Spring 2023

EEE/ETE 141L

Electrical Circuits-I Lab (Sec-19)

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Instructor: Md. Rabiul Karim Khan

Lab Report 07: Verification of Maximum Power Transfer Theorem.

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30 April 2023

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Group no.: 05

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Experiment Name : Verification of Maximum Power Transfer Theorem.

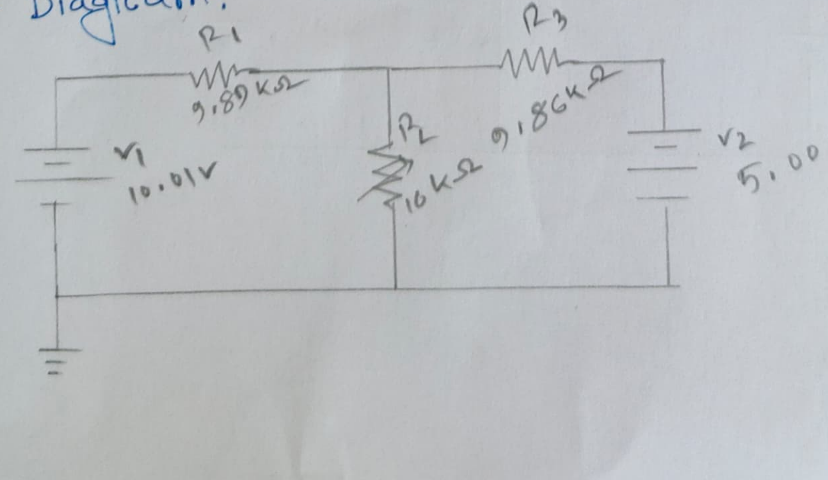
Objectives :

- Experimentally perform Maximum Power Transfer Theorem.
- Perform theoretical calculations.
- Verify the experimental values with theoretical values.

Apparatus :

- Breadboard
- Resistors ($2 \times 10\,k\Omega$)
- Variable Resistors ($0\,k\Omega - 10\,k\Omega$)
- Digital Multimeter (DMM)
- DC Power supply
- Wires

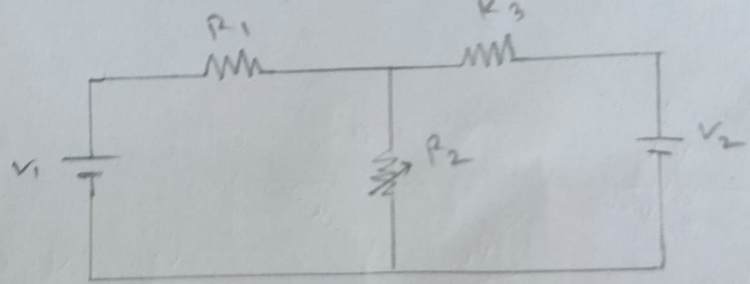
Circuit Diagram:



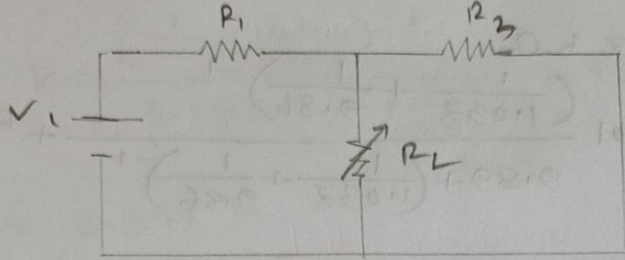
Data table & Calculation:

R_L (kΩ)	V_L Experimental (V)	V_L Theoretical (V)	P_L Experimental (mW)	P_L Theoretical (mW)
1.037	1.240	1.302	1.4827	1.6347
2.018	2.146	2.176	2.2821	2.3464
3.073	2.870	2.878	2.6804	2.6954
4.00	3.345	3.357	2.7973	2.8174
5.02	3.770	3.782	2.8313	2.8493
5.97	4.100	4.106	2.8157	2.8240
6.97	4.380	4.391	2.7524	2.7662
7.99	4.630	4.636	2.6830	2.6899
9.00	4.840	4.844	2.6028	2.6071
10.06	5.030	5.032	2.5150	2.5170

