Lab Documentation Requirements

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What do I need to submit for Lab 01?

Alpha Labs

- Proof of Concepts

Omega Explorations

- Proof of Concepts
- Presentation Video
- Exploration Map

What is needed for a Proof of Concept?

- From Alpha Labs and Omega Explorations Introduction

Proof of Concepts

See the course website for examples.

The Proof of Concepts (template can be found here) demonstrates that you can apply the mathematical concepts you are learning in the course to your circuit. The Proof of Concepts should represent the analysis you've done to design your circuit, program, or system. For each concept, you should include:

- Header with concept name
- A labelled circuit diagram
- A 1-2 sentence description of how you are applying the concept and what circuit variables you are analyzing to demonstrate it
- A mathematical analysis
- A simulation and plot
- A measurement and plot
- A brief discussion of the results
- For application concepts (last part of each lab): an explanation of how this analysis helped in circuit design

Keep in mind that these entries do not need to be long - in fact, keep them as brief as possible! **You can apply multiple concepts to the same circuit.**

If you are doing an **Alpha** lab:

- Submit ALL concepts to the **Lab 01 Alpha – Proof of Concepts** assignment

If you are doing an **Omega** lab:

- Submit ALL concepts to the **Lab 01 Omega – Proof of Concepts** assignment

Proof of Concepts Template

- Template link:

  [Proof of Concepts Template]

Each of your Proofs of Concept must have each of these sections *in this order*.

Delete the instructions from the template in your own submission…

A couple of examples of Proofs of Concept are linked on the course website

Proof of Concepts

You will have an entry with the following format for **each** of the required concepts.

1. Concept name (i.e. Voltage Divider, etc.)

Circuit Schematic:

LTspice circuit schematic of the circuit you will use to prove the concept.

Clearly label all nodes in the you will reference, for example.

Description:

Short description of the concept you will prove and how you will prove it.

Specify which variables in the circuit will be analyzed.

Analysis:

Equation and short description.

Clearly describe how you are applying the concept to your circuit. You should calculate specific values to compare to simulations and experiment.

Simulation:

Screenshot of simulation and short description.

Clearly labeled simulation results with nodes and/or input/output that matches with schematic above. Any important portions of output are identified (i.e. the point at which a comparator switches is circles and/or point to with labeled arrow for easy identification).

Measurement:

Screenshot of Waveforms output from circuit above and short description.

Remember to clearly show all axes in a measurement plot. Also identify any important portions of the output.

Discussion (and answer related questions in Alpha Lab):

Comparison of Analysis, Simulation and Measurement results. Both a simple summary of results (like a numerical chart of values) and a simple description that details if the results are as you expect. Also include any speculation as to why they may be different from one another if they are different. What variation is too much for example…explore this.

Include a table that compares mathematical, simulation, and experimental results.

What is needed for the Presentation Video? *Omega Only*

- From Presentation Video Guidelines

Your presentation should cover the topics to the right *in order*.

You must address each point clearly.

More detailed information on each point is contained in the Presentation Video Guidelines linked above

An example presentation video is linked on the course website

Presentation Standards

1. I can explain the goal of the project.
2. I can present a high-level block diagram that represents the functional blocks, inputs & outputs of for each part of my circuit.
3. I can show mathematical calculations and, if needed, reasonable assumptions that helped me predict the correct function of my circuit.
4. I can show my simulated circuit and show important probe points (simulation results) to compare to my mathematical predictions.
5. I can experimentally demonstrate that important functional blocks fulfill their intended general functions.
6. I can experimentally demonstrate that important functional blocks *work as designed* (backed by mathematical analysis + simulation) OR I can attempt to explain why they failed through troubleshooting.
7. I can discuss design choices directly related to concepts I'm learning in Intro to ECSE.
8. I can briefly mention or discuss new knowledge obtained, design ideas OR design choices or ideas that are beyond the content of Intro to ECSE.
9. I can discuss other possible real-world applications of my circuit.
10. I can articulate at least ONE question based on my experience doing the Omega Exploration.

What is needed for the Exploration Map? *Omega Only*

- From Exploration Map Template

Your exploration map should cover the topics to the right *in order* (use the template).

New Skills Learned

Did you learn a new skill or use a skill you know a bit about in a different way?

New Knowledge Obtained

Did you obtain or use new knowledge? If so where did you get the information?

Failure Points

Did you see any failures through the process? What were those failures?

Troubleshooting Attempts

How did you attempt to troubleshoot and iterate through those failures?

