4. (Lab #4) Digital Multimeter for DC Voltage and DC Current Measurement

Objective:

To become familiarized with the use of Power Supply (PS) and the Digital Multimeter (DMM).

Introduction:

A Triple Output Power Supply is a DC voltage source. It can provide a constant 0 to +6 volts, a constant 0 to +20 volts, or a 0 to ± 20 volts.

The Digital Multimeter (DMM) on your work station can be used to measure five electric circuit variables: resistance, dc voltage, dc current, ac voltage, and ac current. (It can also measure temperature but we will not use this function in the course.) Make sure to select the appropriate variable to be measured with the DMM first before connecting the test leads to the circuit.

Instrument Description:

DC Power Supply

The DC power supply is used to generate either a constant voltage (CV) or a constant current (CC). That is, it may be used as either a DC voltage source or a DC current source. You will be using it primarily as a voltage source. Recall that DC is an acronym for direct current. DC means constant with respect to time. The voltage produced by a power supply is controlled by a knob labeled voltage. If the power supply allows for current adjustment, current is limited by adjusting the knob labeled current. As long as the circuit does not attempt to draw more current than the value set by the current knob, the voltage will remain constant. Current limiting allows the power supply to be set such that the power supply does not generate more current than desired. This can be useful to prevent damage to equipment and parts which may be unable to handle excessive currents.

Function Generator

The function generator is used to provide voltages that vary with time. It has four primary waveforms: sine, square, triangular and ramp. There are various parameters that can be varied for each waveform, three of them are of particular interest:

1. Peak-to-peak voltage (0-10 V)
2. Frequency (0-15MHz)
3. DC offset

To set any of these features, use the knob labeled with the feature you wish to modify.

Digital Multimeter

The digital multimeter measures voltage, current and resistance. There are separate settings for measuring AC and DC values. If you examine the front panel, you will find primary functions are selected using a multi-position knob. Functions are accessed by selecting the desired measurement. For example, to measure DC voltage, you select the DC V option. To measure DC current, you option DC A (or DC mA). The multimeter also has the capability of measuring other quantities such as resistance. There are three aligned holes (banana jacks) in the multimeter. To measure voltage, place the positive terminal in the hole marked with a +V, with the negative terminal in the GND (or -V) hole. The positive hole is red, and the negative is black. To measure current place the terminal (the terminal at which current enters the multimeter) in the hole labeled A (or mA), and the other terminal in the GND hole. If the multimeter is not autoranging, you need to select the proper range using the knob until you identify the required range (for example: 200mV, 2V, 20V, 200V for a voltage measurement).When the value you are measuring is stable on the display, read the value.

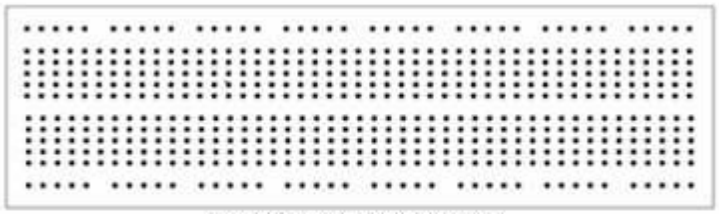
Oscilloscope

An oscilloscope is used to view a voltage waveform on a screen. An electron beam is generated in the cathode ray tube, directed at the back of the screen, and swept in time along the X-Axis. A voltage applied to the scope probes is amplified and applied to a pair of horizontal metal plates through which the electron beam passes. This voltage deflects the beam in the vertical direction (Y-Axis). The sweep in the electron beam combined with vertical deflection results in the appearance of a waveform on the screen of the scope. The scope has two probes: one for Channel 1 and one for Channel 2. The probes are very expensive (approx. $200 each), so please be careful with them. Each channel has a vertical placement knob used to move the waveform for that channel up and down. Each channel also has a knob used to select the vertical scale of the waveform in terms of volts per division. Divisions are the visible grid lines on the oscilloscope screen. The knob used to set the horizontal scale (in time per division) controls both channels.

