

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
22.071/6.071 Introduction to Electronics, Signals and Measurement
Spring 2006

Lab5. Resistor Networks 1.

Experiment 1. Learning about resistors.

The table below gives the color code for assigning resistance values to resistors.

Resistor Color Code				
Value			Tolerance	
Color	Numerical Value		Color	Tolerance
Black	0			
Brown	1			
Red	2		Gold	±5%
Orange	3		Silver	±10%
Yellow	4		No Band	±20%
Green	5			
Blue	6			
Violet	7			
Gray	8			
White	9			

The procedure for reading the resistor values is:

- First find the tolerance band (gold 5%, silver 10%, no band 20%)
- Starting from the other end, identify the first band - write down the number associated with that color. If for example the color is Brown the corresponding number is 1.
- Now identify the next color. If the color is Black the number is 0. So far we have the number 10 in our example.
- The color of the third band gives the multiplier. If the color is orange the multiplier is 1000 (10^3)
- So the resistor value is 10,000 Ω or 10 k Ω .

Complete the following exercises.

A. Find the resistor value for the following color schemes:

- 1) First band: Red
Second band: Black
Third band: Orange
Fourth band: Silver

Value= _____

- 2) First band: Brown
Second band: Black
Third band: Brown
Fourth band: Gold

Value= _____

- 3) First band: Red
Second band: Black
Third band: Green
Fourth band: None

Value= _____

- 4) Unfold the color code for a resistor with value $4.7\text{k}\Omega$ 5%
First band:
Second band:
Third band:
Fourth band:

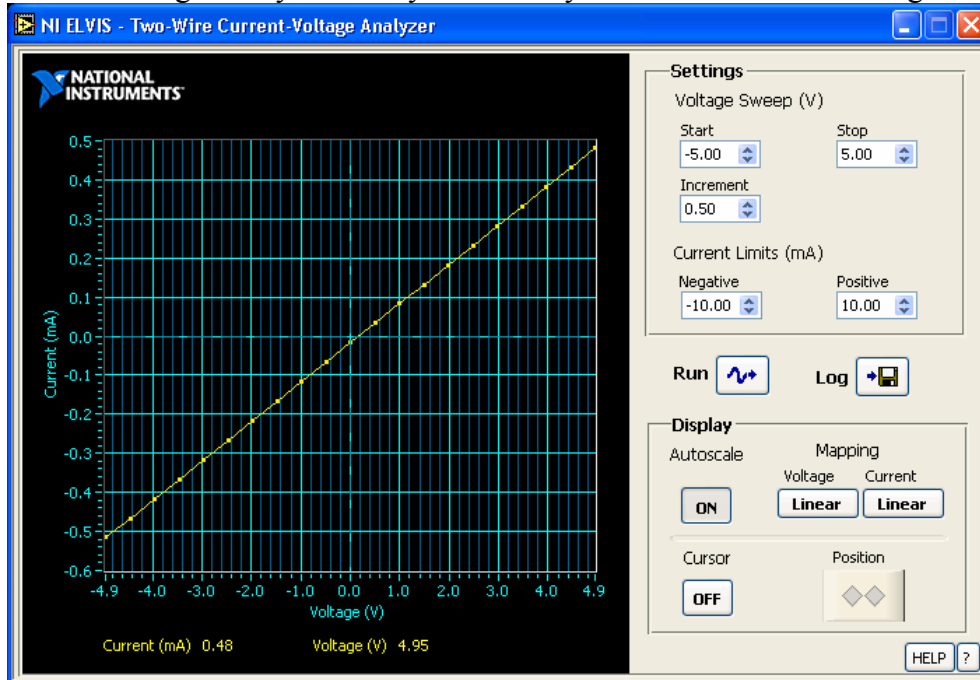
Identify the resistors provided for today's experiments and set them aside in preparation for the following exercises.

Experiment 2. i-v characteristic of a resistor

In general the i-v characteristic of devices is one of the most important tools in understanding their behavior.

