重庆大学-辛辛那提大学联合学院

学生实验报告

CQU-UC Joint Co-op Institute (JCI)

Student Experiment Report

实验课程名称 Experiment Course Name Circuit and Sensor Experiment

开课实验室（学院）Laboratory (School) College of Mechanical Engineering

学院 School Joint Co-op Institut 年级 2018 专业 ME01 班 Student Group 02

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学年 Academic Year 2021 学期 Semester Summer

成绩 Grade		
教师签名 Signature of Instructor		

批改说明 Marking instructions:

指导老师请用红色水笔批改，在扣分处标明所扣分数并给出相应理由，在封面的平时成绩处注明成绩。

Supervisors should mark the report with a **red ink pen**. Please write down **the points deducted** for each section when errors arise and specify the corresponding reasons. Please write down **the total grade** in the table on the cover page.

University of Cincinnati
College of Engineering and Applied Science
School of Dynamic Systems

Course Code : **20-MECH-3070C**
Course Title : **Circuits & Sensing Lab**

Experiment Number : **0**
Experiment Title : **Lab Familiarization**

Date(s) Performed : **May 06, 2021**
Date Submitted : **May 24, 2021**

Group Code : **02**
Group Members : **Yi, Hongrui**
: **Zhuang, Yan**

Instructor : **Hu, Xiaoping**

Experiment Results/Lab Notes	=	______/40
Analysis/Discussion	=	______/30
Answers to Questions	=	______/20
Writing	=	______/10
TOTAL SCORE	**=**	**______/100**

ABSTRACT

This experiment is divided into three parts, UNI-T familiarization, Fluke DMM familiarization and mystery resistor respectively.

In the first part, the method of measuring unknown resistance and voltage is needed. The actual values of two battery voltages and five resistors are measured by UNI-T digital multimeter. The rated resistance of each battery was calculated by recording the rated voltage of each battery and using the resistance ribbon diagram. Then the actual values of voltage and resistance are measured by UNI-T digital multimeter. Finally, the nominal value is compared with the actual value, and the possible error factors are analyzed and discussed.

In the second part, the actual voltage and resistance of the battery are measured by using Fluke digital multimeter. The basic operation method is the same as in the second part. Then, the measured results are compared with results of UNI-T.

In the third part, UNI-T and Fluke digital multimeter are used to measure mysterious resistance and multimeter resistance. We use a multimeter to measure the voltage assigned to the mysterious resistance and the current through the mysterious resistance, and then use Ohm's law to calculate the resistance of the mysterious resistance. Finally, after analysis the data get from the experiments, find the reason and connect our results with theoretical knowledge.

In our results, the experiment shows that the Fluke DMM is more convenient and precision than UNI-T DMM, the internal resistance of battery, wire and digital multimeters sometimes cannot be ignored if we want to get an accurate value. Therefore, we can only reduce the interference of internal resistance as much as possible by scientific methods, but cannot completely eliminate this influence.

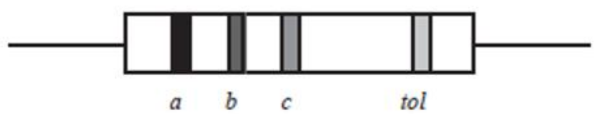
Table of Contents

1. Objectives

At the end of this experiment, the students are expected to:

- Become familiar with the basic electrical elements.
- Be familiar with ELVIS and Fluke DMM and know the differences between them.
- Learn how to calculate the resistor by the color bands on the resistor.
- Learn to use Ohm's law basically.

2. Theoretical Background



a, b, and *c* Bands		*tol* Band	
Color	Value	Color	Value
Black	0	Gold	±5%
Brown	1	Silver	±10%
Red	2	Nothing	±20%
Orange	3		
Yellow	4		
Green	5		
Blue	6		
Violet	7		
Gray	8		
White	9		

Figure 1. Resistor color band codes

The resistance should be expressed as

R = ab $\times 10c \pm tolerance$ (%) or R = abc $\times 10d \pm tolerance$ (%)

Ohm’s law：

U=IR

3. Experimentation

3.1 ELVIS Familiarization

3.1.1 Summary of Procedure

In this part, the equipment used is a AA battery, a 6F22 battery, 5 resistors with different color bands and a UNI-T DMM. The purpose of this part is to recognize the nominal value of each equipment and compare them with the values measured by the UNI-T digital multimeter.

