

Sirindhorn International Institute of Technology

Thammasat University at Rangsit

School of Information, Computer and Communication Technology

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| COURSE | : ECS 204 Basic Electrical Engineering Lab |
| INSTRUCTOR | : Asst. Prof. Dr. Prapun Suksompong (prapun@siit.tu.ac.th) |
| WEB SITE | : http://www2.siiit.tu.ac.th/prapun/ecs204/ |
| EXPERIMENT | : 00 Introduction |

I. OBJECTIVES

1. To introduce the course ECS 204 Basic Electrical Engineering Lab.
2. To gain some understanding of basic equipment and components in the laboratory, and to be able to use them correctly in the experiments throughout the course.

II. BASIC INFORMATION

“Basic Electrical Engineering Lab” is a service course for students with majors outside electronics and communication engineering. The course gives laboratory practices and experimental studies on topics mainly covered in ECS 216 Circuit Analysis, or ECS 203 Basic Electrical Engineering. Topics include basic circuit theory, dc and ac measurements, RLC circuits, nonlinear components, and operational amplifiers.

There are many equipment and components used in the Basic Electrical Engineering Lab. Some of the important ones are described below.

II.1 DC Power Supply

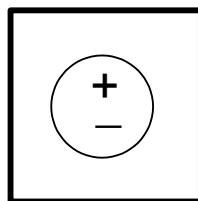


Figure 1: Symbol of a DC power Supply

A DC power supply is used to supply dc voltage to circuits. A symbol and an example of the dc power supply are shown in Figure 1 and Figure 2, respectively.

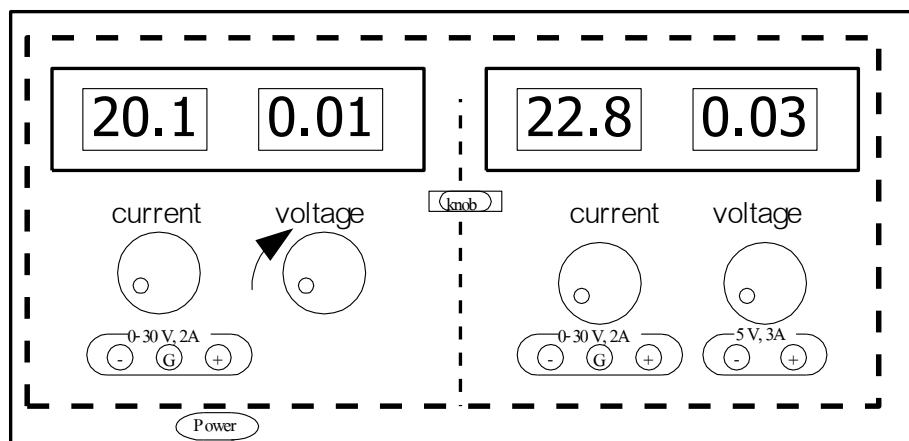


Figure 2: The panel¹ of a dc power supply.

Basic steps of operation of a DC power supply may be summarized as follows:

1. Turn on the power button.
2. Connect power cables to the + and – position of channel A or B (where a **red wire is to +**, and a **black wire is to –**).
3. Adjust the voltage at the voltage knob until the display shows the value that is needed. Since there may be error in the voltage value, a voltmeter² should be used to measure the output voltage for higher precision.
4. Connect the power cables to your circuit.

Note: **Be careful that the power wires + and – do not touch each other.** Otherwise, the circuit will be short, spark, and that can severely damage the equipment and the circuit. Occasionally, you may have them connected in an indirect way; you will see the **red light** on the power supply. If this happens, turn the power supply off immediately and fix your circuit before you turn the power supply on again. The red light should be off if you connect the circuit correctly.

¹ The power supply you see in the lab may have different panel but it should be similar to the one you see here.

² or a DMM set to measure DC voltage

Caution: **Do not adjust the “current limit” knob** on the power supply. Only make sure that the mark on the knob is located near the white mark³.

II.2 Digital Multi-Meter (DMM)

A multi-meter is used to measure not only the **voltage across an element** in the circuit, but also the **current passing through an element**. Voltage can be measured by connecting a multi-meter **in parallel** with the element. On the other hand, current can be measured by connecting a multi-meter **in series** with the element. **Multi-meter can be damaged by wrong measurement connection**, e.g., when the user wants to measure a current but he/she connects the multi-meter in parallel with the element.

