SAN FRANCISCO STATE UNIVERSITY
SCHOOL OF ENGINEERING

ENGR 206 Lab Report

Date

Experiment # 3:
KIRCHHOFF'S LAWS

by

Name

SAMPLE

Lab Partner: Name

Experiment #3: KIRCHHOFF'S LAWS

Objective

To verify experimentally Kirchhoff's voltage and current laws as well as the principles of voltage and current division.

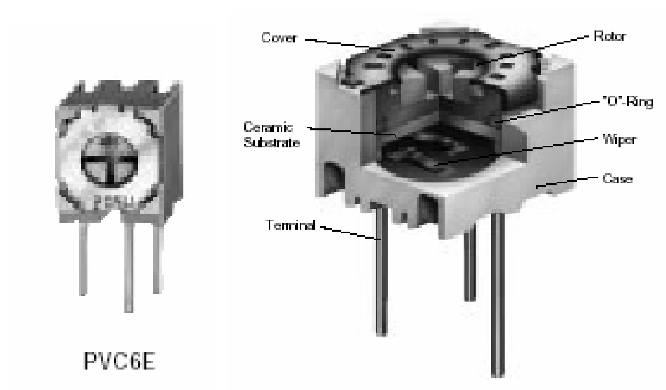
Apparatus

In this experiment, we use the following apparatus:
- Agilent E3630A Triple Output Power Supply,
- Agilent 34401A Digital Multimeter,
- 10KΩ Potentiometer, and
- a Decad

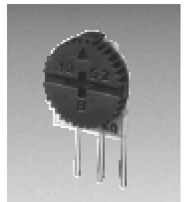
The Tripl
Lab Repo
decade b

The pote
single-tu

Figure #1. Types of Trimmer Potentiometers



a. muRata PVC6E - Lead Sealed Single-turn Potentiometer



b. Bourns 3352 - 3/8'' Single-turn thumb adjustable

A potentiometer, (called "pot" for short), is a resistor with three terminals as shown in Figure # 2. The resistance between terminals A and B is fixed.

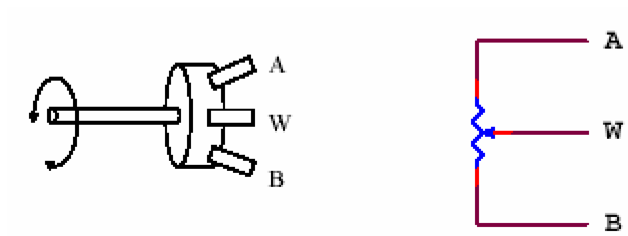


Figure #2. Potentiometer and its equivalent circuit

In our case
wiper blade
resistance
It is obviou
resistance
pot setting
Figure# 3.

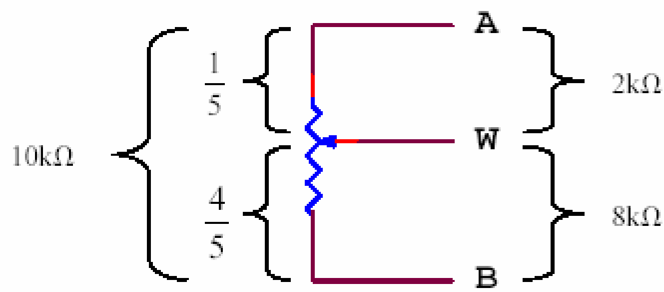


Figure #3. Equivalent circuit for the 10 kΩ potentiometer

A potentiometer can be used as a variable voltage divider or as a variable resistor. In the former case, all three terminals are used (e.g., Figure 5). In the latter case, only two terminals, W and either A or B, are used although it is a common practice to connect the unused terminal to the wiper to eliminate possible noise pickup.

A decade box is used for accurate resistance reading. The one available in our lab has 6 decade switches to allow for 1,000,000 resistance values to be dialed.