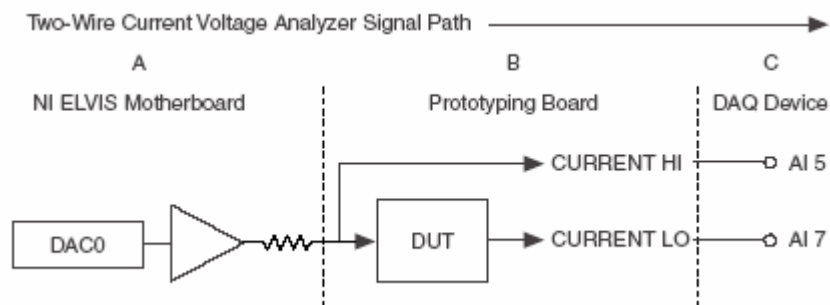
From Ohm's law, $V = IR$, we see that in the I-V space the resistor is represented with a straight line of slope $\frac{1}{R}$.

We will do this experiment with the ELVIS system. Start ELVIS and select the "Two Wire Current-Voltage Analyzer". On your screen you now have the following:

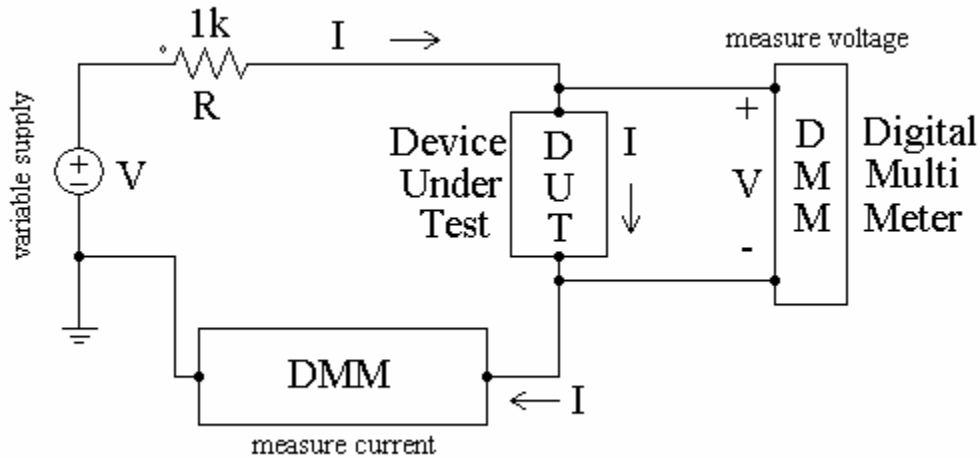


Courtesy of National Instruments. Used with permission.

In our case the Device Under Test (DUT) is a resistor. In the following diagram you see a block diagram representation of the i-v instrument.



In a more simplified representation, with the measurement performed manually with a voltmeter, the block diagram of the instrument would look like:



Connect a $1\text{k}\Omega$ resistor to the pins labeled CURRENT HI and CURRENT LO of your protoboard.

Define the voltage and current range of interest and run the instrument. You may also store the data by pressing on the Log button.

Perform the same experiment for the following resistors: $1\text{k}\Omega$, $10\text{k}\Omega$, and $100\text{k}\Omega$. Record your results.

Resistor Value	Measured Value	Difference
$1\text{k}\Omega$		
$10\text{k}\Omega$		
$100\text{k}\Omega$		

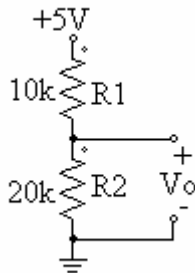
Ideally, the system should be calibrated so that there is no offset (bias voltage or current) in the measurement. Do you detect an offset ($I \neq 0$, when $V = 0$) in your measurement?

Determine the value for this offset and record it. You may record this as voltage at $I=0$ or equivalently as current for $V=0$.

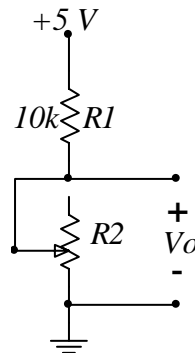
Experiment 3.

Voltage Divider Resistor Network.

Let's build the following circuit on our protoboard. The value 10k implies 10,000 Ω , 20k = 20,000 Ω , etc.