Some measurements made in this lab can be performed automatically using the Auto-scale feature. When you want to capture a waveform on the screen, the first thing to think of is Autoscale. This takes the waveform at the input and displays it so that the entire peak-to-peak voltage is displayed as well as several periods. However, you must be careful with this feature and make sure the instrument has captured the right waveform you are trying to visualize. To measure voltage, push the button marked voltage which is located to the right of the screen near the top of the front panel. This will bring up a menu at the bottom of the screen, listing available voltage measurements. The first choice is to select either channel 1 or 2 for measurement. After that, you may select: Peak to Peak voltage (Vp-p), average voltage (Vave), or rms voltage (Vrms). By pressing the corresponding softkeys, you will automatically get the selected measurement. For more choices, press the softkey labeled Next Menu. The next menu will allow you to select other voltage measurements. Time measurements can be obtained by pressing the Time button (located next to the voltage button). This will give you the following menu options: Frequency, Period, Duty Cycle, +Width, -Width, Rise Time, Fall Time, Delay and Phase Difference. This last command, Phase Difference, is useful for computing the difference in phase between waveforms on channels 1 and 2.

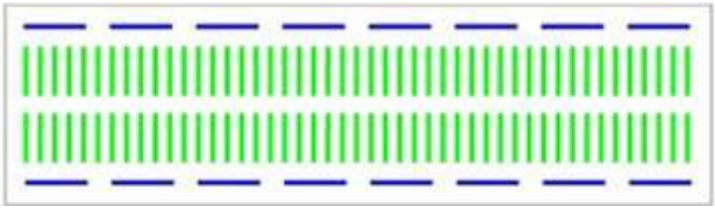
Breadboards/Prototyping boards (Proto-boards)

Solderless breadboards are the most typical option to prototype electronic circuits. A prototype is an initial real implementation of a circuit. It is used to evaluate a design and test actual performance under certain test conditions. Breadboards usually consist of a rectangular plastic enclosure. On the surface of a breadboard, there are many holes for plugging in components (refer to Fig4-1).



[Figure 4-1] Typical Breadboard

The breadboard consists of metal strips running underneath the enclosure as shown in(Fig 4-2). These strips are used as interconnection points (nodes) to build circuits. They can be accessed through the appropriate holes.



[Figure 4-2] Breadboard Internal Connections

The horizontal strips shown in (Fig.4-2) are often used for power supply voltages (i.e. V+, GND) and the vertical strips are for the components.

Procedure:

Discuss with your team how you would go about measuring voltage across and current through a resistor using the multimeter. How would you place the leads? The following hints may be helpful:

1. As a voltmeter, the multimeter must (ideally) have infinite resistance.
2. As an ammeter, the multimeter must (ideally) have zero resistance.

