker using maximum power transfer theorem.

Software required:

LTspice software

A. Thevenin's Theorem

Theory & Circuit Diagram

Any two-terminal linear network composed of voltage sources, current sources, and resistors, can be replaced by an equivalent two-terminal network consisting of an independent voltage source in series with a resistor as shown in Fig. 1. The value of voltage source is equivalent to the open circuit voltage (V_{th}) across two terminals of the network and the resistance is equal to the equivalent resistance (R_{th}) measured between the terminals with all energy sources replaced by their internal resistances.

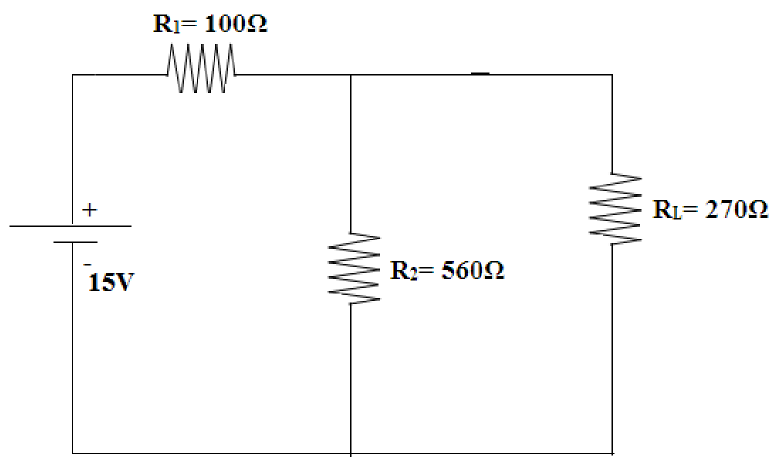
Formulae:

$$I_L = \frac{V_{\mathrm{Th}}}{R_{\mathrm{Th}} + R_L}$$

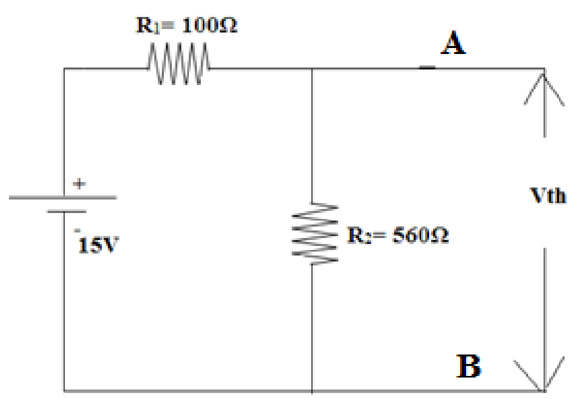
$$V_L = R_L I_L = \frac{R_L}{R_{\mathrm{Th}} + R_L} V_{\mathrm{Th}}$$

Therotical Solution:

Find the thevenin's equivalent voltage and resistance considering R_L is the load terminal in the circuit given below.

