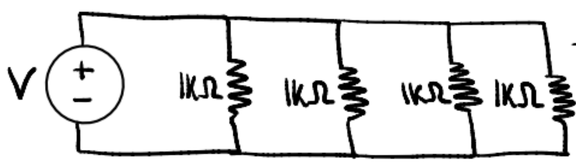
Samvel Manukyan
6173231

Lab 3: Resistive Networks and Voltage Dividers

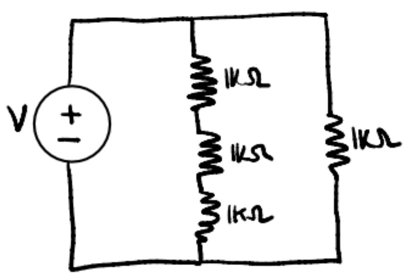
Introduction: This lab is intended to familiarize us with complicated resistor networks by investigating series and parallel simplification of resistors. It is also intended to learn about circuits like the “voltage divider”, circuit elements like the potentiometer, and load effect.

Step 1:
[RP1]



$$\frac{1}{R_{eq}} = \left(\frac{1}{1000}+\frac{1}{1000}+\frac{1}{1000}+\frac{1}{1000}\right)$$

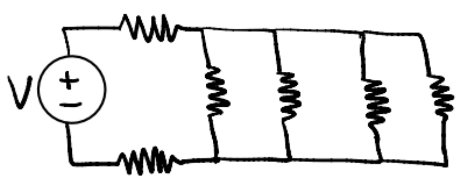
$$R_{eq} = 250\Omega$$



$$R_{eq} = (1000+1000+1000)\,||\,1000$$

$$\frac{1}{R_{eq}} = \left(\frac{1}{3000}+\frac{1}{1000}\right)$$

$$R_{eq} = 750\Omega$$

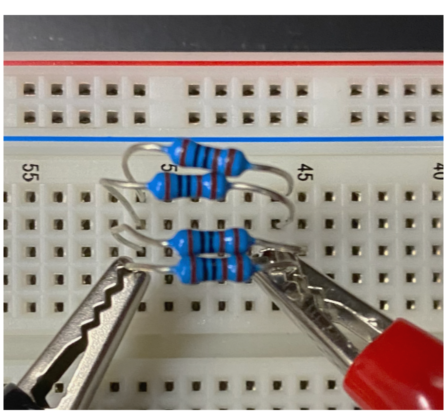


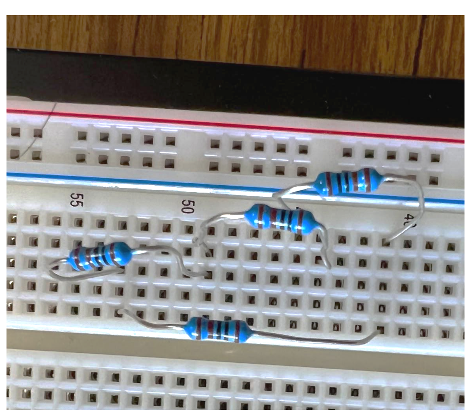
$$R_{eq} = 1000\,||\,1000\,||\,1000\,||\,1000 + (1000+1000)$$

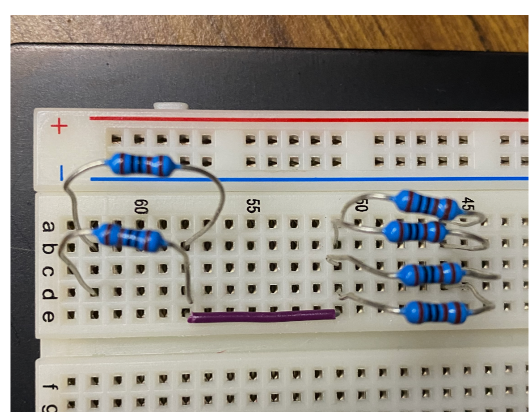
$$R_{eq} = \frac{1}{\left(\frac{1}{1000}+\frac{1}{1000}+\frac{1}{1000}+\frac{1}{1000}\right)} + 2000$$

