Exp. 5: Series and Parallel Circuits

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Abstract

A study was done to determine the equivalent resistance of a circuit that contains two loops. This was done by setting up a circuit board containing two loops with two resistors on each loop, a battery terminal supplying three volts to the circuit, and an ammeter reading the current at the start of the circuit. The equivalent resistance was calculated first by adding all the resistors in series and parallel and by dividing the voltage supplied by the battery terminal by the current leaving it. The equivalent resistance was calculated to be 42.4 Ω and 41.9 Ω, respectively.

Introduction

When multiple resistors are added together in a circuit, the resistance increases. This increase varies depending on how the resistors are ordered, however. When set up in a series configuration, the resistances of the resistors add together simply to form the circuit’s equivalent resistance. This can be represented as . When set up in a parallel configuration, the inverse of the equivalent resistance is equal to the sum of the inverses of the individual resistances. In other words, . These formulas can be combined with each other when there are both series and parallel configurations in the circuit to provide the equivalent resistance.

Also, for the case of a loop in a circuit, the sum of the voltage drops and gains in that loop equals zero. This can be demonstrated by using a digital multimeter to measure the voltage across various elements in a circuit and adding them up to see if they equal zero. Additionally, according to Kirchoff’s Law, the currents into and out of any loop’s junction in a circuit will be equal. This can be demonstrated by using an ammeter to measure the current at various points in the circuit.

Procedure

In this experiment, a circuit board with a two AA battery terminal and various resistors was set up. A Digital Multi-Meter (DMM) was first used to measure the resistance across the various resistors. The measured values of these resistors were compared to the marked tolerance on the resistors themselves. The resistors were then set up, first in various series configurations, and then in various parallel configurations. The equivalent resistances of these configurations were measured using the DMM and compared with their equation values, calculated using the formulas for the equivalent resistance of series and parallel configurations. Afterwards, a circuit was set up with the battery terminal connected via a wire switch (labeled as SW3) to an ammeter set to measure current. This led into a 10 Ω resistor (R1) which split off into Loop 1 and Loop 2 at Junction B. Loop 1 then led into a 68 Ω resistor (R5). Loop 2 contained a 51 Ω resistor (R3), which led into Junction C. This connected to another 10 Ω resistor (R2) before combining with Loop 1 at Junction D and continuing back to the battery terminal. The DMM was then used to measure the voltage across the battery terminal, the ammeter, and all four resistors. The ammeter was used to measure both the current through the battery terminal and the ammeter, while the resistors’ measured voltages were used to calculate the currents across each resistor. The voltage across the battery terminal when not connected to the circuit was also measured. The voltage drops and gains across each loop were summed, as were the currents into and out of each of the three junctions. The ammeter resistance was then calculated, along with the internal resistance of the battery holder. The equivalent resistance of the circuit was measured twice: once by using the measured values of each element’s resistance, and once by using Ohm’s Law and the voltage and current out of the battery terminal.

Results

The equivalent resistance of the circuit when using the series and parallel configuration formulas was 42.4 Ω. The equivalent resistance when using the measured terminal voltage and ammeter current was 41.86 Ω.

Question 1: All the measured values of the resistors are with their corresponding tolerances.

Question 2: They are all off by a very small margin.

Question 3: Human error and possible electric charges in the air interfering with measurement.

Question 4: 0.01 Ω or 0.1 kΩ depending on the size of the resistance.

Question 5: They are nearly identical.

Question 6: They are nearly zero, enough to be accounted for in the DMM’s uncertainty.

Question 7: They are close enough to zero to be explained by the DMM’s uncertainty.

Question 8: It was off by only about 1% the total value of the equivalent resistance.

Questions to Answer

1. The conservation of energy.
2. The conservation of electric charge.
3. The EMF is the source of the energy in volts being supplied to a circuit, while a potential difference describes a change in voltage at a point in a circuit.
4. 5/12 A and 3/4 A.