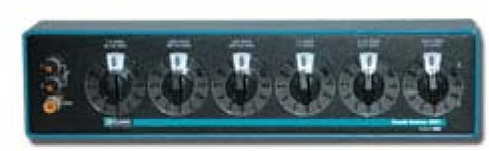


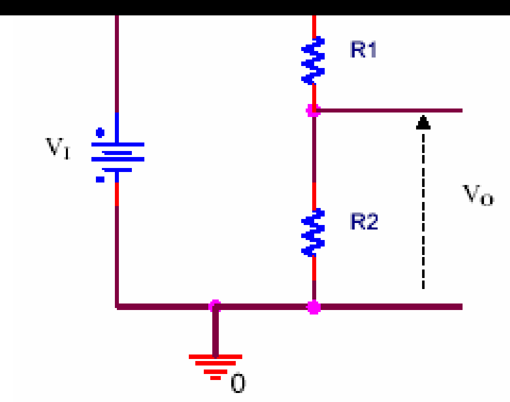
Figure #4, The TEGAM Model DB62-XX is a DEKABOX in-line Decade Resistor.

Procedures, Data, Results and Analysis

A. Voltage Div

1. Constru

We sel



$$V_0 = V_1 \frac{R_2}{R_1 + R_2}$$

Figure #5. Voltage Divider

2. Turn the power supply on. With the help of the DC voltmeter, adjust the power supply to output +10 V.

   We adjusted the power supply to output 10.0114 V.

3. Measure the voltage around the loop and verify the validity of KVL for this particular circuit. Repeat the loop measurements but with test leads reversed. Do these new readings still satisfy KVL?

   Kirchhoff's Voltage Law (KVL) states that the sum of all voltages around a closed loop is zero.

   The voltage measurements are:
   across R1: 5.0079 V
   acros[illegible]
   acros[illegible]
   The sum of all the [illegible]
   KVL is satisfied.

   If we reverse the [illegible]
   acros[illegible]
   acros[illegible]
   across source: 10.0114 V.
   Again, since the sum of all voltage changes is zero (within 5% tolerance), KVL is satisfied.

4. Compare the measured V_0 with the theoretically computed V_0. Account for causes of possible discrepancy.

   We compute the value for V_0 as follows:

   $$V_0 = V_I \frac{R_2}{R_1 + \ldots} \quad 1k\Omega$$ [illegible]

   The measured value for [illegible]
   very small value, within [illegible]
   some resistance in the w[illegible]

5. Leave R2 in place, repeat st[illegible]
   R1=10kΩ.

   <u>CASE 1: R1=100Ω, R2=1k</u>[illegible]
   The voltage measuremen[illegible]
   across R1: [illegible]
   across R2: [illegible]
   <u>across source: -10.0118 V</u>
   Sum = - 0.002 V

The sum of all these voltages is close to zero (within 5% tolerance). Therefore, KVL is sati [redacted]

If we reverse the test [redacted]

across R [redacted]
across R [redacted]
across s [redacted]
Sum = [redacted]

Again, since the sum [redacted] satisfied.

The theoretical value for V_0 is:

$$V_0 = V_I \frac{R_2}{R_1 + R_2} = 10.0114\ V \frac{0.1\ k\Omega}{0.1\ k\Omega + 1 k\Omega} = 0.9101\ V$$

The measured value for V_0 is 0.9168 V. The discrepancy is 0.0067 V (0.7% error, within 5% [redacted] wires and manufactur [redacted]

CASE 2: R1=10kΩ, R2= [redacted]

The voltage measurem [redacted]

across R [redacted]
across R [redacted]
<u>across source: -10.0118 V</u>
Sum = - 0.0059 V

The sum of all these voltages is close to zero (within 5% tolerance). Therefore, KVL is satisfied.

If we reverse the test leads, we get the following readings:

across R1: [redacted]
across R2: [redacted]
across sour [redacted]
Sum = 0.0 [redacted]

Again, since the sum of a [redacted] in 1%, within 5% toleranc [redacted]

The theoretical value fo [redacted]

$$V_0 = V_I \frac{R_2}{R_1 + R_2} = 10.0114\ V \frac{10\ k\Omega}{10\ k\Omega + 1 k\Omega} = 9.1012\ V$$

The measured value for V_0 is 9.9064 V. The discrepancy is 0.8052 V, about 8% error from the theoretical value, which is more than the 5% tolerance. It is [redacted] measurements, [redacted]

