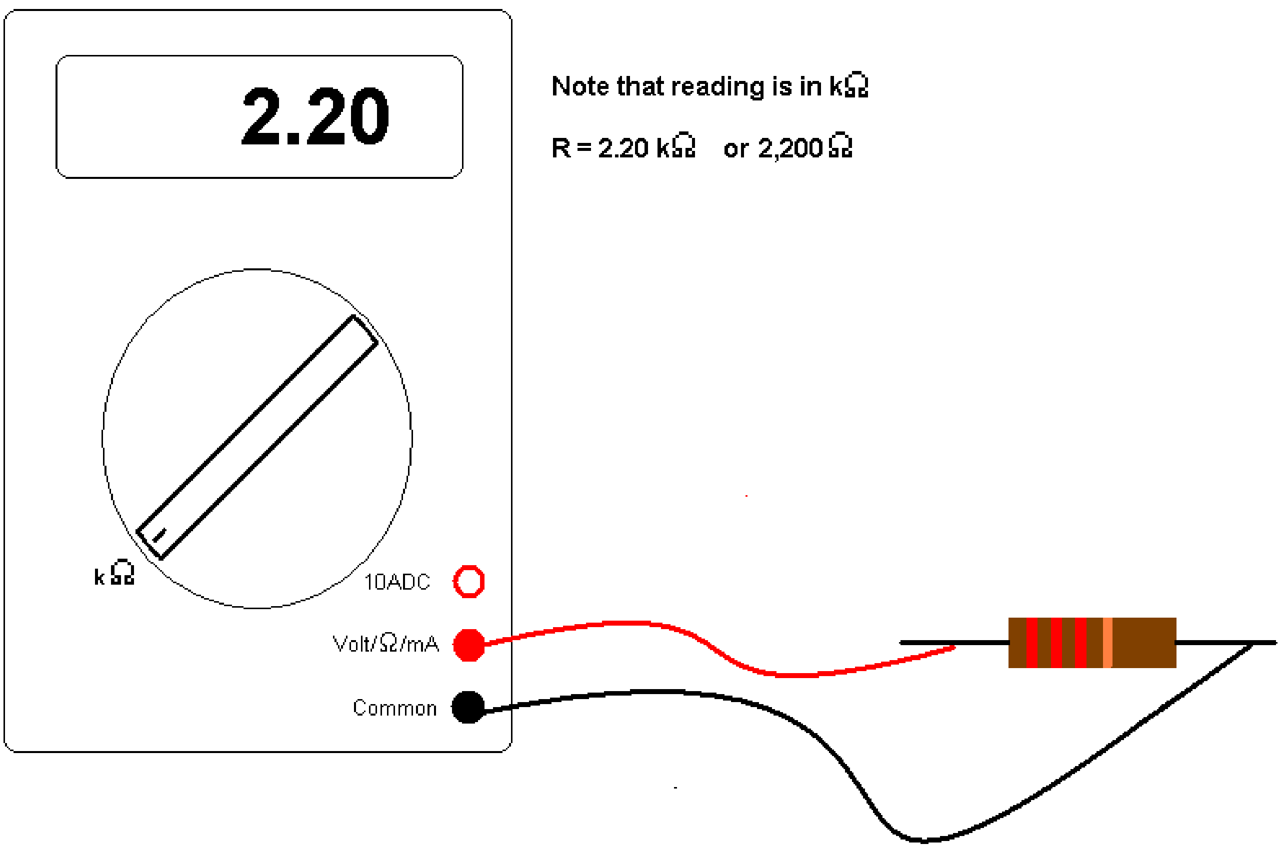
Introduction to the Digital Multi-Meter (DMM) and Use of the Proto Board

Proper use of the Digital Multi-Meter and Proto Board are skills that are extremely important for success in the technical fields, especially the electrical, computer, and telecommunications professions. Following is an introduction to the correct use of these important tools.