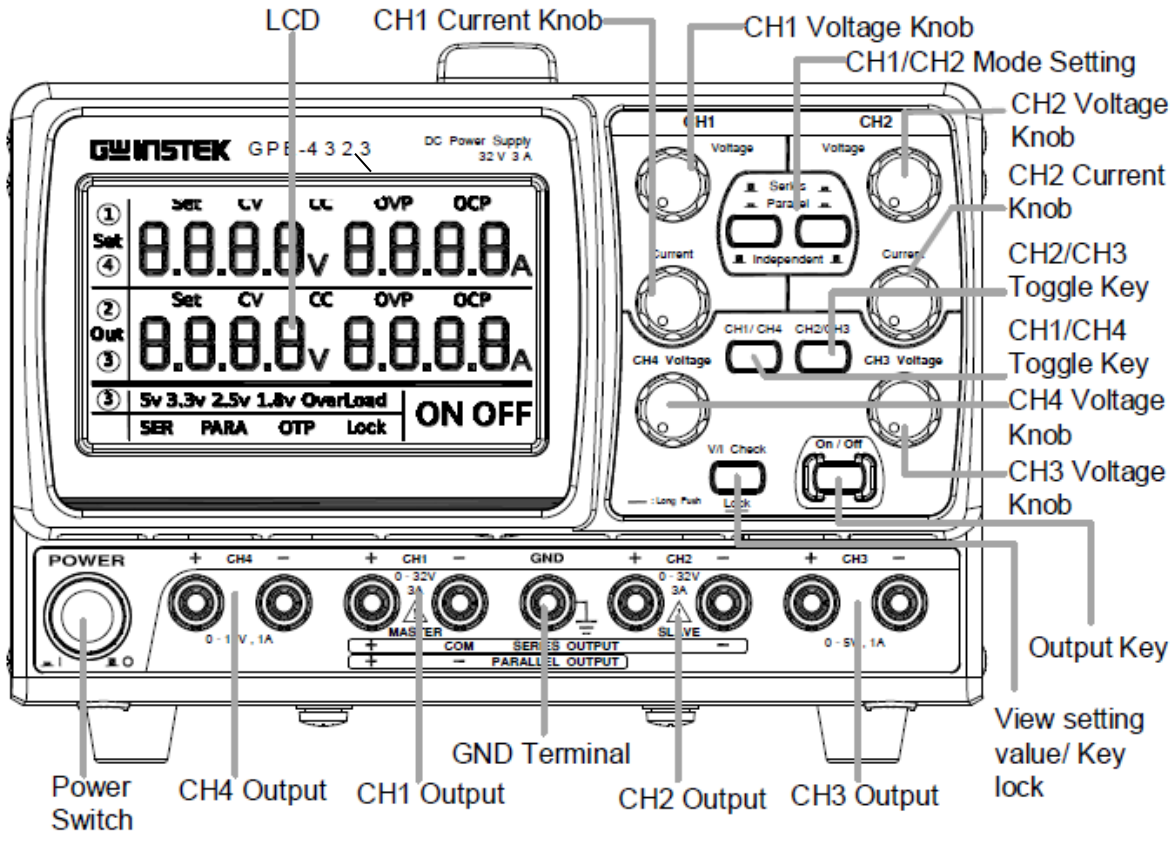
For Enjoy …

Measuring the Resistance of Your Body

1. Holding one probe between the thumb and forefinger of each hand, measure the resistance of your body between your hands. Squeeze the probes tightly so that good contact is established. Record the value of your body's resistance.

2. Considering that a current of 100-200 mA through your heart will almost certainly kill you, how much voltage across your hands would be lethal?

Multi-output DC Power Supply



[Figure 4-3] Front Panel of Power Supply

The GPE 132 6/2323/3323/4323 series regulated DC power supply series are light weight, adjustable, multifunctional work stations. The GPE 1 3 26 has a single independent adjustable voltage output coarse and fine. The remote voltage compensation function is activated f or large changes in current output. The GP E 23 23 has a 2 independent adjustable voltage outputs. The GP E 3 3 23 has three independent outputs: two with adjustable voltage level s and one with fixed level 5V. The GP E 43 2 3 has four independent voltage outputs that are all fully adjustable. The series can be used for logic circuit s where various output voltage or current are needed, and for t racking mode definition systems where plus and minus voltages with insignificant error are required.

