North South University

Department of Electrical & Computer Engineering

LAB REPORT

Course Code : EEE 141

Course Title: Electrical Circuit Lab

Course Instructor: Faculty Name Abu Obaidah (AbO)

Experiment Number: 03

Experiment Name:

Loading Effect of Voltage Divider Circuit.

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A. Objectives

- Learn how to create a ladder circuit and a voltage divider circuit on the bread board.
- Observe the loading effect on voltage divider circuit.
- Learn to use variable resistor.

B. Theory

1. Voltage Divider Rule:

The voltage divider rule is the voltage is divided between two series resistors in direct proportion to their resistance.

2. Loading Effect:

When an ~~isn~~ instrument of lower sensitivity is used with a load the measurement it makes is erroneous, this effect is known as loading effect.

3. potentiometer:

A potentiometer is a three - terminal resistor with a sliding or rotating contact that forms an adjustable voltage divider. If only two terminals are used, one end and the wiper, it acts as a variable resistor.

4. Application of Potentiometer:

Potentiometers are realy used to directly control significant amounts of power. Insted they are used to adjust the level of analog signals (for example: volume controls on audio equipment), and as control inputs for electronic circuits. For example, a light dimmer uses a potentiometer to control the switching of a TRIAC and so indirectly to control the brightness of lamps.

5. The reason we connect load at the end of the ~~ex~~ circuit:

When we observed from the source end, the word 'end' means the output end of the circuit. The output end is where the circuit is designed to deliver power, and the output is where the power is to be utilised. In our home, the power outlets are the output end, and the local distribution transformer is the input end. We connect them at the end because of:

i) A heavy load will draw more current while a light load will draw a less current.

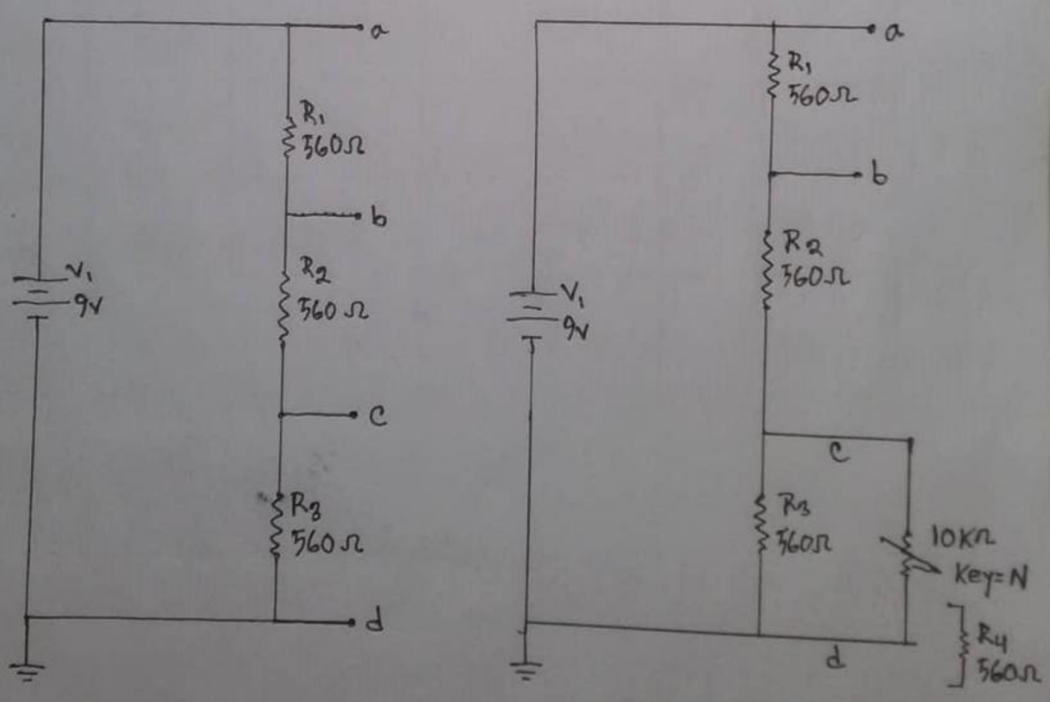
ii) In case of load less circuit it will draw minimal current.

C. Experiment 1:

C.1. Apparatus/List of Equipment:

- Trainer Board.
- DMM.
- 3X560 Ω resistors.
- 1X (0-10kΩ) variable resistor.

Circuit Diagram:



Circuit 1

Circuit 2.