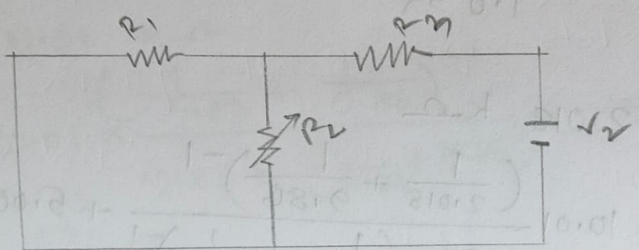
Theoretical value calculation:



using superposition theorem



$$V_L' = \frac{\left(\frac{1}{R_L} + \frac{1}{R_3}\right)^{-1}}{R_1 + \left(\frac{1}{R_2} + \frac{1}{R_3}\right)^{-1}} \times V_1$$



$$V_L'' = \frac{\left(\frac{1}{R_L} + \frac{1}{R_1}\right)^{-1}}{R_3 + \left(\frac{1}{R_L} + \frac{1}{R_1}\right)^{-1}} \times V_2$$

$$\therefore V_L = V_L' + V_L''$$

$$= \frac{\left(\frac{1}{R_L} + \frac{1}{R_3}\right)^{-1}}{R_1 + \left(\frac{1}{R_L} + \frac{1}{R_3}\right)^{-1}} \times V_1 + V_2 \frac{\left(\frac{1}{R_L} + \frac{1}{R_1}\right)^{-1}}{R_3 + \left(\frac{1}{R_L} + \frac{1}{R_1}\right)^{-1}}$$

And $P_L = \frac{(V_L)^2}{R_L}$

Here,

$R_1 = 9.89\ k\Omega$

$R_3 = 9.86\ k\Omega$

$V_1 = 10.01\ V$

$V_2 = 5.00\ V$

Now,

For $R_L = 1.037\ k\Omega$

$$\therefore\ V_L = 10.01\frac{\left(\frac{1}{1.037}+\frac{1}{9.86}\right)^{-1}}{9.89+\left(\frac{1}{1.037}+\frac{1}{9.86}\right)^{-1}} + 5.00\frac{\left(\frac{1}{1.037}+\frac{1}{9.89}\right)^{-1}}{9.86+\left(\frac{1}{1.037}+\frac{1}{9.89}\right)^{-1}}$$

$$= 1.302\ V$$

$$\therefore\ P_L = \frac{(1.302)^2}{1.037} = 1.6347\ mW$$

For $R_L = 2.018\ k\Omega$

$$\therefore\ V_L = 10.01\frac{\left(\frac{1}{2.018}+\frac{1}{9.86}\right)^{-1}}{9.89+\left(\frac{1}{2.018}+\frac{1}{9.86}\right)^{-1}} + 5.00\frac{\left(\frac{1}{2.018}+\frac{1}{9.89}\right)^{-1}}{9.86+\left(\frac{1}{2.018}+\frac{1}{9.89}\right)^{-1}}$$

$$= 2.176\ V$$

$$\therefore\ P_L = \frac{(2.176)^2}{2.018} = 2.3464\ mW$$

For $R_L = 3.073\ k\Omega$

$$\therefore\ V_L = 10.01\frac{\left(\frac{1}{3.073}+\frac{1}{9.86}\right)^{-1}}{9.89+\left(\frac{1}{3.073}+\frac{1}{9.86}\right)^{-1}} + 5.00\frac{\left(\frac{1}{3.073}+\frac{1}{9.89}\right)^{-1}}{9.86+\left(\frac{1}{3.073}+\frac{1}{9.89}\right)^{-1}}$$

$$= 2.878\ V$$

$$\therefore\ P_L = \frac{(2.878)^2}{3.073} = 2.6954\ mW$$

For, $R_L = 4.00\ k\Omega$,

$$V_L = 10.01 \frac{\left(\frac{1}{4}+\frac{1}{9.86}\right)^{-1}}{9.89+\left(\frac{1}{4}+\frac{1}{9.86}\right)^{-1}} + 5.00 \frac{\left(\frac{1}{4}+\frac{1}{9.89}\right)^{-1}}{9.86+\left(\frac{1}{4}+\frac{1}{9.89}\right)^{-1}}$$

$$= 3.357\ V$$

$$P_L = \frac{(3.357)^2}{4.00} = 2.8174\ mW$$

For, $R_L = 5.02\ k\Omega$.