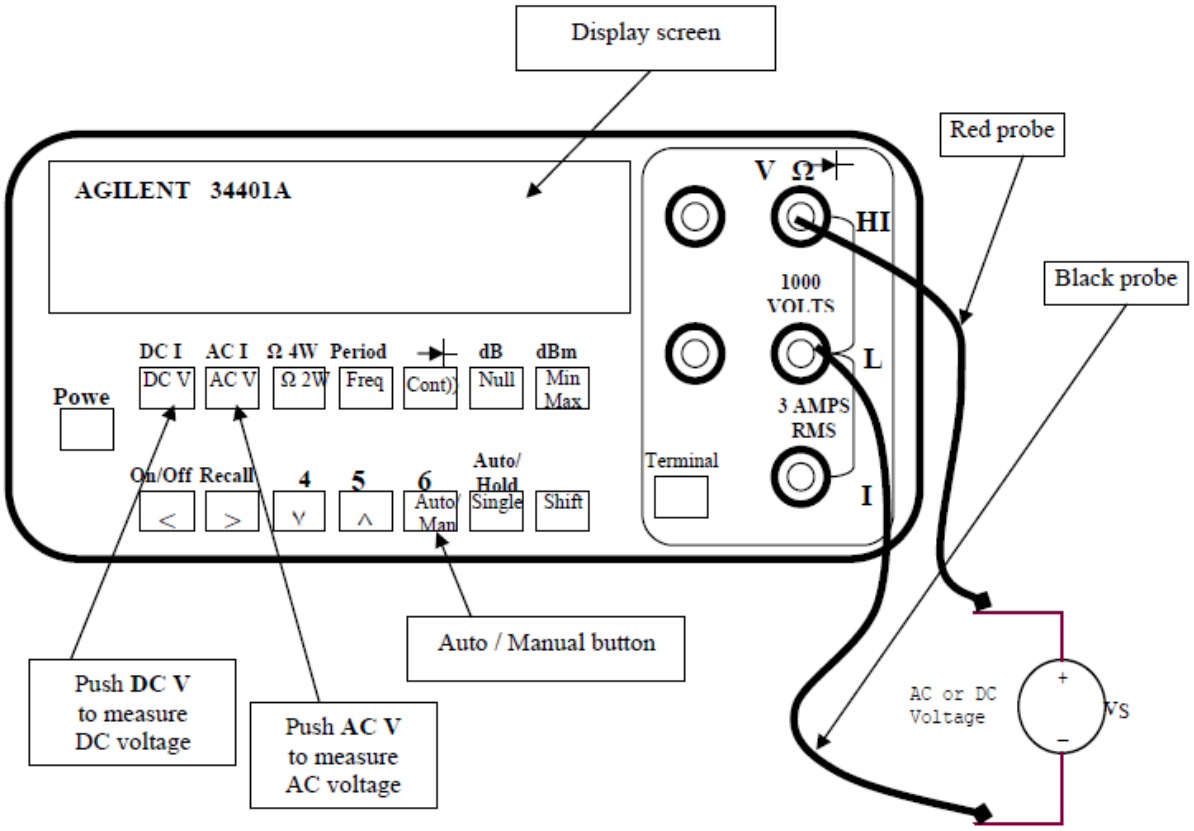
The three output modes of GPE-2323/3323/4323series, independent, series tracking and parallel tracking can be selected through pressing the TRACKING key on the front panel. In the independent mode, the output voltage and current of each channel are controlled separately. In the tracking modes, both theCH1 and CH2 outputs are automatically connected in series or parallel. CH1 is master and CH2 is slave; no need to connect output leads. In the series mode, the output voltage is doubled; in the parallel mode, the output current is doubled. The isolation degree, from output terminal to chassis or from output terminal to output terminal, is 500V

Each output channel works in constant voltage (CV) or constant current (CC) mode. Even at the maximum output current, a fully rated, continuously adjustable output voltage is provided. For a big load, the power supply can be used as a CV source; while for a small load, a CC source. When in the CV mode (independent or tracking mode), output current (overload or short circuit) can be controlled via the front panel. When in the CC mode (independent mode only), the maximum (ceiling) output voltage can be controlled via the front panel. The power supply will automatically cross over from CV to CC operation when the output current reaches the target value. The power supply will automatically cross over from CC to CV when the output voltage reaches the target value.

The front panel display (CH1, CH2) shows the output voltage or current. When operating in the tracking mode, the power supply will automatically connect to the auto-tracking mode.

