Ex. No.:3 **Date:07/08/2020**

Verification of NETWORK THEOREMS –

Thevenin's and Maximum Power Transfer

Aim:

1. **Calculate the Vth and Rth of the given circuit**
2. **Draw the Thevenin's equivalent circuit and connect load resistor RL.**
3. **Find the power delivered to the load resistor for three values of RL – 6 ohms, Rth and 9 ohms and get the maximum power transferred.**

Apparatus/Tool required:

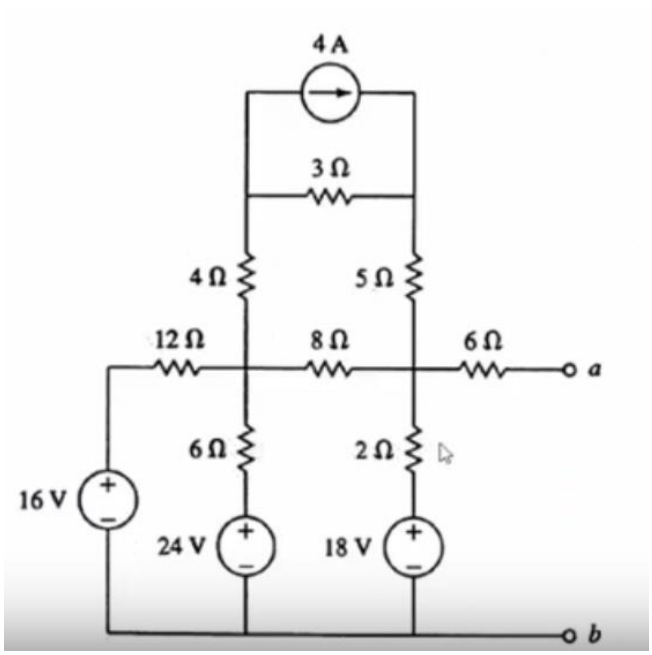
ORCAD / Capture CIS --> k**Analog Library – R,**

Source Library – Vdc, Idc &

Ground (GND) – 0 (zero)

Simulation Settings: **Analysis Type - Bias Point**

Circuit **Diagram:**



Statement:

Thevenin's Theorem:

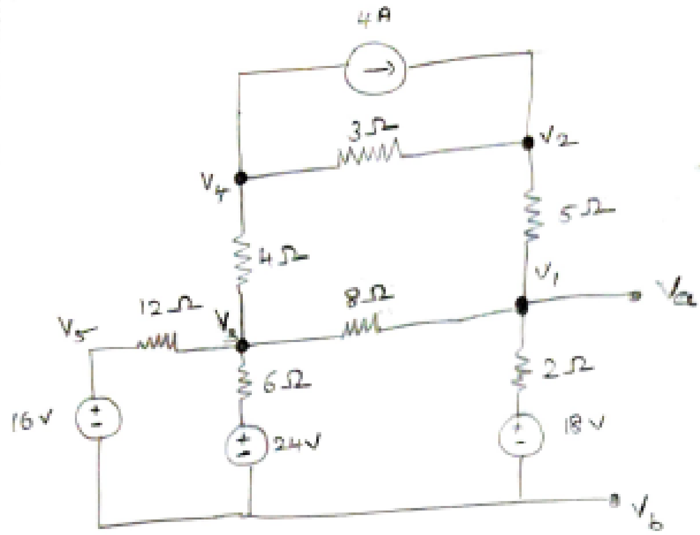
Any linear electrical network with voltage and current sources and only resistances can be replaced at terminals A-B by an equivalent voltage source V_{th} in series connection with an equivalent resistance R_{th}. This equivalent voltage V_{th} is the voltage obtained at terminals A-B of the network with terminals A-B open circuited. This equivalent resistance R_{th} is the resistance obtained at terminals A-B of the network with all its independent current sources open circuited and all its independent voltage sources short circuited

Maximum Power Transfer Theorem:

The maximum power from a source is delivered to a network (black box) which has an internal resistance (Rth) and source (Vth) with an external load resistance (RL) in series, if the resistances connected in series are equal.