$$V_L = 10.01 \frac{\left(\frac{1}{5.02}+\frac{1}{9.86}\right)^{-1}}{9.89+\left(\frac{1}{5.02}+\frac{1}{9.86}\right)^{-1}} + 5.00 \frac{\left(\frac{1}{5.02}+\frac{1}{9.89}\right)^{-1}}{9.86+\left(\frac{1}{5.02}+\frac{1}{9.89}\right)^{-1}}$$

$$= 3.782\ V$$

$$P_L = \frac{(3.782)^2}{5.02} = 2.8493\ mW$$

For $R_L = 5.97\ k\Omega$

$$V_L = 10.01 \frac{\left(\frac{1}{5.97}+\frac{1}{9.86}\right)^{-1}}{9.89+\left(\frac{1}{5.97}+\frac{1}{9.86}\right)^{-1}} + 5.00 \frac{\left(\frac{1}{5.97}+\frac{1}{9.809}\right)^{-1}}{9.86+\left(\frac{1}{5.97}+\frac{1}{9.89}\right)^{-1}}$$

$$= 4.106\ V$$

$$P_L = \frac{(4.106)^2}{5.97} = 2.8240\ mW$$

For $R_L = 6.97\ k\Omega$

$$V_L = 10.01 \frac{\left(\frac{1}{6.97}+\frac{1}{9.86}\right)^{-1}}{9.89+\left(\frac{1}{6.97}+\frac{1}{9.86}\right)^{-1}} + 5.00 \frac{\left(\frac{1}{6.97}+\frac{1}{9.89}\right)^{-1}}{9.86+\left(\frac{1}{6.97}+\frac{1}{9.89}\right)^{-1}}$$

$$= 4.391\ V$$

$$P_L = \frac{(4.391)^2}{6.97} = 2.7662\ mW$$

For $R_L = 7.99\ k\Omega$

$$V_L = 10.01 \frac{\left(\frac{1}{7.99} + \frac{1}{9.86}\right)^{-1}}{9.89 + \left(\frac{1}{7.99} + \frac{1}{9.86}\right)^{-1}} + 5.00 \frac{\left(\frac{1}{7.99} + \frac{1}{9.89}\right)^{-1}}{9.86 + \left(\frac{1}{7.99} + \frac{1}{9.89}\right)^{-1}}$$

$= 4.636\ V$

$$P_L = \frac{(4.636)^2}{7.99} = 2.6899\ mW$$

For $R_L = 9.00\ k\Omega$

$$V_L = 10.01 \frac{\left(\frac{1}{9} + \frac{1}{9.86}\right)^{-1}}{9.89 + \left(\frac{1}{9} + \frac{1}{9.86}\right)^{-1}} + 5.00 \frac{\left(\frac{1}{9} + \frac{1}{9.89}\right)^{-1}}{9.86 + \left(\frac{1}{9} + \frac{1}{9.89}\right)^{-1}}$$

$= 4.844\ V$

$$P_L = \frac{(4.844)^2}{9.00} = 2.6071\ mW$$

For $R_L = 10.06\ k\Omega$

$$V_L = 10.01 \frac{\left(\frac{1}{10.06} + \frac{1}{9.86}\right)^{-1}}{9.89 + \left(\frac{1}{10.06} + \frac{1}{9.86}\right)^{-1}} + 5.00 \frac{\left(\frac{1}{10.06} + \frac{1}{9.89}\right)^{-1}}{9.86 + \left(\frac{1}{10.06} + \frac{1}{9.89}\right)^{-1}}$$

$= 5.032\ V$

$$P_L = \frac{(5.032)^2}{10.06} = 2.5170\ mW$$

Theoretical value of maximum ~~pow~~ power.

$R_{TH} = 4.94\ k\Omega$

$V_{TH} = 7.520\ V$

$$P_{max} = \frac{(V_{TH})^2}{4\ R_{TH}}$$

$$= \frac{(7.520)^2}{4 \times 4.94}$$

$= 2.8619\ mW$

From graph

$R_{TH} = 4.7\ k\Omega$

~~R~~ $P_{max} = 2.8500\ mW$

Error : $\left| \frac{2.8619 - 2.8500}{2.8619} \right| \times 100\%$

$= 0.421\%$

Graph: Attached

Result Analysis: From the table of this experiment we found that the theoretical and measured values of V_L and P_L are approximately the same. We also get that the theoretical value of P_{max} and the P_{max} from the graph are also approximately the same. Therefore, our circuits completely follow the Maximum Power Transfer theorem.

Questions and Answers:

1. Already showed in data-table.
2. Already showed in data-table.

Dicussion:

After completing this experiment, we learnt to verify the Maximum Power Transfer Theorem. Now we can calculate the maximum power of a circuit using this theorem. We need to remove the load and measure the R_t and the voltage of Thevenins Theorem at points a and b; then, using the maximum power Transfer formula, we can calculate the maxi-mum power. In this experiment, we don't face any difficulties. We completed this experiment on time.