6. Connect the 10k[redacted]

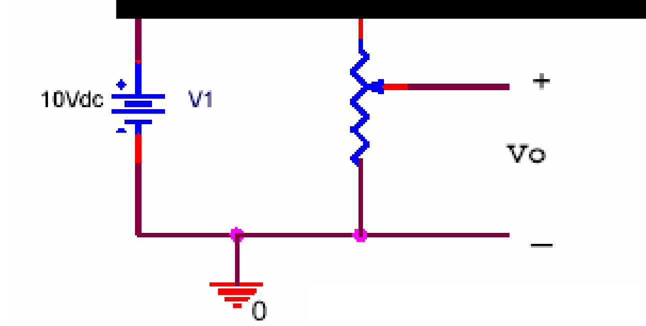


Figure #6. A Variable Voltage Divider

7. Monitor Vo with the dc voltmeter as you rotate the pot shaft back and forth. Within what limits does Vo vary? Why?

   V_0 varies within $V_{max} = 10.0043\ V$ and $V_{min} = 0.242\ mV$. $V_{max} = 10.0043\ V$ is close to the value of $V_{input} = 10.0114\ V$; the discrepancy between the two is 0.0071 (0.07% error). The minimum resistance is not zero because some minimal resistance in the pot can not be avoided.

8. Adjust the shaft positi[redacted] in parallel with Vo. [redacted] change. Compare the [redacted]

   The shaft position [redacted] Vo=5.0096 V. After[redacted] new value is: Vo' =[redacted] R2 is now replaced [redacted] parallel).

$$R_x = R_2 \| R_p = \frac{R_2 x R_p}{R_2 + R_p} = \frac{50\ k\Omega}{10\ k\Omega + 5\ k\Omega} = 3.33\ k\Omega$$

$$V_0 = V_I \frac{R_x}{R_1 + R_x} = 10.0114\ V \frac{3.33\ k\Omega}{3.33\ k\Omega + 5\,k\Omega} = 4.006\ V$$

The difference between [illegible]
Vo"=3.9590 V (1.1% error [illegible]
and human error in mani[illegible]

B. Current Division

1. Use the 0 to 6 volt Power Supply output and construct the voltage divider circuit as shown in Fig. 7. <u>Turn the Power Supply voltage output to 0 volts while constructing the circuit</u>. We will be simulating a constant current source by using a voltage source and adjusting the voltage as needed to create a predetermined current.

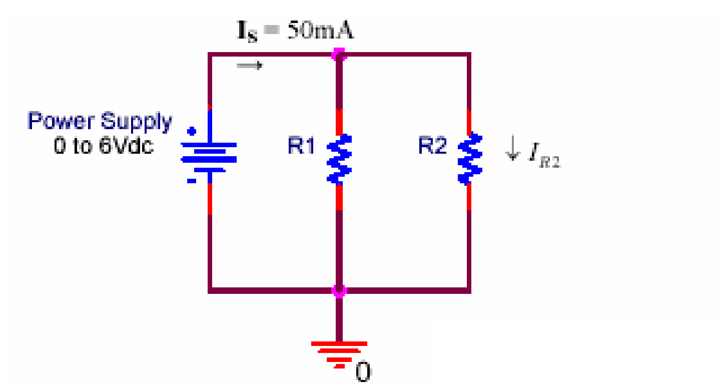


Figure #7. A Current Divider

2. Use R1 = R2 = 100Ω.

   The resistors we use have 5% tolerance level (gold band).

3. Watching the display of the Power Supply, adjust the current **Is** until it reaches 50mA.

   We adjusted the current to 50.139 mA DC. This gives us 0.139 mA error in measurements (0.3%) we should consider when explaining discrepancy later.

4. With the use of the DC ammeter verify KCL by measuring the current **I_{R2}** through the resistor R2.

   Kirchhoff's Current Law (KCL) states that the sum of all currents for any node is zero.

