

LABORATORY 1

INTRODUCTION TO THE CIRCUIT LABORATORY

This is the first laboratory where you will deal with such matters as the course objectives, syllabus, grading policy, laboratory rules and procedures, safety issues, preparation of prelab and lab reports, the resistance color codes, the breadboard, and the Lab VIEW equipment.

Objectives

- To enable students to gain skills in using basic electrical laboratory equipment such as meters, power supplies, and oscilloscopes, which skills they will need in subsequent electrical engineering laboratories and in industry.
- To make the students aware of the limits of the operation of components and equipment.
- To have the students gain skills in recording data and in reporting experimental results--to effectively communicate what they have done and observed.
- To give students self-confidence in electrical laboratories.
- To have the students become safety conscious in a laboratory environment.
- To verify some of the concepts presented in the corequisite course, either EEL 3111 or EEL 3003.

Syllabus

Although each teacher provides his/her own syllabus to the respective section(s), there are some common features. All students perform the same set of experiments (in the order listed in this manual) and all are graded by the same criteria.

Grades

There are 10 labs in total. Lab reports are due for five of them (labs 2, 5, 6, 7, 9) and some of them have prelabs. We will also have a final project for which a lab report will be due. The grades for the reports and lab sessions will be one out of A, B, C.

Prelab Reports

In this manual, the write up for each experiment starts with a brief review of the relevant theory in the Introduction part. The instructor presents the underlying ideas in the class before the experiment is performed. The prelab report will consist of answers to questions posed in the introduction. The report will be due on the day the experiment will be performed. It will be collected at the start of the class. Students not presenting the report will be denied access to that experiment.

Lab Reports

These reports are written after the experiment is complete and they are due a week after. Some general guidelines are given below. Your instructor may give you additional and specific guidelines for preparing these reports.

Guidelines for Lab Reports

Several lab reports will be required during the semester. Typically, they are from four to seven pages long, and are typed. Although the laboratory TA will explain what is required for each lab report, in general each should contain the following sections:

Abstract: A brief summary of the experiment giving the purpose and explaining what is going to be shown or proved, and how this is to be done. The abstract should be fairly general.

Data: This should include a complete list of all the equipment used with model and serial numbers; schematics of the circuits used; all calculated and measured data in the form of tables or graphs; and the calculation of percentage errors. Be sure to show a clear relation between the data and the schematics. The data should be exactly what was obtained in the experiment. Include units with the values. Additionally, carry only the appropriate number of significant digits in your results.

Conclusions: Here, interpret the results (data). Compare the theoretical results from the Introduction with the experimental results from the data, and draw conclusions. For example, were the results different from what was expected? Why were these results different? Specify the errors and include possible sources of error. Answer any questions specified in the lab sheet. Also, always explain why things happened the way they did.

Also,

Be objective and do not use phrases like “I was pleased . . .,” “The lab went well . . .,” “It was good to know . . .”, etc.

Always give numerical results when applicable. Do not just say “the results were as expected.” Specify the actual results, the expected results, any errors, and explain them.

Be careful of the number of significant digits in the calculated results. This number should not be greater than the least number of significant digits in the data used for the calculations.

Be concise. A short direct lab report is more desirable than a long rambling one.

Keep everything neat and label everything clearly. Start each section on a new page. Write on only one side of each sheet.

Remember to number the equations and use figure numbers and table numbers for any drawings or tables.

For reasons of his or her own, the laboratory TA may modify any of the above. Follow the instructions of the laboratory TA.

Final Exam

Passing the course requires also passing the final exam. **A student, who fails the final exam, automatically fails the course, independent of other grades.**

Safety

Although unlikely, it is possible to become injured in this laboratory. Emergency contacts by phone are 911 and 395-0050, the latter is for the Emergency Room at Shands Hospital. On some university phones it may be necessary to dial 9 first. Although there is no phone in this laboratory, one is in EB288. Also, each office has a phone.

When working in any electrical laboratory, always keep electrical safety in mind. Following are some safety rules that each student should be aware of before beginning a laboratory experiment. Some of the rules do not apply to this laboratory, but to other electrical laboratories.