Figure 2 UNI-T DMM

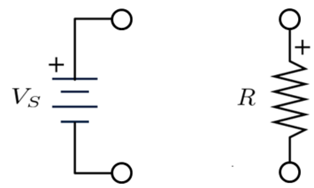


Figure 3 Circuit Element

3.1.2 Results

Table 1. Battery Voltage

PARAMETER	NOMINAL (V)	MEASURED (V)
V_S (AA)	1.5	1.5404
V_S (6F22)	9	9.810

Table 2. Color Bands

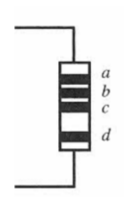
PARAMETER	a	b	c	D	Tol	NOMINAL (Ω)
R_1	Red	Red	Black	Brown	Brown	$220 \times 10 \pm 1\%$
R_2	Blue	Gray	Black	Red	Brown	$680 \times 10^2 \pm 1\%$
R_3	Yellow	Violet	Black	Black	Brown	$470 \times 10^0 \pm 1\%$
R_4	Orange	Black	Red	-	Gold	$30 \times 10^2 \pm 5\%$
R_5	Green	Brown	Black	Silver	Brown	$510 \times 10^{-2} \pm 1\%$

Table 3. Resistance Values

PARAMETER	NOMINAL (Ω)	MEASURED (Ω)
R_1	2178~2222	2187
R_2	67320~68680	67400
R_3	463.5~474.7	467
R_4	2850~3150	2985
R_5	5.049~5.151	5.22

Resistor Color Band Codes Table for 5 Bands					
Color	First band	Second band	Third band	Forth band	Fifth band(±%)
Brown	1	1	1	10^1	1
Red	2	2	2	10^2	2
Orange	3	3	3	10^3	
Yellow	4	4	4	10^4	
Green	5	5	5	10^5	0.5
Blue	6	6	6	10^6	
Violet	7	7	7	10^7	
Grey	8	8	8	10^8	
White	9	9	9	10^9	
Black	0	0	0	10^0	
Gold	-	-	-	10^{-1}	5
Silver	-	-	-	10^{-2}	10

Figure 4. resistor color band codes table for 5 bands



$R = a\,b \times 10^c \pm tol\,\%$

a, b, and c Bands		*d Band (tol)*	
Color	Value	Color	Value
Black	0	Gold	±5%
Brown	1	Silver	±10%
Red	2	Nothing	±20%
Orange	3		
Yellow	4		
Green	5		
Blue	6		
Violet	7		
Gray	8		
White	9		

Figure 5. resistor color band codes table for 4 bands

To acquire the nominal value for resistors owning different numbers of bands, two separated tables are referred.

For resistors with 5 bands, values are referred from figure 4 and the calculation equation is below:

$$R = abc \times 10^d \pm tol\%$$

Take R_1 as an example, a = 2, b=2, c=0, d=1, tolerance=1%. $R_{1\,=}$ $220 \times 10 \pm 1\%$ because band a is red, band b is red, band c is black and band d is brown, and the band for tolerance is brown.

For resistors with 4 bands, values are referred from figure 5 and the calculation equation is below:

$$R = ab \times 10^c \pm tol\%$$

Take R_4 as an example, a=3, b=0, c=2, tolerance=5%, $R_4 = 30 \times 10^2 \pm 5\%$ because band a is orange, band b is black, band c is red and the band for tolerance is gold.

3.1.3 Analysis & Discussion

The aim of the first part is to use UNI-T DMM to measure the battery voltage and the resistor respectively.

Both voltages measured by this multimeter are slightly larger than the nominal value. The reason behind it is that the nominal voltage of a battery refers to the value measured in a circuit with loads rather than the value measured directly. Moreover, there's chemistry energy in battery which also increases the voltages.