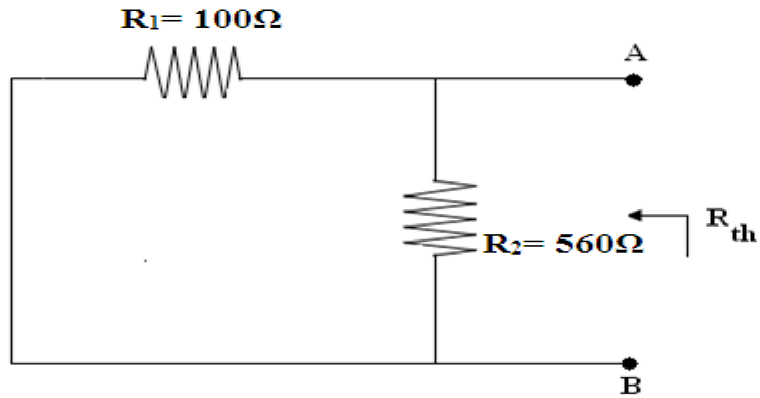


Circuit Diagram for the determination of Thevenin's Voltage, Vth



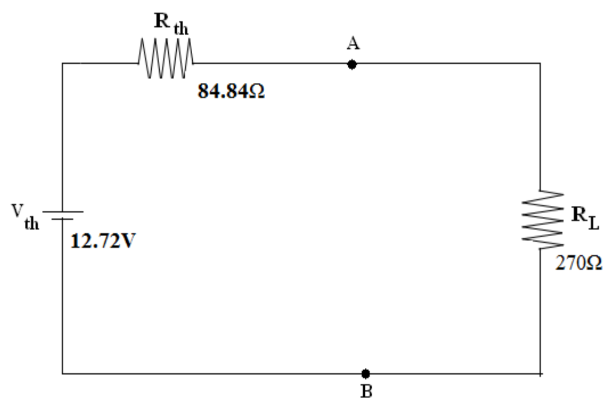
$V_{th}=V_{AB}=\frac{15\times560}{100+560}$ =12.72V (From Voltage division rule)

Circuit Diagram for the determination of Thevenin's Resistance, Rth



$$R_{th} = \frac{100\times560}{100+560} = 84.84\Omega$$

Circuit Diagram of Thevenin's equivalent Circuit



Verification by Simulation:

Procedure

1. Open LTspice. Go to File New Schematic.

2. On the File Menu, click on Edit Component.

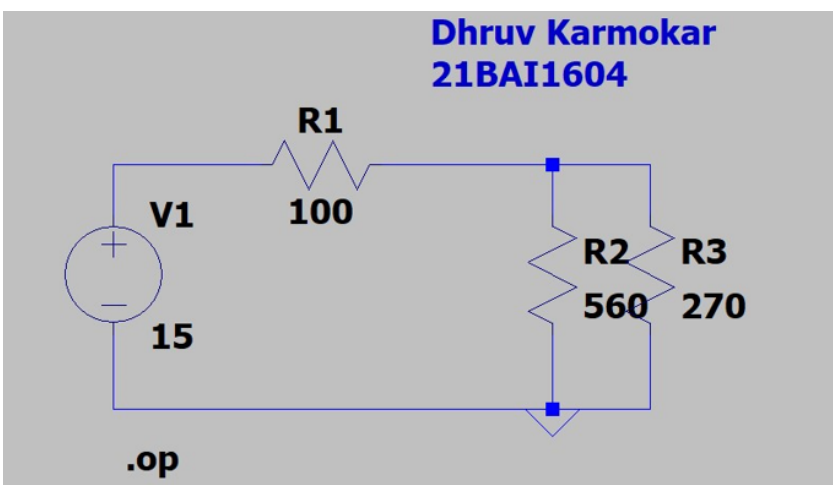
3. Determine the Thevenin's Voltage.

4. Determine the Load Current I_L:

5. Determine the Thevenin's Resistance, Rth:

Circuit diagrams and results from LTspice:

1. Given circuit

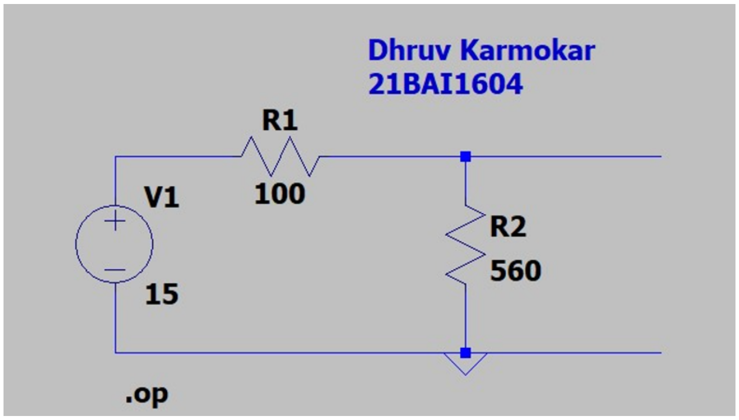


* C:\Users\dhruv\Documents\LTspiceXVII\Draft5.asc

```
       --- Operating Point ---

V(n001):        15              voltage
V(n002):        9.68403         voltage
I(R3):          0.0358668       device_current
I(R2):          0.0172929       device_current
I(R1):          0.0531597       device_current
I(V1):          -0.0531597      device_current
```