Knowledge Gaps

What is some knowledge that you need to obtain to finish, calculate, understand, or improve your design?

Future ECSE/RPI Courses

Can you find any course that might help you in the future to make a better design? Explain how it will if you can.

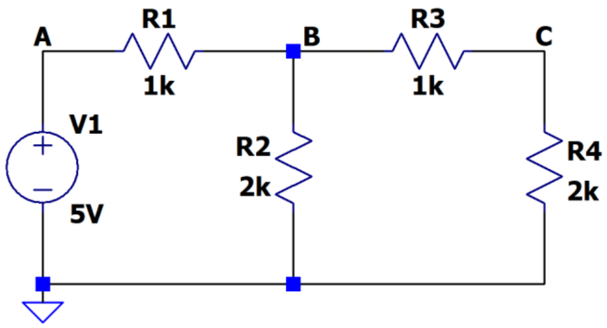
An example exploration map is linked on the course website

Lab 01 Concept #1: KCL, KVL, Ohm's Law

- We will be walking through the steps to do a Proof of Concept for Ohm's Law in class today
    - Mathematical analysis
    - Circuit simulation
    - Experimental measurement
    - Comparison of results

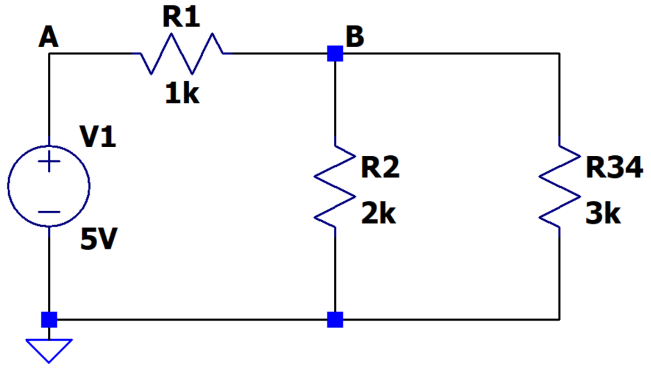
- You will use these results to write your Proof of Concept, then we will peer review them in class next week

Ohm's Law: Mathematical Analysis



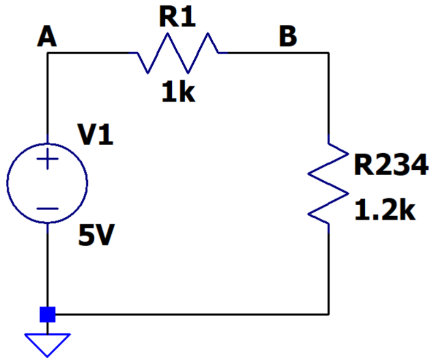
Combining resistances R3 and R4 in series:

$$R_{34} = R_3 + R_4 = 3k\Omega$$

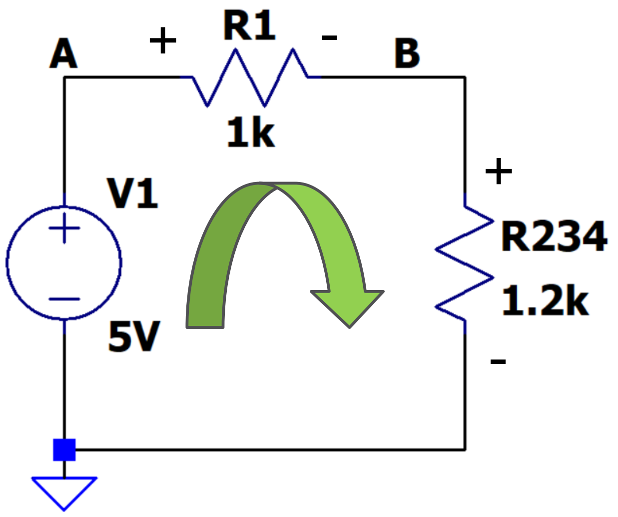


Combining resistances R2 and R34 in parallel:

$$R_{234} = R_2 || R_{34} = \frac{1}{\frac{1}{R_2} + \frac{1}{R_{34}}} = \frac{1}{\frac{1}{2k\Omega} + \frac{1}{3k\Omega}} = 1.2k\Omega$$