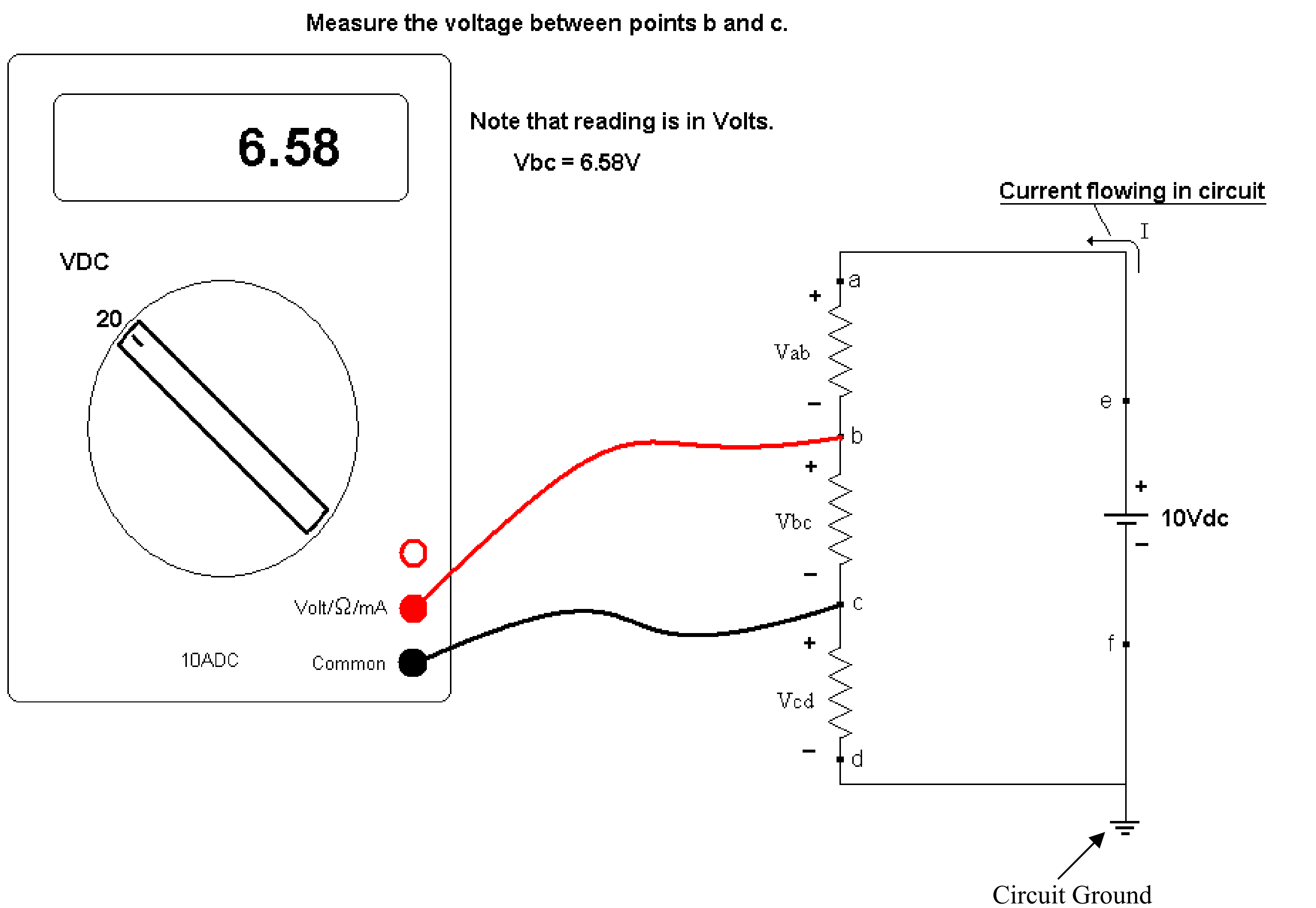
Measuring Resistance

Let's start with the Digital Multi-Meter (we will use the mnemonic DMM). The basic DMM consists of a Meter box with a selector switch, meter readout, and 2 leads, one Red lead and one Black lead. It may be small and portable, like the small yellow meters in the lab, or it may be a high end bench DMM like the Hewlett Packard DMM on the bench. They all do the same job, measurement of Voltage, Current or Resistance. You have to set the DMM to the mode of measurement you wish. We'll start with Resistance measurement. A resistor is a device that opposes (resists) the flow of current in an electric circuit. The amount of resistance any resistor has is a value measured in Ohms (symbol Ω). To measure the resistance of a resistor, set the DMM to resistance (your instructor will show you how with each DMM). Place the Red lead in contact with one lead of the resistor, and the black in contact with the other. The number on the meter readout will be the resistance in Ohms of that resistor. An individual resistor should be removed from a circuit before measuring its resistance so that connected components cannot affect the reading.



Voltage Measurement

Voltage is measured, using the DMM in a similar manner. Since voltage is the <u>difference</u> in potential (pressure) between 2 points in a circuit, the probes are placed in contact with those 2 points to measure the difference in potential between them. Connections in a circuit diagram are usually labeled with letters or numbers, so it makes sense to refer to voltages between 2 points as V_{AB} or V_{12} where the subscripts refer to the labels. For a measurement of V_{AB}, The red lead is placed on point A and the black lead on point B.

