Introduction

Lab Goals

1. To investigate the performance of a general dc circuit
2. To become familiar with the concept of circuit (reference point) ground
3. To design, construct, and test te performance of a simple voltage-divider circuit

Procedure

Part I. General DC Circuit

1. Construct the circuit shown in Fig(1). Adjust the value of the source voltage **"E"** to set the voltages of node #3 **6V**. Measure all node voltages (**w.r.t the reference node**) and all branch currents. Calculate the voltage across and the power absorbed by each device, and record all results in table 1.

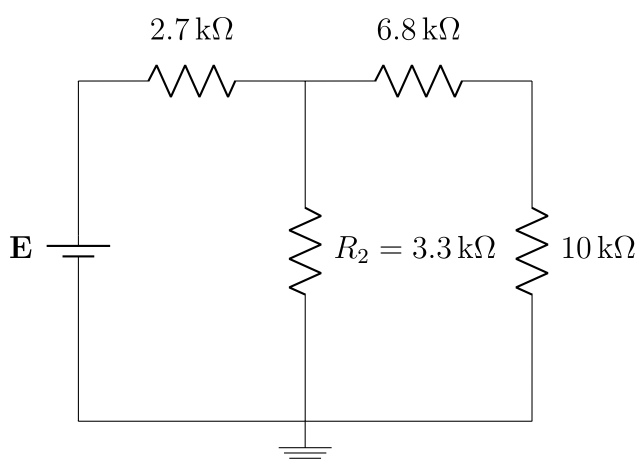


Fig. 1: General DC circuit

2. Replace $\mathbf{R_2}$ with a 4.7kΩ resistor. Repeat Step 1 and record your values in table 2.

Part II. Circuit Reference Point (Ground)

3. Connect the circuit shown in fig(2). Select each node (**One at each time**) in the circuit as the reference point (**ground node**). Measure the voltages of all the other nodes with respect to the ground node, and record your results in table 3.

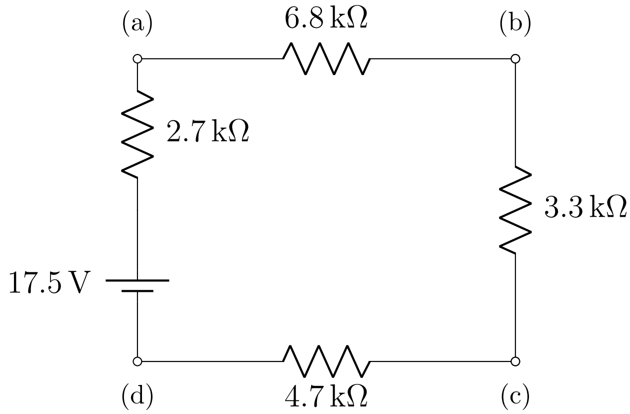


Fig. 2: Ground Reference Point Circuit

Part III. Voltage-Divider

4. Connect your own **Voltage-Divider** circuit as shown below, use a decade resistance box (**whose settings are at their maximum value**) as the variable resistive load.

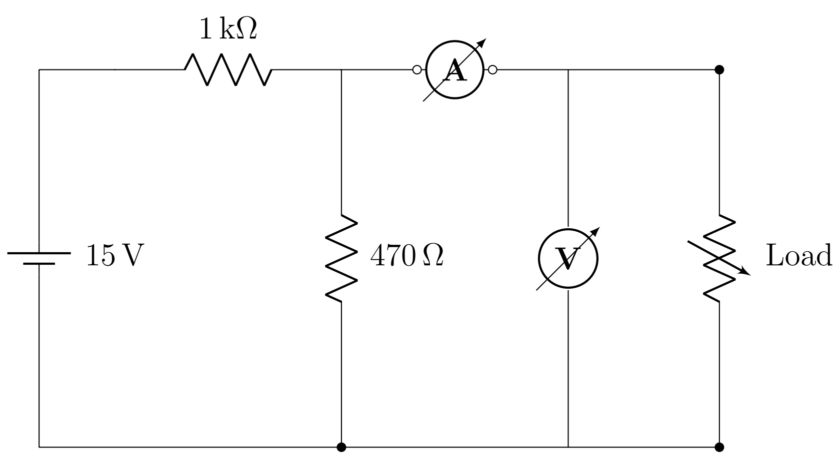


Fig. 3: Voltage Divider Circuit

5. With the decade resistance box open circuit;i.e, the load current $\mathbf{I}_L = 0.0$A, measure the value of the voltage load $\mathbf{V}_L$. Reconnect the decade box and adjust the resistance settings to provide the values of $\mathbf{I}_L$ shown in table 4. For each setting of $\mathbf{I}_L$ measure the corresponding value for $\mathbf{V}_L$.

