

Series and Parallel Circuits
ECE 2100 Circuit Analysis Laboratory
version 22 September 2021

Equipment and Supplies

Breadboard
LTspice® program
2.2kΩ 1/4W 5% resistor
10kΩ 1/4W 5% resistor
3.5 digit digital multimeter
Banana-to-Banana plug cables
Banana plug socketed alligator clips
Hookup wires
DC power supply
SAFETY GLASSES

Learning Outcomes

Students will:

1. Use a breadboard to construct simple electric circuits;
2. Compute, simulate, and measure DC voltages and currents in series and parallel resistive electrical circuits;
3. Compute the error between hand analysis, experimental, and simulation results; and
4. Compute and measure the equivalent resistance of series and parallel-connected resistors.

Pre-Laboratory Assignment (STEPS 1-6)

SERIES CIRCUIT

1. Consider the circuit of Figure 1. Note that the voltage source V_{dum} has no effect on the circuit; it is used to measure $I_s = I(V_{dum})$ in LTspice®.

Compute the voltages and current of Table 1.

Use the ‘hand analysis’ column of Table 1 to report your results.

2. Simulate the circuit of Figure 1 in LTspice® using a transient analysis. The terminals ‘A’ and ‘B’ were drawn using Draw->Circle and the Req arrow was created using Draw->Line. ‘Req’ is text. Nodes ‘1’, ‘2’, and ‘3’ were labelled using the node tool. Use the ‘simulation’ column of Table 1 to report your results.
3. Compute and record the equivalent resistance Req ‘seen’ by the source in Figure 1. Use Req to verify the value of I_s .

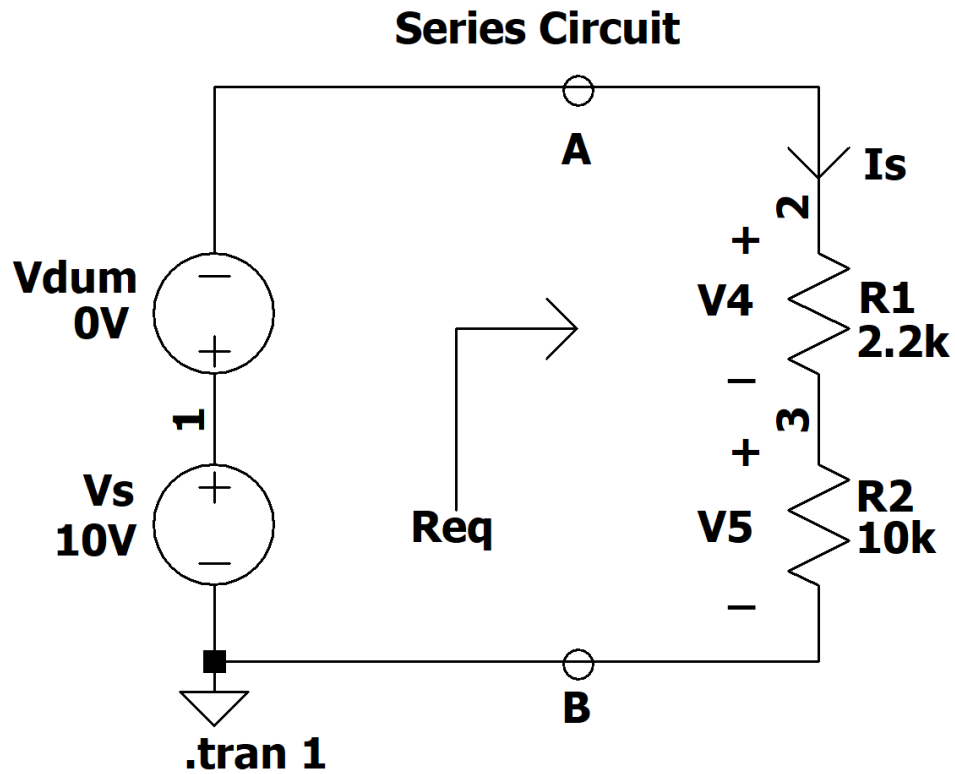


Figure 1. Series circuit

	hand analysis	simulation	% error (compared to hand analysis)	experimental	% error (compared to hand analysis)
V(1) (node voltage)					
V(2) (node voltage)					
V(3) (node voltage)					
V4					
V5					
Is					

Table 1. Series circuit data

PARALLEL CIRCUIT

4. Consider the circuit of Figure 2. Compute the voltages and currents of Table 2. Use the 'hand analysis' column of Table 2 to report your results.
5. Simulate the circuit of Figure 2 in LTspice® using a transient analysis. Use the 'simulation' column of Table 2 to report your results.
6. Compute and record the equivalent resistance R_{eq} 'seen' by the source in Figure 2. Use R_{eq} to verify the value of I_s .

