UNIVERSITY OF MIAMI
Department of Electrical and Computer Engineering
ECE 204

Name: Jing Ma
Section:
Date:

EXPERIMENT 1

VOLTAGE DIVISION

PURPOSE: The purpose of this lab is to introduce a new student to the basics of electric measurements through the use of a simple voltage divider circuit.

Equipment

1 Variable resistance box
1 Digital voltmeter (DVM)
1 D.C. power supply
1 Function generator
1 Oscilloscope

Preliminary Work

Fig. 1.1 shows a voltage divider circuit. For this circuit find:

a) The current I in terms of V_s, R_1, and R_L;
b) The voltage across R_L;
c) The DC power delivered to R_L, and
d) The power supplied by the source.
e) Request the instructor's help to gather information in order to answer discussion item (d).

a). $I = \frac{V_s}{R_1 + R_L}$

b). $V_{R_L} = IR_L = \left(\frac{V_s}{R_1 + R_L}\right) R_L = \frac{5\,VR_L}{10k + R_L}$

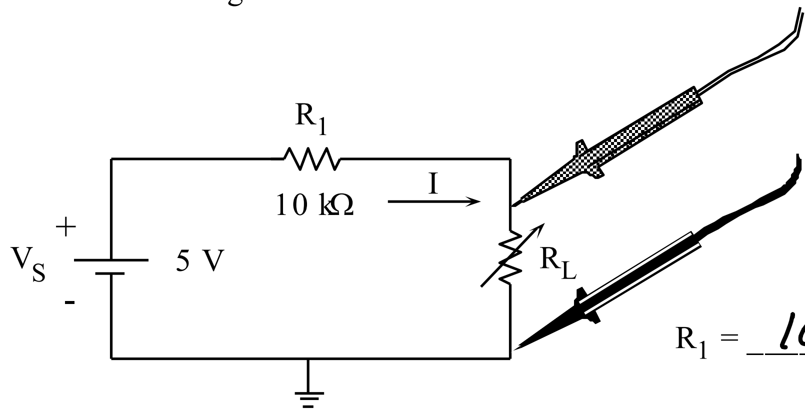
c). $P_{R_L} = VI = \left(\frac{V_s R_L}{10k + R_L}\right)\left(\frac{V_s}{10k + R_L}\right) = \frac{V_s^2 R_L}{(10k + R_L)^2} = \frac{25\,VR_L}{(10k + R_L)^2}$

d). Power $V_s = \frac{V^2}{R} = \frac{25V^2}{R_1 + R_L}$

Experimental Procedure

I. D.C. Measurements:

a) Set up the circuit shown in Fig. 1.1. Measure and record the actual value of R_1.



R_1 = 10k

Figure 1.1 Simple voltage divider circuit with DVM probes shown.

b) Set the dc power supply to 5 V. Measure the voltages across R_1 and R_L using the DVM as shown in Fig. 1.1 (Set the DVM to measure DC). Vary the R_L to the values given in Table 1.1; measure the voltages at each point. Enter all the values in the table under the column labeled *"MEASURED"*.

c) Calculate the voltages across the resistors R_1 and R_L for all values of R_L shown in Table 1.1 using the formulas from your preliminary work. Enter the voltages in the table under the column labeled *"CALCULATED"*. Compare V_{RL} against the measured value by calculating the percentage error. Remember that the percentage error can be found from

$$\%\,Error = \left|\frac{Calculatedvalue - Measuredvalue}{Calculatedvalue}\right| x\ 100\%.$$

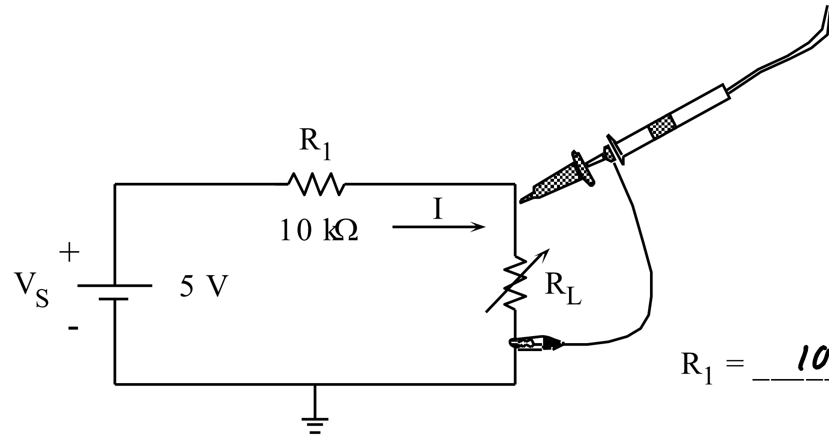
Show a set of calculations for V_{R1}, V_{R2}, and %Error on V_{RL} in detail.