In measuring resistors' part, only one resistor's value is out of the nominal range. It is because the color band on resistor is difficult to recognize under the condition that light in lab is not strong enough. Color black, brown and violet are too similar to distinguish. Additionally, the internal resistance of DMM will also influence the measurement. When measuring the large resistance, such small resistance within DMM can be negligible. The only resistor measured out of nominal range is one with the smallest resistance, which means the internal resistance does affect the process of measuring.

3.2 Fluke DMM Familiarization

3.2.1 Summary of Procedure

In this part, the equipment used is a AA battery, a 6F22 battery, 5 resistors with different color bands and a Fluke DMM. This part has two purposes. The first one is to recognize the nominal value of each equipment and compare them with the values measured by the Fluke digital multimeter. The second one is to compare the results with those measured by UNI-T DMM.

Figure 6. Fluke DMM

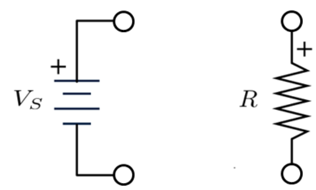


Figure 7. Circuit Element

3.2.2 Results

Table 4. Battery Voltage

PARAMETER	NOMINAL (v)	MEASURED (V) UNI-T DMM	MEASURED (V) Fluke DMM
V_S (AA)	1.5	1.5404	1.535
V_S (AAA)	9	9.810	9.79

Table 5. Color Bands

PARAMETER	a	b	c	d	tol	NOMINAL (Ω)
R_1	Red	Red	Black	Brown	Brown	$220 \times 10 \pm 1\%$
R_2	Blue	Gray	Black	Red	Brown	$680 \times 10^2 \pm 1\%$
R_3	Yellow	Violet	Black	Black	Brown	$470 \times 10^0 \pm 1\%$
R_4	Orange	Black	Red	-	Gold	$30 \times 10^2 \pm 5\%$
R_5	Green	Brown	Black	Silver	Brown	$510 \times 10^{-2} \pm 1\%$

Table 6. Resistance Values

PARAMETER	NOMINAL (Ω)	MEASURED (Ω) UNI-T DMM	MEASURED (Ω) Fluke DMM
R_1	2178~2222	2187	2181
R_2	67320~68680	67400	67430
R_3	463.5~474.7	467	466
R_4	2850~3150	2985	2977
R_5	5.049~5.151	5.22	5.2

3.2.3 Analysis & Discussion

Table 7. Error Analysis

PARAMETER	NOMINAL (Ω)	MEASURED (Ω) UNI-T DMM	MEASURED (Ω) Fluke DMM	Error (%) of UNI-T	Error (%) of Fluke
R_1	$220 \times 10 \pm 1\%$	2187	2181	0.59%	0.86%
R_2	$680 \times 10^2 \pm 1\%$	67400	67430	0.88%	0.83%
R_3	$470 \times 10^0 \pm 1\%$	467	466	0.638%	0.85%
R_4	$30 \times 10^2 \pm 5\%$	2985	2977	0.5%	0.76%
R_5	$510 \times 10^{-2} \pm 1\%$	5.22	5.2	2.35%	1.96%
V_1	1.5	1.5404	1.535	2.69%	2.33%
V2	9	9.810	9.79	9%	8.77%

$$\text{Error (\%)of UNI}-\text{T} = \frac{\left|R_{nominal} - R_{measured\ by\ UNI-T}\right|}{R_{nominal}}$$

$$\text{Error (\%)of UNI}-\text{T} = \frac{\left|R_{nominal} - R_{measured\ by\ Fluke}\right|}{R_{nominal}}$$

For example, for R1:

$$\text{Error (\%)of UNI}-\text{T} = \frac{\left|R_{nominal} - R_{measured\ by\ UNI-T}\right|}{R_{nominal}} = \frac{|220 \times 10 - 2187|}{220 \times 10} = 0.59\%$$

$$\text{Error (\%)of UNI}-\text{T} = \frac{\left|R_{nominal} - R_{measured\ by\ Fluke}\right|}{R_{nominal}} = \frac{|220 \times 10 - 2181|}{220 \times 10} = 0.86\%$$

Although the resistors and battery used for measurement remains same, values acquired by two DMMs are different. Different structures within these two DMMs cause the difference between measuring values.