2. Determination of Thevenin's Voltage

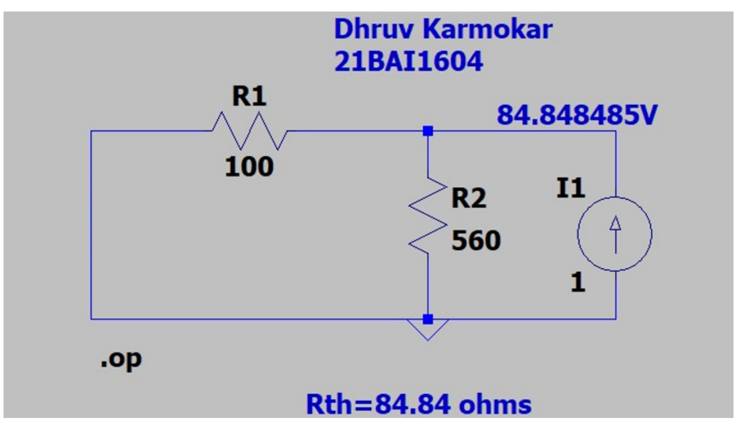


* C:\Users\dhruv\Documents\LTspiceXVII\Draft5.asc

```
       --- Operating Point ---

V(n001):         15            voltage
V(n002):         12.7273       voltage
I(R2):           0.0227273     device_current
I(R1):           0.0227273     device_current
I(V1):           -0.0227273    device_current
```

3. Determination of Thevenin's resistance

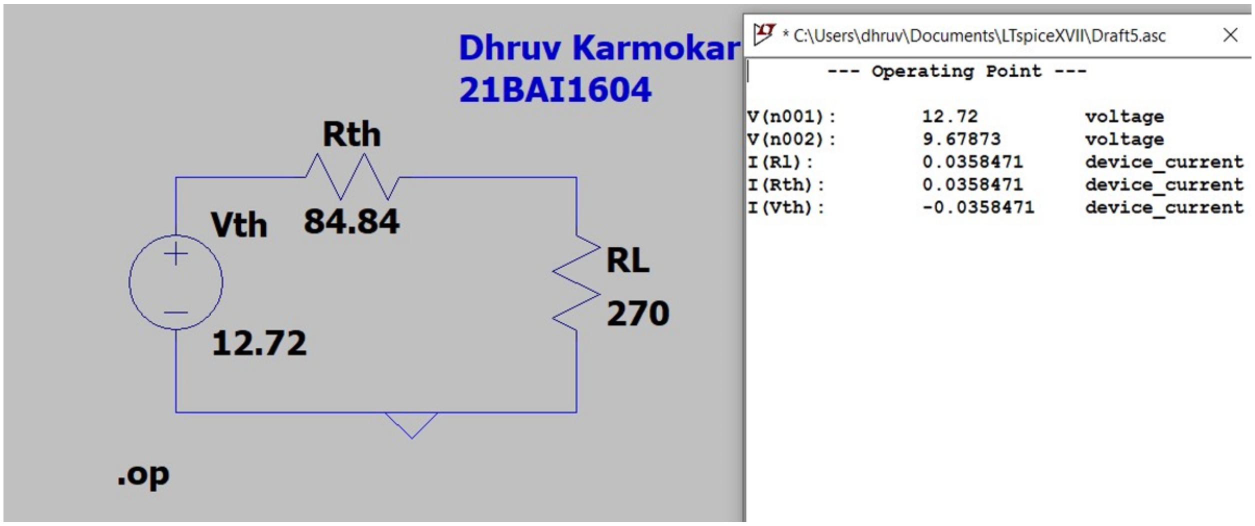


* C:\Users\dhruv\Documents\LTspiceXVII\Draft5.asc

```
       --- Operating Point ---

V(n001):         84.8485       voltage
I(I1):           1             device_current
I(R2):           0.151515      device_current
I(R1):           -0.848485     device_current
```