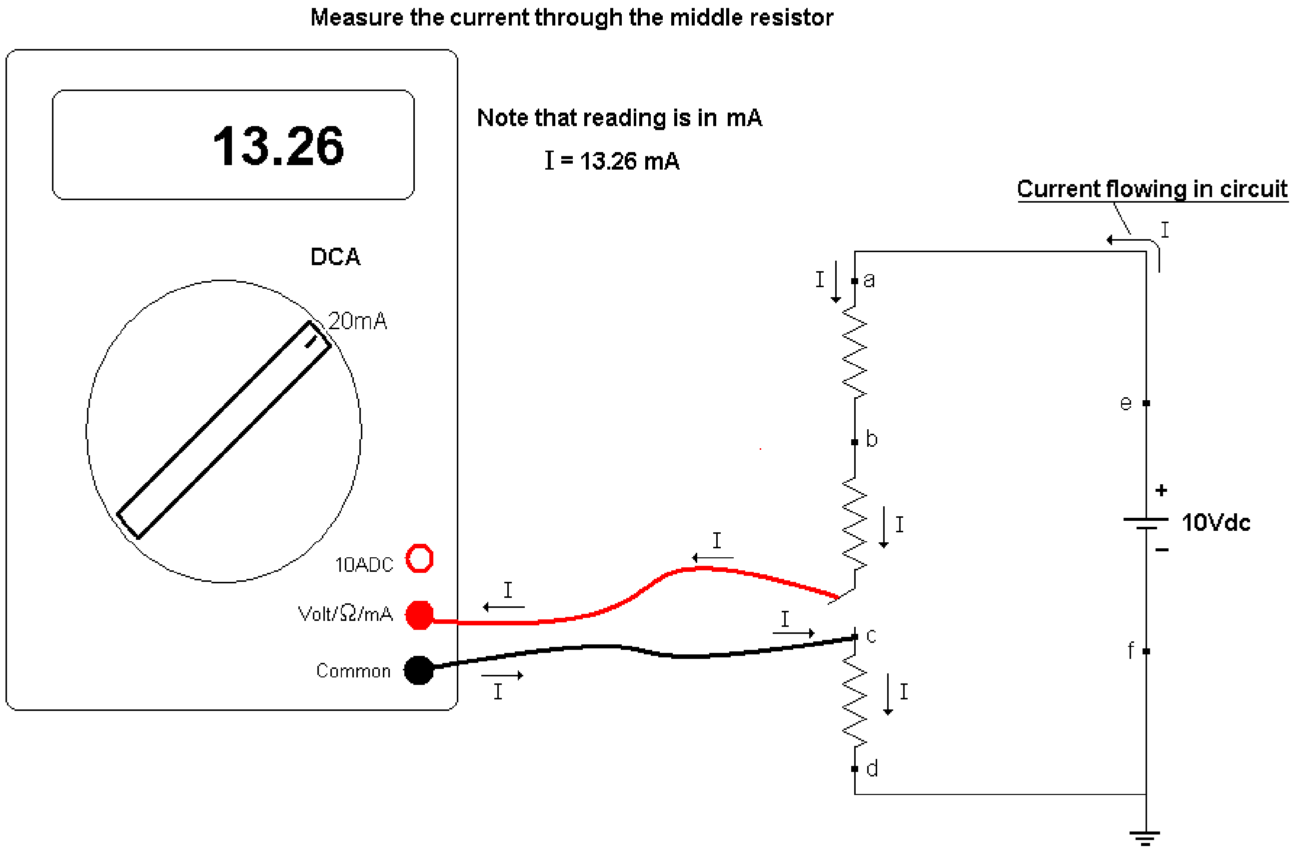


The voltage Vac would be measured by moving the red lead to point a, leaving the black lead on point c. Note that the voltage between points e and f is 10 volts. (Vef = 10V)

Find the points d, f, and the symbol marked "Circuit Ground". They all share the same wire, and therefore the same voltage level. Circuit Ground is a reference point, and its voltage is always 0V. This allows us to refer to the <u>voltage at any point</u> in a circuit by using a single subscript, and the understanding that the <u>second</u> point of reference is <u>Circuit Ground</u> (0V). Then Vef could be written Ve and still refer to the difference in potential between point e and circuit ground. A single subscript voltage is measured by placing the red lead on the point referred to by the subscript, while the black lead is placed at circuit ground. Remember the symbol (⏚), Circuit Ground. It is used to define the 0V reference in circuits we will be using.

Current Measurement