1. Never work totally alone in the laboratory. Someone else, and preferably the laboratory TA, should be present in the case of an emergency.
2. Use only the equipment provided. Do not use other equipment unless the laboratory TA approves the use.
3. Turn off the power before handling any wires.

4. Never use damaged items, whether they are leads, components, equipment, or any other item.
5. To decrease the chances of being shocked, wear dry shoes and do not stand on metal or wet concrete. Also, do not wear any metal or jewelry. Moreover, do not handle wires, components, or equipment with wet hands.
6. In a laboratory in which soldering irons are used, keep an attentive eye on a hot soldering iron. Also, place it in the proper holder when not in use. Never leave a hot soldering iron unattended.
7. Make no connection to the power supply until the very last step. This practice will ensure that a student who is handling leads will not be shocked. Also, the circuit being built will not be harmed during construction.
8. Should someone become incapacitated because of electric shock, **no one should touch** that person until the power is turned off. Otherwise, the rescuer could also be shocked. Call for emergency services as soon as possible since resuscitation is likely if treatment is applied quickly. If breathing has stopped, begin CPR immediately and continue until qualified medical assistance has arrived.
9. If a piece of equipment is not working properly, attach a note and report the problem to the lab TA. The malfunction could possibly lead to a life-threatening situation.

Electrical Shock:

A current of 100 to 200 mA causes ventricular fibrillation of the heart. This is an irregular twitching of the wall of the ventricle of the heart, and is fatal. There is no known remedy or resuscitation. Wet skin has a resistance of only $150\ \Omega$ and the hand-to-foot internal body resistance is from $400\ \Omega$ to $600\ \Omega$. In the case of, for example, 120 V and a skin plus body resistance of $800\ \Omega$, the result is a lethal current of 150 mA.

A current from 8 mA to 100 mA produces a painful shock, and perhaps also loss of muscular control so that the victim cannot free him or herself from the cause of the shock.

Severe burns occur for a current greater than 200 mA. Also, the muscular contractions are so severe that chest muscular reaction clamps the heart and stops it for the duration of the shock. This reaction prevents ventricular fibrillation. Artificial respiration should be administered immediately and in most cases the victim can be revived.

Resistance Color Codes

Unit of Resistance:

The SI unit of resistance is the Ohm, and the unit symbol is the capital Greek letter omega Ω . Unit prefixes are used for writing convenience. For example, the prefixes k and M represent 10^3 and 10^6 , respectively. Thus, 33 000 is written as 33 k Ω (33 kilohms), and 1 200 000 as 1.2 M Ω (1.2 megohms).

Resistance Nominal Values and Tolerances:

Resistor manufacturers print resistance values on resistor casings either in numerical form or in a color code. These values, though, are only *nominal values*. They are only approximately equal to the actual resistances. The possible percentage variation of resistance about the nominal value is called the *tolerance*. The popular carbon-composition resistors have tolerances of 20, 10, and 5 percent, which means that the actual resistances can vary from the nominal values by as much as ± 20 , ± 10 , and ± 5 percent of the nominal values.

Color Code:

The most popular resistance color code has nominal resistance values and tolerances indicated by the colors of either three or four bands around the resistor casing, as shown in Fig. 1.1. (Sometimes there is a fifth band for failure rate. It will not be considered.) The colors of the first and second bands correspond, respectively, to the first two digits of the nominal resistance. The first digit, though, is never a zero. The color of the third band, except for silver and gold, corresponds to the number of zeros that follow the first two digits. A third band of gold corresponds to a multiplier of 10^{-1} , and one of silver to 10^{-2} . The fourth band indicates the tolerance and is either gold, silver, or is missing. Gold corresponds to a tolerance of 5 percent, silver to 10 percent, and a missing band to 20 percent.

