UM–SJTU Joint Institute

Intro to circuits
(VE215)

Laboratory Report

Lab 1
DC Lab

Name: Toshino Kyouko ID: 7143709328
Date: 21 October 2015

1 Introduction

1.1 Objectives

The objective of this experiment is to learn how to use UT60A multimeter for measurements of voltage, current, and resistance, learn to build circuits on a solderless prototype board, verify the basic circuit laws KCL, KVL, and Ohms laws from measurements of currents and voltages, measure the current-voltage characteristics of a 50Ω resistor, and build an LED circuit on a protoboard and learn about non-ohmic circuit components, which do not obey Ohms law.

1.2 Apparatus & Theoretical Background

A multimeter is able to work as a voltmeter to measure voltages, as an ammeter to measure currents, or as an ohmmeter to measure resistances. Every multimeter has two terminals for the two cables that ensure electrical connections to the two nodes. The black cable should be connected to ground, the ground port is labeled COM on the multimeter. The red cable should be connected to HzVΩ port for voltage or resistance measurements, 10A MAX port for current measurements, or μAmA port for small current measurements. The multimeter is presented in Figure 1.

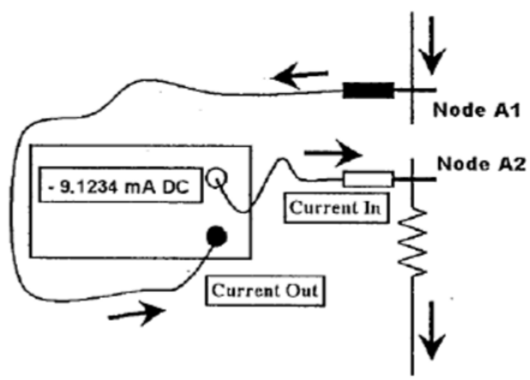
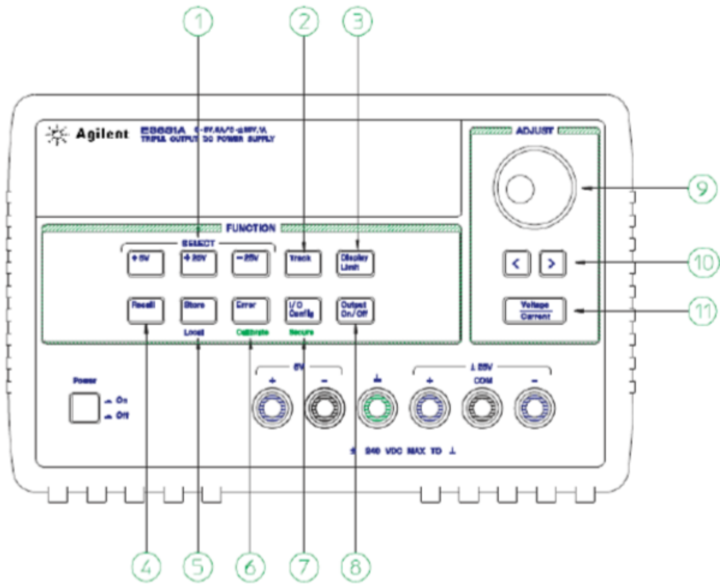


Figure 1: The multimeter.

In this lab, we used Agilent E3631A DC Power Supply (Figure 2) as our DC source.To set up the power supply for constant voltage (CV) operation, we did as follows.

1. Connected a load to the desired output terminals with power-off. .
2. Pressed to turn on the power supply. The power supply went into the power-on / reset state; all outputs were disabled (the OFF annunciator turned on); the display was selected for the +6V supply (the +6V annunciator turned on); and the knob was selected for voltage control.
3. Adjusted the knob for the desired output voltage. Set the knob for voltage control. The second digit of the voltmeter was then blinking. We adjusted the knob to the desired output voltage.



1 Meter and adjust selection keys
2 Tracking enable/disable key
3 Display limit key
4 Recall operating state key
5 Store operating state/Local key
6 Error/Calibrate key
7 I/O Configuration / Secure key
8 Output On/Off key
9 Control knob
10 Resolution selection keys
11 Voltage/current adjust selection key

Figure 2: Agilent E3631A DC Power Supply.

In this lab, we connected resistors, LEDs and other components to each other on a circuit board. Circuits boards are also called protoboards, because they are used for prototyping the circuits. A prototyping board used in the lab consists of several plastic blocks. These plastic blocks are mounted on a metal plate along with terminal (blind) posts. Each plastic block has many holes, into which we insert wires, plug in resistors, op amps, and other circuit components. Inside the plastic block, themetal clips snugly hold our wires, resistors, etc., and ensure electric connections between circuit components.

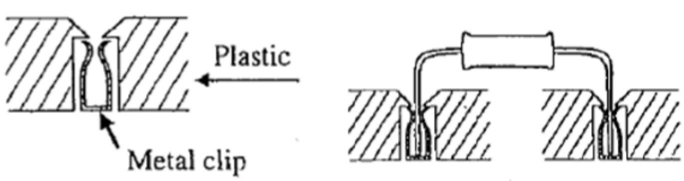


Figure 3: The metal clips.

