BasicMeasurements

Breadboard

Circuits in this course will be built on breadboards. It is imperative to know the topology of the breadboard. Buses are available to connect components together. Any doubt should be resolved with the digital multimeter (DMM) configured to measure resistance. Determine which rows and columns of holes are electrically common.

Resistance Measurement

The resistors used in this course are 1/4 Watt 5% resistors. They have a color code which indicates the nominal value of the resistance. This means that if the resistance were a random variable the mean would be the nominal value indicated by the color code with the standard deviation being 5% of the nominal value. Another definition model the resistor values as a random variable having a mean equal to the nominal value and a uniform distribution from 0.95 to 1.05 of the nominal value. In either case the actual value of the resistance should be close to the nominal value. There are 1% and 0.1% resistors but such precision is not need for basic lab courses.

Color codes for 5% resistors can be found at many web locations such as (use the 4 band model)

http://www.resistorguide.com/resistor-color-code-calculator/

Obtain the following resistors.

	R1	R2	R3	R4	R5	R6
Nominal	1 kΩ	2 kΩ	5.1 kΩ	3.3 kΩ	1.2 kΩ	10 MΩ
Measured						

Table 1

Configure the DMM to measure resistance. Push the button $2W\Omega$.Connect leads with banana plugs on both ends. One end goes in the banana jack on the DMM in the upper right. The other should be connected to an alligator clip and then the small hook up wire should be connected to the alligator clip. (Fig 1) These will be the probes for the Ohmmeter. Measure and record the actual resistance of each of the resistances in the above table.