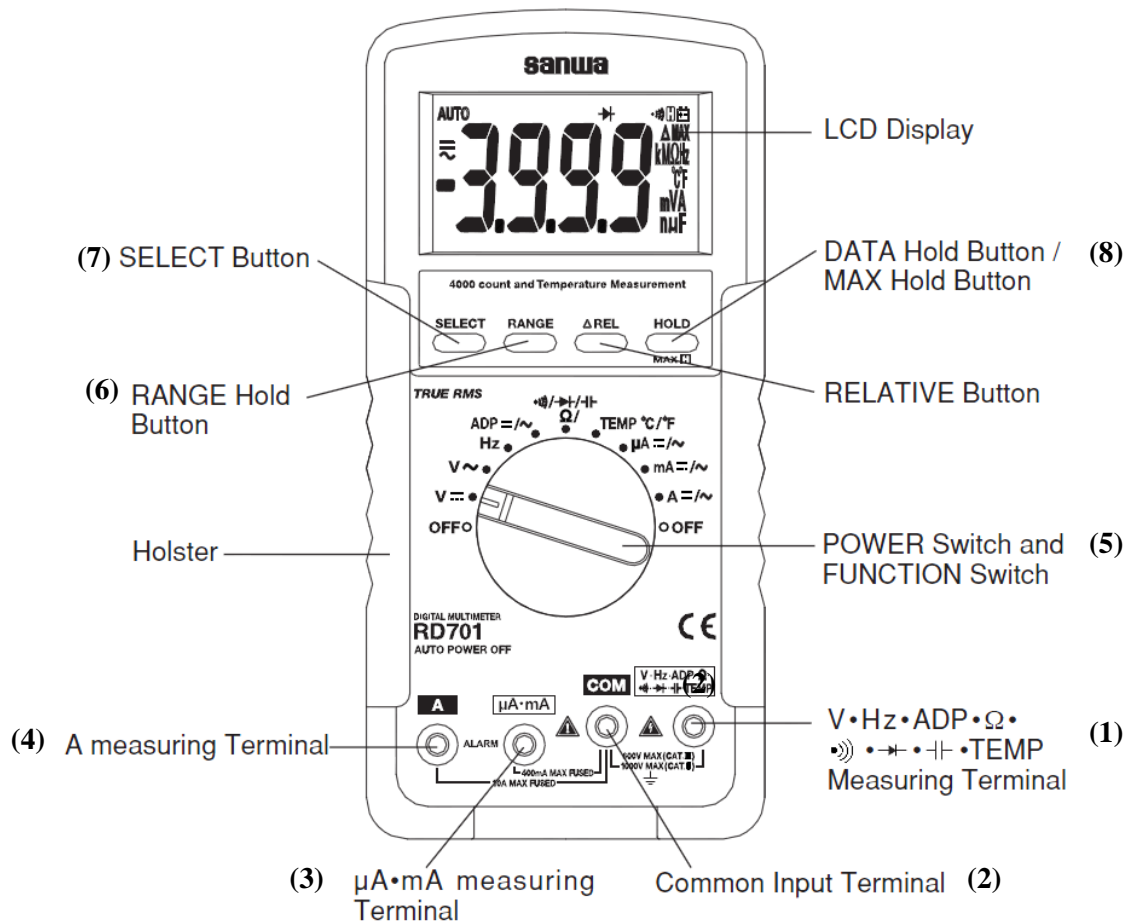


Figure 3: A digital multi-meter.

³ The power supply here is acting as a voltage source. For ideal voltage source, the current can be any value. We limit the amount of the current to be under some safe level. The experiments in this course are designed so that the currents are under this limit.

Figure 3 shows the important components of a multi-meter. Their functions are summarized in Table 1. Figure 4 shows a display of a multi-meter. Table 2 summarizes descriptions of such a display.