	Measured		Calculated		
R_L (KΩ)	**V_{R1} (V)**	**V_{RL} (V)**	**V_{R1} (V)**	**V_{RL} (V)**	**% Error (V_{RL})**
1	4.545	- 0.454	4.54	0.454	0
5	3.333	-1.667	3.333	1.667	0
10	2.5	-2.5	2.5	2.5	0
15	2	-3	2	3	0
20	1.667	-3.333	1.667	3.333	0
40	1	-4	1	4	0

Measured value of V_s = 5 V

Table 1.1 Measured and calculated dc voltages using DVM

d) Repeat parts (a) - (c) but use the oscilloscope instead of the DVM (see Fig. 1.2). Record your values in Table 1.2. Measure and record the actual value of R_1. Note that the measurement has to be taken as V_{R1}=VS-V_{RL}.



R_1 = 10k

Figure 1.2 Simple voltage divider circuit with oscilloscope probes shown.

	Measured		Calculated		
RL (KΩ)	**VR1 (V)**	**VRL (V)**	**VR1 (V)**	**VRL (V)**	**% Error (VRL)**
1	4.545	- 0.45459	4.54	0.454	0
5	3.333	-1.667	3.333	1.667	0
10	2.5	-2.5	2.5	2.5	0
15	2	- 3	2	3	0
20	1.667	-3.333	1.667	3.333	0
40	1	-4	1	4	0

Measured value of V_S = 5 V

Table 1.2 Measured and calculated dc voltages using oscilloscope.

II. AC Measurements:

a) *DVM measurements:* Replace the dc power supply in Fig. 1.1 with the frequency (function) generator. Adjust the voltage to 5 V_{p-p} at 1 kHz. Repeat parts (a) - (c) of the dc measurements. Tabulate your data in Table 1.3. Note that the DVM should be in AC mode in order to measure AC rms. values.

	Measured		Calculated		
R_L (KΩ)	V_{R1} (V)	V_{RL} (V)	V_{R1} (V)	V_{RL} (V)	% Error (V_{RL})
1	4.545	0.454	4.54	0.454	0
5	3.333	1.667	3.333	1.667	0
10	2.5	2.5	2.5	2.5	0
15	2	3	2	3	0
20	1.667	3.33	1.667	3.333	0
40	1	4	1	4	0

Measured value of V_s = 5 V_{rms}

Table 1.3 Measured and calculated rms. AC voltages using DVM.

b) *Oscilloscope measurements:* Repeat part (a) of the ac measurements using the oscilloscope. Tabulate your data in Table 1.4.

	Measured		Calculated		
R_L (KΩ)	V_{R1} (V)	V_{RL} (V)	V_{R1} (V)	V_{RL} (V)	% Error (V_{RL})
1	4.545	0.454	4.54	0.454	0
5	3.333	1.667	3.333	1.667	0
10	2.5	2.5	2.5	2.5	0
15	2	3	2	3	0
20	1.667	3.33	1.667	3.333	0
40	1	4	1	4	0

Measured value of V_s = 5 V_{p-p}

Table 1.4 Measured and calculated peak-to-peak AC voltages using oscilloscope.

Discussion of Results

a) Comment on the benefits of using either the DVM or the SCOPE for particular situations.

b) Find the current in the circuit of Fig. 1.1 when $R_L = 50\ k\Omega$.

c) In the circuit of Fig. 1.3 R_1 is fixed. Derive the condition under which maximum power will be delivered to R_2. Why?