Ohm's Law: Mathematical Analysis



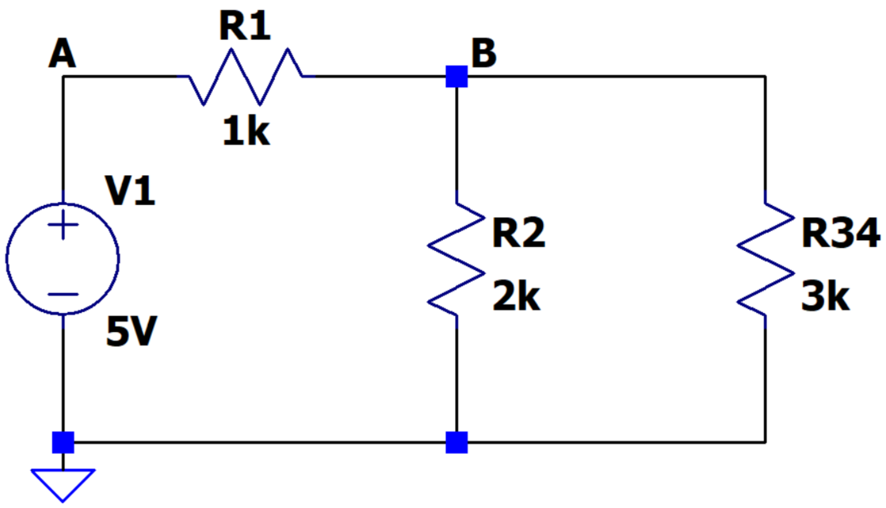
Voltage divider:

$$V_{R234} = V_B = V_1 \frac{R_{234}}{R_1 + R_{234}} = 5V \frac{1.2k\Omega}{1k\Omega + 1.2k\Omega} = 2.727V$$

KVL:

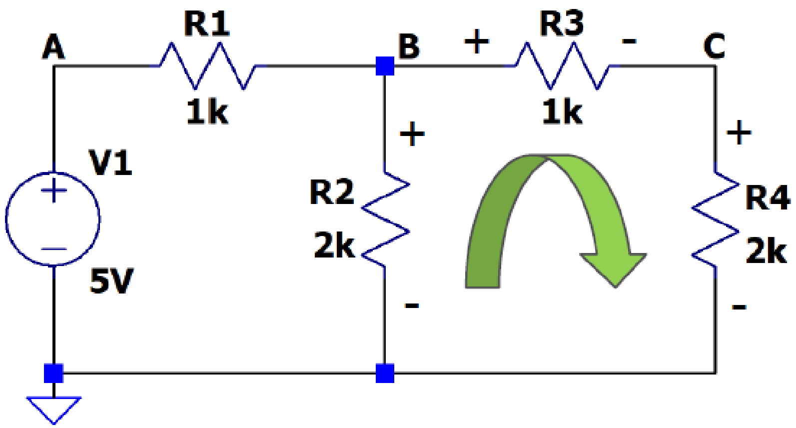
$$-V_1 + V_{R1} + V_{R234} = 0 \rightarrow -5V + V_{R1} + 2.727V = 0$$

$$\boldsymbol{V_{R1} = 2.273V}$$



$$\boldsymbol{V_{R2}} = V_{R34} = V_B = \boldsymbol{2.727V}$$

Ohm's Law: Mathematical Analysis



Voltage divider:

$$\boldsymbol{V_{R4}} = V_C = V_B \frac{R_4}{R_3 + R_4} = 2.727V \frac{2k\Omega}{1k\Omega + 2k\Omega} = \boldsymbol{1.818V}$$

KVL:

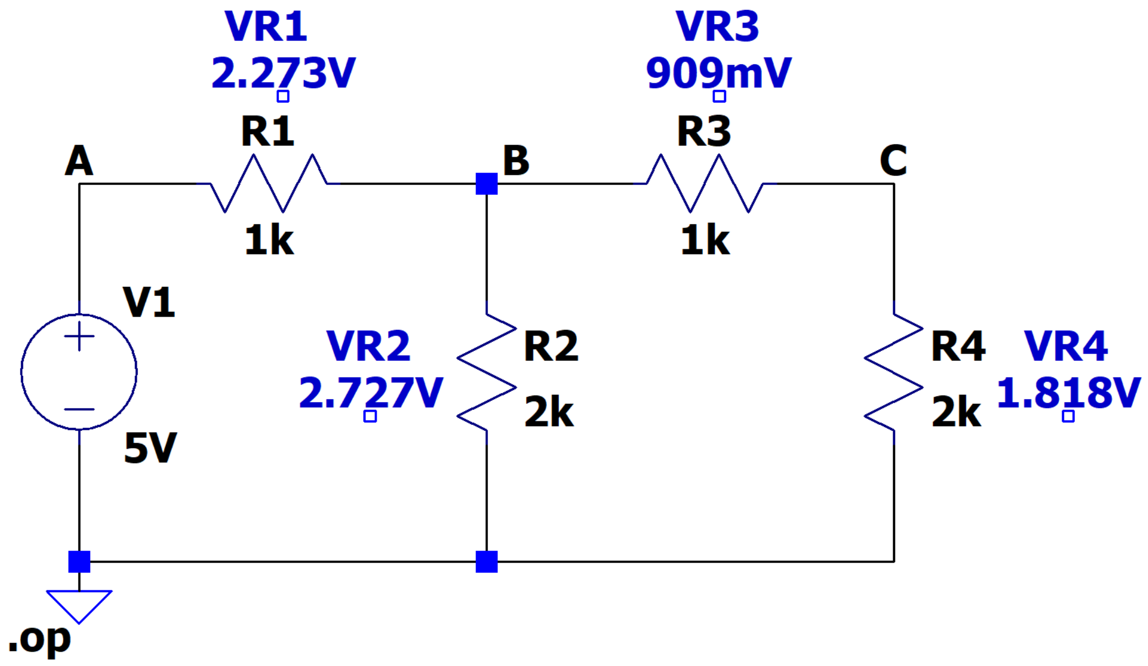
$$-V_{R2} + V_{R3} + V_{R4} = 0 \rightarrow -2.727V + V_{R3} + 1.818V$$

$$\boldsymbol{V_{R3} = 0.909V}$$

Calculated all currents using Ohm's Law: $\boldsymbol{V = IR}$

Element Name	Voltage (V)	Current (mA)	Resistance (Ω)
R1	2.273	2.273	1000
R2	2.727	1.364	2000
R3	0.909	0.909	1000
R4	1.818	0.909	2000

Ohm’s Law: Simulation

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--- Operating Point ---

V(a):        5             voltage
V(b):        2.72727       voltage
V(c):        1.81818       voltage
I(R1):       0.00227273    device_current
I(R2):       0.00136364    device_current
I(R3):       0.000909091   device_current
I(R4):       0.000909091   device_current
I(V1):       -0.00227273   device_current
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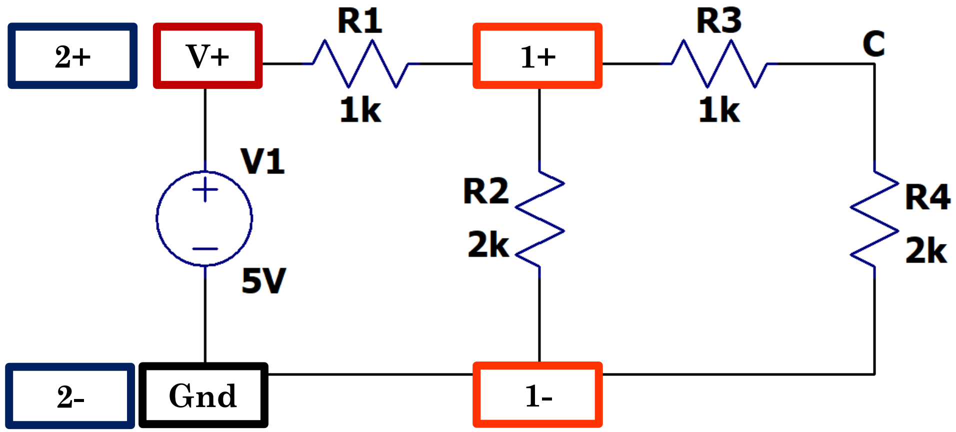
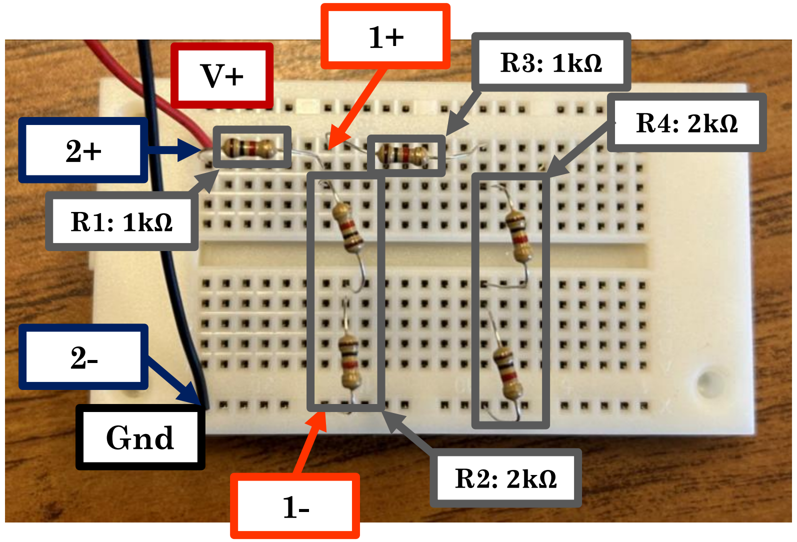
Element Name	Math. Analysis Voltage (V)	Simulation Voltage (V)
R1	2.273	2.273
R2	2.727	2.727
R3	0.909	0.909
R4	1.818	1.818