   Use Graph 1 to plot $\mathbf{V}_L$ vs $\mathbf{I}_L$ [which is known as the **load-regulation characteristic**] of your voltage-divider circuit.

Results

Table 1: Values from the General DC Circuit

Device	Voltage Across (V)	Current Through (mV)	Absorbed Power (mW)
Source	19.9	3.731	74.25
$\mathbf{R}_1$	10.06	3.731	37.53
$\mathbf{R}_2$	10.06	3.124	31.45
$\mathbf{R}_3$	4.08	0.608	2.481
$\mathbf{R}_4$	6.00	0.608	3.648

Table 2: Values from the General DC Circuit with 4.7kΩ resistor

Device	Voltage Across (V)	Current Through (mV)	Absorbed Power (mW)
Source	19.9	3.210	63.879
$\mathbf{R}_1$	8.65	3.210	26.815
$\mathbf{R}_2 = 4.7\mathbf{k\Omega}$ "$\uparrow$"	11.50	2.517	28.95
$\mathbf{R}_3$	4.66	0.693	3.229
$\mathbf{R}_4$	6.83	0.693	4.733

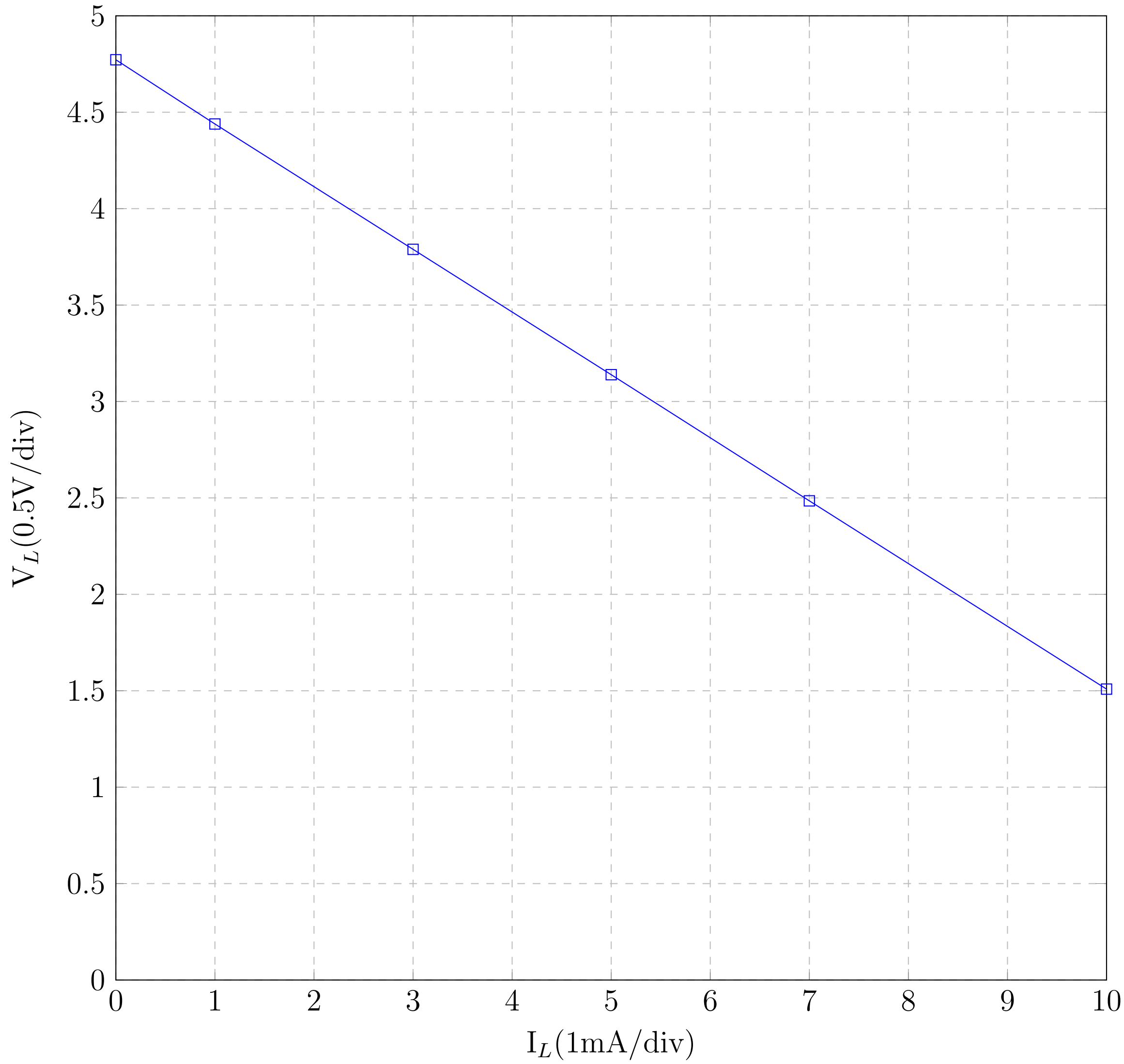
Table 3: Circuit Reference Point Ground Circuit Results