Most of the measuring values satisfy nominal values. Only when measuring the small resistance like R_5, both DMMs perform bad. This is because internal resistance will have influence on measuring small resistance while it can be ignored in measuring large resistance.

When measuring voltages, both DMMs doesn't perform well. This is because the nominal voltage of a battery refers to the value measured in a circuit with loads rather than the value measured directly. Moreover, there's chemistry energy in battery which also increases the voltages.

In theory, Fluke DMM should be more accurate than UNI-T DMM. Although the difference between this two instruments is not obvious, the result still reflect that the theory is correct.

3.3 Mystery Resistor (Measurement Challenges)

3.3.1 Summary of Procedure

In this part, the equipment used is an unknown resistor, a UNI-T DMM and a Fluke DMM. Purpose of this part is to measure the actual resistance of an unknown resistor twice, once for raw value and once for null value.

3.3.2 Results

Table 8. Mystery Resistor

PARAMETER	NOMINAL (Ω)	MEASURED (Ω) UNI-T DMM	MEASURED (Ω) Fluke DMM
R_{raw}	1	1.08	0.99
R_{null}	1	1.08	0.99

3.3.3 Analysis & Discussion

Though the difference between nominal value and measuring is small, it still has some errors. Such errors may come from the resistor itself because the resistor is scraped by teacher so that the color band on it can not be observed however, such scraping will cause the change of resistance.

4. Answers/Solutions to Questions/Problems

Answer each of questions provided at the end of the experiment procedure. If the item is a problem that needs to be solved, provide a step-by-step calculation leading to your answer.

1. What equipment is being used? (type, model, serial, etc.)

Answer: Two batteries (1.5V 9V); Five resistors; DC Power Supply HN3003D; Unit UT56 Multimeter; Fluke Multimeter 15B+; Breadboard.

2. What is the battery chemistry?

Answer: The battery chemistry is devices that convert chemical energy into electricity. The main part includes electrolyte solution and immersion solution of positive and negative two electrodes. When in use, the conductor is connected with two electrodes, i.e. a current pass through (discharges), thus obtaining electric energy.

3. What differences in readings were observed between the results from the ELVIS and the Fluke DMM?

Answer: When we use UNI-T DMM we need to choose a proper range and notice the unit and decimal point. While using Fluke DMM, we just need to choose which value we need and the unit is displayed on the screen. From the data we get, we find that data get from the UNI-T DMM is more accurate.

4. Were there any challenges making the measurements? What?

Answer: Yes. When we use our equipment to measure the resistance of resistors, we find that it's hard to make our equipment contact with the resistor stably because the two ends of the resistor are thin and smooth.

5. Conclusions

Having performed the experiment, and after a thorough analysis of the data, the following points are therefore concluded:

- In the ELVIS Familiarization part, first we use the multimeter to measure the voltage of two batteries and find that the actual values of the batteries are bigger than its nominal value, and then we measured the resistance of resistors and know that part of measured values are not in the range of tolerance.
- In the Fluke DMM Familiarization part, we also use the Fluke digital multimeter to measure the value of batteries and resistors, and we find similar result with the ELVIS multimeter, but from comparison we find that the ELVIS seems to be more accurate.
- In Mystery Resistor Measurement experiment, we use both multimeters to take measurement of an unknown resistor, the internal resistance of battery influences the

results and the internal resistance of Fluke DMM is smaller than UNI-T DMM. Using DMM to measure resistance is a more efficient way than using Ohm's Law.