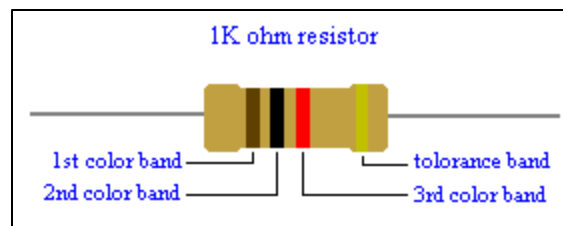


Fig. 1.1 - Reference: <http://the12volt.com/resistors/index.html>

The resistance color code is shown in Table 1.1. As can be determined from it, a resistor with bands of red, yellow, orange, and gold is a 24 k Ω resistor of 5% tolerance. Also, a

resistor with bands of blue, gray, yellow, and silver is a 680 k Ω resistor of 10% tolerance. And, a 1 Ω resistor of 20% tolerance has color bands of brown, black, gold, and missing. Remember that the first digit is never zero, which means that the first color band is never black.

Band Color	1st Band #	2nd Band #	*3rd Band #	Multiplier x	Tolerances \pm %
Black	0	0	0	1	
Brown	1	1	1	10	$\pm 1\%$
Red	2	2	2	100	$\pm 2\%$
Orange	3	3	3	1000	
Yellow	4	4	4	10,000	
Green	5	5	5	100,000	$\pm 0.5\%$
Blue	6	6	6	1,000,000	$\pm 0.25\%$
Violet	7	7	7	10,000,000	$\pm 0.10\%$
Grey	8	8	8	100,000,000	$\pm 0.05\%$
White	9	9	9	1,000,000,000	
Gold				0.1	$\pm 5\%$
Silver				0.01	$\pm 10\%$
None					$\pm 20\%$

Table 1.1 – Reference: <http://the12volt.com/resistors/index.html>

Breadboard Description

Most of the circuits built and tested in this laboratory will be assembled on a “breadboard,” which looks like a piece of plastic with holes in it. Electrical components (resistors, capacitors, wires, etc.) are inserted into the holes. What makes a breadboard unique is that certain combinations of the holes are electrically connected with each other. Since these connections are inside the plastic, they cannot be seen. Thus, a user must know which holes are connected. Most breadboards have a similar pattern of interconnections.

BREADBOARD CONNECTIONS:

The internal connections inside the breadboard run in both vertical and horizontal lines, as shown in Fig. 1.2. It is important to remember that

1. The vertical connections are in groups of five.
2. The horizontal connections are in groups of twenty-five.

3. No group of five (or twenty-five) is interconnected with any other group of five (or twenty-five).



Fig. 1.2

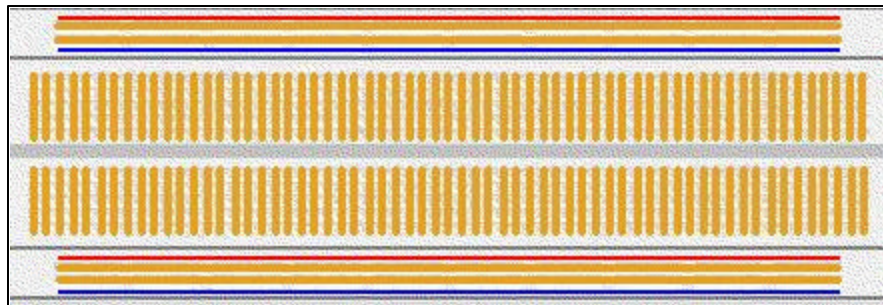


Fig. 1.3

Therefore, separate components can be connected together at one point or node by inserting the proper component(s) into the proper breadboard holes. The advantage of using a breadboard is that relatively large circuits can be assembled neatly without having a maze of interconnecting wires. Further, when connections must be made from the assembled circuit to external equipment such as power supplies and meters, leads with alligator clips on one or both ends can be used. The alligator clips are connected directly to the circuit components. Preferably, a circuit should be assembled first and checked before any external connections are made.

Note: Measurements of voltage, current, and resistance can be performed either by the virtual bench digital multimeter (DMM) or by the hand-held multimeter. The connections for each measurement are shown in the Appendix on the last two pages of the write up of this experiment (Circuit Synthesis on a Breadboard). Note that for voltage measurements, the meter is connected in parallel and for current measurements it is connected in series. **In order to avoid damage to components and instruments, it is essential that the source be connected or turned on only when you have verified that the connections have been correctly made.**

Introduction to the NI ELVIS Workspace

ELVIS is a combination of hardware and software elements comprising a complete laboratory suite. A user interacts with the desktop proto-board via the control panel in the workstation. Circuits are constructed on the proto-board. No external equipment is needed; the desktop unit is capable of generating both AC and DC signals as well as measuring the output of AC and DC circuits. Measurements can be made through ELVIS or with external measuring devices. Manual adjustments can also be made on the unit by disabling the control panel interface.