$$= 2250\Omega$$

Step 2:
[RP2] **250Ω:** **750Ω:** **2250Ω:**



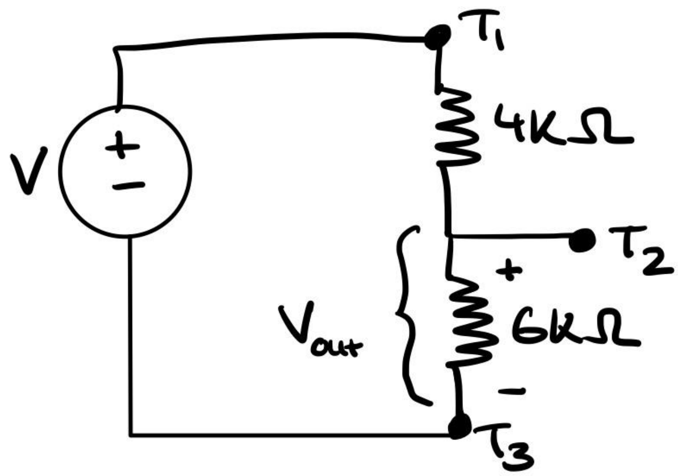




Desired R (Ω)	R = 250	R = 750	R = 2250
Measured R (Ω)	250.85	749.27	2237.7

Table 1. Desired and measured R. **[RP3]**

Step 3:
3.3. [RP4]



Step 4:
4.5. [RP5]

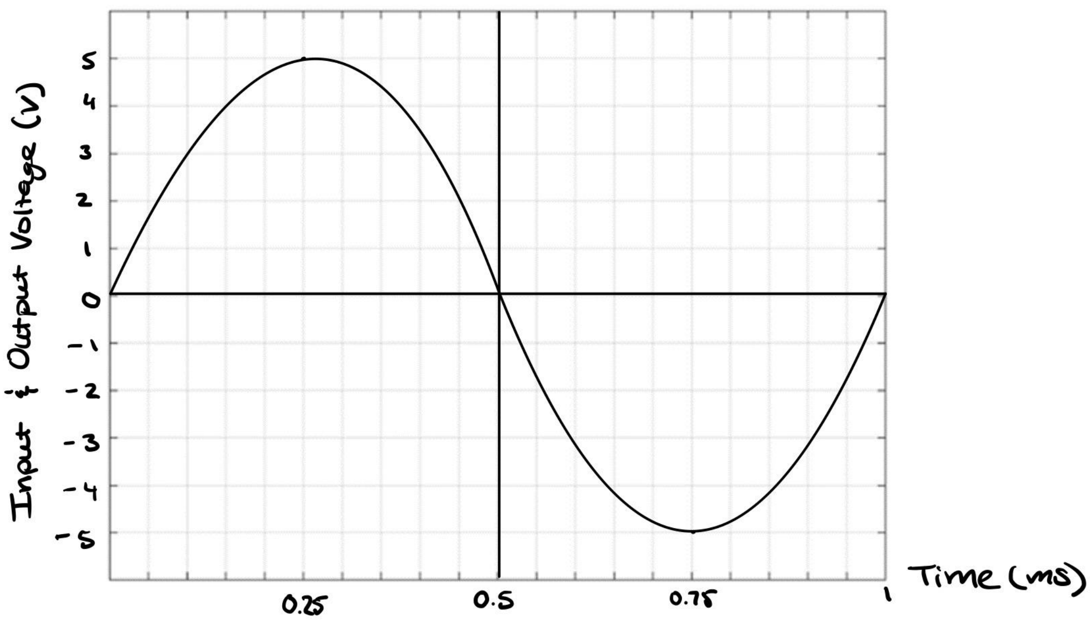
Case	1	2	3	4	5
Output voltage, V_{out} (V)	0.5	1.0	2.0	3.0	4.0
Measured R_{23} (kΩ)	1.046	2.075	4.135	6.216	8.305
Measured R_{13} (kΩ)	10.326	10.355	10.345	10.359	10.334
Divider ratio $K = R_{23}/R_{13}$	0.1013	0.201	0.399	0.600	0.803

Table 2. R_{23}, R_{13} and their ratio at different output voltages without load.