Tasks for the (Lab #4): Digital Multimeter for DC Voltage and DC Current Measurement

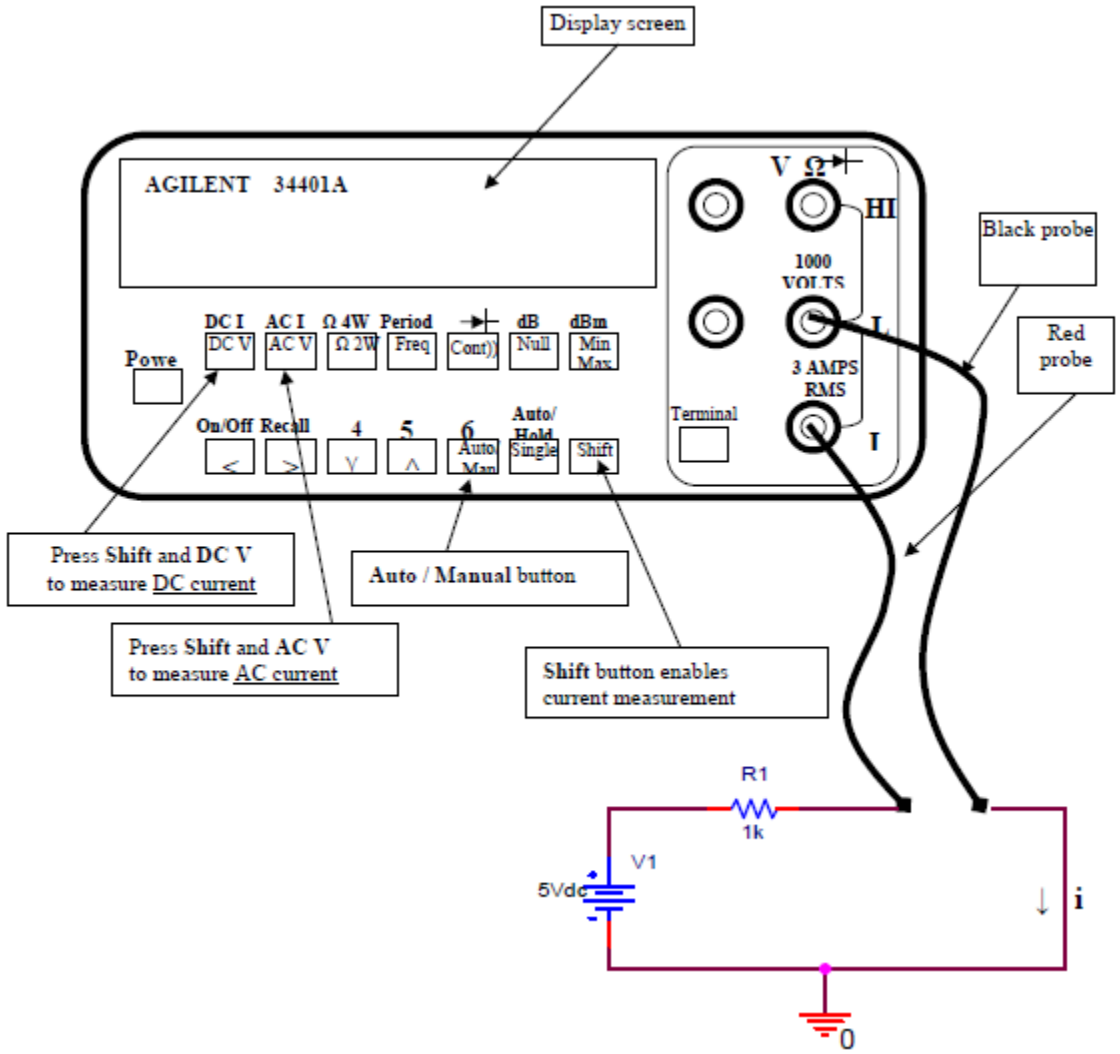
1) Measuring Voltage



[Figure 4-4] Using Multimeter to Measure Voltage

- Plug the red probe into the red terminal VΩ labeled HI and the black probe into the black terminal labeled LO.
- Make sure Terminals button is set to the “Out” position for front connecting terminals.
- Press DC V button to measure DC voltage (or press AC V button to measure AC voltage).
- Press Auto / Man button so that the “Man” disappears from the display; the automatic mode is now in effect.
- Measure the power source with the probes, then view the voltage measurement on the display screen.