4. Determination of Load current



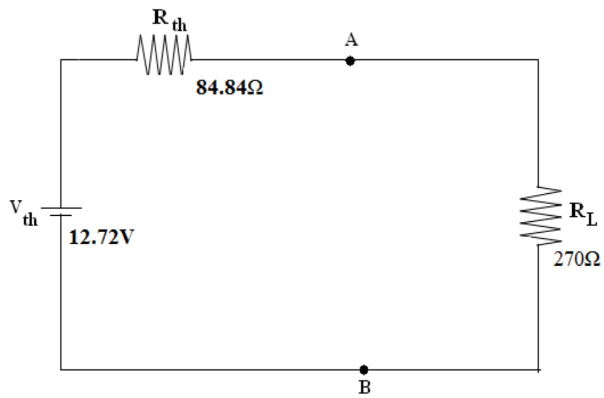
Observation Table:

S. No	V_s (V)	V_{TH} (V)	(R_{th}) (Ω)	Current through Load Resistance I_L(mA)			
				Practical Value		Theoretical Value	
1.	15	12.72	84.84	Main circuit	35.86	Main circuit	35.87
				Thevenin's circuit		Thevenin's circuit	

B. Maximum Power Transfer Theorem

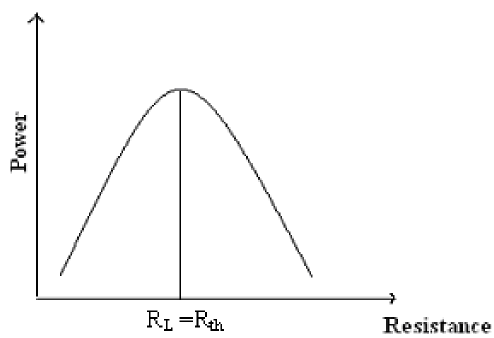
Theory & Circuit Diagram

The maximum power transfer theorem states that maximum power is delivered from a source to a load when the load resistance is equal to source resistance



For finding the Thevenin's equivalent circuit steps 1 to 6 is followed. Then as per the maximum power transfer theorem, maximum power will be delivered to the load when the load resistance is equal to the internal or Thevenin's resistance of the network.

Model Graph:



Condition for maximum power transfer:

$$R_L = R_{\text{Th}}$$

Maximum power transferred:

$$p_{\max} = \frac{V_{\mathrm{Th}}^2}{4R_{\mathrm{Th}}}$$

Procedure:

1. Take the Thevenin's Equivalent circuit from the previous experiment.

2. Take three values for the load resistance. One equal to Rth, one greater and one smaller. Click on edit simulate command under simulate section then select DC op pnt. Run the simulation by clicking on the run command and obtain the output.