Step 5:
5.1. [RP6]

Case	1	2	3	4	5
Peak-to-peak voltage, $V_{out,pp}$ (V)	0.56	1.08	2.13	3.10	4.10

5.2. **[RP7]**



5.3. **[RP8]**

The values of $V_{out,pp}$ were not exact to V_{out} from table 2, but the differences are negligible.

Case	1	2	3	4	5
Measured R_{23} (kΩ)	0.9986	2.053	4.142	6.228	8.317
Measured R_{13} (kΩ)	10.323	10.326	10.356	10.353	10.327
Divider ratio $K = R_{23}/R_{13}$	0.0967	0.199	0.400	0.602	0.805
Peak-to-Peak output voltage, $V_{out,pp}$ (V)	0.7	1.3	2.3	3.1	4.4

Table 3. Peak-to-peak output voltages for the sinusoidal input voltage.

Step 6:

6.2. **[RP9]**

Case	1	2	3	4	5
Output voltage, V_{out} (V)	0.5	1.0	2.0	3.0	4.0
Measured R_{23} (kΩ)	0.7717	0.8778	0.8992	0.90635	0.90975
Measured R_{13} (kΩ)	7.7079	4.3669	2.2227	1.4964	1.1293
Divider ratio $K = R_{23}/R_{13}$	0.100	0.201	0.405	0.606	0.806

Table 4. R_{23}, R_{13} and their ratio at different output voltages with 1kΩ load.

6.3. [RP10]

V_{out} : K = 1 : 0.2

$V_{out} = \frac{1}{0.2}K = 5K$

6.4. [RP11]

In both tables 2 and 4, R_{23} increases. R_{23}, however, increases linearly in table 2 and logarithmically in table 4, respectively. R_{13} decreases logarithmically in table 4 (where it is now in parallel with a 1k resistor) but remains about constant in table 2 (where it is no longer in series). Every time V_{out} increases by one, K increases by roughly 0.2 in tables 2 and 4. The divider ratio was roughly maintained while the equivalent resistance was reduced due to the load resistor.

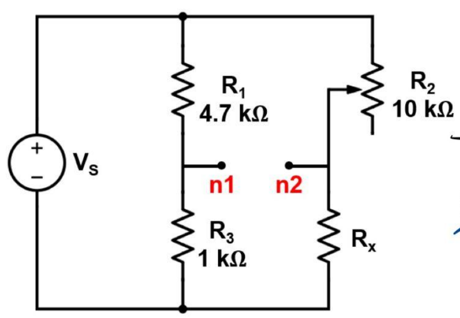
Step 7:

7.1. [RP12]

$$V_{n_1} = V_{R_1} = \frac{R_1}{R_1+R_3}\cdot V_s$$

$$V_{n_2} = V_{R_2} = \frac{R_2}{R_2+R_3}\cdot V_s$$

$$V_{n_1} = V_{n_2}$$



$$\frac{R_1}{R_1+R_2}\cdot \cancel{V_s} = \frac{R_2}{R_2+R_x}\cdot \cancel{V_s}$$

$$\cancel{R_1R_2} + R_1R_x = \cancel{R_1R_2} + R_2R_3$$

$$\boxed{R_x = \frac{R_2R_3}{R_1}}$$

Figure 6. Wheatstone bridge resistive network.

7.4. [RP13]

R_1 (Ω)	R_2 (Ω)	R_1 (Ω)	R_1 (Ω)
4690.9	1038.8	998.98	221.22

Table 6. Values of resistors in the Wheatstone bridge resistive network (figure 6).

7.5. [RP14]

The results in table 6 would not change if the power supply voltage was changed to 3.3V because resistance is not affected by voltage or current.

Conclusion:

The data gathered during the lab can be used to draw the conclusion that the orientation of resistors—series or parallel—is more significant than the total number of resistors in a circuit. It was discovered that in order to produce a linear ratio while using a potentiometer, it was best to change the load to potentiometer resistance, which was typically achieved by large load resistances. When there is no load voltage present, the potentiometer maintains a constant V_{out} across its first and third terminals. To ensure a linear relationship and dependability, potentiometers should be employed either with no load or with very big loads.