Table 1: Summaries of functions of a digital multi-meter.

| Components | Functions |
|--------------------------------------|--|
| 1. V•mV• Ω measuring terminal | Positive input terminal for all functions except current measurements (connection is made to it using a red test lead) |
| 2. COM Common input terminal | Negative (ground) input terminal for all measurement modes (connection is made to it using a black test lead) |
| 3. μ A•mA measuring terminal | Positive input terminal for current measurement up to 500 mA (connection is made to it using a red test lead) |
| 4. A measuring terminal | Positive input terminal for current measurement up to 10 A |
| 5. POWER Switch and FUNCTION Switch | Turn this rotary switch to power off the DMM or select the functions of measurement |
| 6. RANGE button | Select between manual and auto range mode (pressing this button for 1 second or more results in auto mode ('AUTO' appears on the display)) |
| 7. SELECT button | Select DC or AC type of the measurements (in mV, μ A, mA, A measurements), A beep sound for a short circuit. |
| 8. DATA HOLD button | When pressed, the data display at that time is hold ('H' is shown on the display) |

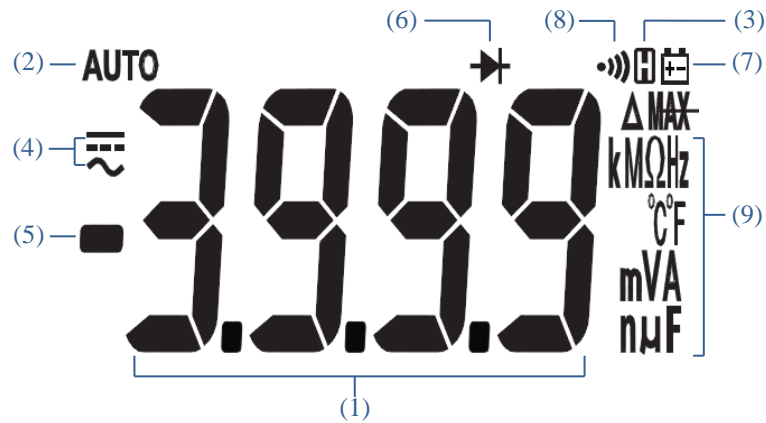


Figure 4: A multi-meter LCD display

Table 2: Summaries of the display of a multi-meter.

| Subdisplays | Functions |
|-------------|---|
| 1 | Display value in the main display area |
| 2 | Auto range display |
| 3 | H : Data hold display |
| 4 | ---- : DC measurement display ~ : AC measurement display |
| 5 | Minus polarity for numerical data |
| 6 | Testing diode display |
| 7 | Battery discharge warning display |
| 8 | Checking continuity display |
| 9 | Measurement unit display |

II.2.a Measurement of a DC voltage

A multi-meter can be used as a voltmeter to measure a DC voltage. Figure 1 shows a symbol of a voltmeter using a multi-meter. Basic steps of operation of a voltmeter may be summarized as follows:

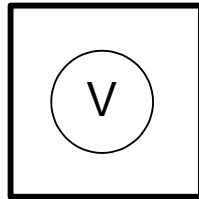


Figure 5: Symbol of a voltmeter

1. As shown in Figure 3, set the FUNCTION switch (5) of the multi-meter to V dc, or mV. Press SELECT button (7) to dc.
2. As shown in Figure 3, plug the black-test lead into COM terminal (2) of the multi-meter as, and the red-test lead into the V input terminal (1).
3. By using the RANGE button (6), select the range or the auto range mode.
4. Connect the voltmeter in parallel with the element, i.e. the black-test lead is connected to the negative terminal of the element being measured, and the red-test lead is connected to the positive terminal of the element, as shown in Figure 6.

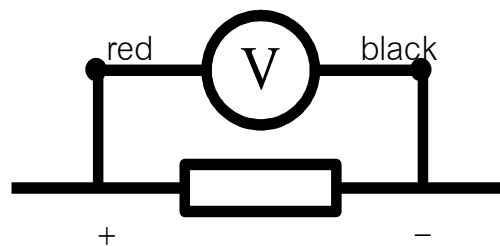


Figure 6: Measurement of a DC voltage

5. Turn on the power supply of the circuit.
6. Read the voltage value shown on the LCD display.

Note: For ac voltage measurements, press the SELECT button (7) to the ac mode and follow the steps (2) to (6).

II.2.b Measurement of a DC current

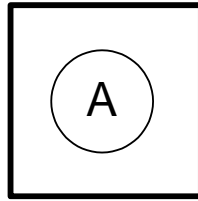


Figure 7: Symbol of an amp-meter

A multi-meter can be used as an amp-meter to measure a DC current. Figure 7 shows a symbol of an amp-meter using a multi-meter. Basic steps of operation of an amp-meter may be summarized as follows:

1. As shown in Figure 3, set the FUNCTION switch (5) of the multi-meter to either μA , mA or A. Press SELECT button (7) to dc.
2. Plug the black-test lead into the COM terminal (2). Plug the red-test lead into the measuring terminal (3) for μA and mA, or into the measuring terminal (4) for A.
3. By using the RANGE button, select the range or the auto range mode.
4. Open the existing connection of the element that the current is to be measured. Insert the amp-meter in series with the element as shown in Figure 8, and then reconnect the circuit.