   I_s=50.139 mA
   I_{R2}=-26.296 mA
   <u>I_{R2} x</u>
   Sum=

   This is close to zer
   discrepancy is due
   wires or bad conne

5. Using the principle of current division calculate the theoretical value of **I_{R2}** and compare it with the measured value. Account for the causes of possible disagreements.

$$I_{R2} = I_I \frac{R_2}{R_1 + R_2} = 50.139\ mA \frac{100\ \Omega}{100\ \Omega + 100\Omega} = 25.0695\ mA$$

   The measured value is I_{R2}= 26.296 mA. The discrepancy is 1.226 mA (4.5% error), within 5% tolerance. This disagreement is possibly due to inaccuracy in measurement apparatus and resistor tolerances.

6. Leave R2 in place, repeat steps 4 and 5 for the case R1 = 10 . and for the case R1 = 1 k.. Be sure to maint
   Supply display.

   <u>CASE 1: R1=10Ω, R2=</u>
   I_s=-50.3
   I_{R2}=6.88
   <u>I_{R1} =47.2</u>
   Sum=-3

   This is close to zero, within tolerance. Hence, KCL is satisfied. The discrepancy is due to the inaccuracy of the measuring equipment and resistance tolerance.

$$I_{R2} = I_I \frac{R_1}{R_1 + R_2} = 50.312\ mA \frac{10\ \Omega}{10\ \Omega + 100\Omega} = 4.573\ mA$$

There is a discrepancy of 2.31 mA (50% error). This error is too high to be explained simply by the resistor tolerances or resistance in wires. (For example, even if we take that the actual resistor value is 95 Ω instead of 100 Ω, and plug-in exactly 50mA in the formula, the error goes down to 40%)
There is a possibility we made an error in this measurement.

<u>CASE 2: R1=1kΩ, R2=100Ω</u>

I_s=-50.151 mA
I_{R2}=45.66 mA
<u>I_{R1} =4.821 mA</u>
Sum=0.33 mA

This is close to zero, within 5% tolerance. Hence, KCL is satisfied. The discrepancy is due to some resistance in the wires and resistor tolerance.

$I_{R2} =$

The measure
within 5% to n
wires and resistor tolerances.

C. Bridge Circuit

1. Using the principle of voltage division show that for the bridge circuit shown in Figure # 8, $R_x = \frac{R_2 R_3}{R_1}$, if the voltage between points **p** and **q** is zero. When points **p** and **q** are at
the meter (either volt

We can see that th
R3, and R2 and Rx)
voltage between p
Applying the volta

$$v_0 = \left(\frac{1}{1+ \ldots} \quad \frac{1}{\ldots} \right.$$

when $v_S = 0$, the ...
and we have:

$$\frac{R1}{R3} = \frac{R2}{Rx} \ldots R_1$$

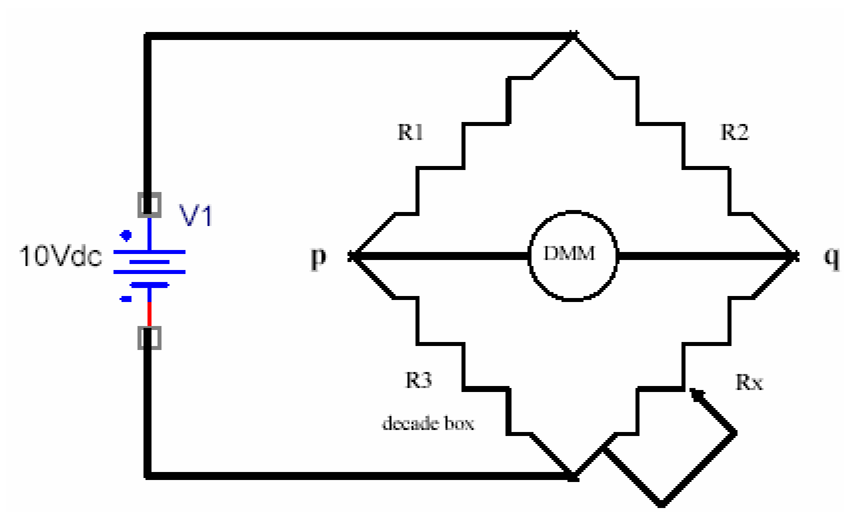


Figure #8. Bridge Circuit

2. Construct the br...
   box for R3 and ...
   and the pot shaf...

3. Turn the power ...

4. Monitor the volt...
   decade box resis...
   possible. Based on the formula given in step 1, find Rx.

   We adjust the value of the decade box to 4,601 Ω instead of 3,000 Ω. Applying the formula, we have:

$$R_x = \frac{R_2 R_3}{R_1} = \frac{4.7\ k\Omega * 4.6\ k\Omega}{2.2\ k\Omega} = 9.82\ k\Omega.$$