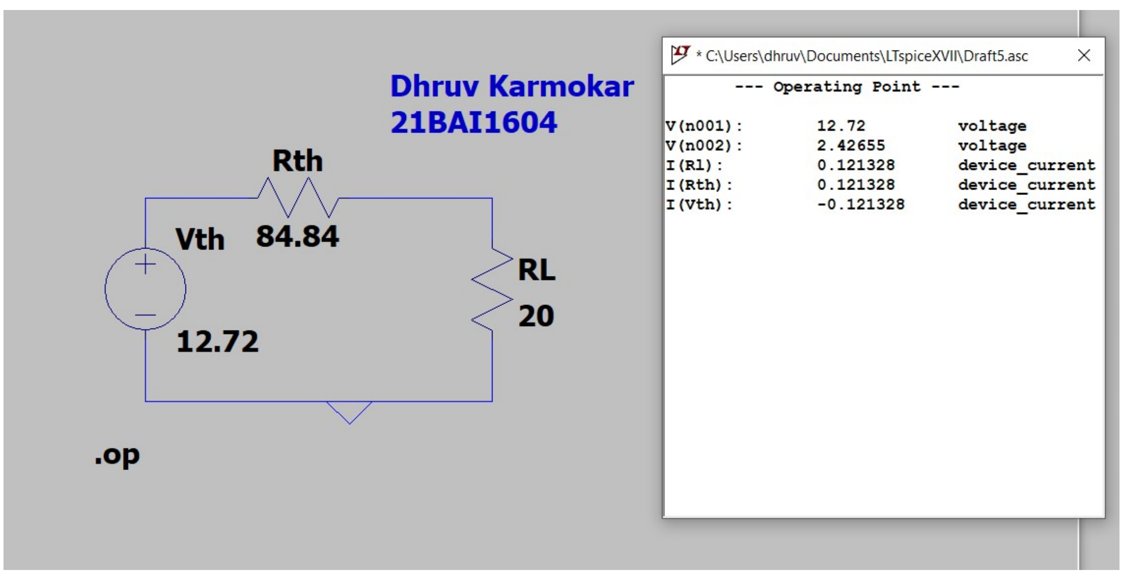
Observation Table :

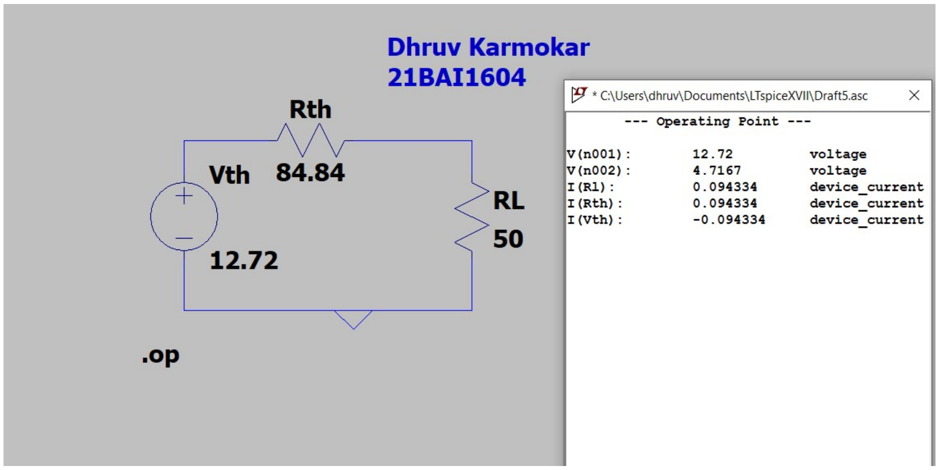
R_{TH} = 84.84 (Ω)

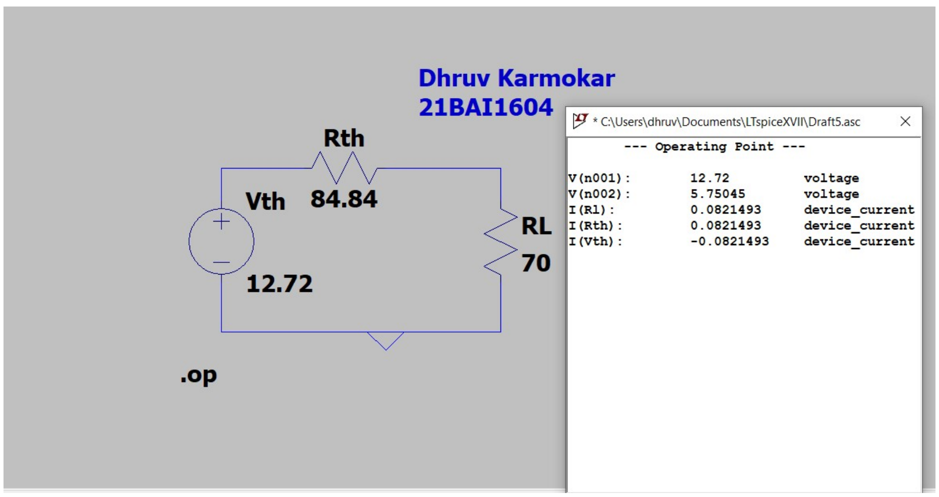
S.No.	R_L (Ω)	I_L(mA)	$P_L=I_L^2R_L$(mW)
1.	20	121.32	294.37
2.	50	94.33	444.90