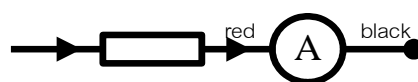


Figure 8: Measurement of a DC current

5. Turn on the power supply of the circuit.
6. Read the current value shown on the LCD display.

Note: For the ac current measurement, press the SELECT button (7) to the ac mode and follow the steps (2) to (6).

Caution: **Do not directly measure the current from the power supply.**

II.2.c Resistance measurement

1. Set the FUNCTION switch (5) to Ω .
2. Press the SELECT button (7) to enter the mode of resistance measurement (' Ω ' appears on the display *without continuity checking mark*).
3. Put the black-test lead into COM terminal, and the red-test lead into Ω measuring terminal (1). Press SELECT button (7), a beep sound will be generated when the red and the black leads are shorted together.
4. Do not forget to isolate the resistor to be measured from the circuit. Connect the black-test lead to one end of the resistor to be measured, and the red-test lead to the other end. **It is very important to note that the resistor must NOT be connected to a circuit while its resistance is being measured.**
5. Read the resistance value shown on the LCD display.

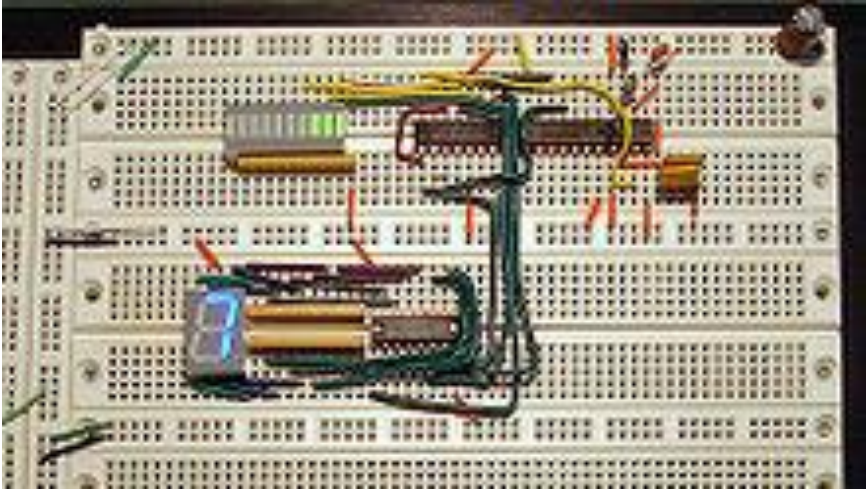
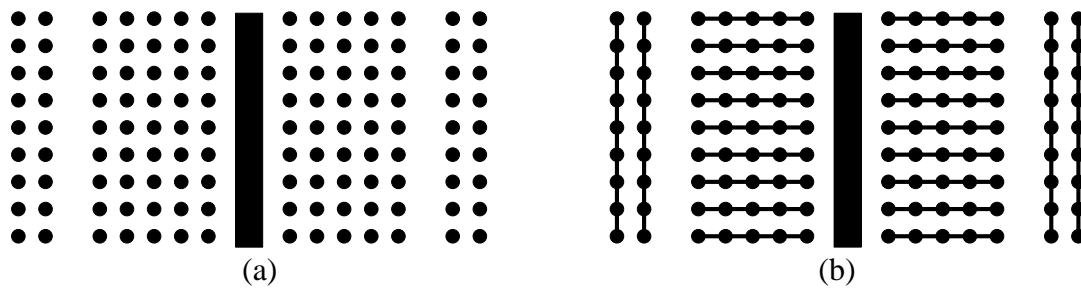
Note: Resistance can also be read from the resistor color code (see the appendix section for more details).

Remark: Refer to the manual of the digital multi-meter for more information.

Caution: Measure the resistance values first before you use the resistors. Measuring the resistance values when the resistors are connected to other components may not give the correct resistance values.