Figure C.1

	circuit 1	circuit 2 $R_4 = 4\,k\Omega$	circuit 2 $R_4 = 7\,k\Omega$	circuit 2 $R_4 = 10\,k\Omega$
R_T	1.66	1.58	1.62	1.64
E	8.93	8.93	8.92	8.93
I	5.38	5.65	5.51	5.45
V_{R_1}	2.98	3.15	3.07	2.95
V_{R_2}	2.98	3.10	3.05	2.91
V_{R_3}	2.97	2.31	2.81	2.82
V_{R_4}	xxx	2.75	2.82	2.84
I_{R_1}	5.42	5.73	5.58	5.36
I_{R_2}	5.32	5.54	5.45	5.20
I_{R_3}	5.30	4.84	5.02	5.04
I_{R_4}	xxx	0.69	0.40	0.28

Table C.1

Table: 1

RL	Vout (Measured)	Vout (Calculated)	% Error
0	2.97	3.0	1%
4k	2.75	2.70	0.36%
7k	2.82	2.85	1.05%
10K	2.84	2.89	1.73%

For Table 1:

1. Given,

$R_1 = 0.36\ k\Omega$

$R_2 = 0.56\ k\Omega$

$R_3 = 0.56\ k\Omega$

& $R_4 = 0\ k\Omega$

We know,

$$V_{out} = V_{in} \frac{\cancel{\frac{R_3 R_4}{R_3 + R_4}}\ R_3}{R_1 + R_2 + \cancel{\frac{R_3 R_4}{R_3 + R_4}} + R_3}$$

$$= 9 \cdot \left(\frac{\cancel{\frac{0.36 \times 0}{0.36 + 0}}}{\cancel{0.36} + 0.36 + \cancel{\frac{0.36 \times 0}{0.36 + 0}}} \right) = 9 \cdot \frac{0.56}{0.56 + 0.56 + 0.56}$$

$= 3V.$

For,

$R_4 = 1 k\Omega$

$$V_{out} = 9 \cdot \frac{\frac{0.36 \times 1}{0.36 + 1}}{0.36 + 0.36 + \frac{0.36 \times 1}{0.56 + 1}}$$

$= 2.18\ V.$

For,

$R_4 = 4K$

$$V_{out} = 9 \cdot \frac{\frac{0.56 \times 4}{0.56 + 4}}{0.36 + 0.56 + \frac{0.56 \times 4}{0.56 + 4}}$$

$= 2.74\ V.$

$$E_{I_{R_1}} = \left|\frac{5.58 - 5.73}{5.58}\right| \times 100 = 2.69\%$$

$$E_{I_{R_2}} = \left|\frac{5.58 - 5.54}{5.58}\right| \times 100 = 0.75\%$$

$$E_{I_{R_3}} = \left|\frac{4 - 4.84}{4}\right| \times 100 = 0.2\%$$

$$E_{I_{R_4}} = \left|\frac{0.68 - 0.69}{0.68}\right| \times 100 = 1.47\%$$

Circuit - 2 : R_4 ($7k\Omega$)

$$E_I = \left|\frac{5.49 - 5.31}{5.49}\right| \times 100 = 0.36\%$$

$$E_{I_{R_1}} = \left|\frac{5.5 - 5.58}{5.5}\right| \times 100 = 1.45\%$$

$$E_{I_{R_2}} = \left|\frac{5.5 - 5.45}{5.5}\right| \times 100 = 0.9\%$$

$$E_{I_{R_3}} = \left|\frac{5.02 - 5.02}{5.02}\right| \times 100 = 0\%$$

$$E_{I_{R_4}} = \left|\frac{0.41 - 0.40}{0.41}\right| \times 100 = 2.44\%$$

For, $R_4 = 7\,k\Omega$.

$$\therefore V_{out} = 9 \cdot \frac{\frac{0.56 \times 7}{0.56+7}}{0.56 + 0.56 + \frac{0.56 \times 7}{0.56+7}}$$

$$= 2.84\,V$$

For, $R_4 = 10\,k\Omega$

$$\therefore V_{out} = 9 \cdot \frac{\frac{0.56 \times 10}{0.56+10}}{0.56 + 0.56 + \frac{0.56 \times 10}{0.56+10}}$$

$$= 2.89\,V.$$

2. <u>Percentage of Errors:</u>

For Circuit 1:

$$E_1 = \left| \frac{J-P}{J} \times 100 \right| = \left| \frac{3 - 2.97}{3} \times 100 \right| = 1\%.$$