Attachment:

(i) signed Data table.

(ii) simulation using Multisim.

(iii) Graph of R_L Vs P_{max}.

Group-5

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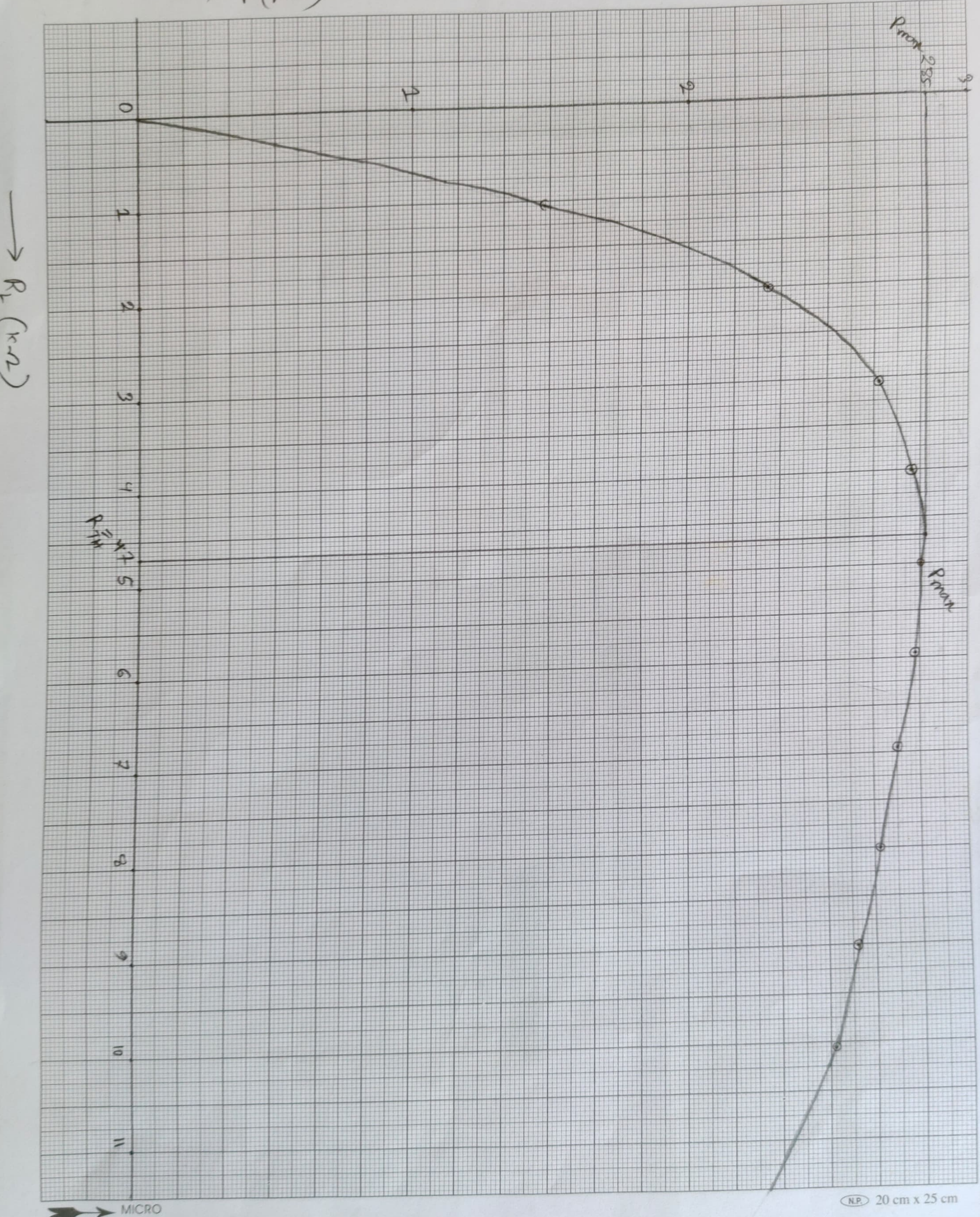
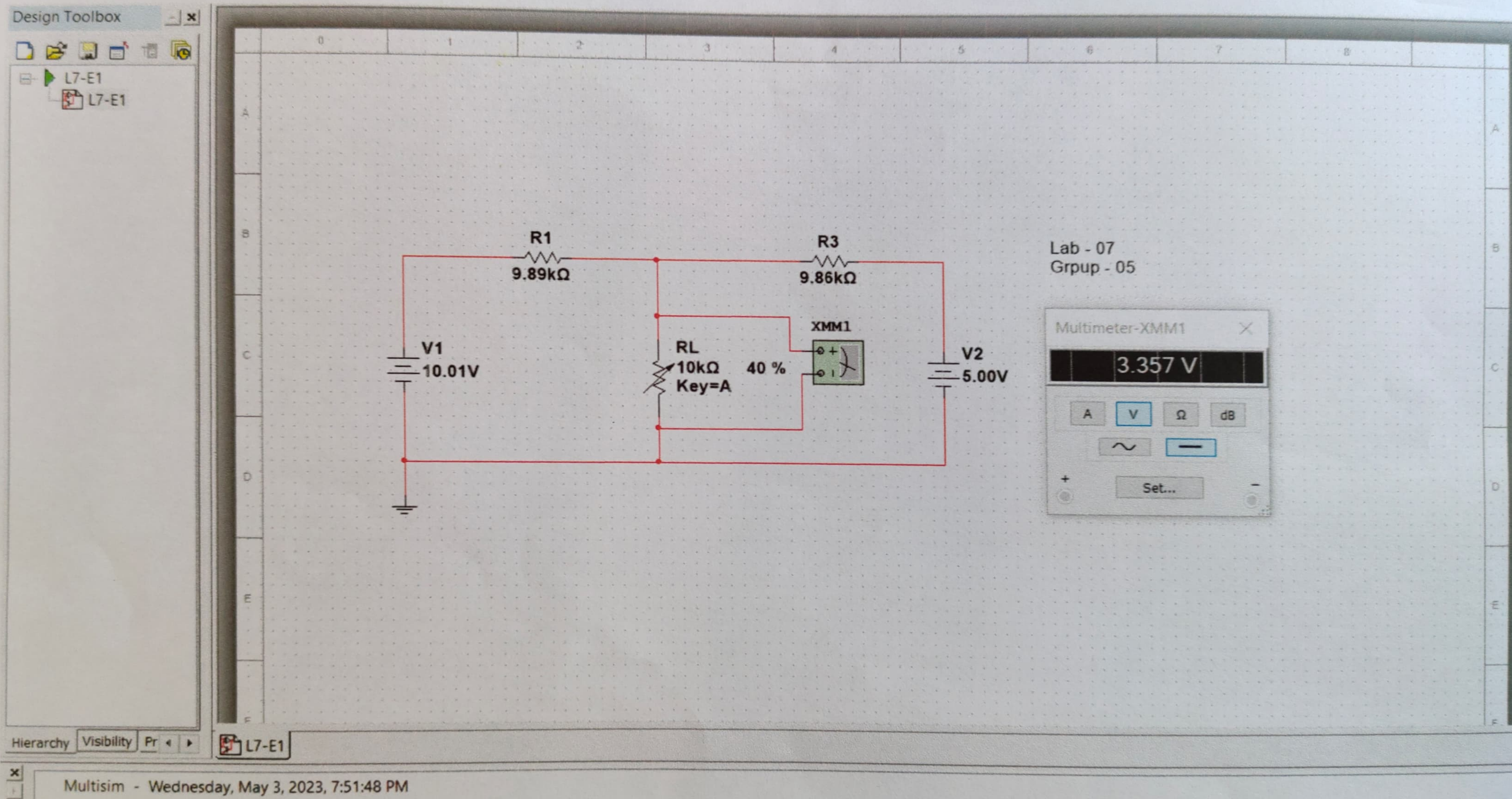
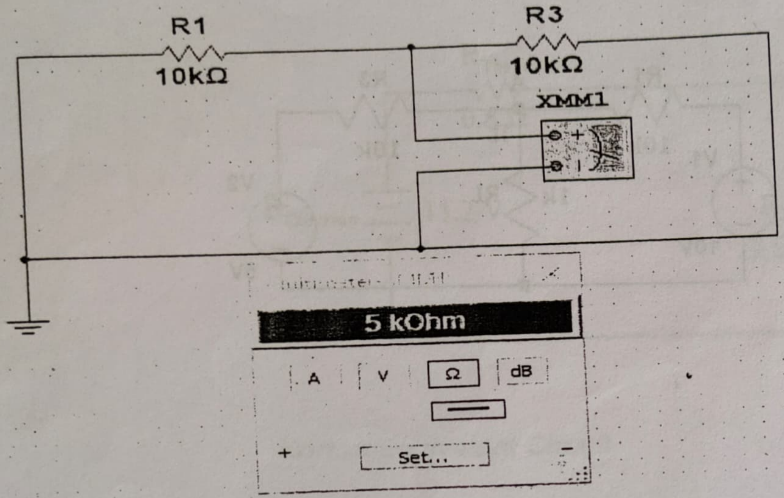