Consider a water meter. All the water that is to be measured must flow through the meter. Current measurement is the same idea. In a complete electric circuit, current flows through devices. In order to measure the current through a device, all of the current that flows through the device must be diverted through a meter. At the same time, the presence of the meter must not affect the operation of the circuit in a measurable way. This requires that the meter act like a piece of wire (zero resistance). In the figure below, the DMM is set to measure the current through the middle resistor. Note that the resistor lead was disconnected from the circuit, the meter connected in such a manner that the current enters the red lead, passes through the meter, and re-enters the circuit through the black lead.

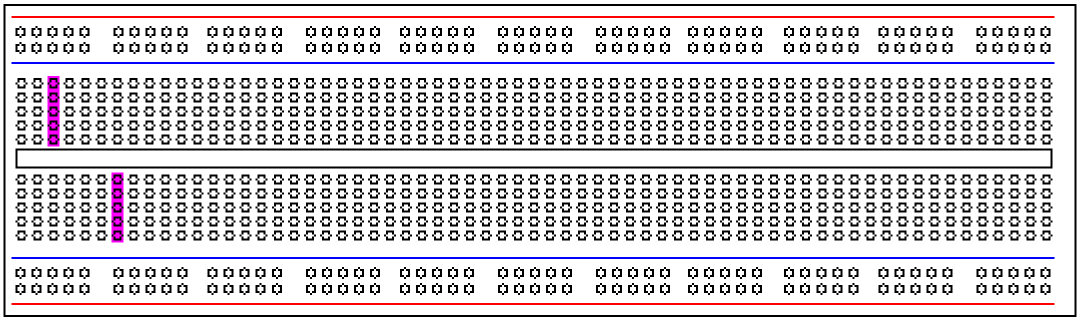


Follow the current (I) around the path of the circuit. It starts at the battery (positive terminal), flows through the first resistor, through the second resistor, then, because the connection was broken there, through the meter, and back into the circuit at point c. The current is measured in the DMM without being affected by the ammeter, and returned to the circuit. The circuit operation is not changed in any way by the presence of the DMM because its internal resistance is very low (ideally = 0).