The control panel is also referred to as a soft front panel (from LabView). The soft panel is capable of launching several instruments including an arbitrary waveform generator, Bode analyzer, digital bus reader/writer, digital multimeter (DMM), dynamic signal analyzer, function generator, impedance analyzer, oscilloscope, I-V analyzer, and variable power supplies. Additional panels can be written through the LabView API to interface with ELVIS. The use of these functions will be covered as the semester progresses.

I. Launching the DMM Panel

- a. Start NI ELVIS by going to the Windows *Start* menu and selecting *Programs -> National Instruments -> NI ELVIS 2.0 -> NI ELVIS*
- b. You can launch the DMM by selecting *Digital Multimeter* from the menu. Once active, you should have a new panel similar to the one depicted in Figure 1. The DMM can be used for a variety of operations including measuring AC and DC voltages and currents, resistance, capacitance, and inductance.

II. Voltage Measurements:

Measuring AC or DC voltage with the NI ELVIS DMM requires no external hardware and can be done as follows.

- a. For AC and DC voltage measurements, use the *VOLTAGE HI* and *VOLTAGE LO* lines. These inputs are on the left-hand side of the proto-board, shown in Figure 2, area 6.
- b. The DMM runs in DC Voltage mode when launched. Select the V_{AC} or V_{DC} button on the front panel of the DMM, depending on the signal to be measured, and the measurement type changes to show the value of the signal. Auto scaling should work best for most applications.
- c. Connect signal leads. Remember that voltage is measured in **PARALLEL** to the device in question.
- d. Select the *Single* or *Run* option from the front panel controls. Selecting the *Single* option displays an instantaneous value of the voltage. Selecting *Run* provides continuous measurements of voltage.

III. Current Measurements

Measuring AC or DC voltage with the NI ELVIS DMM requires no external hardware and can be done as follows.

- For AC and DC current, resistor, capacitor, inductor, diode, and continuity measurements, use the *CURRENT HI* and *CURRENT LO* lines. These inputs are on the left-hand side of the proto-board, shown in Figure 2, area 6.
- The DMM runs in DC Voltage mode when launched. Select the V_{AC} or V_{DC} button on the front panel of the DMM, depending on the signal to be measured, and the measurement type changes to show the value of the signal. Auto scaling should work best for most applications.
- Connect signal leads. Remember that current is measured in **SERIES** with the device in question.
- Select the *Single* or *Run* option from the front panel controls. Selecting the *Single* option displays an instantaneous value of the voltage. Selecting *Run* provides continuous measurements of voltage.

