Experiment 3
Introduction to Voltage, Current, and Resistance Measurements

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1 Introduction

In this experiment, as students, we are expected to experiment with how to use measure voltage, current and resistance by completing the steps described in the third experiment laboratory manual. Throughout these steps, the how to determine the resistance via reading resistor color codes and using multimeter is expected to be learnt. As students, we are expected to discriminate the analog and digital multimeters by taking into account their internal voltage sources. It is observed how to measure the AC line voltage. How to measure DC current and voltage, how the potentiometer works, the characteristics of linear and non-linear resistors ,and equivalent resistances are observed by connecting the multimeters directly to each other and the circuit. The results of the steps were noted and plotted for further comments.

2 Experimental Results

In this section, the results of Experiment 3 are discussed.

2.1 Step 1

In this step the resistances of the three resistors are read and measured.

2.1.1 a

The resistances of the resistors are noted after reading them using the color code convention. In Table 1 the values are given.

Color Order	Value	Tolerance
Brown / Black / Red / Gold	1KΩ	% 5
Yellow / Violet / Red / Gold	4.7KΩ	% 5
Brown / Grey / Orange / Gold	18KΩ	% 5

Table 1: Resistance reading by color code convention.

2.1.2 b

The resistances of the resistors are measured using digital multimeter. The measurements are given in the Table 2.

Resistor	Measured Value
1KΩ	0.987KΩ
4.7KΩ	4.865KΩ
18KΩ	17.851KΩ

Table 2: Resistance reading by color code convention.

It is observed that the actual value of the resistances can be different than their expected value. This difference could be stemmed from environmental factors as well as probing. Although there are a precision factor the tolerance values are verified.

2.2 Step 2

In Step 2, the digital multimeter instrument is used only. Using resistance measurement feature of the multimeter, the resistance value of the opposings ends of the 1K and 10K potentiometers are measured. Then The maximum and minimum resistance values between their middle terminals and another terminals are recorded. The recorded resistance values are provided in the Table 3.

Potentiometer	Resistance Between Opposing Ends	Maximum Resistance	Minimum Resistance
1KΩ	0.983KΩ	0.981KΩ	0.001Ω
10KΩ	8.695KΩ	8.690KΩ	0.004Ω

Table 3: Resistance measurements of the potentiometer

It can be inferred that the resistance does not change when we connect the measurement probes to the opposing ends because there is a static resistance between those terminals which approximately corresponds the maximum value of the dynamic terminal.

2.3 Step 3

In this step the internal battery voltages of the analog and digital multimeters are measured and compared.

2.3.1 a

Analog multimeter is set for resistance measurement. Then the digital multimeter is set to voltage measurement and its probes are connected to the probes of the analog multimeter. As a result even though the ohmmeter scale is different the measured voltage is observed constant. The measurements are given in the Table 4

Scale	Voltage Value
x1Ω	-1.5924 V
x10Ω	-1.5924 V
x100 Ω	-1.5921 V
x1KΩ	-1.5890 V

Table 4: Internal battery measurements of the analog multimeter.

2.3.2 b

Digital multimeter is set for resistance measurement. Then the analog multimeter is set to voltage measurement and its probes are connected to the probes of the digital multimeter. So, the internal battery voltage differs when the digital multimeter set to different ohmmeter scales. The measurements are given in the Table 5.

Scale	Voltage Value
x100 Ω	6V
x1 kΩ	6V
x10 kΩ	6.25 V
x100 kΩ	3V
x1 MΩ	1.5V
x10 MΩ	∼0.1 V (or zero)
x100 MΩ	∼0.1 V (or zero)

Table 5: Internal battery measurements of the digital multimeter.

This results shows us the digital multimeters are able to adjust its internal voltage when they are measuring resistances in different scales. It can be concluded that digital multimeters have higher precision in measurement.

2.4 Step 4

In this step, the line voltage is measured using analog multimeter. Multimeters range is set "500V AC". The measurement is stated in Table 6.
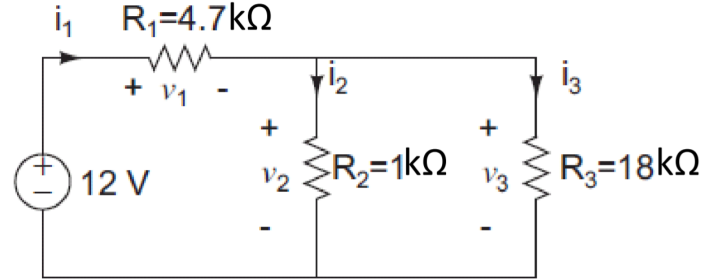
Line Voltage	Approximately $220V_{ac}$

Table 6: Line voltage measurement

2.5 Step 5

In Step 5, power supply and digital multimeter instruments are used. The circuit in the Figure 1 is constructed on the breadboard.