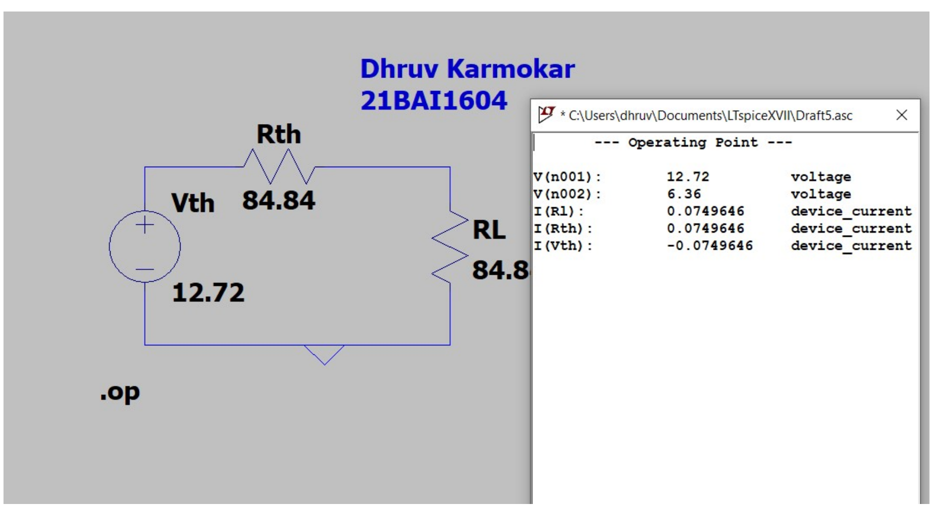
3.	70	82.15	472.40
4.	84.84	75	477.22
5.	100	68.81	473.48
6.	120	62.1	462.76
7.	300	33	326.70

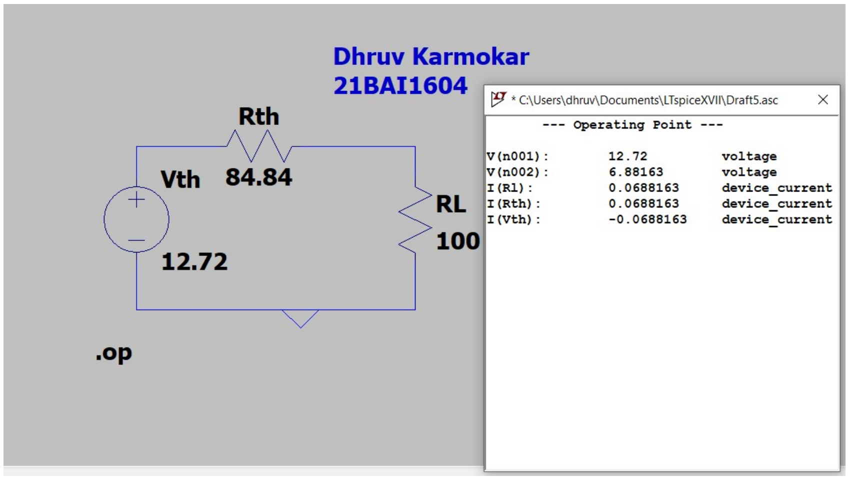
Circuits with varying Load resistance:

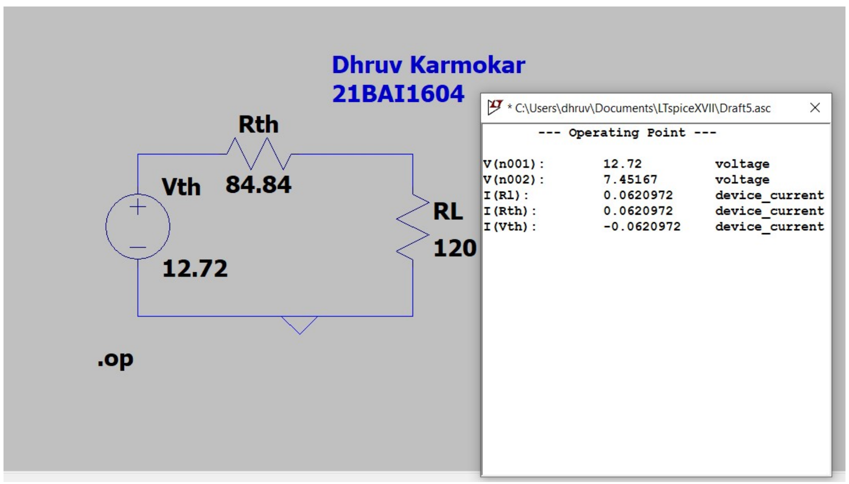


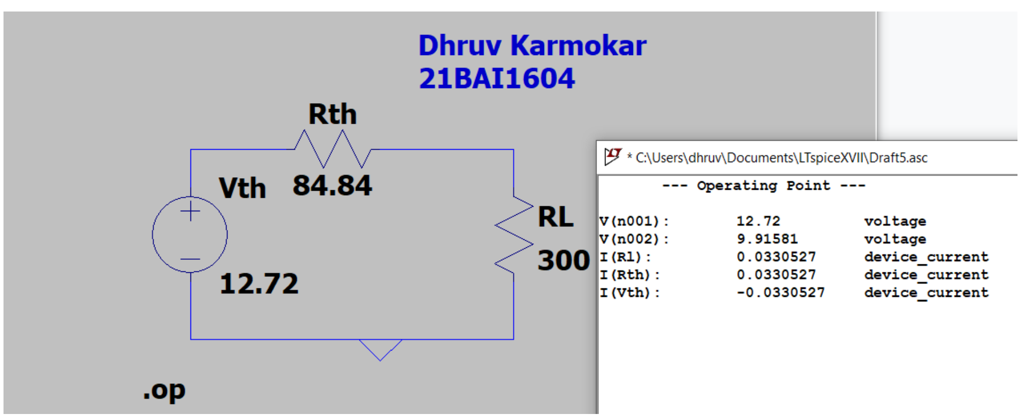

Dhruv Karmokar
21BAI1604
Rth
Vth
84.84
12.72
RL
50
.op
* C:\Users\dhruv\Documents\LTspiceXVII\Draft5.asc
--- Operating Point ---
V(n001): 12.72 voltage
V(n002): 4.7167 voltage
I(Rl): 0.094334 device_current
I(Rth): 0.094334 device_current
I(Vth): -0.094334 device_current


Dhruv Karmokar
21BAI1604
Rth
Vth
84.84
12.72
RL
70
.op
* C:\Users\dhruv\Documents\LTspiceXVII\Draft5.asc
--- Operating Point ---
V(n001): 12.72 voltage
V(n002): 5.75045 voltage
I(Rl): 0.0821493 device_current
I(Rth): 0.0821493 device_current
I(Vth): -0.0821493 device_current