2) Measuring Current



[Figure 4-5] Using Multimeter To Measure Current

CAUTION:

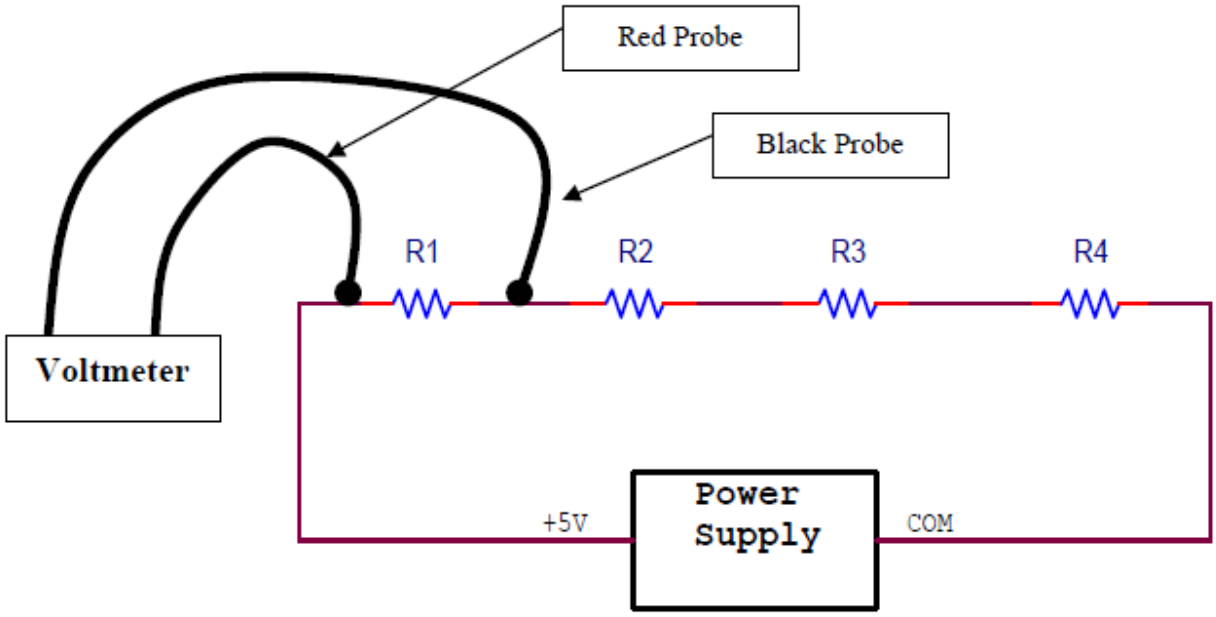
For current measurements, the probes must be in series with the load only and current limited to less than 3 amps. If the circuit draws 3 amps or more, a fuse will blow and disable the instrument.

- Insert the black probe into the black terminal labeled LO; then insert the red probe into the red terminal labeled I (at the bottom of the right-hand corner) for current measurements.
- Make sure Terminals button is set to the "Out" position for front connecting terminals.
- Press the Shift button and the DC V button to measure DC current.

- Press the Shift button and the AC V button to measure AC current.
- Press Auto / Man button so that the “Man” disappears from the display; the automatic mode is now in effect.
- Measure the current with probes in series with the load; then view the current measurement on the display screen.

3) DC Voltage Measurements

1. Set up the DMM to measure dc voltage. Without connecting the test leads to anything, what is displayed on the DMM? Why? Connect the two test leads together, what is the reading? Why?
2. Connect R1, R2, R3, and R4 in series as shown in Fig(4-6).



[Figure 4-6] Using Multimeter to Measure Voltage in Series Resistors

3. Measure the voltage drop across R1 with the red probe on the +5V side and the black probe between R1 and R2. What is the voltage reading? Now exchange the red and black probe. What is the voltage reading? Comment. The conventional approach is to use the black probe so that it is “closest” to the COM (which is the “ground” reference of the circuit), and to use the red probe so that it is “closest” to the Voltage source (+5 volts in this circuit).
4. Measure the voltage drop across the remaining resistors R2, R3, and R4. What is the sum of the voltage drops? Comment.