II.C Breadboard (Protoboard)

A common way to connect circuits in the experiments is to use a breadboard or prototype board (protoboard). A plastic protoboard has sets of holes into which we can insert wires and terminals of circuit components. Inside each hole is a metallic socket that firmly receives a wire pushed into it. Sets of sockets are arranged in rows and columns, and are connected together internally. Figure 9 shows an example of a part of the protoboard. Figure 9(a) shows holes as they appear externally. Figure 9(b) illustrates the internal connections of holes beneath the plastic surface. Each set of holes can be used as a node in the actual circuit since they are short-circuited together. This means components connected to the same node in a circuit can be pushed into the same set of holes on the protoboard.



(c)
Figure 9: An example of a breadboard (prototype board)

To connect a circuit correctly, you have to know the format of connections of the holes or sets of holes on the board. Since Figure 9 is only an example, it may be different to the protoboard you use in the lab. However, it is very simple to verify the connections of holes on the board. This can be done by setting up a multi-meter for resistance measurement, and measure the resistance between any pairs of holes. Recall that a short circuit exists among the same set of holes. If the reading of the multi-meter shows a short circuit (i.e. a very low resistance value or a beep sound), it implies that the two holes belong to the same set, and can be used as a common node in the connection of a real circuit. Useful recommendations to wire a circuit may be summarized as follows :

- ✓ Keep the power supplies **OFF** while you are wiring a circuit.
- ✓ Make sure that all leads for power supplies are connected firmly on the protoboard. Floating connection in the free air or outside the proto-board is dangerous and vulnerable to accidentally shorted circuits.
- ✓ Always start your wiring from a carefully drawn schematic diagram of the circuit that you want to build.
- ✓ Make sure that all leads for signals are connected firmly on the protoboard. Floating connection in the free air or outside the protoboard is dangerous and vulnerable to accidentally shorted circuits.

- ✓ Mark all completed connections on your diagram as you go.
- ✓ Use connections as short as possible.
- ✓ *As shown in Figure 9c, keep wires down as close as possible to the surface of the board.* This will help you to open up the space and to clearly see and make investigation.
- ✓ Do not use more wires than you have to.
- ✓ If possible, as shown in Figure 9c, avoid passing wires over components or over other wires.
- ✓ Be careful that bare wires or component terminals are clear of each other so that they cannot be accidentally shorted together.

II.D Oscilloscope

An oscilloscope, as shown in Figure 10, is used to observe circuit behavior graphically by displaying waveforms on a screen. It is a basic tool used in the study of time varying phenomenon of voltage and current in electric circuits, such as the measurements of frequency and period of waveforms. We will learn more about it in Experiment 04.

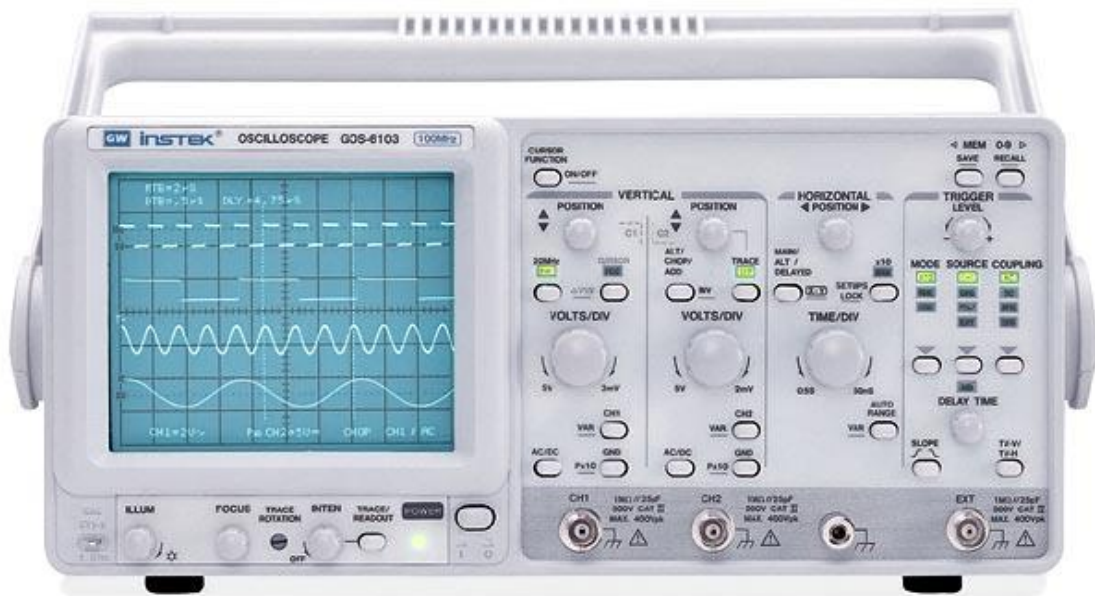


Figure 10: An oscilloscope.

