Ollscoil na Gaillimhe
University of Galway

Scoil na hInnealtóireachta
School of Engineering

EE130: Fundamentals of Electrical & Electronic Engineering I
Laboratory 1: Voltage Measurement and Circuit Ground

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Reading:
Floyd, Sections 2-6 and 2-7. (Optional: Additional info on circuit ground is found in Section 4-9.)

Objectives:
After performing this experiment, you will be able to:
1. Build and simulate a circuit from a schematic diagram in CircuitLab.
2. Use voltages measured with respect to ground to compute the voltage drop across a resistor.
3. Explain the meaning of circuit ground and subscripts used in voltage definitions.

Summary of Theory:
Energy is required to move a charge from a point of lower potential to one of higher potential. Voltage is a measure of this energy per charge. Energy is given up when a charge moves from a point of higher potential to one of lower potential.

Voltage is always measured with respect to some point in the circuit. For this reason, only potential *differences* have meaning. We can refer to the voltage *across* a component, in which case the reference is one side of the component. Alternatively, we can refer to the voltage at some point in the circuit. In this case the reference point is assumed to be “ground.” Circuit ground is usually called *reference ground* to differentiate it from the potential of the earth, which is called *earth ground*. Circuit or earth grounds are shown with the ≑ symbol used in Figure 1.

An analogy can clarify the meaning of reference ground. Assume a building has two floors below ground level. The floors in the building could be numbered from the ground floor, by numbering the lower floors with negative numbers. The reference for numbering the floors could be made the lowest floor in the basement. Then all floors would have a positive floor number. The choice of the numbering system does not change the height of the building, but it does change each floor number. Likewise, the ground reference is used in circuits as a point of reference for voltage measurements. The circuit is not changed by the ground reference chosen.

Figure 1 illustrates the same circuit with two different ground reference points.

For *both* circuits, V_{AB} = 4 V, V_{BC} = 8 V, V_{AC} = 12 V.

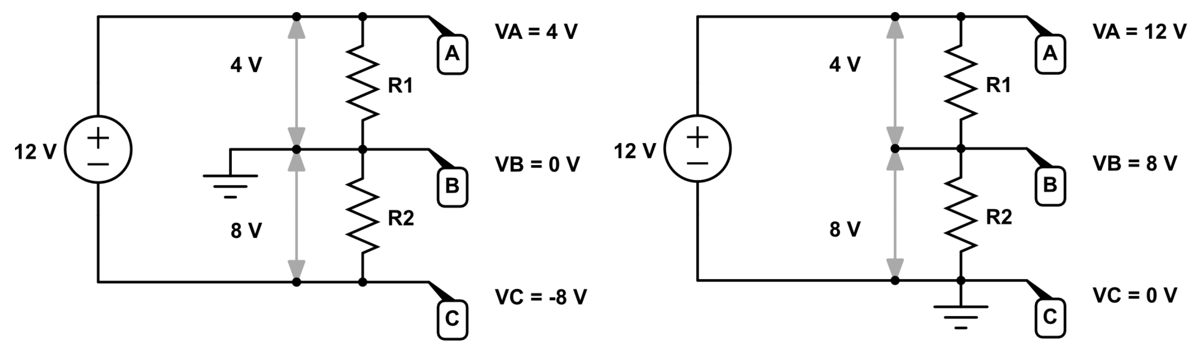

Figure 1 (a) **Figure 1 (b)**

The circuit in Figure 1 (a) has as its reference point **B**. Positive and negative voltages are shown. If the reference point is moved to point **C**, the circuit voltages are all positive, as shown in Figure 1 (b). Voltage is always measured between two points. To define the two points, subscripts are used. The voltage difference (or simply voltage) between points **A** and **B** is written as V_{AB} where the second letter in the subscript identifies the reference point. If a single subscripted letter is shown, the voltage is defined between the lettered point and the circuit's reference ground.

Elements Needed:

Resistors:

R_1 = 330 Ω, R_2 = 680 Ω, and R_3 = the first four digits of your student ID (e.g., 2345 Ω).

Procedure:

1. For the first two resistors with the listed values given in Table 1, write down the expected resistor colour bands (1st digit, 2nd digit, multiplier, tolerance of 5%) for each one.