These metal clips (Figure 3) hidden under the plastic create nodes on the protoboard, to which we connected our circuit components.

Connections under the plastic are different for the wide and narrow blocks, as is shown in Figure 4. Straight lines on the diagram below show the metal clips that connect holes under the plastic.

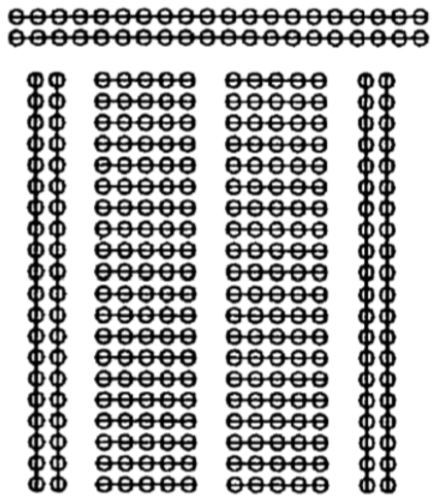


Figure 4: Connections under the plastic.

In the lab, we also used semiconductor diodes, which is presented in Figure 5.

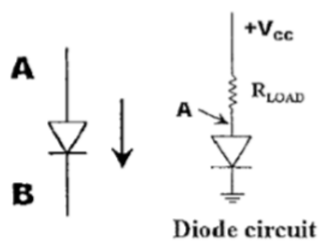


Figure 5: The semiconductor diodes.

The simplest semiconductor device is a diode. Its circuit symbol looks like an arrow because the diode allows the current flow only in the direction of that arrow. If $V_A > V_B$ (which is called direct bias) the conductor will conduct. If $V_A < V_B$ (which is called reverse bias) the conductor will not conduct. Thus a diode is not an Ohmic resistor.

Moreover, even under direct bias the resistance of a diode does not remain constant. At small values of the voltage difference $V_A - V_B$ the current through the diode is very small, because its resistance is large. The diodes resistance abruptly changes as soon as the direct bias voltage across the diode reaches the threshold value, which is called the turn-on voltage and equals about 0.5 to 0.7V for many diodes. Above this voltage the current through the diode rapidly increases and becomes practically independent of the voltage. The diode resistance becomes so small that in real circuits the diodes have to be protected from high currents that may damage them. A load resistor

(50Ω in this lab) connected in series with the diode ensures the simplest protection. Light-emitting diodes emit light (visible or infrared) when the direct current becomes large enough. The LED, which we used in this lab, has the turn-on voltage of about 1.6V.

2 Measurements

2.1 Voltage, Current & Resistance Measurement

1. Use the multimeter to measure the resistance R1 labeled 100Ω directly and record the result.
2. Connect the resistance R1 = 100Ω with the power supply and set the voltage 3V.
3. Use the multimeter to measure the Voltage (m) across the resistor.
4. Use the multimeter to measure the Current (m) through the resistor.

The obtained data is presented in Table 1.

2.2 Voltage Division & Current Division

1. Before measurement, measure the actual resistances of the two resistors you are using in this section.
2. Connect the R1 = 100Ω and R2 = 50Ω in series and in parallel, respectively.
3. Use the multimeter to measure the voltage across the R1, R2 and the power supply.
4. Use the multimeter to measure the current through R1, R2 and the power supply.

The obtained data is presented in Table 2.

2.3 Ohm's Law

1. Measure the resistance of R = 50Ω and record the result.
2. Connect the R with the power supply.
3. Set the voltage outputs and record the corresponding currents.
4. Sketch the voltage-current characteristic curve of the resistor.

The obtained data is presented in Table 3.

2.4 Non-ohmic LED

1. Connect the resistor R = 50Ω and the LED in series with the power supply.
2. Change the voltage output and record the corresponding current.

The obtained data is presented in Table 4.

3 Results & Discussion

3.1 Voltage, Current & Resistance Measurement

Resistance [Ω]	98.2		
Voltage(m)[V]	2.992	Voltage(s)[V]	3.000
Current(m)[A]	0.029	Current(s)[A]	0.030

Table 1. Measurement of voltage, current, and resistance.

The resistance, voltage and current was measured in the procedure described in section **??** and based on the results presented in Table 1, we can calculate the relative error of resistance measurement:

$$u_R = \frac{100 - 98.2}{100} = 1.8\%$$

3.2 Voltage Division & Current Division

Resistance R1[Ω]	98.2	Resistance R2[Ω]		50.5
	Voltage Division		Current Division	
	Current [A]	Voltage [V]	Current [A]	Voltage [V]
Total	0.019	2.993	0.085	2.990
R1	0.019	1.975	0.030	2.990
R2	0.019	1.019	0.058	2.990

Table 2. Voltage division and current division.

The resistance, voltage and current was measured in the procedure described in section **??** and based on the results presented in Table 2, we can see that our results match the KCL and KVL theorem.

3.3 Ohm's Law

Resistance [Ω]	50.4
Voltage [V]	Current [A]
0.5	0.010
1.0	0.020
1.5	0.030
2.0	0.040
3.0	0.060
4.0	0.080
5.0	0.101

Table 3. Ohm's law

The voltage and corresponding current was measured in the procedure described in section **??** and based on the results presented in Table 3, we can use Origin to fit the data, which is shown in Figure 6.