II.E A Function Generator

A function generator is shown in Figure 11. It can be used to generate various waveforms of basic signals of various frequencies and amplitudes. Typical applications include a wide range of audio response testing applications, vibration testing, servo system evaluation, ultra sound applications, etc. We will learn more about it in Experiment 04.

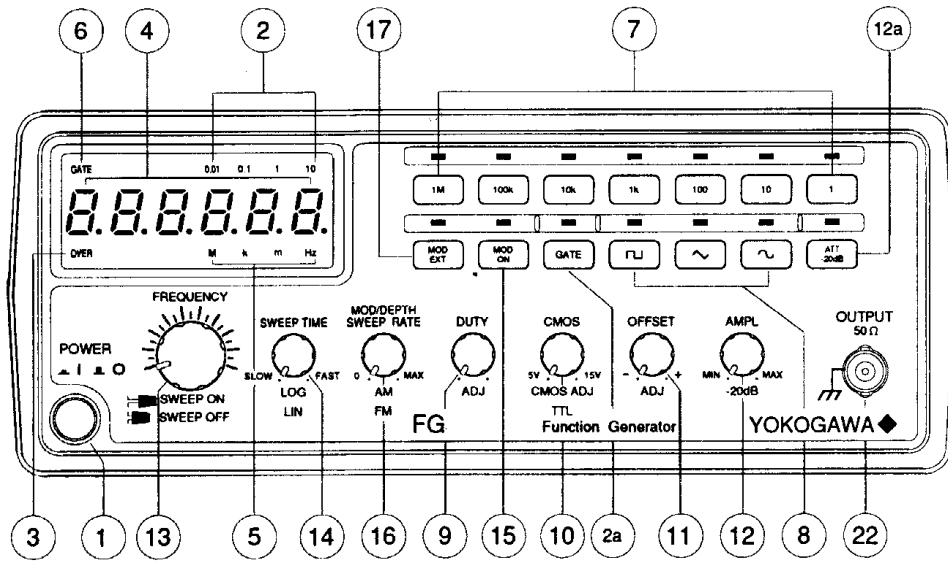


Figure 11: Function generator

Reference: Yannis Tsvividis, "A First Lab in Circuits and Electronics," John Wiley & Sons, New York, 2001.

III. MATERIALS REQUIRED

- DC power supply
- Digital multi-meter
- Resistors: 1 k Ω , 2 k Ω , and 10 k Ω .

IV. PROCEDURE

You will undoubtedly have to encounter problems and difficulties during your experiment. You should **PREPARE** yourself well before coming to the lab by reading the manual beforehand, starting from the next lab. You should also try to **THINK** carefully and **SYSTEMATICALLY** in order to solve the problem. Help is also available from the TA and the instructor. They are here to guide you. Note that **asking the TA to assemble the circuit for you is prohibited.**

Part A:

- 1) Use a DMM to measure the actual value of resistance of R_1 and R_2 , where $R_1 = 1\text{ k}\Omega$ and $R_2 = 2\text{ k}\Omega$. Record your results in Table 3.
- 2) Adjust the dc power supply to 6 volts.
- 3) Connect the circuit in **Figure 12**.
- 4) Use the DMM to measure the voltage across R_1 , and the voltage across R_2 . Record your results in Table 3.
- 5) Use the DMM to measure the current passing through R_1 , and that passing through R_2 . Record the results in Table 3.

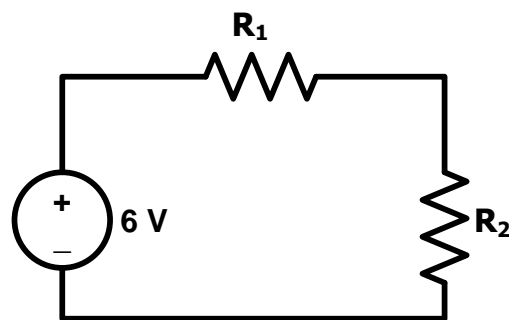


Figure 12: The circuit for Part A.