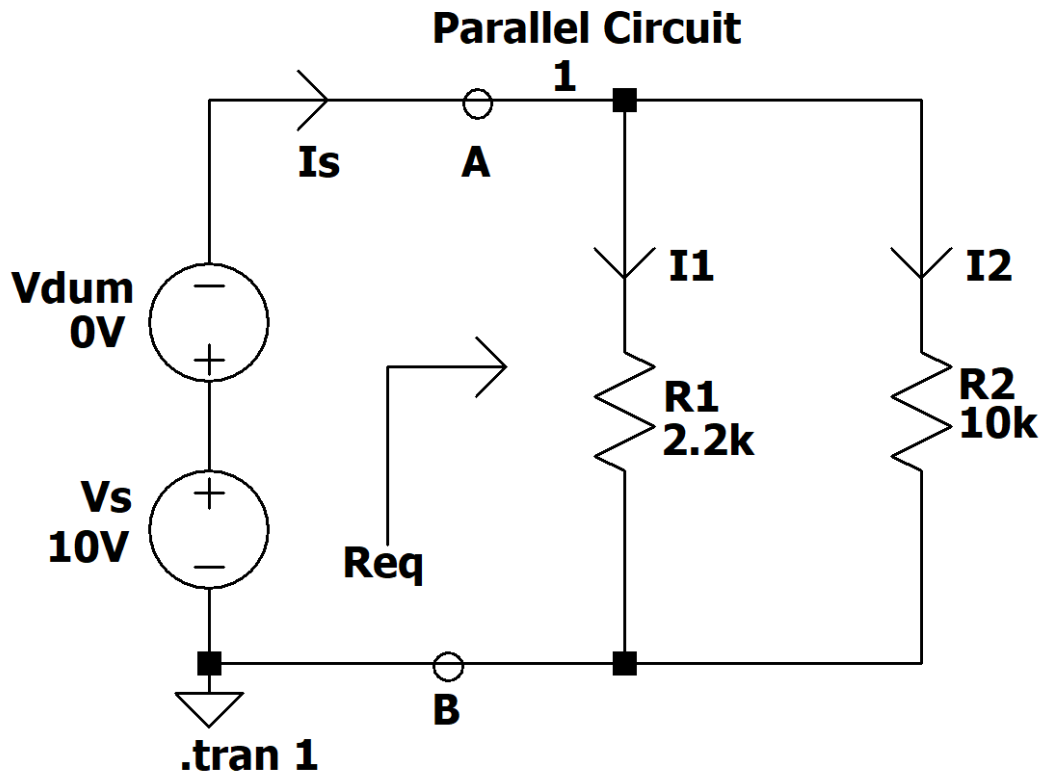


Figure 2. Parallel circuit

	hand analysis	simulation	% error (compared to hand analysis)	experimental	% error (compared to hand analysis)
V_s					
$V(1)$					
I_1					
I_2					

Table 2. Parallel circuit data

Procedure

SERIES CIRCUIT

1. Ensure that the power supply output is disabled (OUTPUT button is not illuminated).
Adjust the power supply current limit to be about 10% greater than the maximum expected current I_s .

2. Construct the circuit of Figure 1. Your circuit will look something like Figure 3.

3. **BEFORE CONNECTING THE POWER SUPPLY TO THE CIRCUIT**

Measure and record the resistance R_{eq} between terminals A and B.
Compare to the value computed in your prelab.

Do not proceed unless your computed and simulated values of R_{eq} are in close agreement.

Did you remember to return your DMM to a voltage measurement mode?

4. Connect the power supply to the circuit and enable the power supply output (press OUTPUT button so it is illuminated).

Measure the voltages of Table 1 and put results in that table in the 'experimental column'.
Disable the power supply output.

Do not proceed unless your experimental results are in close agreement with your hand analysis and simulated values.

5. Place DMM in a current measurement mode and insert into the circuit as shown in Figure 4.
REMEMBER THAT AN AMMETER IS A SHORT. IT MUST BE IN SERIES AS SHOWN.

6. **DOUBLE CHECK YOUR WIRING** and then enable the power supply output.
Measure the current of Table 1 and put result in that table in the 'experimental column'.

Disable the power supply output.