5. Carefully remove the pot from the circuit without changing its shaft position. Now measure the resistance Rx using the ohmmeter and compare with the value obtained [redacted] discrepancies. [redacted] of unknown res[redacted] of them.

   The measured [redacted] This represent[redacted] the potentiom[redacted] fragility. The [redacted] opinion, most[redacted] sensitive pote[redacted] mistake in our [redacted]

Conclusion

In this lab experiment w[redacted] division. We also tried t[redacted] and KCL.

In Part A we built a volta[redacted] time, we confirmed KVL [redacted] fixed voltage divider and [redacted] agreed with the theoreti[redacted]

In Part B, using a curren[redacted] verified KCL and the cur[redacted]

In Part C we built a bridg[redacted] balanced bridge.

Reference

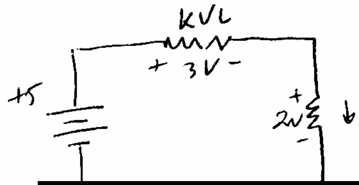
Hu, Dr. Sung C, and Klingenberg, Larry "ENGR 206 Electric Circuits and Instrumentation: Laboratory Manual" April 2002

Attachments: Lab Notes

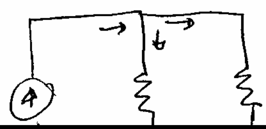
Tues. 2/17

Eng 206.

* Intro to PSpice
* Lab #3



KCL



Lab

A. V

a

a

R

(5) R_2

R_1:

$V_0 = \frac{10}{1100}$

$V_0 \stackrel{R_1}{=} 0.909091$ V across R_1

(6) R_2 : 10K Ω

R_1 : 1 KΩ

R_1 = 99.455mV −99.457mV

R_2 : 9.9064 V −9.9058V

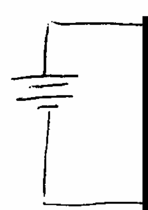
$V_0 \stackrel{R_2}{=} 9.9099$ V

$V_0 \stackrel{R_1}{=} 0.09901$

D. Current Division

Adjusted to 50.139 mA DC

(4)



(5) I_{R2} =

(6) leave R

R_1 = 1C

Adjust to 50

~~I_{R2} = 26.16~~

I_{R2} = 6.88

I_{R1} = 47.

C. Bridge Circuit

Box at 4601Ω not 3kΩ

$R_x = \frac{R_2 R_3}{R_1} = 9.827$ kΩ

Measured R_x = 7.1058 kΩ

(a) Potentiometer 10 kΩ

$V_{max} = 10.$

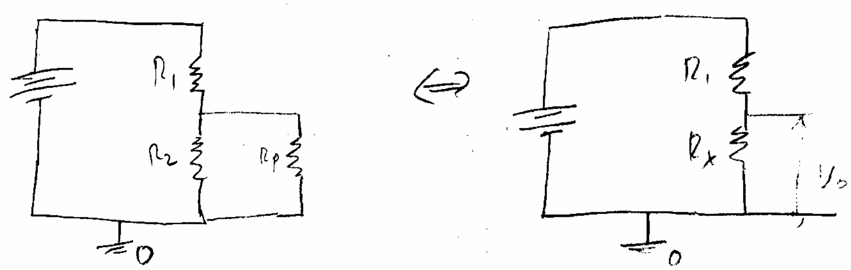
$V_{min} = 0.$

(b) $V_0 = 5.$

$V_0' = 6.$

$V_0' =$

10V



$R_x = \frac{10}{3}$ kΩ

$V_0' = 10V \cdot \frac{R_x}{R_1 + R_x} = \frac{10 \cdot \frac{10}{3}}{3.3 + 5} = 4.0616$

measured V_0 = 3.9590.