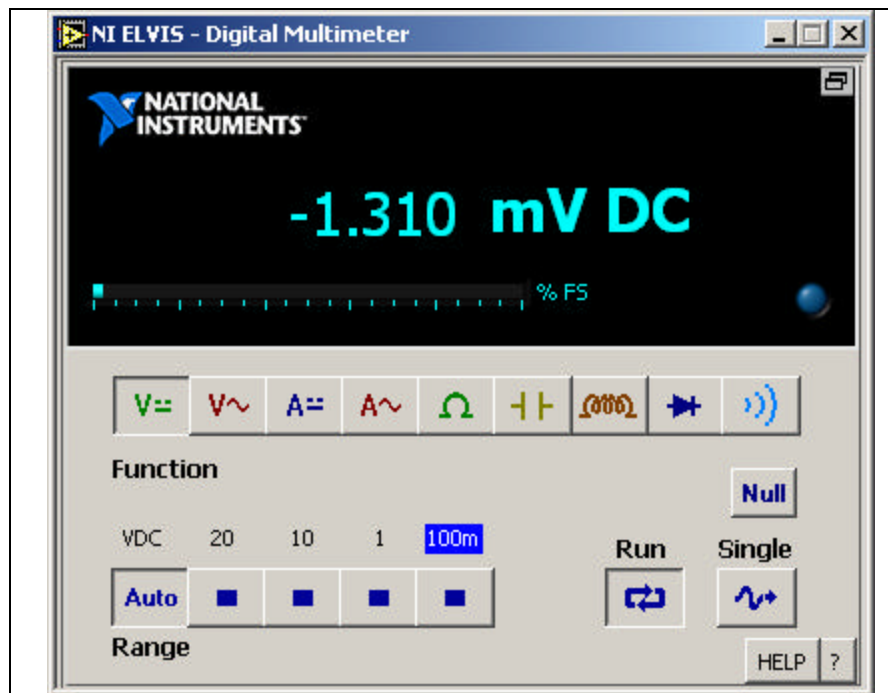


Figure 1 – NI ELVIS DMM

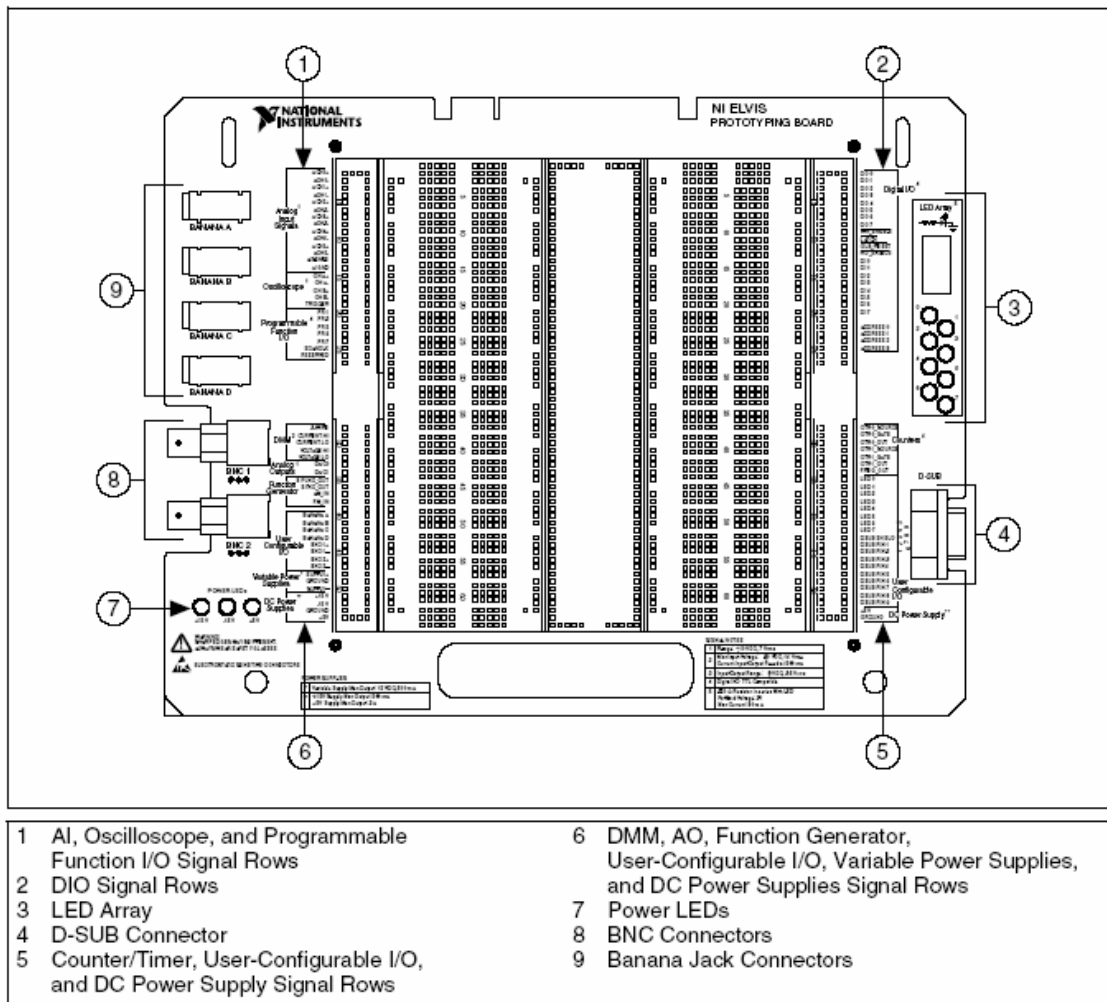


Figure 2 - Prototyping Board Parts Locator Diagram

IV. Launching the Variable Power Supply Panel

This is a top-level, stand-alone instrument that controls the variable DC supplies in the NI ELVIS Benchtop Workstation. You can control the variable power supplies either through the NI ELVIS - Variable Power Supplies SFP (Software Mode) or the hardware controls on the benchtop workstation (Manual Mode).