5. Did you remember to return your DMM to a voltage measurement mode?

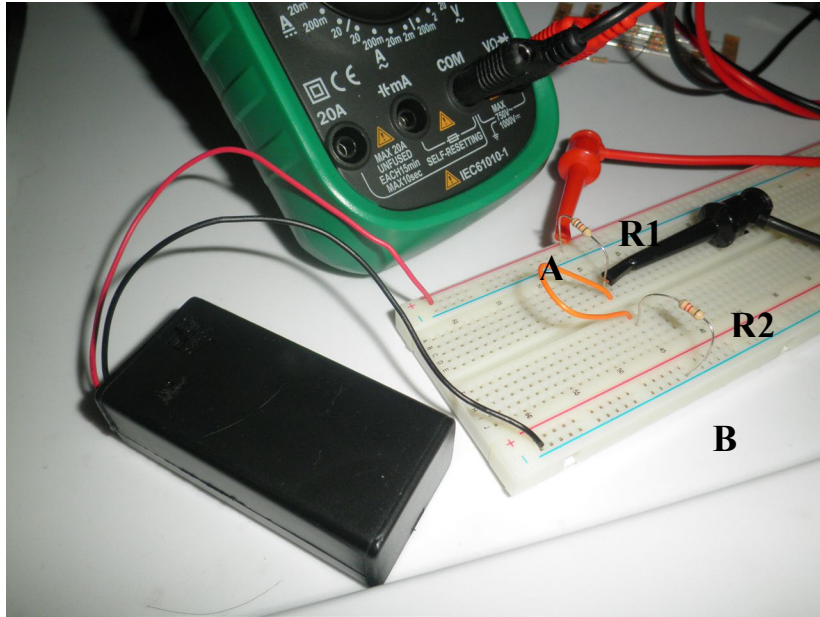


Figure 3. Circuit of Figure 1 constructed using a breadboard. Voltage V_4 is being measured. The orange jumper wire will be replaced with an ammeter to measure I_s in Figure 4. *Your resistor values are different and you are using a power supply instead of a battery.*

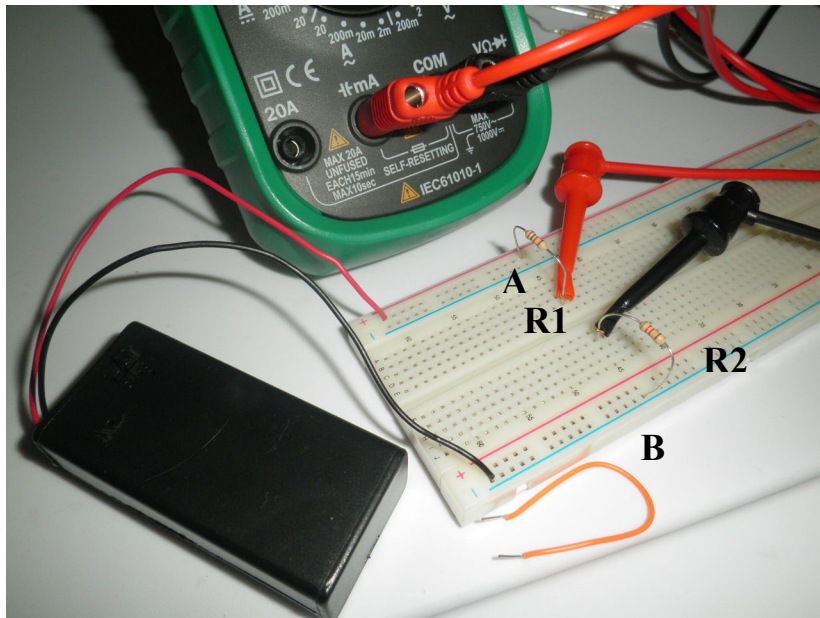


Figure 4. Measuring I_s using an ammeter. The ammeter is placed IN SERIES. *Your resistor values are different and you are using a power supply instead of a battery.*

PARALLEL CIRCUIT

7. Ensure that the power supply output is disabled (OUTPUT button is not illuminated). Adjust the power supply current limit to be about 10% greater than the maximum expected current I_s .

Ensure your DMM is in voltage measurement mode.

8. Construct the circuit of Figure 2 as shown in Figure 5.

9. **BEFORE CONNECTING THE POWER SUPPLY TO THE CIRCUIT**

Measure and record the resistance R_{eq} between terminals A and B. Compare to the value computed in your prelab.

Do not proceed unless your computed and simulated values of R_{eq} are in close agreement.

Did you remember to return your DMM to a voltage measurement mode?

10. Connect the power supply to the circuit and enable the power supply output (press OUTPUT button so it is illuminated).

Measure the voltages of Table 2 and put results in that table in the 'experimental column'.
Disable the power supply output.

11. Place DMM in a current measurement mode and insert into the circuit as shown in Figure 6 to measure I_1 . **REMEMBER THAT AN AMMETER IS A SHORT. IT MUST BE IN SERIES AS SHOWN.** The ammeter REPLACES the orange jumper.

Enable the power supply output. Measure I_1 . Place result in Table 2.
Disable the power supply output.

Do not proceed unless your experimental results are in close agreement with your hand analysis and simulated values.

12. Place DMM in a current measurement mode and insert into the circuit to measure I_2 . **REMEMBER THAT AN AMMETER IS A SHORT. IT MUST BE IN SERIES.** Thus the yellow jumper is replaced with the ammeter.