For Circuit 2:

$$E_1 = \left| \frac{2.74 - 2.75}{2.74} \times 100 \right| = 0.36\%.$$

For Circuit 3:

$$E_1 = \left| \frac{2.84 - 2.83}{2.84} \times 100 \right| = 1.05\%.$$

$$V_{R_1} = \frac{V}{R_1 + R_2 + (R_3 \parallel R_4)} \times R_1 = \frac{9}{1611.228} \times 560 = 3.13\,V$$

$$V_{R_2} = \frac{V}{R_1 + R_2 + (R_3 \parallel R_4)} \times R_2 = \frac{9}{1611.228} \times 560 = 3.13\,V$$

$$V_{R_3 \parallel R_4} = \frac{V}{R_1 + R_2 + (R_3 \parallel R_4)} \times R(R_3 \parallel R_4) = \frac{9}{1611.228} \times 491.\cancel{85}228 = 2.74\,V$$

$\because$ R_3 & R_4 are in parallel

so, $V_{R_3} = V_{R_4} = 2.74\,V$

$$I_{R_1} = V_{R_1}/R_1 = 3.13/560 = 5.58\text{ mA}$$

$$I_{R_2} = V_{R_2}/R_2 = 3.13/560 = 5.58\text{ mA}$$

$$I_{R_3} = V_{R_3}/R_3 = 2.31/560 = 4.13\text{ mA}$$

$$I_{R_4} = V_{R_4}/R_4 = 2.74/4000 = \cancel{6.85\text{ mA}}\ 0.68\text{ mA}$$

Circuit-2: $(R_4 = 7\,k\Omega = 7000\,\Omega)$

$V = 9V$, $R_1 = R_2 = R_3 = 560\,\Omega$; $R_4 = 7000\,\Omega$

$R_3 \parallel R_4$; so, $R(R_3 \parallel R_4) = \frac{560 \times 7000}{560 + 7000} = 518.5\,\Omega$

$$R_{eq} = R_1 + R_2 + R(R_3 \parallel R_4) = (560 + 560 + 518.5) = 1638.5\,\Omega$$

$$I = \frac{V}{R_{eq}} = \frac{9}{1638.5} = 5.49\text{ mA}$$

$$\therefore V_{R_1} = V/R_{eq} \times R_1 = 9/1638.5 \times 560 = 3.08\,V$$

$V_{R_2} = V/R_{eq} \times R_2 = 9/1638.5 \times 560 = 3.08V$

$V_{R_3 \| R_4} = V/R_{eq} \times R(R_3 \| R_4) = 9/1638.5 \times 518.5 = 2.85V$

R_3 & R_4 are in parallel so, $V_{R_3} = V_{R_4} = 2.85V$

$I_{R_1} = V_{R_1}/R_1 = 3.08/560 = 5.5 mA$

$I_{R_2} = V_{R_2}/R_2 = 3.08/560 = 5.5 mA$

$I_{R_3} = V_{R_3}/R_3 = 2.81/560 = 5.02 mA$

$I_{R_4} = V_{R_4}/R_4 = 2.85/7000 = 0.41 mA$

Circuit - 2: ($R_4 = 10 K\Omega = 10000\Omega$)

$V = 9V, R_1 = R_2 = R_3 = 360\Omega$; $R_4 = 10000\Omega$

$R_3 \| R_4$; so, $R(R_3 \| R_4) = \frac{360 \times 10000}{360 + 10000} = 330.30\Omega$

$R_{eq} = R_1 + R_2 + R(R_3 \| R_4) = 360 + 360 + 530.30 = 1630.3\Omega$

$I = V/R_{eq} = 9/1630.3 = 5.45 mA$

■ Circuit-2: (R_4 = 10KΩ)

$$E_I = \left| \frac{5.45 - 5.45}{5.45} \right| \times 100 = 0\%$$

$$E_{I_{R_1}} = \left| \frac{5.45 - 5.36}{5.45} \right| \times 100 = 1.65\%$$

$$E_{I_{R_2}} = \left| \frac{5.45 - 5.20}{5.45} \right| \times 100 = 4.6\%$$

$$E_{I_{R_3}} = \left| \frac{5.18 - 5.04}{5.18} \right| \times 100 = 2.7\%$$

$$E_{I_{R_4}} = \left| \frac{0.29 - 0.28}{0.29} \right| \times 100 = 3.4\%$$

3. Compare and comment on the theoretical and experimental values:

■ Circuit-1:

$$I = P - T$$
$$= 5.38 - 5.35$$
$$= 0.03\ mA$$

C.3. Report:

1. Theoretically analyse circuits in Figure C.1. using VDR and obtain all theoretical values of Table C.1:

Circuit 1:

$V = 9V$, $R_1 = R_2 = R_3 = 360\Omega$

R_1, R_2 & R_3 are in series & $R_{eq} = R_1 + R_2 + R_3 = (360 + 360 + 360)\Omega$
$= 1680\Omega$

According to VDR,

$$V_{R_1} = \frac{V}{R_{eq}} \times R_1 = \frac{9}{1680} \times 360 = 3V.$$

$$V_{R_2} = \frac{V}{R_{eq}} \times R_2 = \frac{9}{1680} \times 360 = 3V$$

$$V_{R_3} = \frac{V}{R_{eq}} \times R_3 = \frac{9}{1680} \times 360 = 3V.$$

$$\therefore I = \frac{V}{R_{eq}} = \frac{9}{1680} = 0.00535\,A = 5.35\,mA.$$

Circuit-1 is a series circuit so, $I_{R_1}, I_{R_2}, I_{R_3}$ all are same. $I_{R_1} = I_{R_2} = I_{R_3} = 5.35\,mA$.

Circuit-2: $(R_4 = 4k\Omega)$

$R_4 = 4k\Omega \Rightarrow R_4 = 4000\Omega$, $V = 9V$, $R_1 = R_2 = R_3 = 360\Omega$

Here,

$$(R_3 \parallel R_4) = \frac{360 \times 4000}{360 + 4000} = 491.228\Omega$$

$$R_{eq} = R_1 + R_2 + (R_3 \parallel R_4) = (360 + 360 + 491.228) = 1611.228\Omega$$

$$I = \frac{V}{R_{eq}} = \frac{9}{1611.228} = 5.58\,mA$$

$V_{R_1} = \frac{V}{R_{eq}} \times R_1 = 9/_{1650.3} \times 560 = 3.05\ V$

$V_{R_2} = \frac{V}{R_{eq}} \times R_2 = 9/_{1630.3} \times 560 = 3.05\ V$

$V_{R(R_3 \parallel R_4)} = \frac{V}{R_{eq}} \times V_R(R_3 \parallel R_4) = 9/_{1630.3} \times 530.30 = 2.90\ V$

$\because R_3 \parallel R_4 \therefore V_{R_3} = V_{R_4} = 2.90\ V$

$I_{R_1} = V_{R_1}/R_1 = \cancel{3.15}\ 3.05/560 = 5.45\ mA$

$I_{R_2} = V_{R_2}/R_2 = 3.05/560 = 5.45\ mA$

$I_{R_3} = V_{R_3}/R_3 = 2.9/560 = 5.18\ mA$

$I_{R_4} = V_{R_4}/R_4 = 2.9/\cancel{560}\ 10000 = 0.29\ mA$

2. Percentage of Errors:

For Circuit - 1:

$E_I = \left|\frac{T-P}{T}\right| \times 100 = \left|\frac{5.35 - 5.38}{5.35}\right| \times 100 = 0.56\ \%$

For Circuit - 2: ($R_4 = 4.00\ k\Omega$)

$E_I = \left|\frac{5.58 - 5.65}{5.58}\right| \times 100 = 1.25\ \%$

$I_{R_1} = 5.58 - 5.5 = 0.08$

$I_{R_2} = 5.45 - 5.5 = -0.05$

$I_{R_3} = 5.02 - 5.02 = 0$

$I_{R_4} = 0.40 - 0.41 = -0.01$

Circuit - 2 : ($R_4 = 10k\Omega = 10000\,\Omega$)

$I = 5.43 - 5.43 = 0$

$V_{R_1} = 2.95 - 3.05 = -0.1$

$V_{R_2} = 2.91 - 3.05 = -0.14$

$V_{R_3} = 2.82 - 2.90 = -0.08$

$V_{R_4} = 2.84 - 2.90 = -0.06$

$I_{R_1} = 5.36 - 5.45 = -0.09$

$I_{R_2} = 5.20 - 5.45 = -0.25$

$I_{R_3} = 5.04 - 5.18 = -0.14$

$I_{R_4} = 0.28 - 0.29 = -0.01$

Comment : Theoretical and practical value of the experiment are very close. Values are almost same.