Table 1

Component Listed Value	Colour Bands			
	1	2	M	T
R_1 = 330 Ω				
R_2 = 680 Ω				
R_3 (from ID)				

Table 2

	Measured Value
V_S	10 V
V_{AB}	976 mV
V_{BC}	2.011 V
V_{CD}	7.013 V

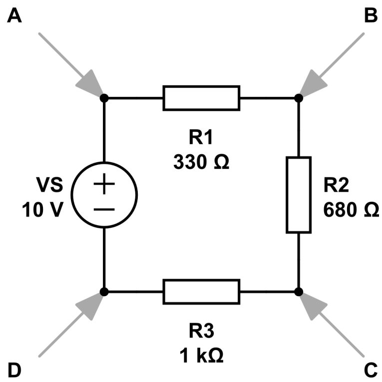

Figure 2

2. Build the resistor circuit shown in Figure 2 using CircuitLab. Add a power supply with a DC voltage of +10 V, and include a ground at point **D**. Measure the voltage across each resistor in the circuit using the Simulate function. Enter the measured values in Table 2.

3. Keep point **D** as the reference ground in CircuitLab (the downwards arrow symbol). Measure the voltage at points **A**, **B**, and **C** with respect to point **D**. The voltage readings are made with the reference ground at point **D**. Enter the measured values in Table 3. Then use the measured voltages to compute the voltage differences V_{AB}, V_{BC}, and V_{CD}.

Table 3

	Measured Voltage
V_A	10 V
V_B	9.024 V
V_C	7.013 V
V_D	0.0 V (reference ground)

Voltage Difference Calculation
$V_{AB} = V_A - V_B =$ 976 mV
$V_{BC} = V_B - V_C =$ 2.011 V
$V_{CD} = V_C - V_D =$ 7.013 V

4. Now measure the voltages in the circuit with respect to point **C**. The circuit is *not changed*. Only the reference point changes. Change the reference to point **C**. This point will now represent ground. The voltage at point **D** now has a negative value. Enter the measured voltages in Table 4. Compute the voltage differences as before and enter them in Table 4.

Table 4

	Measured Voltage
V_A	2.987 V
V_B	2.011 V
V_C	0.0 V (reference ground)
V_D	-7.013 V

Voltage Difference Calculation
$V_{AB} = V_A - V_B =$ 976 mV
$V_{BC} = V_B - V_C =$ 2.011 V
$V_{CD} = V_C - V_D =$ 7.013 V

5. Change the circuit reference point to point **B**. Again, there is no change to the circuit other than the reference ground. Repeat the measurements of the voltages with respect to circuit ground. Compute the voltage differences and enter the data in Table 5.

Table 5

	Measured Voltage
V_A	976 mV
V_B	0.0 V (reference ground)
V_C	-2.011 V
V_D	-9.024 V

Voltage Difference Calculation
$V_{AB} = V_A - V_B =$ 976 mV
$V_{BC} = V_B - V_C =$ 2.011 V
$V_{CD} = V_C - V_D =$ 7.013 V

6. Now make point **A** reference ground and repeat measurements. Enter data in Table 6.

Table 6

	Measured Voltage
V_A	0.0 V (reference ground)
V_B	-976 mV
V_C	-2.987 V
V_D	-10 V

Voltage Difference Calculation
$V_{AB} = V_A - V_B =$ 976 mV
$V_{BC} = V_B - V_C =$ 2.011 V
$V_{CD} = V_C - V_D =$ 7.013 V

Conclusions: (What did you learn overall?)

In this experiment, I have learned how to build circuits, measure voltages, and analyze results

Evaluation and Review Questions:

1. Compare the *voltage difference calculation* in Table 3 through Table 6. Does the circuit's reference point have any effect on the voltage differences across any of the resistors? Explain your answer.

   Cicrcuit refrence point does not have any effect on the voltage diffrences across any of the re

2. Define the term *reference ground*.

   The reference ground is the point in the circuit where the voltage value is equal to zero. It is u

3. If you measured V_{AB} as 12.0 V, what is the V_{BA}?

   -12 V

4. Assume V_M = -220 V and V_N = 150 V. What is V_{MN}?

   -370 V

5. If a test point in a circuit is marked +5.0 V and a second test point is marked -3.3 V, what voltage reading would you expect on a voltmeter connected between the two test points? Assume the reference lead on the meter is at the lowest potential.

   8.3V

For Further Investigation:

Replace the +10 V supply used in this experiment with two +5 V supplies in series. Attach the +5 V output of one supply to the negative side of the second supply. Call this point (in between the two power supplies) the reference ground for the circuit. Measure the voltages throughout the circuit. Summarise your results.

The voltage across the resistor is the same, but the voltage values ??at points A, B, C, and D