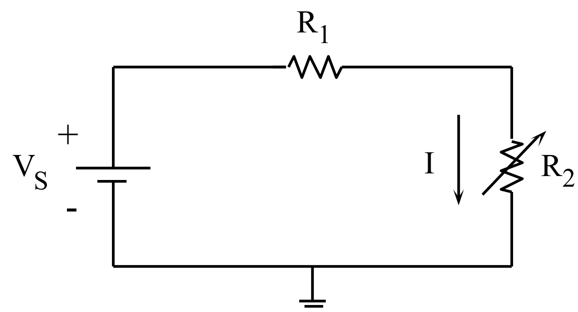


Figure 1.3 Simple voltage divider circuit.

d) Prepare a table indicating the possible measurements that can be carried out using each equipment you used during the experiment.

e) Write a conclusion.

a). DC Measurements

- Two methods of measurement can be compared based on accuracy and precision. In terms of precision, DVM can provide more precise measurements of up to 4 decimal places, while the scope only provides up to 2 decimal places. And by using DVM, it could possibly lower the percent error since it provides more precise measurements compared to the scope.

AC Measurements

- Scope can provide more information about an AC voltage compared to DVM, even though DVM can provide more precise measurements. But the scope can show the wave form, peak-to-peak, and V_{rms} while the DVM only reads V_{rms} voltage.

b). $$I = \frac{V_s}{R_1 + R_L} = \frac{5.00V}{10k + 50k} = 83mA$$

c). $P = I^2 R_L$, $I = \dfrac{V_s}{R_1 + R_L}$ $\Bigg\}$ $P = \dfrac{V_s^2}{(R_1 + R_L)^2} R_L$

*To maximize Power, I and V has to be pretty big.

$$P_L = \frac{V_s^2}{\left(\frac{R_s}{\sqrt{R_L}} + \sqrt{R_2}\right)^2} = \frac{V_s^2}{R_1\left(\frac{\sqrt{R_1}}{\sqrt{R_L}} + \frac{\sqrt{R_2}}{\sqrt{R_s}}\right)^2}$$

$$\frac{V_s^2}{V_s^2} = \frac{R_1\left(\frac{\sqrt{R_1}}{\sqrt{R_2}} + \frac{\sqrt{R_2}}{\sqrt{R_2}}\right)^2}{\left(\frac{R_s}{\sqrt{R_2}} + \sqrt{R_2}\right)^2}$$

$$I = \frac{\sqrt{R_1}}{\sqrt{R_L}}$$

$\therefore$ max if $R_1 = R_L$

d).

	Function Generator	R_L	DMM	Ocilliscope
Resistance	✗	✗	✓	✗
Vpp	✗	✗	✗	✓
V_{rms}	✗	✗	✓	✓
frequency	✗	✗	✓	✓
Wave Shape	✗	✗	✗	✓
i_{ac}	✗	✗	✓	✗
i_{dc}	✗	✗	✓	✗
V_{oc}	✗	✗	✓	✓

- From what I read I think this is how the chart should look like.

e). Due to my groups special circumstances, we were not able to attend labs in person, but only virtually through Zoom. And so we completed our experiment through an online simulation that measured everything percisely for us, without us having measure anything in the real world. And so it may not be very clear to me which method, DMM or

oscilliscope method is useful for measuring Ω, V, Amps for both AC and DC ciruits, but from some research it seems DVM method is very useful, and can get very high precisions.
From what I have read, DVM is very useful for measuring resistance, voltage and current for both AC and DC circuits as it can provide very high precision and accuracy for the outcome results. And oscilliscope is useful in determing wave shape and measuring the peak-to-peak voltage for an AC signal, but not useful in measuring resistance or current. Though scope can also get accurate results like the DVM, it's still not as precise as the DVM, since there prescribed usages are different. DVM can be used to measure DC Voltage, resistance, and current while scope should be used to determine a waves characteristics, like the wave-shape.
Our group was only able to use an online simulation group to complete the experiment, where we were able to sort of perform the DVM part of the experiment, but for the scope portion we had to ignore it since the simulation could not provide it for us. And so each time we performed the simulation, it came out to exact percise measurement's since the machine was a computer and could not make major mistakes. In the end, we got zero % error for each part and assumed our measurements to be correct and very accurate.