$V_{R_1} = P - T$
$= 2.98 - 3$
$= -0.02$

$V_{R_2} = 2.98 - 3$
$= -0.02$

$V_{R_3} = 2.97 - 3$
$= -0.03$

Circuit 2: ($R_4 = 4 k\Omega$)

$I = 5.65 - 5.58$
$= 0.07$

$V_{R_1} = 3.15 - 3.13$
$= 0.02$

$V_{R_2} = 3.10 - 3.13$
$= 0.02$

$V_{R_3} = 2.31 - 2.74$
$= -0.42$

$V_{R_4} = 2.75 - 2.74$
$= 0.1$

$I_{R_1} = 5.73 - 5.58$
$= 0.15$

$I_{R_2} = 5.54 - 5.58$
$= -0.04$

$I_{R_3} = 4.84 - 4.13$
$= 0.71$

$I_{R_4} = 0.69 - 0.68$
$= 0.01$

Circuit 2: ($R_4 = 7 k\Omega$)

$I = 5.51 - 5.49$
$= 0.02$

$V_{R_1} = 3.07 - \cancel{0.} 3.03$
$= 0.04$

$V_{R_2} = 3.05 - 3.08$
$= -0.02$

$V_{R_3} = 2.81 - 2.85$
$= -0.04$

$V_{R_4} = 2.82 - 2.85$
$= 0.24$

$$V_{R_1} = \frac{V}{R_1+R_2+(R_3 \| R_4)} \times R_1 = \frac{9}{1611.228} \times 360 = 3.13\ V$$

$$V_{R_2} = \frac{V}{R_1+R_2+(R_3 \| R_4)} \times R_2 = \frac{9}{1611.228} \times 360 = 3.13\ V$$

$$V_{R_3 \| R_4} = \frac{V}{R_1+R_2+(R_3 \| R_4)} \times R(R_3 \| R_4) = \frac{9}{1611.228} \times 491.228 = 2.74\ V$$

$\because$ R_3 & R_4 are in parallel

so, $V_{R_3} = V_{R_4} = 2.74V$

$$I_{R_1} = V_{R_1}/R_1 = 3.13/360 = 8.58\ mA$$

$$I_{R_2} = V_{R_2}/R_2 = 3.13/360 = 8.58\ mA$$

$$I_{R_3} = V_{R_3}/R_3 = 2.31/360 = 4.13\ mA$$

$$I_{R_4} = V_{R_4}/R_4 = 2.74/4000 = 0.68\ mA$$

Circuit-2: ($R_4 = 7K\Omega = 7000\ \Omega$)

$V = 9V$, $R_1 = R_2 = R_3 = 360\Omega$; $R_4 = 7000\Omega$

$R_3 \| R_4$; so, $R(R_3 \| R_4) = \frac{360 \times 7000}{360+7000} = 318.5\ \Omega$

$$R_{eq} = R_1 + R_2 + R(R_3 \| R_4) = (360 + 360 + 318.5) = 1638.5\ \Omega$$

$$I = \frac{V}{R_{eq}} = \frac{9}{1638.5} = 5.49\ mA$$

$$V_{R_1} = V/R_{eq} \times R_1 = 9/1638.5 \times 360 = 3.08\ V$$

For Circuit 4:

$$E_1 = \left| \frac{2.89 - 2.84}{2.89} \times 100 \right| = 1.73\%$$

3. Compare & Comment on theoritical & experimental values:

Theoretical and practical value of the experiment are very close. Values are almost same.

Result Analysis and Discussion:

In this experiment, we got to know about the effects of load resistance.

If we want to add an potentiometer which is a variable resistance. We set it on parallel with R_3. We have to be very careful about ~~Submitting~~ connecting. We can connect with leg-A,B or B,C. We can not connect leg A,C.

Here we have 3 resistor and a variable resistor. 1st 3 ones are connected in seris. We have to find each voltage and current for every resistance. For 1st measurement, there is no load resistance. And now we got the highest voltage output. For 2nd measurement, we add 4 kΩ load resistance, And now v(out) drops. But as we increase ~~Ro~~ Load resistance, Vo also rises.

4. Discuss on the loading effect of the voltage divider circuit:

we did there careful measurement of all values. we observed the voltage divider circuit & In this experiment we've learnt how to create a ladder circuit, how to form a voltage divider circuit on a bread bord and we knew uses of variable resistor. For this experiment, the variable resistor was so sensitive for us, actully its measurement.

There were very small differnces between the theoretical and experimental values. such differences can be avoided.

No problem faced while doing this experiment. But one thing, because of some issues in the components. the theoritical & practical values were slightly different.

Conclusion

In Conclusion, we have learned about the loading effect of the voltage divider circuit. we have learned about also ladder circuit. With variable resistor, we can now build the voltage divider circuit. We have learned actully so many things from this lab. we measured all values including theoretical & practical values. while doing this lab we tuned the variable resistor to getting our actual need. without some DMM & other componants issues, the lab was so knowledgeable & ~~lots of usess~~ comfortable for our learning.