- Connect the Variable Power Supplies signals, *SUPPLY+* and *SUPPLY-*, on the NI ELVIS Prototyping Board to the location where they are needed. These are independent power supplies, and both signals are referenced to the *GROUND* signal.
- The variable power supplies are active and output 0V when the panel is launched. Select the desired voltage for each supply in the Voltage Adjust control, and the output updates accordingly.

V. Exercise

This part of the experiment will demonstrate LabVIEW's ability in making both voltage and current measurements.

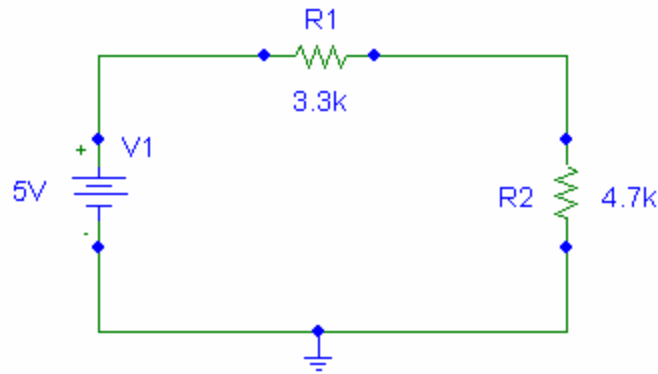


Figure 3.

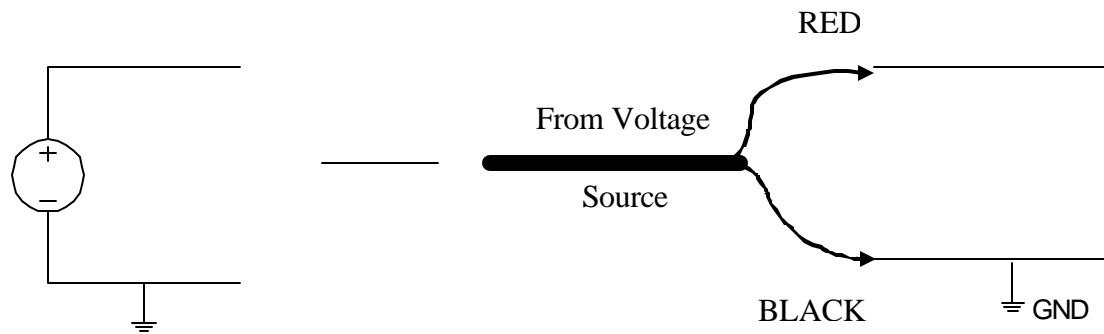
1. Set up the circuit in Figure 3. Do not forget to ground your circuit.
2. Measure the voltage across all the branches, including V_1 , in Figure 3 using the procedure described in step II.
3. Measure all branch currents in Figure 3 using the procedure described in step III.
4. Measure the above voltages by also using the hand-held multimeter. Compare these values to those obtained in step 2.
5. Measure the above branch currents by also using the hand-held multimeter. Compare these values to those obtained in step 3.
6. Compare these results with theoretical values given to you by the instructor. Make sure to include percent error calculations as well.

$$\frac{|\text{your result} - \text{accepted value}|}{\text{accepted value}} * 100$$