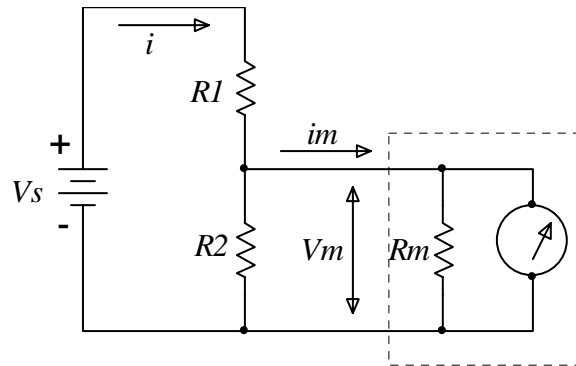


Measure the voltage V_o with your DMM. Replace resistor R2 with a potentiometer (variable resistor) and observe the change in V_o as you trim (change the value of) the potentiometer. The electronic schematic now looks like:



In the next set of experiments we will explore the effect of the measuring device characteristics on the measurement itself. The circuit below shows a voltage divider circuit and a voltage measuring device enclosed by the dotted rectangle that is used to measure the voltage across resistor R_2 .

The voltmeter (enclosed by the dotted box in the figure below) is modeled as having an internal resistance R_m .



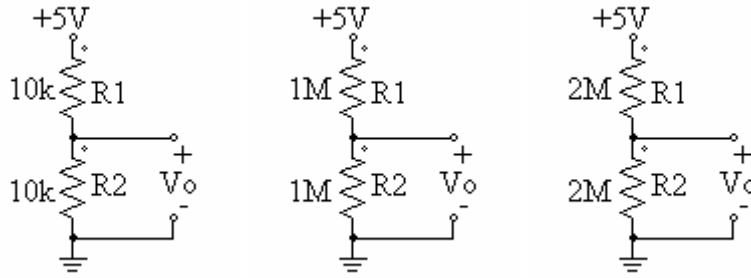
We know that if $R_m \rightarrow \infty$ then the voltage across R_2 is: $V_m = V_s \frac{R_2}{R_1 + R_2}$

If R_m is finite, then there is an amount of current i_m flowing into the voltmeter. This current is proportional to the ratio $\frac{R_2}{R_2 + R_m}$

Calculate the value of V_m when R_m is finite

Calculate V_m when $R_1 = R_2 = R_m = R$

Now let's construct the following circuits and use our voltmeter to measure the voltage V_o as indicated.



Measure the voltage V_o and record the result for the three cases.

R1, R2	V_o (Volts) Expected	V_o (Volts) Measured
10k		
1M		
2M		

Explain the results.

From the data you have just obtained estimate the internal resistance of the voltmeter you are using.

Experiment 4. Power rating of resistors.

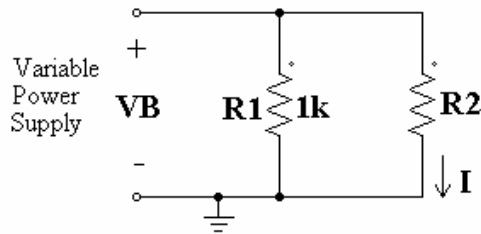
Power rating is a very important characteristic of electronic devices. These devices may be complex electronic systems or simple electronic components such as resistors. In your lab kit you have a set of resistors which are rated for $\frac{1}{4}$ Watt.

Explain briefly the meaning and importance of this rating.

Draw the i-v space and indicate the region inside which you are able to safely operate your $\frac{1}{4}$ Watt resistors.

We will next experiment with our resistors to see what actually happens when the stated power rating is exceeded.

Lets construct the circuit shown below.



Resistors R1 and R2 form a current divider network. We will experiment with resistor R2 to determine the minimum resistance that it can have without violating the power rating. Violation of the power rating will simply result in the destruction of the component. (Be careful here. The resistor will get very hot and it will eventually burn with a very characteristic odor)

Set the voltage VB to 5 Volts. Experiment and complete the table below. Start with R2=1k and decrease it until you violate the power rating. (a set of test resistors could be 1k Ω , 100 Ω , 10 Ω , 5 Ω) It is expected that you destroy at least one resistor in this experiment.

R2 (Ω)	I2 (mA) Calculated	Power (W) in R2 Calculated	Observation