APPENDICES

A – EQUIPMENT LIST

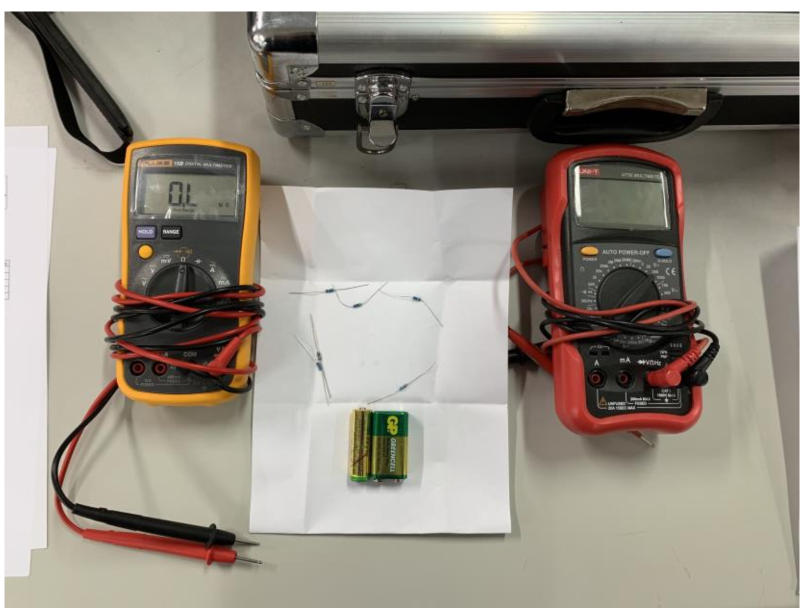
Table 9. Equipment List

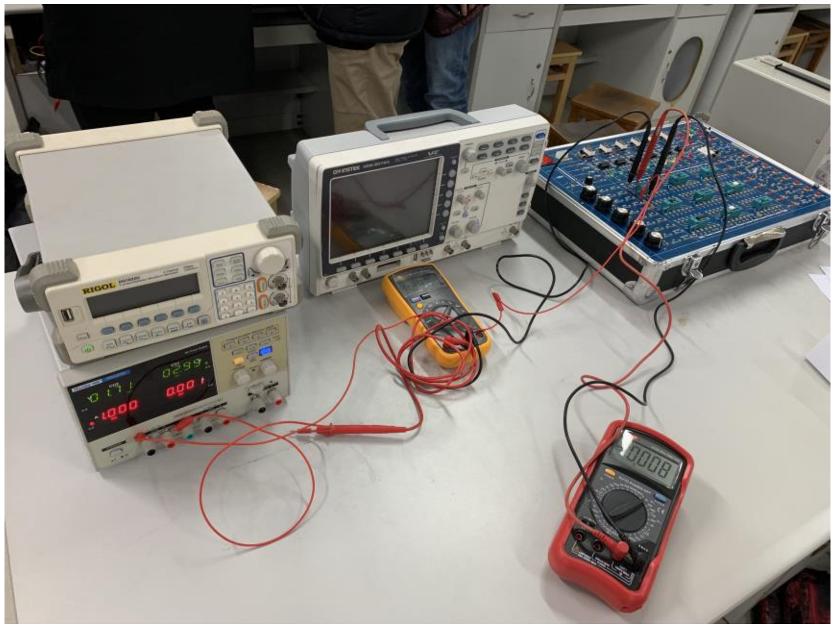
Equipment Description	Model Number
Fluke Multimeter	15B
UNI-T	UT-56
RIGOL	DG1022U