Element Name	Math. Analysis Current (mA)	Simulation Current (mA)
R1	2.273	2.273
R2	1.364	1.364
R3	0.909	0.909
R4	0.909	1.909

Ohm's Law: Experimental Measurement





For R2 and R4: two $1k\Omega$ resistors were used in series to provide $2k\Omega$

Element Name	Measured Voltage (V)	Measured Current* (mA)	Measured Resistance (Ω)
V1	5.00	N/A	N/A
R1	2.27	2.32	977
R2	2.72	1.39	1950
R3	0.91	0.93	978
R4	1.81	0.93	1954

**Current was determined by dividing the measured voltage by the measured resistance.*

Note: if you do not directly measure current (you cannot directly measure with the M2K or AD3), you should state how you determined your values for current.

Ohm’s Law: Comparison

Voltages (in V)

Element Name	Mathematical Analysis	Simulation	Experiment	% Error
V1	5.000	5.000	5.00	0.00
R1	2.273	2.273	2.27	0.13
R2	2.727	2.727	2.72	0.26
R3	0.909	0.909	0.91	-0.11
R4	1.818	1.818	1.81	0.44

Currents (in mA)

Element Name	Mathematical Analysis	Simulation	Experiment	% Error
R1	2.273	2.273	2.32	-2.07
R2	1.364	1.364	1.39	-1.91
R3	0.909	0.909	0.93	-2.31
R4	0.909	1.909	0.93	-2.31

Are the experimental results in agreement with the simulation and mathematical analysis results? Why or why not? What are the sources of error in the experiment?

Checklist for Proof of Concepts

Mathematical Analysis

- ☐ Is the mathematical analysis legible?
- ☐ Is the mathematical analysis laid out in a logical order and is it easy to follow?
- ☐ Have I included equations for all relevant concepts I'm proving?
- ☐ Have I calculated *numerical values* for all relevant concepts I'm proving?

Simulation

- ☐ Are my schematic and plot backgrounds set to white for maximum legibility?
- ☐ Have I made my schematic and plot lines thicker for maximum legibility?
- ☐ Are all simulation results labeled with the names of components or nodes that are also labeled in the circuit schematic?
- ☐ Are the axes labels and numbers in my simulation result plots large enough to read?
- ☐ Are my simulation result plot axis ranges set so that the most relevant parts of the waveforms are visible?

Checklist for Proof of Concepts

Experimental Measurement

- ☐ Have I used consistent color coding of wires on my breadboard?
- ☐ Are all relevant sources, measurement locations and components on my breadboard labeled in the photo of my circuit?
- ☐ Are all relevant sources, measurement locations and components on my breadboard also labeled on my simulation circuit schematic with the same names?
- ☐ Is my oscilloscope background set to white for maximum legibility?
- ☐ Have I made my oscilloscope traces thicker for maximum legibility?
- ☐ Is the time (x-axis) scale of my oscilloscope set so that the most relevant parts of my measurement are legible?
- ☐ Is the voltage (y-axis) scale of my oscilloscope set so that the most relevant parts of my measurement are legible?

Discussion

- ☐ Have I created a table comparing my results from mathematical analysis, simulation and experimental measurement?
- ☐ Have I identified *reasonable* sources for the error between my mathematical analysis, simulation and experimental measurements?
- ☐ Have I justified the magnitude of the error from these sources of error?

What’s next?

- Put your proof of concept from today in the form specified by the template, complete with descriptions and discussion
- Your group will swap documents with another group and you will give feedback on your proof of concept for Ohm’s Law