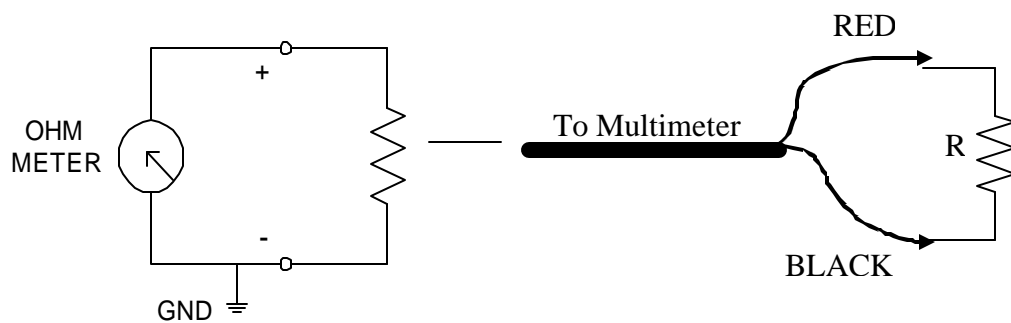
CIRCUIT SYNTHESIS ON A BREADBOARD

ELEMENTS AND CONNECTIONS

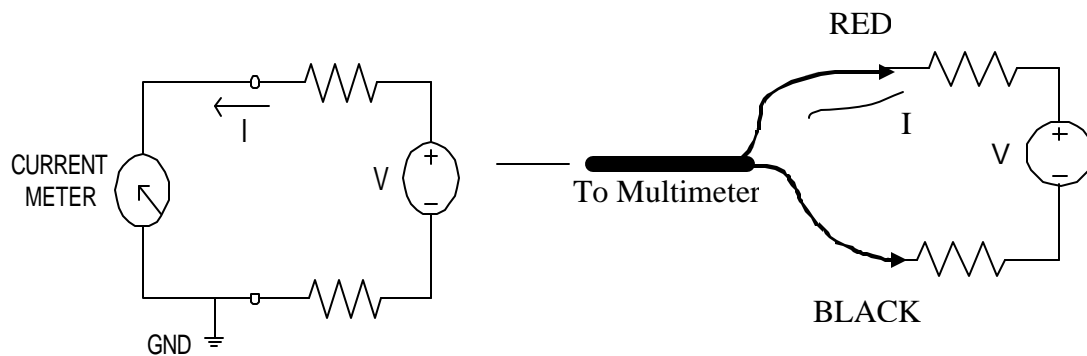
VOLTAGE SOURCE



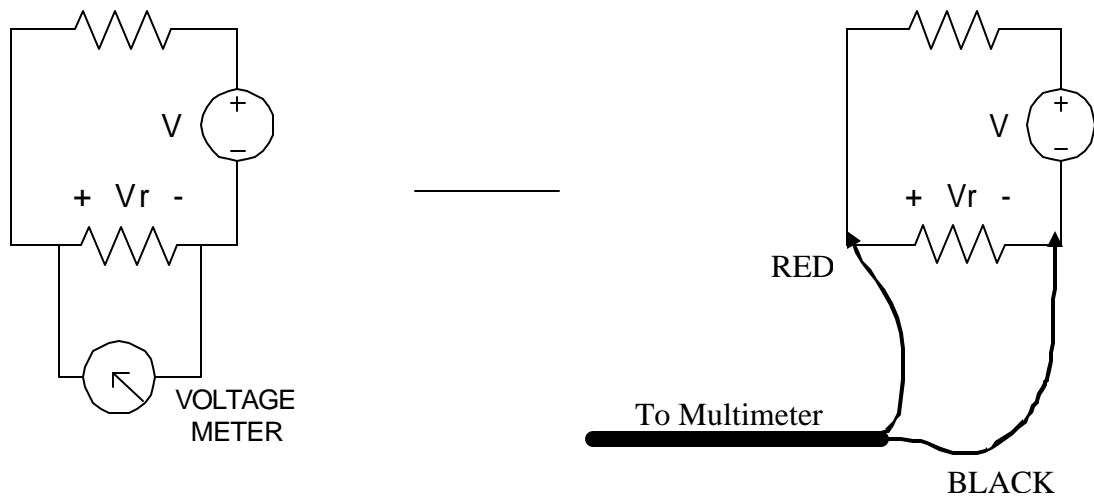
OHMMETER (RESISTANCE MEASUREMENT)



AMMETER (CURRENT MEASUREMENT)



VOLTMETER (VOLTAGE MEASUREMENT)



EXAMPLE