5. Knowing the voltage drop across each resistor, use Ohm's Law to calculate the current through each resistor. Comment.

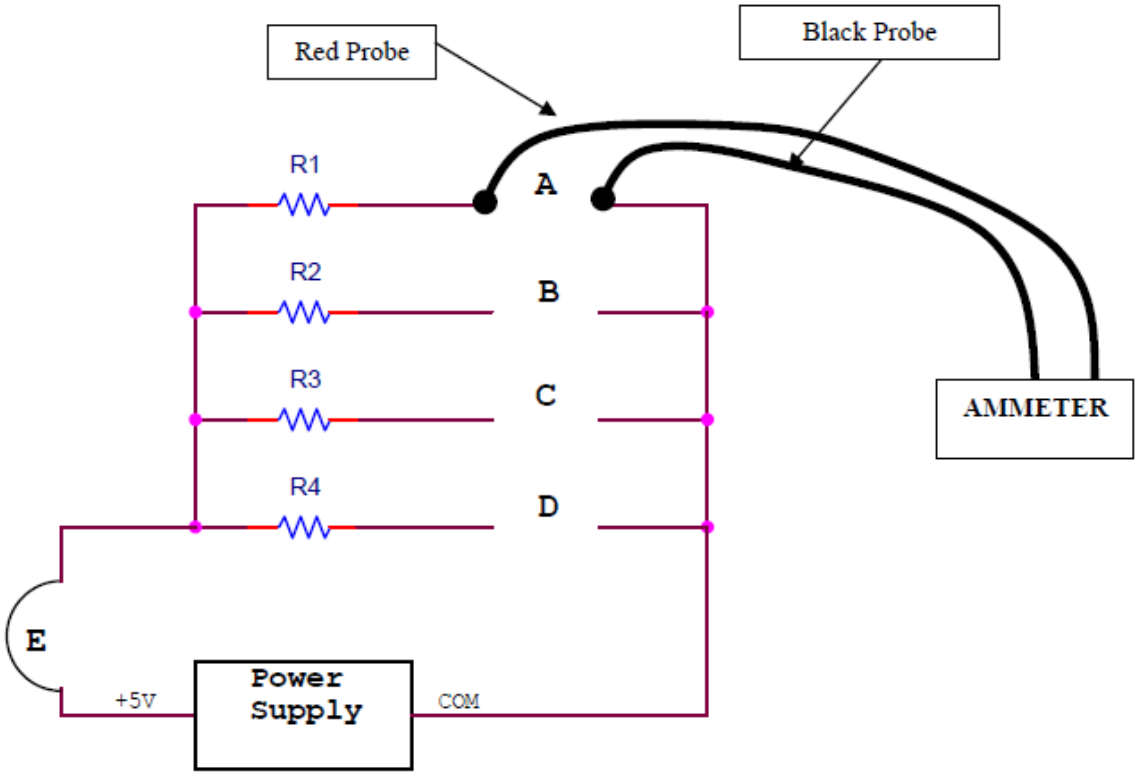
6. Using the sum of the voltage drops across the resistors and the sum of the resistors, use Ohm's Law to calculate the current. Comment.

4) DC Current Measurements

1. Set up the DMM to measure dc current. Without connecting the test leads to anything, what is displayed on the DMM? Why? Connect the two test leads together, what is the reading? Why?

2. Set up the parallel circuit. Adjust the output of the power supply to 5 V. Place R1, R2, R3, and R4 in parallel as shown and open connections across A, B, C, and D. Connect across point E.

3. Place an ammeter across A to measure the current through R1. What is the current reading? Exchange the probes across point A. What is the current reading? Comment.



[Figure 4-7] Using Multimeter to Measure Current in Parallel Resistors

4. Measure the current through the remaining resistors R2, R3, and R4. What is the sum of the currents through R1 to R4? Comment.

5. Knowing the current through each resistor, use Ohm's Law to calculate the voltage drop across each resistor. Comment.

6. Complete the connection across points A, B, C, and D and disconnect the connection at point E. Measure the current through point E. How does it compare with the sum of the currents through the resistors?