Ground Node #	$\mathbf{V}_a$	$\mathbf{V}_b$	$\mathbf{V}_c$	$\mathbf{V}_d$
a	0.0	6.914	10.233‘	14.930
b	6.915	0.0	3.319	8.013
c	10.230	3.320	0.0	4.694
d	14.930	8.014	4.695	0.0

Table 4: Voltage Divider Circuit

I_L(mA)	**0**	**1**	**3**	**5**	**7**	**10**
V_L(V)	4.7821	4.4392	3.7891	3.1292	2.4848	1.5085

Graph 1: Voltage Divider Circuit I_L vs V_L



Conclusions

1. Use your recorded data from table 1 to verify KVL for each loop and KCL at each node for the general DC circuit.
   Comment on the possible causes for any deviations from what would you expect theoretically.

   KVL

   Loop1

   $$-19.9+2.7I_1 + 3.3(I_1 - I_2) = 0$$
   $$6I_1 - 3.3I_2 = 19.9$$

   Loop2

   $$6.8I_2+10I_2 + 3.3(I_1 - I_2) = 0$$
   $$20.1I_2 - 3.3I_1 = 0$$

   Solving,

   $$I_1 = 3.65\text{mA}$$
   $$I_2 = 0.599\text{mA}$$

   KCL

   $$\frac{(19.9 - V)}{2.7} - \frac{V}{3.3} - \frac{V}{16.8} = 0$$

   $$V = 10.0V$$

   The recorded values of I_1 andI_2 are 3.72 and 0.608. The slight significant difference in these theoretical and measured values could be the uncertainty and other lab approximations. Voltages recorded during the lab are provided with instruments whose calibration may not be perfect. In reality, there exists resistance in the wire, along with worn out resistors, and small amounts of EMF. The current flow does not follow our calculations in a perfect flow rate, and the heat produced. These are all factors which may have caused our theoretical calculations to vary from the real measured values.

2. Based on your observations from step #3, design a DC circuit utilizing a **15V** battery to provide the following node voltages: **+10,+5V,**and**-5V** w.r.t a circuit ground node. Select your resistors such that the maximum power demand on the battery does not exceed **1mW**.

$$P = V_s I$$
$$1\text{mW} = 15I$$
$$I = 6.67 \cdot 10^{-2}\text{mA}$$

$$V = IR_T$$
$$15\text{V} = 6.67 \cdot 10^{-2}\text{mA} \cdot R_T$$
$$R_T = 225\text{k}\Omega$$
$$R_1 + R_2 + R_3 = 225\text{k}\Omega$$

Notice there is a 5V drop through each resistor, so they must all be the same value. Additionally we only need to add 3 resistors as there are only 3 voltage drops. The last resistor is the same drop, but it is below the voltage, so we can assume a ground node before that resistor.

$$R_n = \frac{5\text{V}}{6.67 \cdot 10^{-2}\text{mA}}$$
$$R_n = 75\text{K}\Omega$$

Check for consistency,

$$3(75\text{k}\Omega) = 225\text{k}\Omega$$

Therefore, we can now draw the circuit, and label all the resistors.

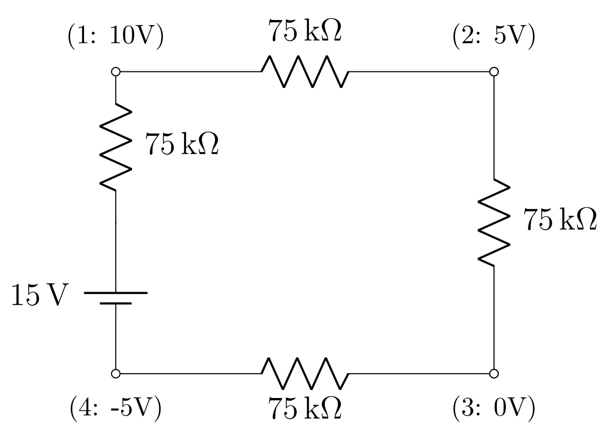


Fig. 4: Q2 Reference

3. Explain your observation of the **load-regulation characteristic** on graph 1. Does your voltage-divider meet the design objectives?

   Decreasing the resistance of the decade box tp achieve the required values of I_L resulted in a constantly decreasing for the voltage (slope constant and negative). This observation agrees with Ohm's Law. Smaller resistances would allow larger surges of current to flow, while decreasing the voltage required, all by the same ratios.