Figure 1: Circuit schematic for the step 5

Then the required voltage and current measurements are made. The measurements are given in the Table 7.
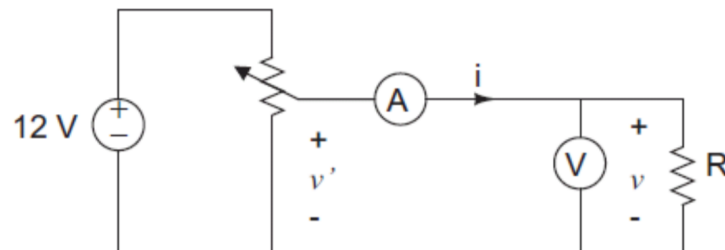
V_1	V_2	V_3
10.041V	1.948V	1.948

i_1	i_2	i_3
2.064mA	1.957mA	0.109mA

Table 7: Voltage and current measurements for the step 5

2.6 Step 6

In this step, power supply , analog multimeter ,and digital multimeter instruments are used. The circuit illustrated in Figure 2 is set.

Figure 2: Circuit schematic for the step 6

The resistor with resistance "R" is selected as "4.7KΩ". The potentiometer is adjusted so that the voltage value becomes 9, 7, 5, 0 volts. For all cases the current i is measured and recorded.

2.6.1   a

The current and voltage measurements are made and plotted in MATLAB. The Figure 3 shows i versus v. The resistor with resistance "R" is measured as approximately "4.602kΩ" using the equation " R = $\frac{V}{I}$ ".

Figure 3: Plot of i versus v
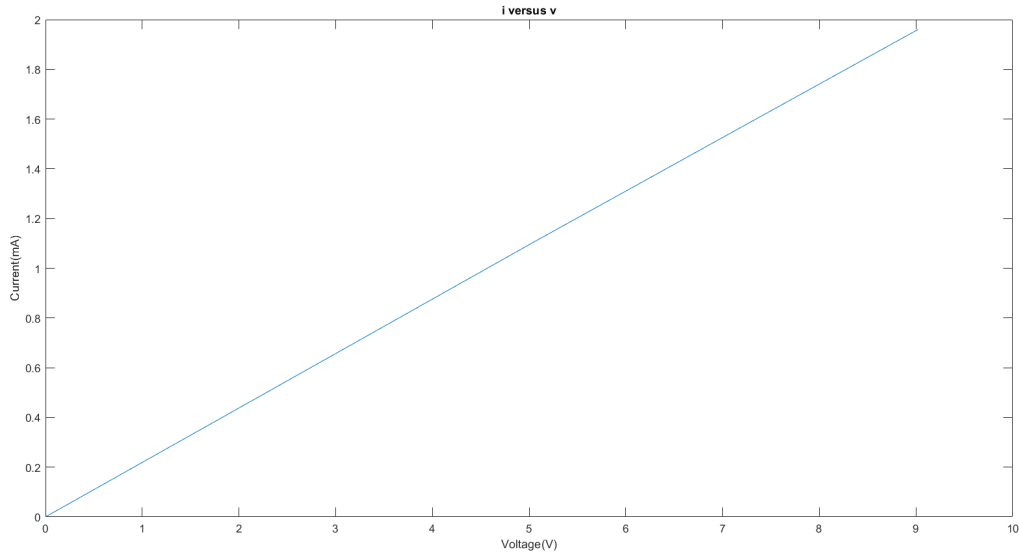
2.6.2   b

The resistor with resistance "R" is measured as approximately "4kΩ" using analog multimeter.

2.6.3   c

The resistor with resistance "R" is measured as "4.60kΩ" using digital multimeter.

2.6.4   d

It can be seen from the Figure 3 that the plot is approximately linear. This is because the equation of R *(constant)* = $\frac{V}{I}$. Also the measurements from the analog and digital multimeters practically shows that the digital multimeters have higher resolution ,whose measurement is approximately same with the experimental and given resistance data.

2.7 Step 7

3 Conclusion

In conclusion, in experiment 2, "Signal Generators and Oscilloscopes," as students, we have learned how to use the signal generator and oscilloscopes instruments' behavior under nine steps. The scaling and movement properties of the oscilloscope channels are explored on a square waveform then the difference between "AC" and "DC" coupling methods are observed and explained. Also, inversion of the signal is observed then interpreted. The experiment repeated for the second channel, and the results are verified. Using cursor functions of the DSO, various measurements are made. The measurement features of the oscilloscope instrument are experienced. Different circuits are set and supplied by the signal generator, and the outputs are observed and plotted using DSO. The outputs of the function waveform generator and the prob comparison port of the oscilloscope are compared, and the trigger signal effect of the DSO is observed so that both signals are fit to the same time frame steady. Lastly, the mathematical operation ability is used to add and subtract the signals, then the results are observed. In this experiment, as students, we have experimented with how to use signal generators and oscilloscopes.

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Appendix I

Total time spent on/during:

- Pre-lab preparation: 1 hours (including the preliminary work and simulations)

- Experimental work: 2 hours (hours spent in lab)

- Report writing: 8 hours