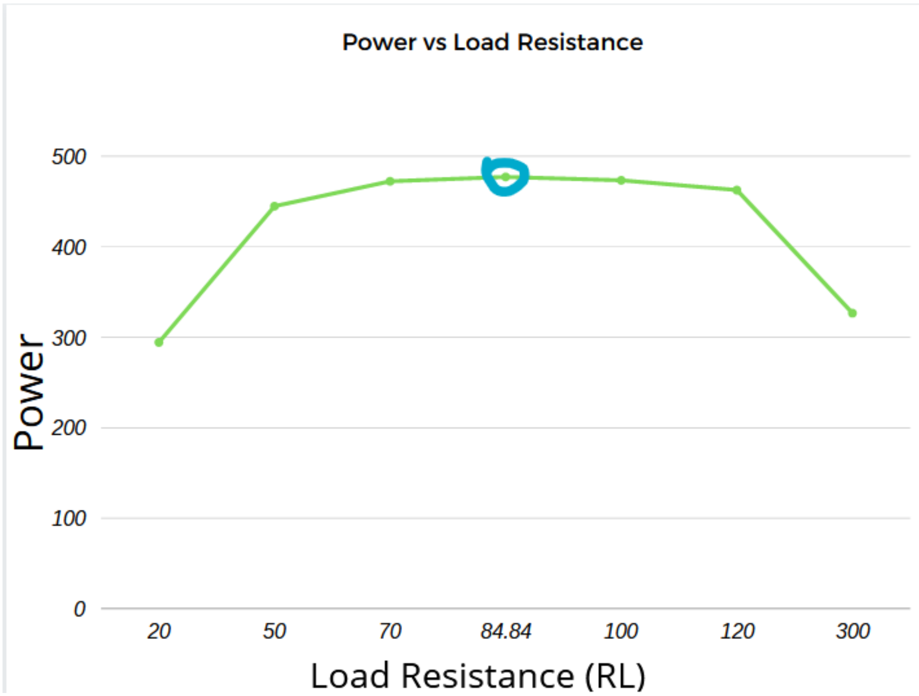

Dhruv Karmokar
21BAI1604
Rth
Vth
84.84
12.72
RL
84.8
.op
* C:\Users\dhruv\Documents\LTspiceXVII\Draft5.asc
--- Operating Point ---
V(n001): 12.72 voltage
V(n002): 6.36 voltage
I(Rl): 0.0749646 device_current
I(Rth): 0.0749646 device_current
I(Vth): -0.0749646 device_current


Dhruv Karmokar
21BAI1604
Rth
84.84
Vth
12.72
RL
100
.op
* C:\Users\dhruv\Documents\LTspiceXVII\Draft5.asc
--- Operating Point ---
V(n001): 12.72 voltage
V(n002): 6.88163 voltage
I(Rl): 0.0688163 device_current
I(Rth): 0.0688163 device_current
I(Vth): -0.0688163 device_current


Dhruv Karmokar
21BAI1604
Rth
84.84
Vth
12.72
RL
120
.op
* C:\Users\dhruv\Documents\LTspiceXVII\Draft5.asc
--- Operating Point ---
V(n001): 12.72 voltage
V(n002): 7.45167 voltage
I(Rl): 0.0620972 device_current
I(Rth): 0.0620972 device_current
I(Vth): -0.0620972 device_current


Dhruv Karmokar
21BAI1604
Rth
84.84
Vth
12.72
RL
300
.op
* C:\Users\dhruv\Documents\LTspiceXVII\Draft5.asc
--- Operating Point ---
V(n001): 12.72 voltage
V(n002): 9.91581 voltage
I(Rl): 0.0330527 device_current
I(Rth): 0.0330527 device_current
I(Vth): -0.0330527 device_current

Graph:



Result & Inferences: Thus the Thevenin's and Maximum power transfer theorem have been verified for the given circuit.
Practical Applications: Impedance Matching Transformers In cases requiring impedance matching, impedance matching transformers come into play. Impedance matching transformers are designed to provide maximum power transfer from source to load, altering circuit impedances to allow for necessary matching. By applying an appropriate turns ratio to the ratio of load impedance to output impedance, these devices translate resistance on one side of the circuit into the required value on the other side.