Manual Calculations:

To Find V_{th}:



$$\boxed{V_5 \Rightarrow 16V}$$

At Node 1)

$$\frac{V_3 - V_5}{12} + \frac{V_3 - V_4}{4} + \frac{V_3 - 24}{6} + \frac{V_3 - V_1}{8} \Rightarrow 0$$

$$\frac{V_3 - 16}{12} + \frac{V_3 - V_4}{4} + \frac{V_3 - 24}{6} + \frac{V_3 - V_1}{8} \Rightarrow 0$$

$$V_3/12 - 16/12 + V_3/4 - V_4/4 + V_3/6 - 24/6 + V_3/8 - V_1/8 \Rightarrow 0$$

$$0.083\,V_3 - 1.33 + 0.25\,V_3 - 0.25\,V_4 + 0.166\,V_3 - 4 + 0.125\,V_3 - 0.125\,V_1 \Rightarrow$$

$$-0.125\,V_1 + (0.083 + 0.25 + 0.166 + 0.125)\,V_3$$

$$-0.25\,V_4 - 1.33 - 4 \Rightarrow 0$$

$$-0.125\,V_1 + 0.624\,V_3 - 0.25\,V_4 - 5.33 \Rightarrow 0$$

$$\boxed{0.125\,V_1 - 0.624\,V_3 + 0.25\,V_4 \Rightarrow -5.33}$$

Node 2)

$$\frac{V_4 - V_2}{3} + \frac{V_4 - V_3}{4} + 4 \Rightarrow 0$$

$$V_4/3 - V_2/3 + V_4/4 - V_3/4 \Rightarrow -4$$

$$0.33V_4 - 0.33V_2 + 0.25V_4 - 0.25V_3 \Rightarrow -4$$

$$\boxed{0.33V_2 + 0.25V_3 - 0.58V_4 \Rightarrow 4}$$

Node 3)

$$\frac{V_2 - V_4}{3} + \frac{V_2 - V_1}{5} - 4 \Rightarrow 0$$

$$0.33V_2 - 0.33V_4 + 0.2V_2 - 0.2V_1 \Rightarrow 4$$

$$\boxed{0.2V_1 - 0.53V_2 + 0.33V_4 \Rightarrow -4}$$

Node 4)

$$\frac{V_1 - V_2}{5} + \frac{V_1 - V_3}{8} + \frac{V_1 - 18}{2} \Rightarrow 0$$

$$0.2V_1 - 0.2V_2 + 0.125V_1 - 0.125V_3 + 0.5V_1 - 9 \Rightarrow 0$$

$$\boxed{0.825V_1 - 0.2V_2 - 0.125V_3 \Rightarrow 9}$$

$$\begin{array}{r} 0.2 \\ 0.5 \\ 0.125 \\ \hline 0.825 \end{array}$$

$\therefore V_1 \Rightarrow 19.52\text{ V}$

$V_2 \Rightarrow 24.07\text{ V}$

$V_3 \Rightarrow 18.34\text{ V}$

$V_4 \Rightarrow 14.70\text{ V}$

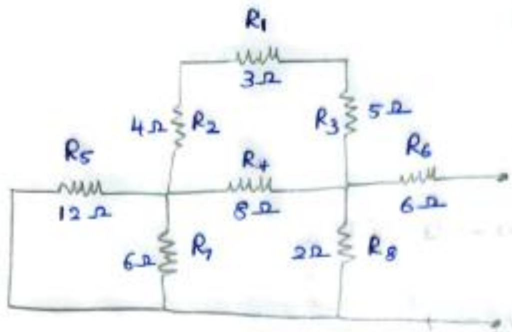
since, it is an open circuit the voltage across V_1 is the thevenin voltage

$$V_{th} \Rightarrow V_{ab}$$

$$\Rightarrow 19.52 - 0$$

$$\boxed{V_{th} \Rightarrow 19.52\text{ V}}$$

To Find R_{th}:



R_1, R_2 and R_3 are in series

$$R_{123} \Rightarrow 4+3+5 \Rightarrow 12\ \Omega$$

R_{123} and R_4 are parallel

$$R_{1234} \Rightarrow \frac{R_{123}\,R_4}{R_{123}+R_4} \Rightarrow \frac{12(8)}{12+8} \Rightarrow \frac{96}{20} \Rightarrow 4.8\ \Omega$$

R_5 and R_7 are parallel

$$R_{57} \Rightarrow \frac{12(6)}{12+6} \Rightarrow \frac{72}{18} \Rightarrow 4\ \Omega$$

R_6 and R_8 are parallel

$$R_{68} \Rightarrow \frac{2(6)}{2+6} \Rightarrow \frac{12}{8} \Rightarrow 1.5\ \Omega$$

R_{1234}, R_{57}, R_{68} are in series

$$R_{eq} \Rightarrow R_{1234} + R_{57} + R_{68}$$

$$\Rightarrow 4.8 + 4 + 1.5$$

R_{1234} and R_{57} ~~and~~ R_8 are in series

$$R_{123457} \Rightarrow 4.8 + 4$$
$$\Rightarrow 8.8\,\Omega$$

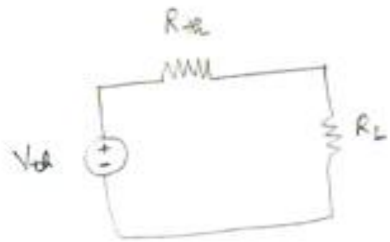
R_{123457} and R_8 are in parallel

$$R_{1234578} \Rightarrow \cancel{R_{eq}} \Rightarrow \frac{8.8\,(2)}{8.8+2} \Rightarrow \frac{17.6}{10.8} \Rightarrow 1.629\,\Omega$$

$$R_{1234578} + R_6 \Rightarrow R_{eq} \Rightarrow 1.629 + 6$$

$$\boxed{R_{eq} \Rightarrow 7.629\,\Omega}$$

To Find Power:



In the thevenin equivalent circuit,

$V_{th} \Rightarrow 19.417\,V$

$R_{th} \Rightarrow 7.629\,\Omega$

$$\left.\begin{array}{l}\text{Maximum}\\ \text{power}\end{array}\right\} \quad P_L \Rightarrow \frac{V_{th}^2 R_L}{(R_{th}+R_L)^2}$$

i) When $\underline{R_L \Rightarrow 6\,\Omega}$

$$P_L \Rightarrow \frac{(19.417)^2 (6)}{(6+7.629)^2}$$

$$\boxed{P_L \Rightarrow 12.178\,W}$$

ii) When $\underline{R_L \Rightarrow 9\,\Omega}$

$$P_L \Rightarrow \frac{(19.417)^2 (9)}{(9+7.629)^2}$$

$$\boxed{P_L \Rightarrow 12.270\,W}$$

iii) When $R_{th} = R_L$

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

$$\Rightarrow \frac{V_{th}^2 R_L}{(2R_L)^2} \Rightarrow \frac{V_{th}^2 \cancel{R_L}}{4 R_L^{\cancel{2}}}$$

