To: Professor Darish
From: Trever Wagenhals
Subject: Designing Ohmmeter, voltmeter, and ammeter with galvanometer

Date: 2014 November 25, 2014
Course & Section Number:
Partner(s):
TA: Kyle

SUMMARY

This lab involved creating an ohmmeter, ammeter, and voltmeter by using a galvanometer that was provided. The galvanometer was placed in various types of circuits in order to transform the readings it displayed into the proper units needed, i.e. Ohms, amps, and volts. Other data, such as internal resistance of the galvanometer, were also calculated in order to carry out the rest of the lab. The galvanometer had an internal resistance of 1300 ohms, and all following meter design values fell in accordance with the galvanometer conversion values.

EXPERIMENTAL APPROACH

Equipment and Materials

- Resistors
- Breadboard
- Power Supply
- Multimeter
- Test Leads
- Galvanometer
- Banana cables
- Alligator Clip

Procedure

This lab began with determining the deflection current of the system. With the galvanometer placed in series with a 10k ohm resistor, and the voltage altered until values from 100-500uA were displayed on the galvanometer, the deflection current was able to be calculated and recorded in Table 6-1. The next step was determining the internal resistance of the galvanometer. To calculate this, the galvanometer was placed in a circuit with a 10k ohm resistor and a voltage supply. The voltage supply was increased until the galvanometer read its max reading of 500 uA. Next, a decade box was put in parallel with the galvanometer and the resistance was altered until the galvanometer read 250 uA.

Next, the ammeter was to be constructed with the galvanometer in parallel with a shunt resistance. The shunt resistance, as calculated in the prelab, was 166.7 Ohms. Placing this in series with a 10k Ohm resistor, Voltage was added to the system until the measured current through the system was 0-5 mA in integer intervals. With these currents, the meter can be read and the current can be calculated from the reading. All data was placed in Table 6-2 for this section.

The voltmeter was very similar to the setup of the ammeter, except that a calculated series resistance was used with the galvanometer, which was calculated to be 8500 ohms in the prelab. The new voltmeter was placed in parallel with a 3.3k resistor and voltages ranging from 0-5V were supplied. From here, the galvanometer could be read and converted to an appropriate value of voltage. All data was recorded in Table 6-3.

Lastly, the ohmmeter was constructed. The simplest of the three, the galvanometer was put in series with the series resistance, just as the last step, and was put in parallel with a decade box. Five volts were supplied and the resistance of the decade box was adjusted to match the values in Table 6-4. From the galvanometer readings, the values could then be placed into Equation 12 to determine what resistance reading there is on the ohmmeter.

Discussion of Results:

The formula, $I_X = \frac{galvanometer\ \ scale\ \ reading}{500\ \mu A} \cdot I_{X,\max}$, was used to calculate the currents across the digital multimeter.

Table 6-1

D’Arsonval Galvanometer	Current (DMM)
500 μA	5.05 mA
400μ A	4.04 mA
300 μA	3.05 mA
200 μA	2.04 mA
100 μA	1.02 mA

The conversion from the meter reading based on different supplied currents was exactly the same since it is still the same current readings, just a backwards approach.

Table 6-2

DMM	Meter Reading	Current
0 mA	0	0 uA
1 mA	9	90 uA
2 mA	21	210 uA
3 mA	31	310 uA
4 mA	40	400 uA
5 mA	49	490 uA

The voltage conversion was probably the simplest, which just involved dividing the meter reading by 10 to get the voltage reading.

Table 6-3

DMM	Meter Reading	Voltage (Full scale of 10V)
0 V	0	0
1 V	10	1.00
2 V	20	2.00
3 V	30	3.00
4 V	39	3.9
5 V	49	4.9

The readings on the galvanometer were placed in Equation 12 to calculate the resistance. The resistance values all fall within acceptable range of the Rx resistance.

Table 6-4

Rx	Meter Reading	Resistance
2.27 kΩ	41	2.36k
15 kΩ	20	16.1k
27.5 kΩ	14	27.7k
30 kΩ	12	30.7k

Question:

- **Explain why the final resistance of the decade box is equal to the internal resistance of the Galvanometer.**
  The resistance of the decade box is equal because with two resistors in parallel with identical resistances, the current across both is the same. With the value of the current dropping to exactly half, that means half of the current went to the new resistor, making the resistance values equal.

  How did you get the current from the galvanometer scale? Show the calculations!

The current from the galvanometer used the equation

$$I_X = \frac{galvanometer\ scale\ reading}{500\ \mu A} \cdot I_{X,\max}$$

Ex. 500uA/500uA x 5 = 5mA

How did you get the voltage scale from the meter reading? Show the calculations!

Similar to the last question, except the equation is

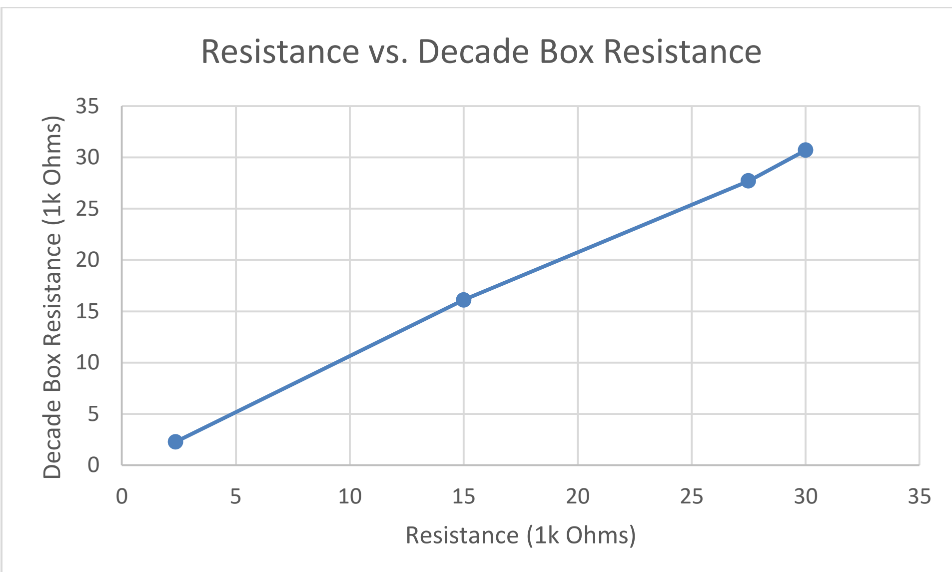
$$V_X = \frac{galvanometer\ scale\ reading}{500\ \mu A} \cdot V_{X,\max} \ .$$

Vx = 100ua/500uA x 5 = 1V

How did you get the resistance from the meter reading scale? Show the calculations!

$$R_X = \left(\frac{I_{G\max}}{I_g} - 1\right) \times (R_G + R_S)$$

Rx = (500uA/410uA – 1) * (8500 + 2.27k) = 2.36k Ohms



The graph should be a perfect 45 degree angle because they should be increasing at the same exact rate, thus making a perfectly straight line. The data is slightly off due to calculation rounding and resistance tolerance, as well as internal resistance variation.