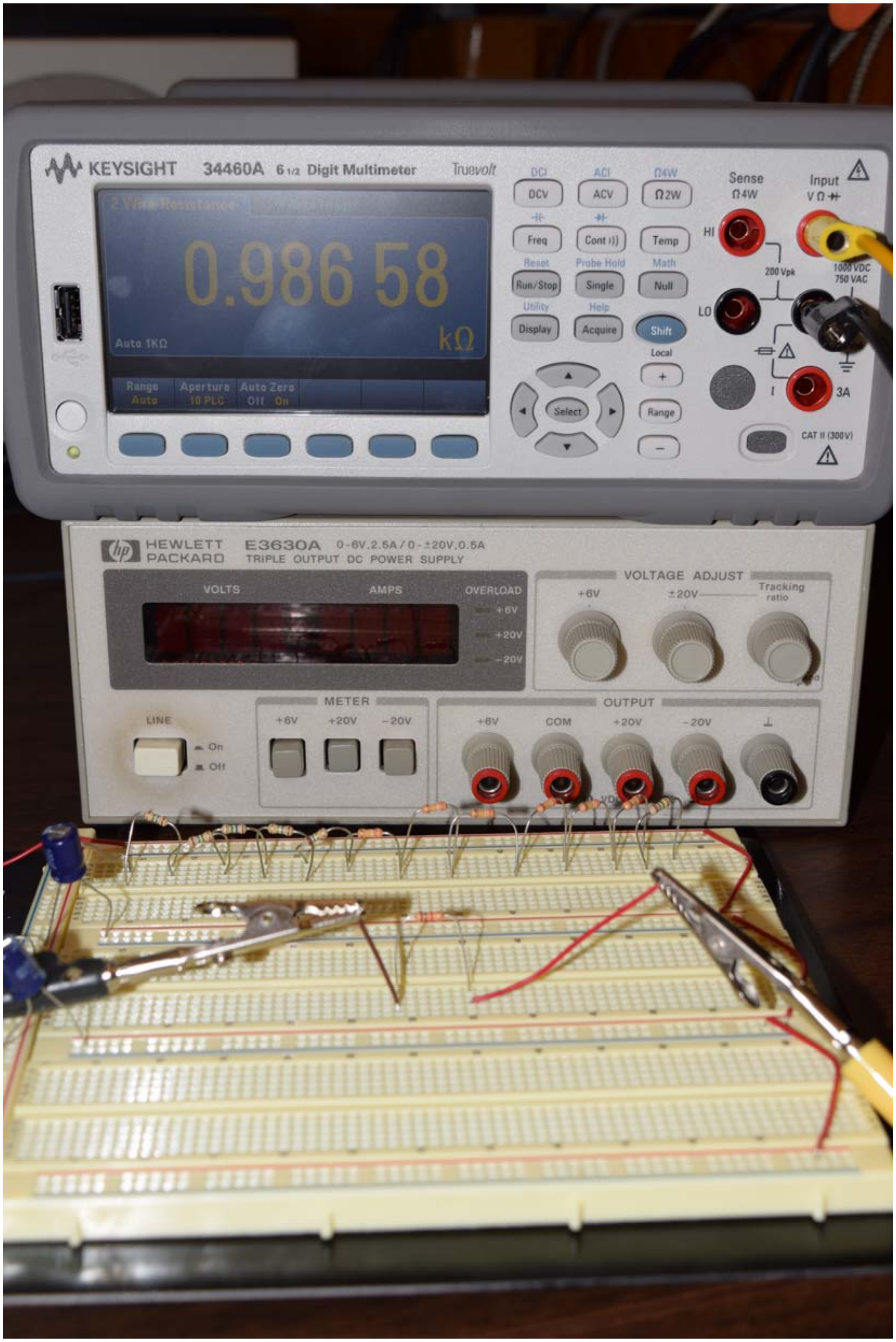

Fig 1. Measurement of Resistance with DMM

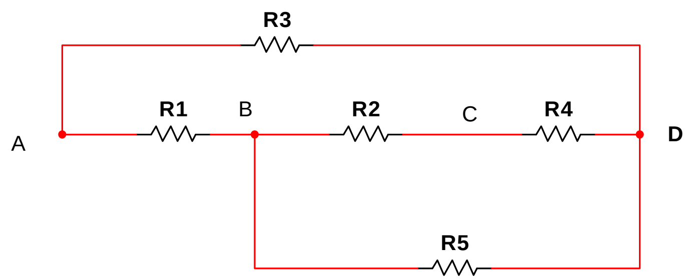

Figure 2 Resistive Network

Assemble the resistive network shown in Fig. 2. Measure and record the resistances shown in Table 2 with the DMM.

	R_{AB}	R_{BC}	R_{CD}	R_{AD}	R_{BD}	R_{AC}
Expected						
Measured						

Table 2

Voltage Measurement

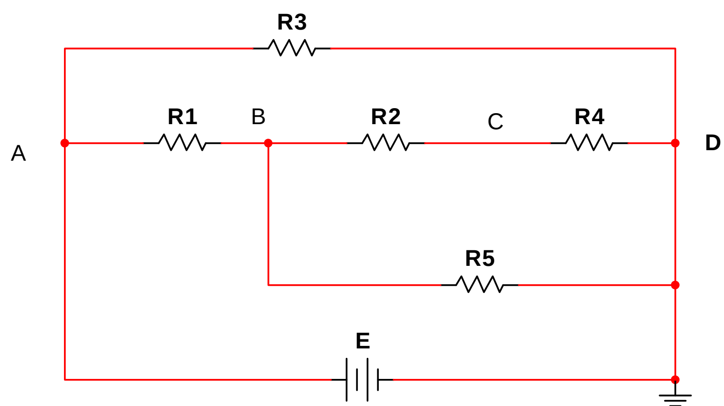

Fig 3. Voltage Network

Assemble the circuit shown in Fig. 3. The dc voltage source is obtained from the dc power supply. The common terminal is taken a 0 V.The ground symbol is used to indicate the voltage taken as 0 V.The positive terminal on the DC source (the one on the left) is obtained from the variable $0 - 20$ V.Voltages are measured with the DMM using the same terminals as the measurement of resistance. The leads are placed across the element for which the voltage is being measured. Push the button that says DCV on the DMM. Use the DMM to measure the dc voltage V_{AD}.Adjust the dc power supply until the voltage is 10 V.Measure the voltages shown in Table 3. Measure the dc currents flowing from left to right in the resistors by dividing the voltage measured across the resistor by the resistor values (use the measured value of these resistors) and record in Table 4.

	V_{AB}	V_{BC}	V_{CD}	V_{CD}	V_{BD}	V_{AC}
Expected						
Measured						

Table 3

	I_1	I_2	I_3	I_4	I_5
Expected					
Measured					

Table 4

Current Measurement with Ammeter

Currents may also be measured with an ammeter. The ammeter is always placed in series with the element for which the current is desired. Turn the dc power supply off. Assemble the circuit shown in Fig. 4. Remove the wire from the right side of R_5 and insert the ammeter is placed of the wire. The terminals on the DMM for configuration as an ammeter are the common terminal and the terminal on the lower right. Configure the DMM as an ammeter by pressing the button DCI. Turn the dc power supply on. Measure and record the current flowing from left to right in the resistor R_5. Measure and record the current in R_5.The ammeter inputs are fused. If the no current is measured the fuse may be blown.

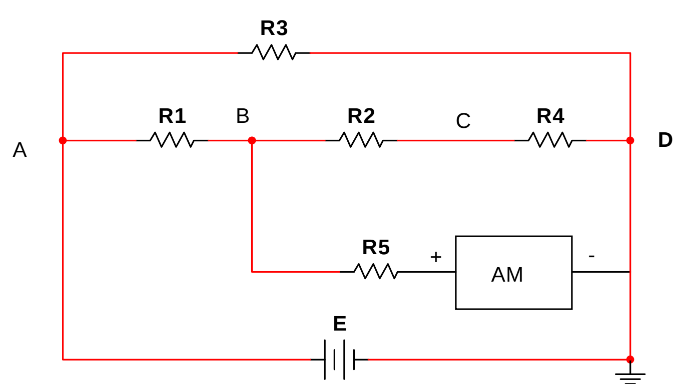

Fig. 4. Measurement of Current with Ammeter

$I_5 =$ ____________________

Thevenin Theorem

Thevenin's Theorem states that the circuit external to any element in a linear circuit may be replaced with the Thevenin Equivalent circuit with respect to that element and the voltages and currents associated with the element will be unaltered. The Thevenin Equivalent circuit is an impedance in series with a voltage source. The voltage source is the value of the voltage across other terminals where the element was located after it is removed and the impedance is that found between the terminals with the sources nulled and the element removed.

