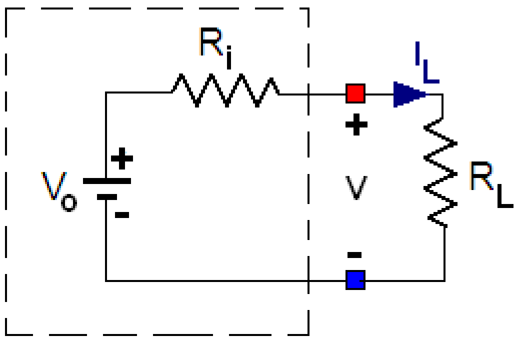
Electronics Lab

Sources and Thevenin

First Experiment: An ideal voltage source will always give you a constant output voltage independent of other parameters like the load current or load resistance.
Real sources, like batteries, give you a voltage that is less and less for larger and larger load currents. This behavior can be modeled with two components: an ideal voltage source in series with an internal resistor:

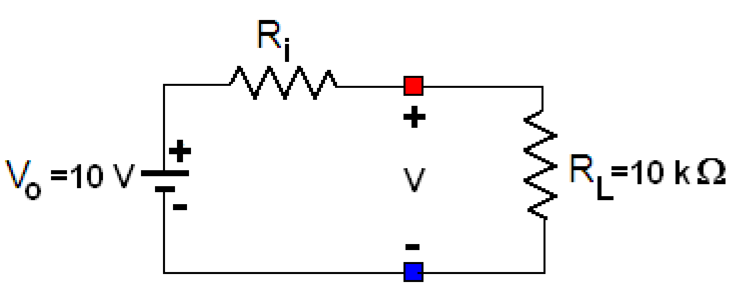


In this case the voltage at the terminals is given by: $V = R_L I_L = V_o - R_i I_L$
You can also calculate the voltage at the terminals using the voltage divider rule. It goes like this: the ideal voltage is divided among the two resistors R_i and R_L proportionally to the values of the resistors, so:

$$V = V_o\left(\frac{R_L}{R_L + R_i}\right) = \frac{V_o}{1 + R_i/R_L}$$

This last equation tells you explicitly that the output voltage will be lower than the internal ideal voltage.

Procedure: Set the following circuit using the regulated power supply as the ideal voltage source:

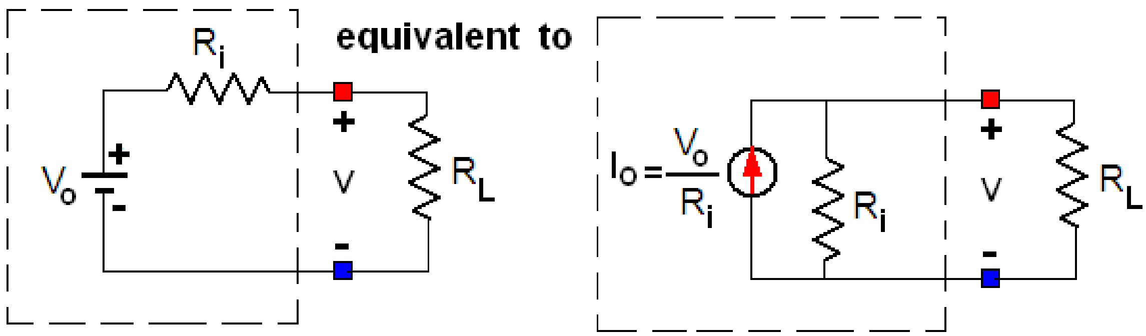


Make sure that the output of the power supply is 10V (the display in front of the P.S. is only a rough indication, use the multimeter for a more precise reading).
For the internal resistor use 10Ω, 47Ω, 100Ω, 470Ω, 1kΩ, 4.7kΩ and 10kΩ.

In each case calculate the expected output voltage and measure it.

In which cases can you consider this to be a "stiff" voltage source?