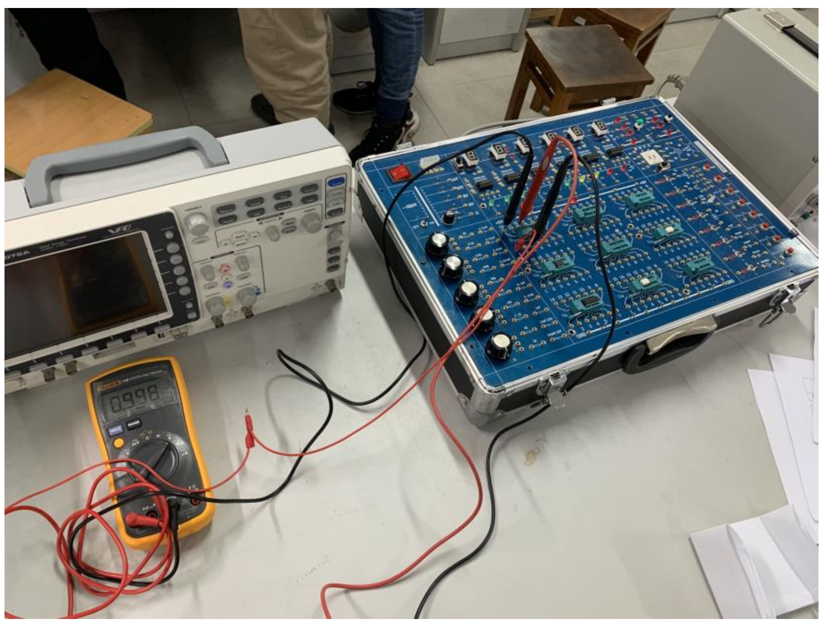
UNI-T DMM

Fluke DMM

Pictures of the experiment equipment:




RIGOL



B – Lab Notes

Group Number	2
Expt. Number	0

Names	Yi, Hongrui Zhuang, Yan
Expt. Title	**Lab Familiarization**

Date	2021/5/6

Part 1: UNI-T Familiarization

Table 1. Battery Voltage

PARAMETER	NOMINAL (V)	MEASURED (V)
V_S (AA)	1.5	1.5404
V_S (6F22)	9.0	9.810

Table 2. Color Bands

PARAMETER	a	b	c	d	Tol	NOMINAL (Ω)
R_1	Red	Red	Black	Brown	Brown	220 x 10 ±1%
R_2	Blue	Gray	Black	Red	Brown	680 x 10^2 ±1%
R_3	Yellow	Violet	Black	Black	Brown	470 x 10^1 ±1%
R_4	Orange	Black	Red	–	Gold	30 x 10^2 ±5%
R_5	Green	Brown	Black	Silver	Brown	510 x 10^{-2} ±1%

Table 3. Resistance Values

PARAMETER	NOMINAL (Ω)	MEASURED (Ω)
R_1	2178 ~ 2222	2187
R_2	67320 ~ 74800	68680
R_3	4653 ~ 4747	467
R_4	2850 ~ 3150	2985
R_5	5.049 ~ 5.151	5.22

Group Number	2	Names	Yi, Hongrui Zhuang, Yan	Date	2021/5/6
Expt. Number	0	Expt. Title	**Lab Familiarization**		

Part 2: Fluke DMM Familiarization

Table 4. Battery Voltage

PARAMETER	NOMINAL (v)	MEASURED (V) ELVIS	MEASURED (V) Fluke DMM
V_S (AA)	1.5	1.5404	1.535
V_S (6F22)	9.0	9.81	9.78

Table 5. Color Bands

PARAMETER	a	b	c	d	Tol	NOMINAL (Ω)
R_1	Red	Red	Black	Brown	Brown	$220\times10 \pm1\%$
R_2	Blue	Gray	Black	Red	Brown	$680\times10^2\pm1\%$
R_3	Yellow	Violet	Black	Black	Brown	$470\times10^0\pm1\%$
R_4	Orange	Black	Red	–	Gold	$30\times10^2\pm5\%$
R_5	Green	Brown	Black	Silver	Brown	$510\times10^{-2}\pm1\%$

Table 6. Resistance Values

PARAMETER	NOMINAL (Ω)	MEASURED (Ω) ELVIS	MEASURED (Ω) Fluke DMM
R_1	2178 ~ 2222	2187	2181
R_2	67320 ~ 74800	6740	67430
R_3	4653 ~ 4747	0.467	466
R_4	2850 ~ 3150	2985	2977
R_5	5.049 ~ 5.151	5.22	5.2

Group Number	2	Names	Yi, Hongrui Zhuang, Yan	Date	2021/5/6
Expt. Number	0	Expt. Title	**Lab Familiarization**		

Part 3: Mystery Resistor (Measurement Challenges)

Table 7. Mystery Resistor

PARAMETER	NOMINAL (Ω)	MEASURED (Ω) UNI-T	MEASURED (Ω) Fluke DMM
$R_{?\text{-raw}}$	1	1.08	0.99
$R_{?\text{-null}}$	1	1.08	0.99