Determine the Thevenin equivalent circuit in Fig. 3 with respect to the element R_4.Remove the element R_4 from the circuit and determine the voltage V_{CD};this is E_{th}.With the resistor R_4 removed replace the voltage source with a short circuit and determine the resistance between terminals C and D; this is the Thevenin equivalent resistance, $R_{CD} = R_{th}$. Use the values measured for the resistors rather than the nominal values. Assemble the circuit shown in Fig. 5. Use a $10\,\mathrm{k}\Omega$ pot (potentiometer) for R_{th}.

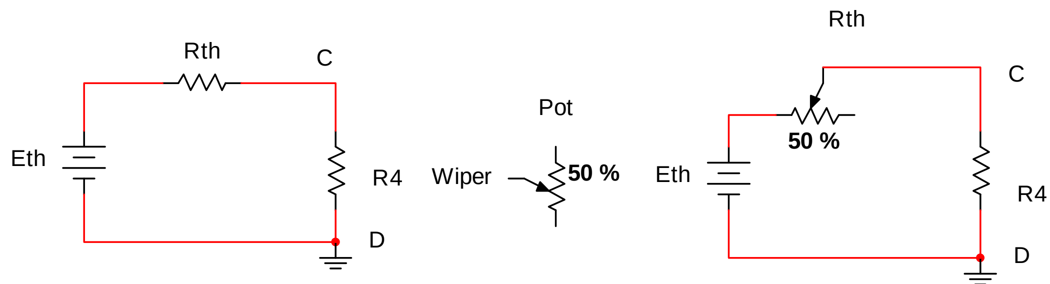

Fig. 5. Thevenin Circuit

The pot is a 3 terminal device. If it is a $10\,\mathrm{k}\Omega$ pot the resistance from the two extreme terminals is $10\,\mathrm{k}\Omega$.The position of the wiper is varied with a small screwdriver called a trim pot. If the wiper is positioned at the half way position (50%) the resistance from the wiper to either side would be $5\,\mathrm{k}\Omega$. Adjust the value of the dc power supply to E_{th}. With the pot not in the circuit use the DMM to set the resistance from the wiper to the side that will be connected to E_{th} to R_{th}.With the circuit complete measure and record the dc voltage V_{CD}.

$V_{CD} =$ ____________________

VOLTMETER LOADING

Assemble the circuit shown in Fig. 6. The $10\,\mathrm{M}\Omega$ resistor in placed in series with the positive lead of the voltmeter. The resistance R_{in} is the input impedance of the voltmeter for the measurement of dc voltages; it is an internal resistance and an intrinsic part of the voltmeter and not a resistor placed on the breadboard. The voltage that will be measured by the voltmeter is V. Set the dc power supply, E, to $10\,\mathrm{V}$, DMM to measure dc voltage and measure and record the value of the voltage V; if it has an input impedance that can be varied set it to $10\,\mathrm{M}\Omega$.The voltage V will differ from E because the input impedance of the voltmeter is not infinite. Compute the value of the input impedance for the measurement of dc voltages to confirm that it is reasonably close to $10\,\mathrm{M}\Omega$.

DC

$V =$ ____________________ $R_{in} =$ ____________________

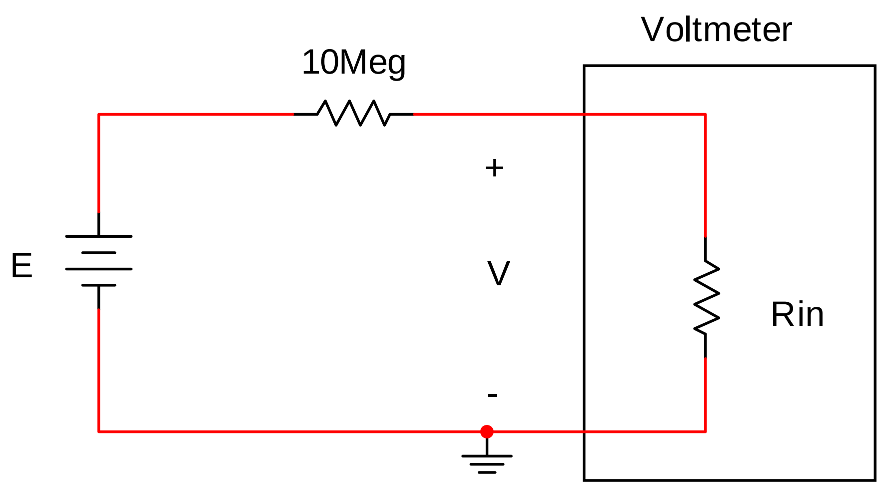

Fig 6. DC Voltmeter Loading

Turn the dc power supply off and place a function generator where it was. Set the function generator to produce a sine wave with a frequency of 1 kHz and an amplitude of 5 Vrms. Set the function generator output for HI Z. Set the DMM to measure AC voltage and repeat the above.

AC

$V =$ ____________________ $R_{in} =$ ____________________