$$\Rightarrow \frac{V_{th}^2}{4 R_L}$$

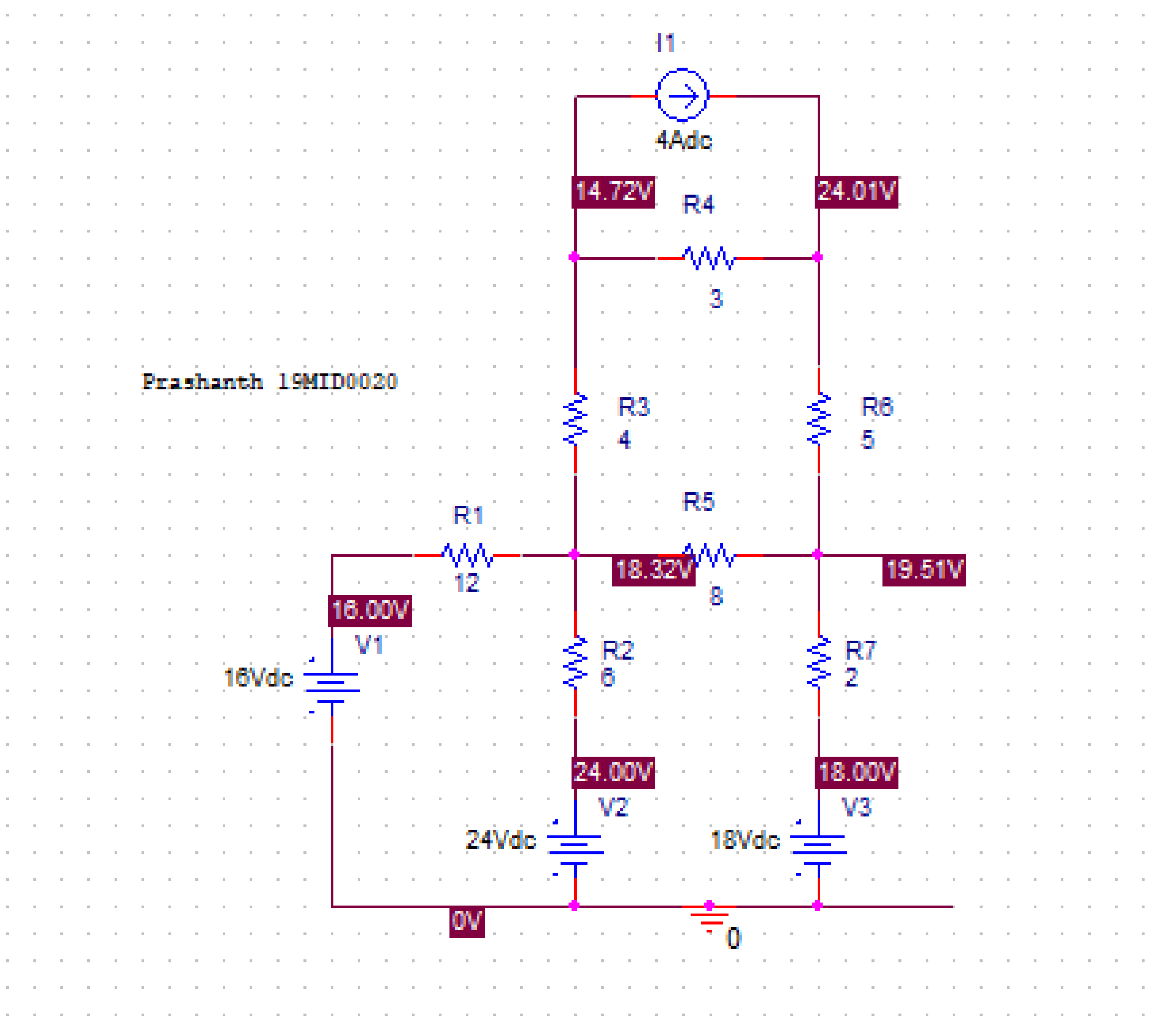
$$\Rightarrow \frac{(19.417)^2}{(4 * 7.629)}$$