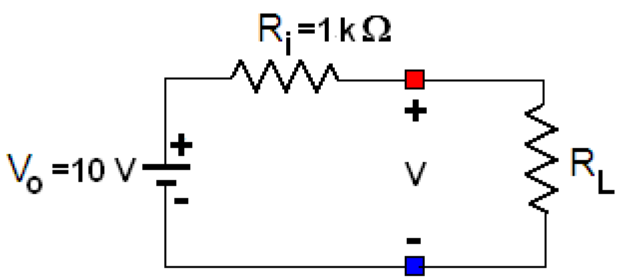
Second Experiment: An ideal current source will always give you a constant current output independent of the load resistance (or load voltage).
To generate a real source that behaves like a current source you could use a voltage source in series with a large resistor as shown in the following schematic:



In this case, the current flowing through the load resistor can be calculated with the current divider rule. It goes like this: the ideal current is divided between the two resistors R_i and R_L inversely proportional to the values of the resistors, so:

$$I_L = I_o \left(\frac{1/R_L}{1/R_L + 1/R_i} \right) = \frac{I_o}{1 + R_L/R_i}$$

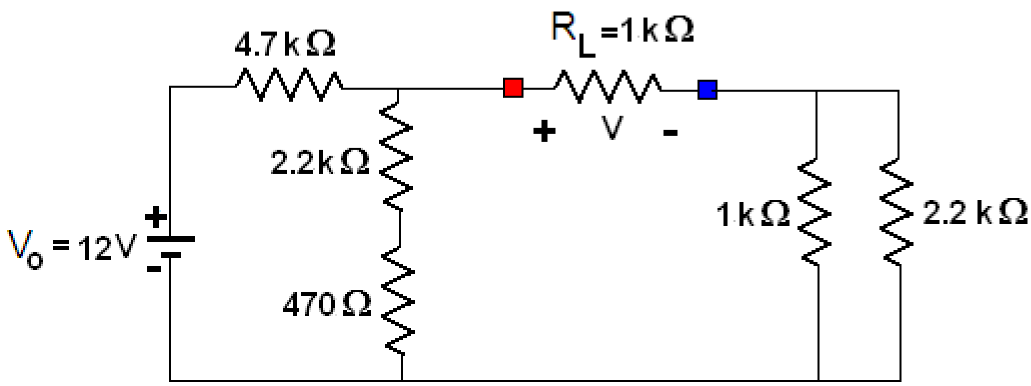
Procedure: Set the following circuit using the regulated power supply as the ideal voltage source:



This circuit will behave like a 10mA current source with an internal resistance of 1kΩ.
Calculate and measure the expected current for load resistors of 0Ω (short circuit), 10Ω, 47Ω, 100Ω, 470Ω and 1kΩ.

Third Experiment: We are going to examine Thevenin's theorem in a real circuit. We will calculate and measure the voltage and resistance in the model and we will use this information to test the validity of the model under a load resistance.

Procedure: Set the following circuit using the regulated power supply as the voltage source:



Calculate the Thevenin voltage and resistance from the point of view of the load resistance. In your calculations use the actual values of the resistors with 3 significant figures, not the nominal values.

Measure the Thevenin voltage by opening the load resistor and using a digital multimeter. The high internal resistance of the instrument will not affect the reading very much.

To measure the Thevenin resistance remove the 12V-voltage source and replace it with a short circuit, then you can use the multimeter to measure the resistance directly across the output terminals.

With the values of the model predict the voltage output with the load resistor in place and compare to the measured value.

Match load method: We are going to estimate the value of the Thevenin resistance by matching the internal resistance with an external variable one. To do this replace the load resistance with a potentiometer and vary its resistance until you get one half of the Thevenin voltage, disconnect the potentiometer and measure its resistance. It should match your previous measurement.

Application of the Match load method: Use the method that you just learned to find the internal resistance of the function generator. To do this select an output of 2V with the circuit open and then connect a potentiometer to vary the load resistance until you get 1V, then measure the resistance of the potentiometer.