Part B:

- 1) Use a DMM to measure the actual value of resistance of R_1 and R_2 , where $R_1 = 2\text{ k}\Omega$ and $R_2 = 10\text{ k}\Omega$. Record your results in Table 3.
- 2) Adjust the dc power supply to 10 volts.
- 3) Connect the circuit in **Figure 13**.
- 4) Use the DMM to measure the voltage across each resistor: R_1 and R_2 . Record your results in Table 3.
- 5) Use the DMM to measure the current passing through each resistor: R_1 and R_2 . Record your results in Table 3.

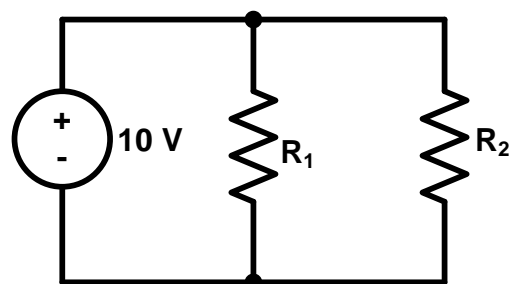


Figure 13: The circuit for Part B.

Part C:

- 1) Use a DMM to measure the actual value of resistance of R_1 , R_2 , and R_3 , where $R_1 = 10\text{ k}\Omega$, $R_2 = 2\text{ k}\Omega$, and $R_3 = 1\text{ k}\Omega$. Record your results in Table 3.
- 2) Adjust the dc power supply to 12 volts.
- 3) Connect the circuit in **Figure 14**.
- 4) Use the DMM to measure the voltage across each resistor: R_1 , R_2 , and R_3 . Record your results in Table 3.
- 5) Use the DMM to measure the current passing through each resistor: R_1 , R_2 , and R_3 . Record the results in Table 3.

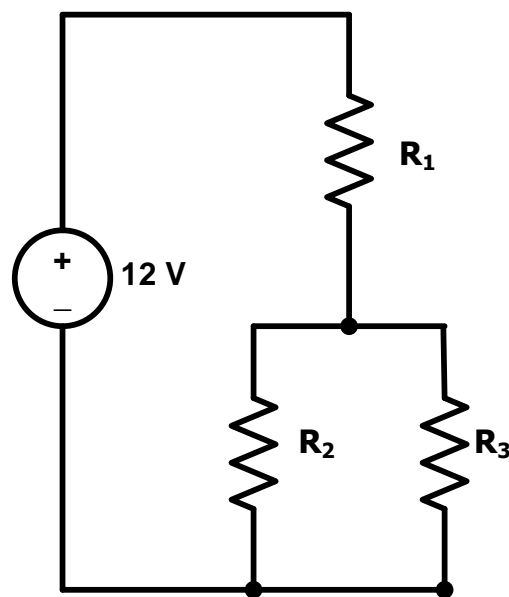


Figure 14: The circuit for Part C.

Table 3

| | Part A | | Part B | | Part C | | |
|----------------------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|
| | R ₁ | R ₂ | R ₁ | R ₂ | R ₁ | R ₂ | R ₃ |
| Resistance (Ω) | | | | | | | |
| Voltage (V) | | | | | | | |
| Current (A) | | | | | | | |

Remark: Starting from the *next lab*, you will need signature from the TAs or the lab instructor for each part of the experiment. The signatures are required for both your sheet and your lab partner sheet. You need to submit both sheets in the lab report. You do not need any signatures for this lab. When you complete Table 3, you may leave the lab.

Do not forget to clean your desk before you leave the lab.

APPENDIX

A. Resistor Color Code

There is no way to determine a resistor's value from its size or shape. The resistance value could be stamped or painted on the body of the component, but the numbers could be quite small and difficult to read. On older components, the markings could eventually rub off or become smeared. Also, when a resistor is used in a circuit, the marking would not always be visible unless the component was mounted in a very specific way. Because of these problems, a standardized color-coding system was devised for resistors. This color code is virtually universal in electronics work all over the world.