$$\boxed{P_{L_{max}} \Rightarrow 12.335\ W}$$

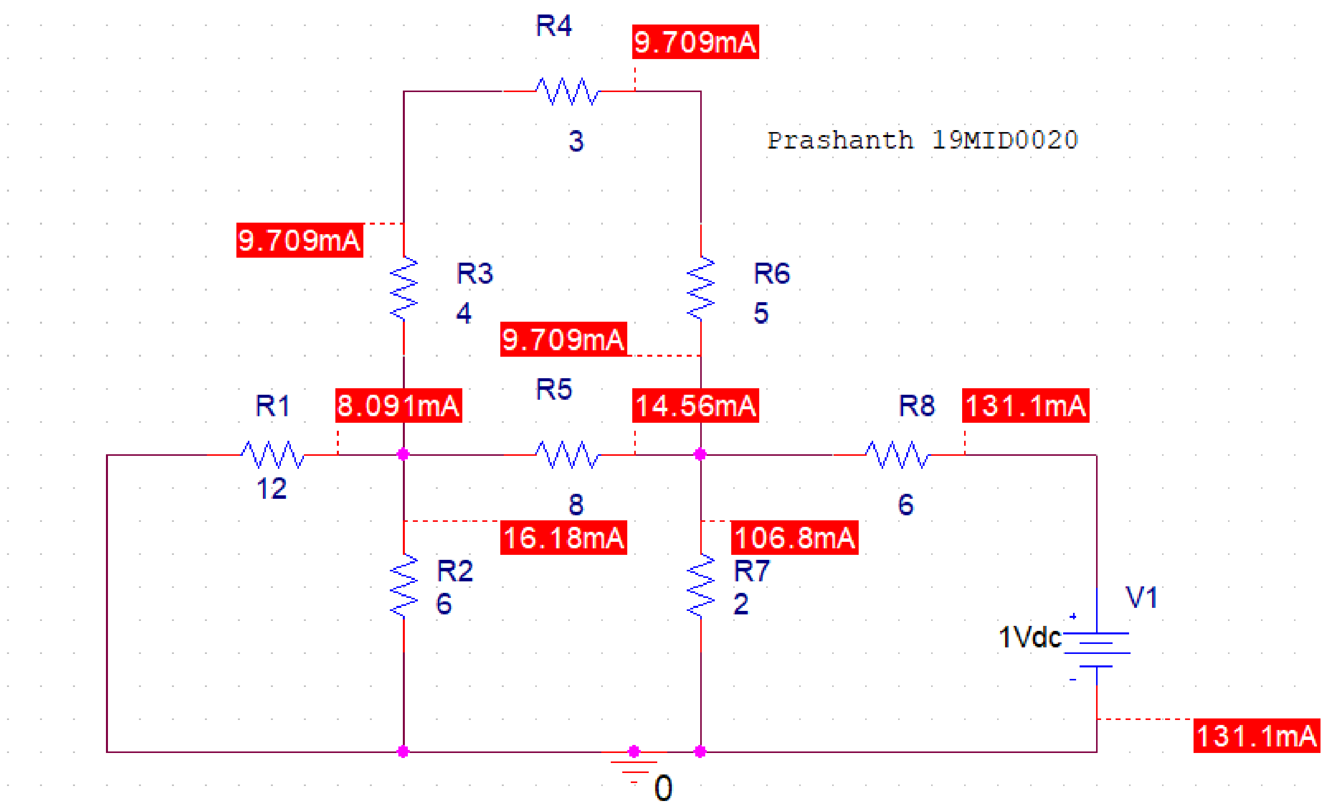
The maximum power transferred is 12.335 W

Simulation Circuit:

To Find V_{th}:

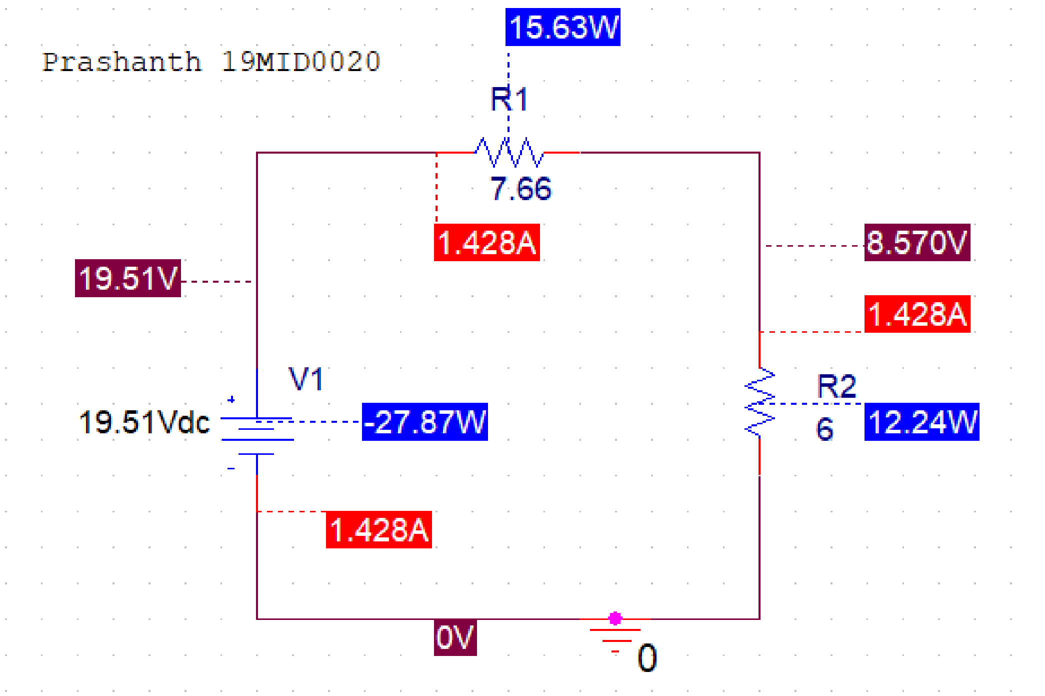


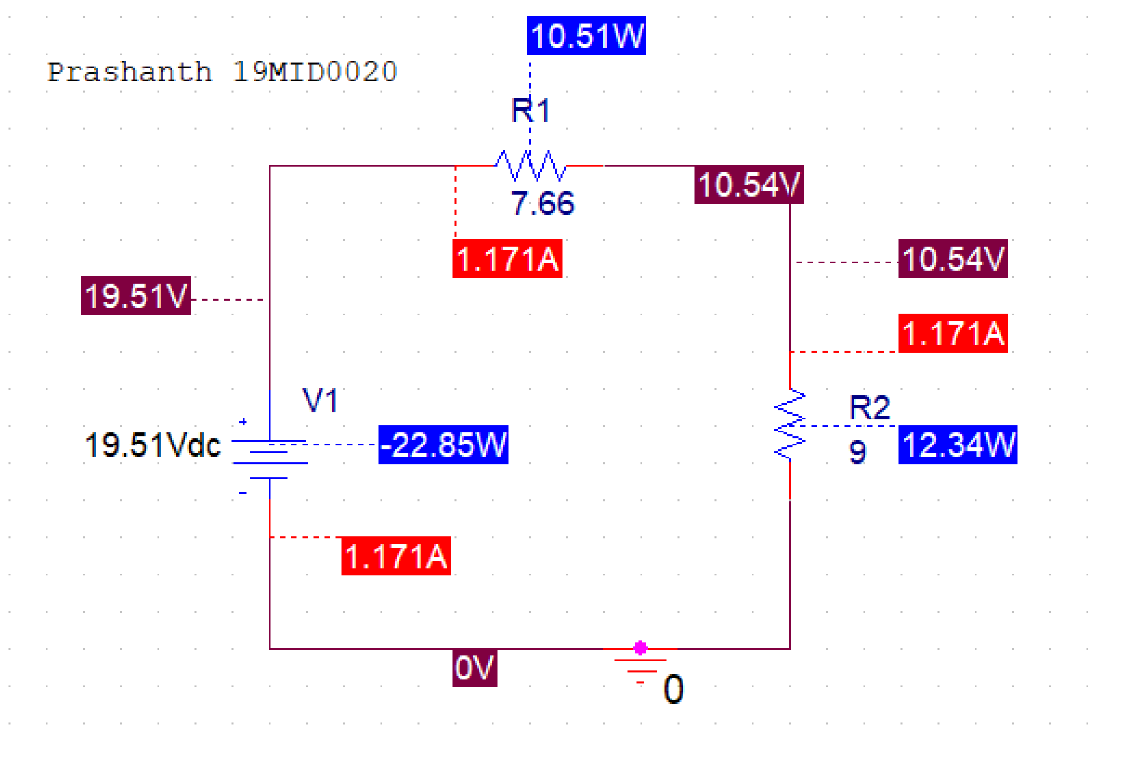
To Find R_{th}:

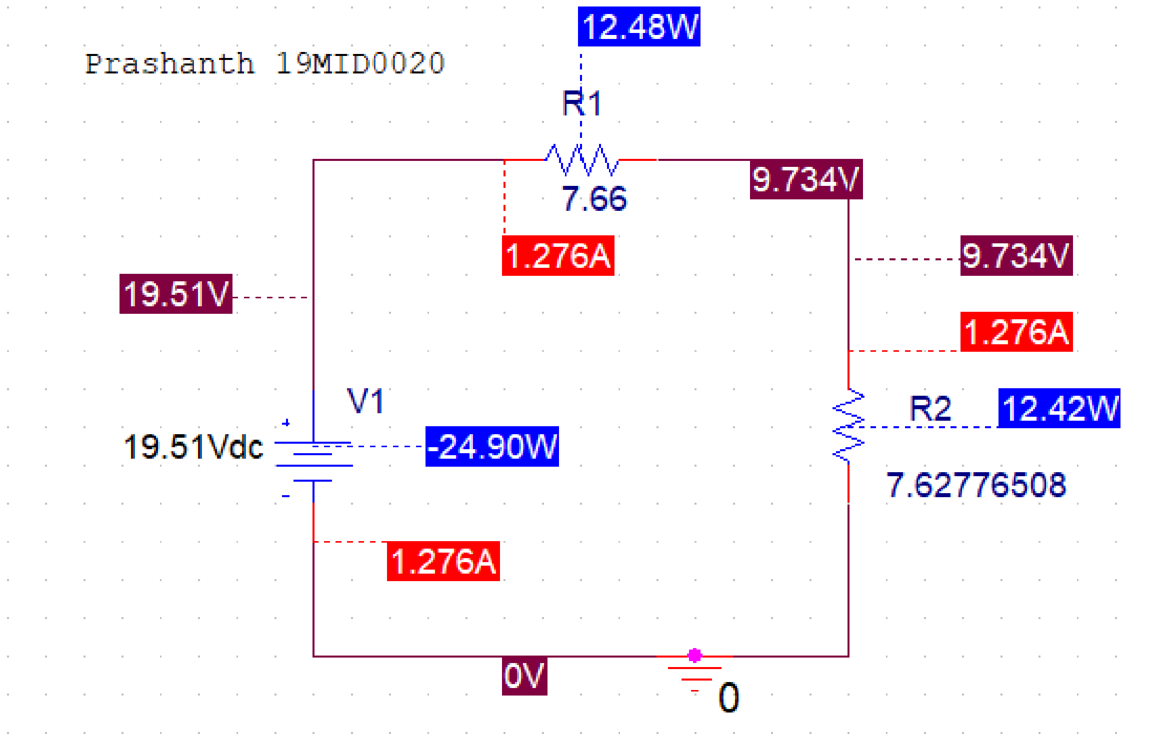


R4
9.709mA
3
Prashanth 19MID0020
9.709mA
R3
4
R6
5
9.709mA
R1
8.091mA
R5
14.56mA
R8
131.1mA
12
8
6
16.18mA
106.8mA
R2
6
R7
2
V1
1Vdc
131.1mA
0

To Find Power:







Result:

Thevenin's theorem & Max.Power transfer	Manual calulation	Simulation Result
V_{Th}	19.506 V	19.51 V
R_{Th}	7.629 Ω	7.62776506 Ω
P_L	12.29 W	12.30 W
P_L	12.383 W	12.39 W
P_{Lmax}	12.468 W	12.48 W

Inference :

The values of Manual calculations and Simulated circuit result are similar approximately equal. Hence Thevenin’s theorem is verified

Inference :

The values of Manual calculations and Simulated circuit result are similar approximately equal. Hence Maximum Power Transfer theorem is verified

Reg. No: 19MID0020	**Name: Prashanth.S**	**Date: 07/08/2020**