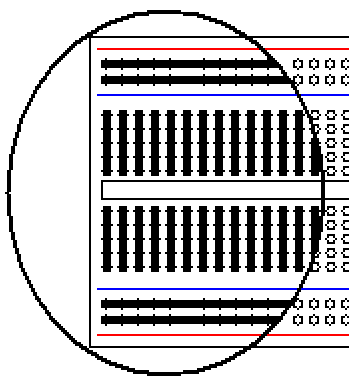
A common error in measuring current is to place the leads across the element. This actually short-circuits (shorts) the device, causing current to flow around, and not through it. The reading is at best no good, and damages the DMM and power supply at worst. Remember that in order to measure the current through a device, ALL the current that passes through it must be diverted through the DMM, and allowed to re-enter the circuit at the point where it normally would flow.

The Proto Board

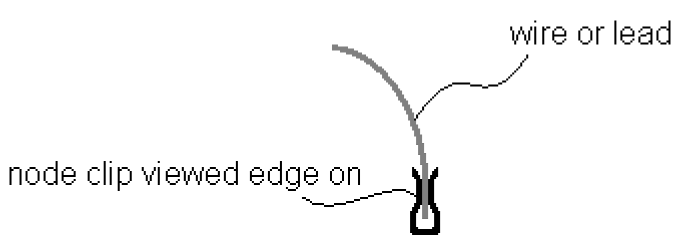
The original method that engineers used to build prototype circuits was to drive nails in a large bread board and connect circuitry up to the nails. This is where the term “breadboard” or build a prototype circuit comes from. The modern breadboard is called a proto board, and makes it very convenient to build, modify, and take apart circuits for testing. The proto board is a set of nodes that are electrically connected, where leads of components can be inserted, and connected to other components. The trick to using the proto board is to recognize the pattern of 5 holes. 5 distinct holes form a node. The 5 holes are electrically connected, but are not connected to any other node. Below is a typical single-set proto board with buss lines.



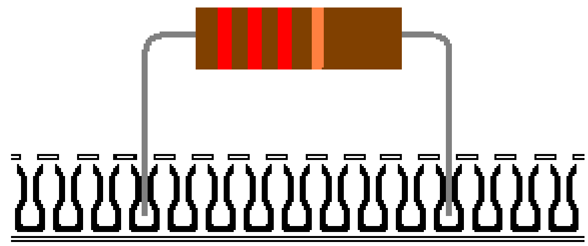
Note that two of the nodes have been shaded in red to show the holes that are common to the node. Up to five leads can be connected together in one of the nodes. The other groups of 5 holes are also nodes. Take a look at the red and blue lines that mark the buss lines. These holes are connected all along the red or blue lines, and are used to carry the supply and return voltages to the circuit being built. If you had x-ray vision, you could see the metal connectors inside the proto board like the illustration below:



Each black line represents a node connection available to connect a lead to. The metal bars inside are made of spring steel plated for a good electrical connection to a copper wire or tinned component lead. Looking at the clip edge on, the shape of it makes it easy to insert or remove a lead to form or break an electrical connection:



Connecting a resistor to the proto board would look like this:



The 2 leads are each connected to separate nodes, and holes next to these leads are available to connect other components to.

Using the proto board, complex circuits can be built and tested. The holes are spaced 0.1” apart. This is the standard dimension that is used to space pins in IC chips. That means the proto board can be used to build and test circuits using PC board Integrated Circuit chips as well. For the purpose of this course, we will be using the proto board with circuits made from individual (discrete) components. The following information will help in the completion of the first lab exercise.

The circuit in Lab 1 is shown here.

