University of Kentucky Department of Physics

Lab 4: Series and Parallel Resistors

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1 Introduction

The **purpose** of Lab 4 is, to compare direct measurements of the effective resistance of a collection of resistors to the values predicted by the series and parallel formulas. A few technical terms that will be used in this report are Voltage $V[V]$, resistance $R[\Omega]$, current $I[A]$. They are related by Ohm's law as $V = IR$. We measured the resistance of the four ohmic devices labeled $R_a, R_b, R_c.R_d$ by three different methods: (i) Color code of resistor (ii) Ohm's law (iii) Direct measurement with a digital multimeter (DMM).
Of these three methods, **Method (3) is most accurate** because it has lowest % error[1], and we report these resistor values as $R_a = 989 \pm 0.5\,\Omega, R_b = 494.8 \pm 0.5\,\Omega, R_c = 1982 \pm 0.5\,\Omega, R_d = 1481 \pm 0.5\,\Omega$.

2 Procedure

Part I: Calculation of Resistances using 3 Methods. We explain here how the resistor of each resistor in Step 7 is calculated.

(1) **Color code** The four band color code for brown-black-red-gold is, since brown=1,black=0, red=10^2, gold=5% $\Rightarrow R_a = 10 \cdot 10^2 \pm 5\% = 1000 \pm (1000 \cdot 5\%) = 1000 \pm 50\,\Omega$. To find $R_b = \frac{R_a}{2}$, note since the resistors are in parallel, so we use $\frac{1}{R_b} = \frac{1}{R_a} + \frac{1}{R_a} = \frac{R_a}{2}$. To find $R_c = 2R_a$, note since the resistors are in series we use $R_c = R_a + R_a = 2R_a$. To find $R_d \Rightarrow R_d = R_{ab} + R_c$.

(2) **Ohm Law** The voltage and current is measured, then use $V = IR \Rightarrow R = \frac{V}{I}$.

(3) **DMM** The Ω setting is used and two DMM wires are applied at the end of the resistors.

3 Data

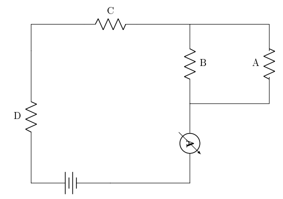
Resistor Values for part 1 using 3 methods.[2]

	$R_{\text{colorCode}} \pm \delta R_{\text{colorCode}}$	$R_{\text{DMM}} \pm \delta R_{\text{DMM}}$	$R_{\text{DMM}} \pm \delta R_{\text{DMM}}$
Ra	1000 ± 50.00	947.36842 ± 26.2465	989 ± 0.5
Rb	500 ± 25.00	481.25 ± 60.7812	494.8 ± 0.5
Rc	2000 ± 100.00	1950 ± 100	1982 ± 0.5
Rd	1500 ± 75.00	1423.07692 ± 56.6568	1481 ± 0.5

Part 4: Mixed Circuit.[3]

[1] This answers Problem 7. However see Data section.
[2] This answers Problem 7 and Problem 19
[3] This answers Problem 17

Figure 3.1: Schematic Diagram of Mixed Circuit,$R_{eq} = 3795\Omega$



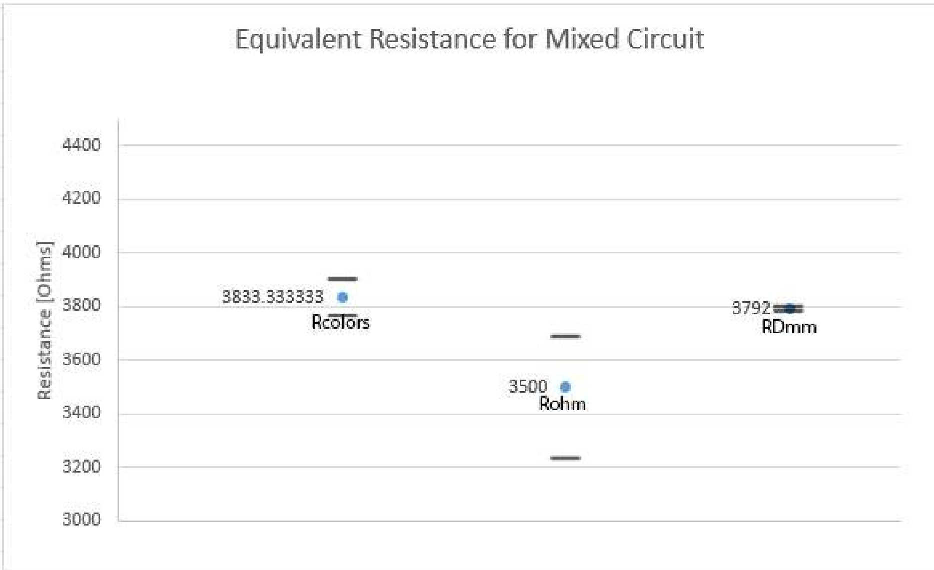


Figure 3.2: Equiv Resistance for mixed circuit. Note all 3 values within each other's error bars.

Calculation of $R_{\textbf{effective}}$.[4] To determine $R_{\text{effective}}$ of the mixed resistors of part 4, we refer to Fig 2.1. Note $R_A = 989 \pm 0.5$ and $R_B = 494.8 \pm 0.5$ are in parallel $\Rightarrow R_{AB} = 329.80 \pm 0.5$. Then R_{AB} are in series with R_C and R_D so

$$\begin{aligned} R_{\text{effective}} &= (R_{AB} + R_C + R_D) \\ &= (329.80 \pm 0.5 + 1982.0 + \pm 0.5 + 1481.0 \pm 0.5)\ \Omega \\ &= 3792.8 \pm 0.5\,\Omega \end{aligned} \tag{3.1}$$

Calculation of $\delta R_{\textbf{effective}}$.[5] For $y_1 = V$, $y_2 = I$, and $X = R$ using the following notation: $\delta X(y_1, y_2, \ldots) = \sum_{\text{all } y_i} \left| \frac{\partial}{\partial y_i}[X] \cdot \partial y_i \right|$

[4] This answers Problem 20

[5] This answers Problem 22.

, and using $R = \frac{V}{I}$,

$$\delta R = \left|\frac{\partial R}{\partial V}\delta V\right| + \left|\frac{\partial R}{\partial I}\delta I\right| = \left|\frac{\partial\left(\frac{V}{I}\right)}{\partial V}\,\partial V\right| + \left|\frac{\partial\left(\frac{1}{I}\right)}{\partial I}\,\partial I\right| = \left|\frac{\partial V}{\partial I}\right| + \left|V\frac{(-1)}{I^2}\,\partial I\right|$$

$$= \left|\frac{\partial V}{\partial I}\right| + \left|V\frac{(-1)}{I}\,\frac{\partial I}{I}\right| = \left|\frac{\partial V}{\partial I}\right| + \left|R\,\frac{\partial I}{I}\right| = \left|\frac{\partial V}{I}\,\frac{I}{V}\right| + \left|\frac{\partial I}{I}\right| \Rightarrow \text{ so finally}$$

$$\frac{\partial R}{R} = \frac{\partial V}{V} + \frac{\partial I}{I} \text{ or } \partial R = R\left(\frac{\partial V}{V} + \frac{\partial I}{I}\right).$$

4 Conclusion

Largest source of uncertainty.[6] largest source of uncertainty is resistance R of resistors. These values are larger than systematic uncertainty such as heating of the wires. Of the 3 methods discussed, the color codes (with gold having 5% uncertainty) have the most error as discussed above, and is smallest for the DMM.

[6]This answers problem 23.