A typical resistor is shown in Figure A-1. The standard color-code marking consists of four bands encircled around the body of the resistor. The color of the first band indicates the first significant figure of the resistance value. The second band indicates the second significant figure. The color of the third band indicates the number of zeros that follow the first two significant figures. If the third band is gold or silver, the resistance value is less than 10 Ω . In this case, the third band indicates a fractional value of the first two significant figures:

- A *gold* band means the resistance is 1/10 the value of the first two significant figures.
- A *silver* band means the resistance is 1/100 the value of the first two significant figures.

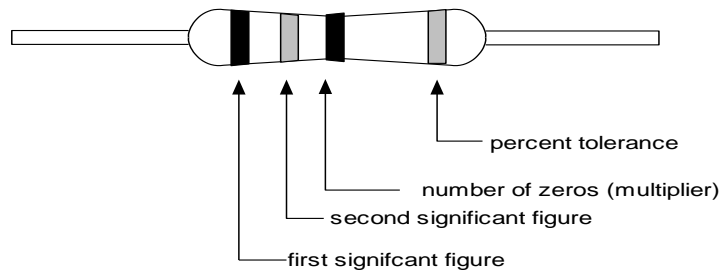


Figure A-1: Resistor color code.

The fourth band indicates the *percent tolerance* of the resistance. Percent tolerance is the amount of the resistance that may vary from the value indicated by the color code. Since resistors are mass-produced, variations in materials can affect their actual resistance. However, many circuits can still operate as designed even if the resistors in the circuit do not have the precise value specified. Tolerances are usually given as plus or minus the nominal, or color-code, value.

High-precision resistors have five bands. The first three bands indicate the first three significant figures of the resistance; the fourth band indicates the number of zeros; the fifth band is the percent tolerance.

Table 4

| Color | Significant figure (First and Second Bands) | The number of 0s (Multiplier) (Third Band) | % Tolerance (Fourth Band) | % Tolerance (Fifth Band) |
|----------|---|--|---------------------------|--------------------------|
| Black | 0 | 0 ($10^0 = 1$) | - | 1 |
| Brown | 1 | 1 (10^1) | - | 2 |
| Red | 2 | 2 (10^2) | - | - |
| Orange | 3 | 3 (10^3) | - | - |
| Yellow | 4 | 4 (10^4) | - | - |
| Green | 5 | 5 (10^5) | - | - |
| Blue | 6 | 6 (10^6) | - | - |
| Violet | 7 | 7 (10^7) | - | - |
| Gray | 8 | 8 (10^8) | - | - |
| White | 9 | 9 (10^9) | - | - |
| Gold | - | (0.1 or 10^{-1}) | 5 | - |
| Silver | - | (0.01 or 10^{-2}) | 10 | - |
| No color | - | - | 20 | - |

B. Capacitor Markings

Value markings on capacitors are not nearly as standardized as those on resistors. Several different marking systems are widely used. Many capacitors, especially those used in some commercially manufactured electronic equipment, may not be marked at all.

On many capacitors, especially those with larger body sizes, the actual value may be stamped or printed directly on the body of the component. For example, an electrolytic capacitor may be marked “50 V, 470 μ F.” This is perfectly straightforward. The capacitor in question has a nominal capacitance of 470 μ F, and the maximum voltage that can be safely applied across this device is 50 V.

A few capacitors may also indicate that the marked (working) voltage is a DC voltage. This is somewhat unnecessary because the voltage limit rating for any capacitor is assumed to be a DC voltage unless otherwise indicated. This means that you must be careful when using a capacitor in a circuit carrying AC signals. You must consider the peak voltage, not the RMS voltage.

Some capacitor manufacturers use a three-digit numerical code that is somewhat similar in concept to the standard resistor color code described in Appendix A. The first two digits in this code are the two most significant digits of the capacitance value. The third digit is a multiplier value. The multiplier indicates the number of zeros to follow the significant digits. For example, a code of 473 would indicate a capacitance value of 47,000. But 47,000 what? Is the capacitance measured in microfarads or picofarads? This is not directly indicated by the capacitance marking. The physical size of the capacitor in question is the only direct indication of whether the indicated capacitance value is measured in microfarads or picofarads. Of course, the capacitor measured in microfarads will be considerably larger than a capacitor measured in picofarads. As it happens, this particular coding system will most likely be used on picofarad capacitors. The third digit (multiplier) in the code is only useful if the capacitance value is at least 100 (the code would read 101). A capacitor of 100 μ F or larger would probably have enough space on its body for a printout of the full value, without resorting to any abbreviation code.