Design Toolbox
L7-E1
L7-E1
R1
9.89kΩ
R3
9.86kΩ
V1
10.01V
RL
10kΩ
Key=A
40 %
XMM1
V2
5.00V
Lab - 07
Grpup - 05
Multimeter-XMM1
3.357 V
A
V
Ω
dB
Set...
Hierarchy
Visibility
L7-E1
Multisim - Wednesday, May 3, 2023, 7:51:48 PM

Thevenin's equivalent resistance, R_{TH}:



Data Collections:

Group No. ________

Instructor's Signature ____________

Table 1:

Theoretical R	Measured R	% Error
	$R_1 = 9.77\ k\Omega$, $R_3 = 10.150\ k\Omega$	
	$R_L = 1.005\ k\Omega$, $R_{Th} = 4.930\ k\Omega$	

Table 2:

Value	Measured	% Error
V_L(V)	1.263 V	
I_L(mA)		

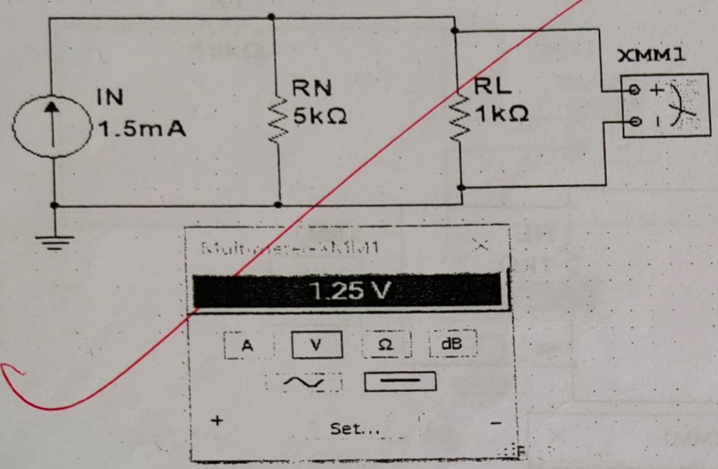
Table 3:

Measurement	Measured	Calculated	% Error
V_{TH}(V)	7.520		
I_N(mA)	1.520		
R_{TH}(KΩ)= RN (KΩ)	4.980		
V_L(V)	1.274		
I_L(mA)			

$I_{Th} = 1.55\ mA$

$V_{RL} = 1.293\ V$

Norton's equivalent circuit:



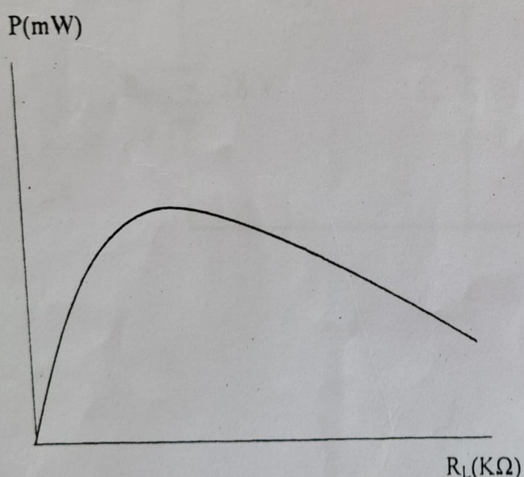
Rabani
9/4/23

Table 4:

R_L (kΩ)	V_L (Experimental)	P_L (Experimental)(mW)
1.0 (1.037)	1.240	1.4827
2.0 (2.018)	2.146	2.2821
3.0 (3.073)	2.870	2.6804
4.0 (4.00)	3.345	2.7973
5.0 (5.02)	3.770	2.8313
6.0 (5.97)	4.100	2.8157
7.0 (6.97)	4.38	2.7524
8.0 (7.99)	4.63	2.6830
9.0 (9.00)	4.84	2.6028
10 (10.06)	5.03	2.5150

Rabin
30/04/23

Graph :



$R_{Th} = 4.94$ kΩ

Report :

1. Find the theoretical values of V_L, R_{TH} , V_{TH}, P_{MAX} and I_N.
2. Compare the theoretical values with practical values.