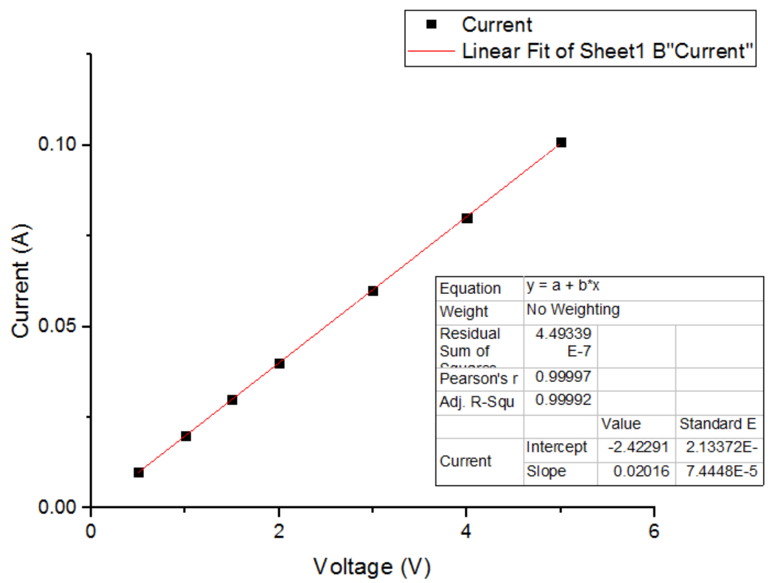


Figure 6: The voltage-current characteristic curve .

From the figure, we can see that the Adj.R-Square is 0.99992, which is close to 1. Thus this resistor obeys the Ohm's law.

3.4 Non-ohmic LED

Total Voltage [V]	Semiconductor Voltage [V]	Current [A]
0.5	0.500	0.000
1.5	1.500	0.000
2.0	1.849	0.003
2.5	2.097	0.008
3.0	2.244	0.015
3.5	2.341	0.023
4.0	2.438	0.031
4.5	2.534	0.039
5.0	2.631	0.047

Table4. Semiconductor diodes

The voltage and corresponding current was measured in the procedure described in section **??** and based on the results presented in Table 4, we can use Origin to sketch the characteristic curve, which is shown in Figure 7.

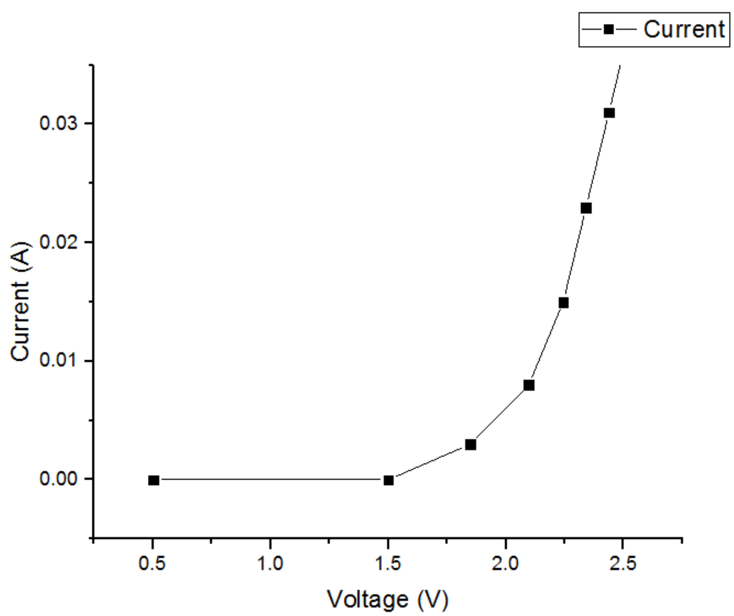


Figure 7: The voltage-current characteristic curve for LED.

We can see that the graph is quite in accordance with the expectation of the theorectical model, and the trun-on voltage is about 1.6V as expected in the last part of the section 1.2.

4 Conclusions

In the experiment, we successfully measured the resistances, verified the KCL and KVL theorem, verified the Ohm's law by drawing a fitting curve, and sketched a voltage-current characteristic curve for LED. The data we got all have the acceptable uncertainty for verifying, and all the graphs are quite in accordance with the expectation of the theorectical model. Therefore, generally speaking, this experiment is quite successful.

The fundamental source of inaccuracy is the fact that we can only use our hands to connected the nodes of the multimeter to the circuit that we want measure, due to some partial disabilities of our protoboard. We originally planned to use the screws on the protoboard for connection, but then we were told that they were broken.

The other factors that have been neglected in the model include the resistance of the wires and the connections, which is a small effect that can usually be safely neglected.

From the experiment, we learned how to use UT60A multimeter for measurements of voltage, current, and resistance, how to use the Agilent E3631A DC Power Supply and how to build circuits on a solderless prototype board. And we think the precision of the measurements can be further increased by using better protoboards.

Data Sheet