13. Enable the power supply output. Measure I_2 . Place result in Table 2.
Disable the power supply output.

14. Did you remember to return your DMM to a voltage measurement mode?

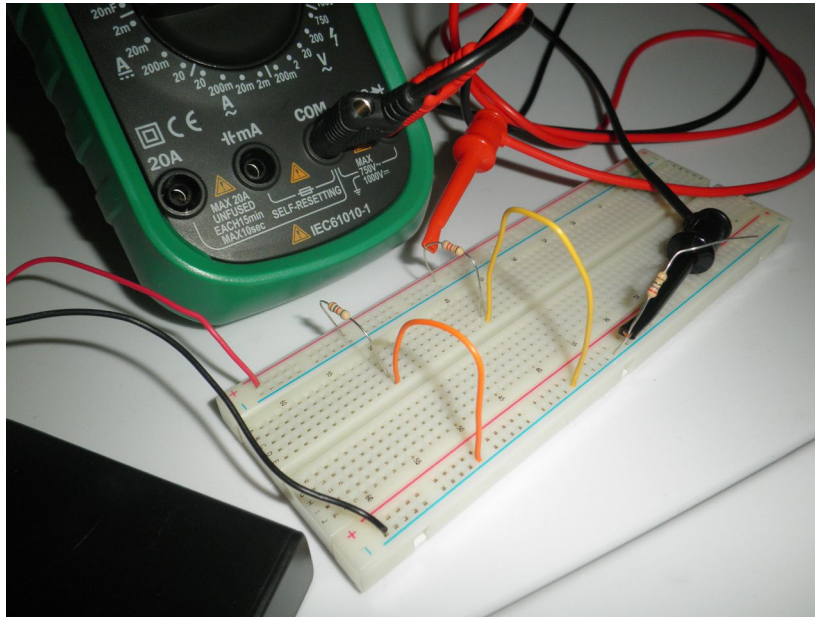


Figure 5. Circuit of Figure 2 constructed using a breadboard. Voltage V_s is being measured. Note that the lead of one resistor is used to probe the circuit ground. Since only one lead is being used that resistor has no effect on the circuit. The orange jumper wire will be replaced with an ammeter to measure I_s in Figure 6.

Your resistor values are different and you are using a power supply instead of a battery.

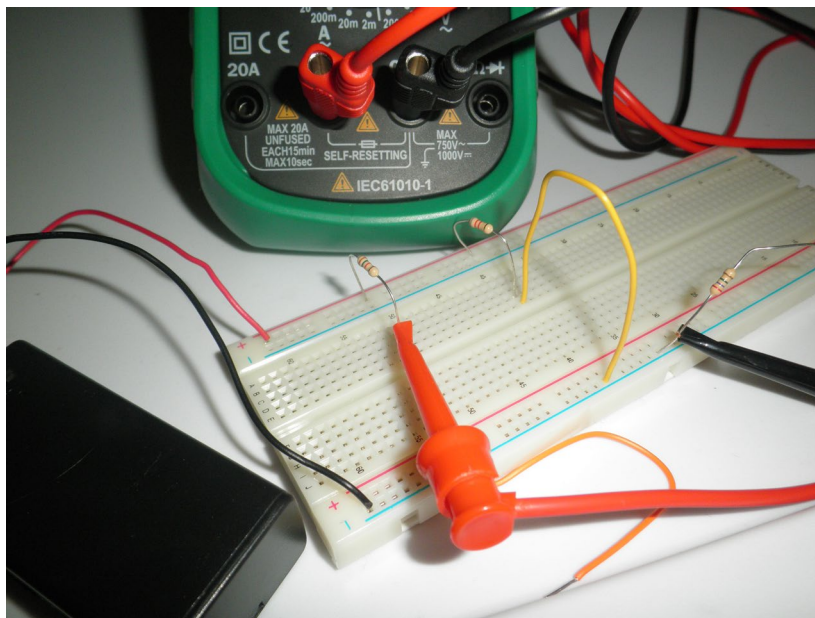


Figure 6. Measuring I_1 using an ammeter. Measure I_2 by reinserting the orange jumper and replacing the yellow jumper with the ammeter in a similar manner.

Your resistor values are different and you are using a power supply instead of a battery.

Analysis

1. What is the most obvious source of error between hand analysis and experimental results?
2. Use your *measured* values of $V(1)$ and $V5$ to verify the voltage divider rule for $V5$.
3. Use your *measured* values of I_1 and I_2 to verify the current divider rule for I_2 .

Credits and Copyright

Adapted from material developed by current and former ECE faculty, including J. Kelemen and F. Severance. Modified based on input from ECE laboratory instructors, particularly M. El Yabroudi, S. Hajian, and S. Masihi. S. Durbin contributed to the development of this laboratory.

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