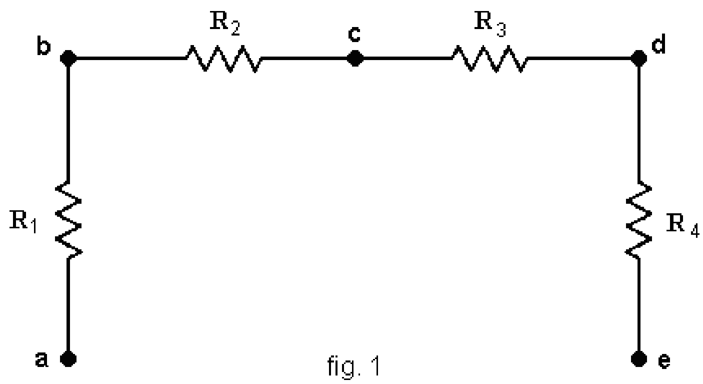
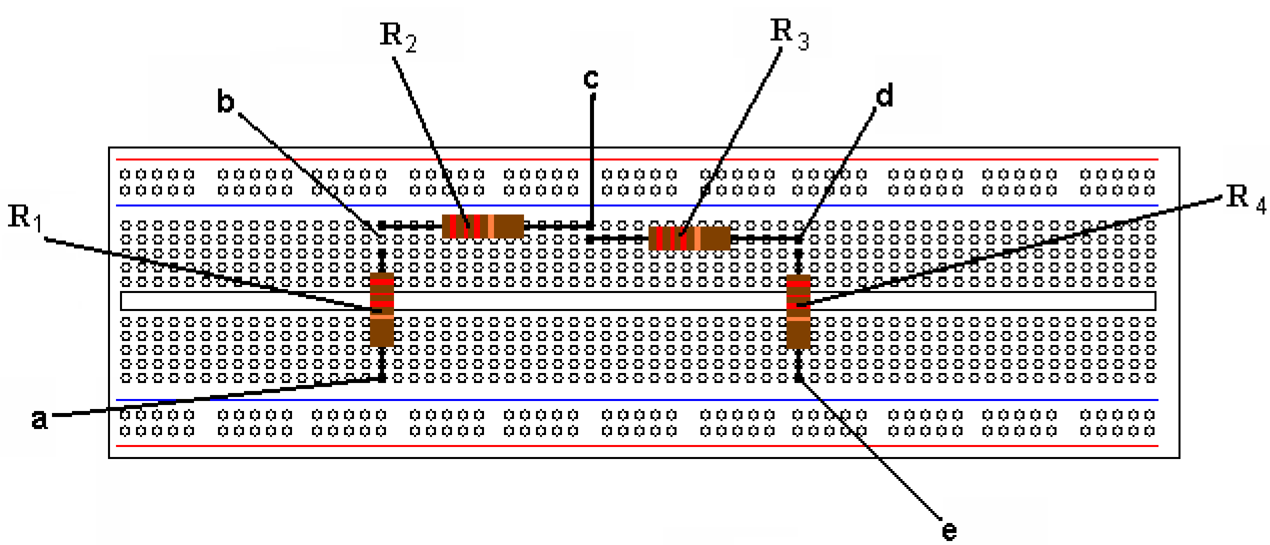


fig. 1

Note the “shape” of the circuit. Whenever building a circuit on the proto board, always build the actual circuit so that it looks like the circuit in the diagram. This will make it much easier to test and troubleshoot the circuit. All the labeled points in the circuit will be apparent in the actual circuit, and the individual components will be easier to recognize and identify. See the diagram below of the circuit as built on the proto board:



Look at the circuit diagram (fig. 1) and at the layout diagram above. See how the components (R_1 to R_4) and labeled test points (a through e) agree in position. This is what makes a test circuit easy to work on.

At this point, you should be prepared to perform Lab #1. Good luck, this is where the fun begins!