

2.4: Non-Ideal Power Sources

Overview:

Though many theoretical models of electrical circuits assume that power supplies are ideal, actual circuit implementations can depend upon non-ideal limitations of the power supplies. In this lab assignment, we will experimentally explore the behavior of non-ideal power sources. The experiments in this assignment illustrate some of the effects of non-ideal power supplies.

Before beginning this lab, you should be able to:

- State Ohm's law
- Determine the equivalent resistance of series and parallel resistive networks
- State the voltage divider and current divider formulae
- Use a digital multimeter to measure resistance, voltage, and current
- Use the Analog Discovery's waveform generator to apply constant voltages
- Use the Analog Discovery voltmeter to measure a constant voltage
- Model non-ideal sources

After completing this lab, you should be able to:

- Estimate the internal resistance of a non-ideal power supply
- Describe qualitatively, the effects of power supply internal resistances

This lab exercise requires:

- Analog Discovery module
- Digilent Analog Parts Kit
- Digital multimeter

Symbol Key:

	Demonstrate circuit operation to teaching assistant; teaching assistant should initial lab notebook and grade sheet, indicating that circuit operation is acceptable.
	Analysis; include principle results of analysis in laboratory report.
	Numerical simulation (using PSPICE or MATLAB as indicated); include results of MATLAB numerical analysis and/or simulation in laboratory report.
	Record data in your lab notebook.

General Discussion:

Consider the circuit of Figure 1. Our goal is to reduce the circuit resistance to the point where the internal resistance of the power source begins to have an effect on the circuit's behavior.

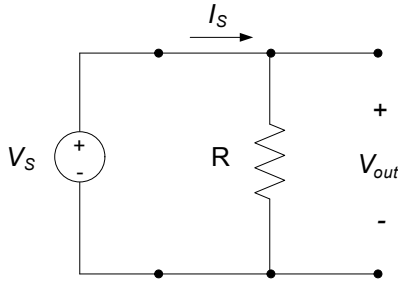


Figure 1. Circuit schematic.

Pre-lab:

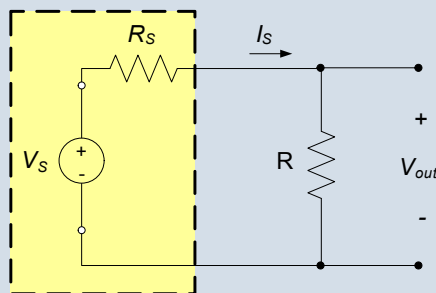
ANALYSIS

If $R = 25\Omega$ and $V_S = 1V$, analyze the circuit of Figure 1 to determine expected values for the measured voltage V_{out} , source current I_S , and power dissipated by the resistor, for the cases in which

- The voltage source is ideal, and
- The voltage source is non-ideal, and has an internal resistance R_S . (Note: your answer here will be a function of R_S .)

Hint – non-ideal voltage sources:

Per module 1.5.1, a non-ideal voltage source can be modeled as an ideal voltage source in series with an internal resistance as shown in the figure below.



Applying KVL around the loop of the above circuit results in:

$$V_S - R_S I_S = V_{out}$$

Note that we do not have the ability to measure V_S or R_S (they are inside the power supply), but we can potentially measure V_{out} and I_S .

Lab Procedures:

- a) Construct the circuit of Figure 1, using $R \approx 25\Omega$ and $V_s \approx 1V$, and estimate the source resistance of your voltage source. The following steps are suggested in order to do this:

DATA

1. Measure and record the actual value of R for your circuit.

DATA

2. Use the waveform generator to apply the voltage $V_s = 1V$. Measure and record the actual value of V_s by open-circuiting the waveform generator terminals and using a voltmeter or your Analog Discovery module to measure the voltage across the its terminals. Fine tune the waveform generator voltage until you measure exactly 1V across the terminals. (Note that under these conditions, there is essentially no current supplied by the voltage source so that the internal source resistance is not affecting your voltage measurement.)

DATA

3. Connect the resistor to your waveform generator. Measure the voltage V_{out} using your Analog Discovery module and the source current I_s using your digital multimeter. Compare the measured voltage with your estimate from part (a) of the pre-lab. Use your measurement of V_{out} and the V_s from part (2) above to estimate the internal resistance of the voltage source. (Note that we are assuming that the ideal voltage source portion of the non-ideal voltage source is not affected by the application of the load resistance R . This is a fairly large assumption!)

DEMO

4. Demonstrate operation of your circuit to the Teaching Assistant. Have the TA initial the appropriate page(s) of your lab notebook and the lab checklist.

- b) Repeat the source resistance estimate of part (a) above for two other values of R : $R \approx 30\Omega$ and $R \approx 20\Omega$. Comment on the consistency between the results for the three different values of R .

Note:

This is not a good way to get an accurate estimate of the internal resistance of the power source, but it should give you an idea of the overall concepts involved.