TITLE – Resistors in Series and Parallel

OBJECTIVE – To analyze the properties of resistors connected in series and parallel.

EQUIPMENT

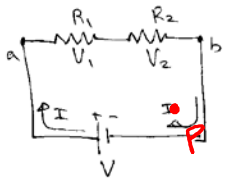
1. HP-DMM (used as an ammeter)
2. Hand-held DMM (used as a voltmeter)
3. Power Supply
4. 2 different resistors less than 5K Ω
5. Circuit boards
6. Leads and alligator clips

THEORY

$$\Delta U_{P\to P} = 0$$

$$qV + q(-V_1) + q(-V_2) = 0$$

Resistors in Series



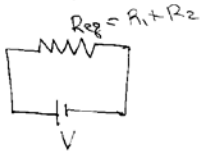
$V = V_1 + V_2$

$V = IR_1 + IR_2$

$\frac{V}{I} = R_1 + R_2$

$R_{eq} = R_1 + R_2$

* When resistors are connected in series, the current is the same through all resistors.

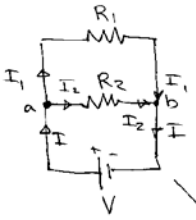


$R_{eq} = \frac{V}{I}$

In general,

$R_{eq} = R_1 + R_2 + R_3 - - -$ Resistors connected in Series

Resistors in Parallel



* When resistors are connected in parallel, the potential is the same across all the resistors.

junction – a point on a circuit where the current splits

$I = I_1 + I_2$

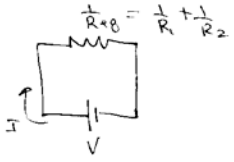
$I = \frac{V}{R_1} + \frac{V}{R_2}$

$\frac{I}{V} = \frac{1}{R_1} + \frac{1}{R_2}$

$\left[\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2}\right]$

$\frac{1}{R_{eq}} = \frac{I}{V}$

$\left[R_{eq} = \frac{V}{I}\right]$



In general,

$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \cdots$ Resistors connected in Parallel

Since $V_1 = V_2 = V$, then $I_1 R_1 = I_2 R_2$

$$I_1 = \left(\frac{R_2}{R_1}\right) I_2$$

If $R_1 < R_2$, then $I_1 > I_2$
If $R_2 < R_1$, then $I_2 > I_1$

∴ More current flows through path of least resistance.

Procedure

Part 1: Measuring R_{eq}

1. Measure R_1 and R_2 with the DMM.
2. Connect R_1 and R_2 in series, using the circuit board, and measure R_{eq} with the DMM. Compare R_{eq} with the expected value of $R_{eq} = R_1 + R_2$.
3. Connect R_1 and R_2 in parallel, using the circuit board, and measure R_{eq} with the DMM. Compare R_{eq} with the expected value of $1/R_{eq} = 1/R_1 + 1/R_2$.

Part 1: Series Combination

1. Connect R_1 and R_2 in series and apply a voltage of ≈10V with power supply.
2. Measure the total current in the circuit and compare with expected value of $I_{expected} = V/R_{eq}$, where $R_{eq} = R_1 + R_2$.
3. Measure V_1 and V_2 and show that $V = V_1 + V_2$.
4. Calculate $I_1 = V_1/R_1$ and $I_2 = V_2/R_2$ and show that $I_1 = I_2 = I$.

Part 2: Parallel Combination

1. Connect R_1 and R_2 in parallel and apply the same voltage as in the series combination.
2. Measure the total current in the circuit and compare with the expected value of $I_{expected} = V/R_{eq}$, where $1/R_{eq} = 1/R_1 + 1/R_2$
3. Measure I_1 and I_2 and show that $I_1 + I_2 = I_{measured}$
4. Measure V_1 and V_2 and show that $V_1 = V_2 = V$.
5. Calculate $I_1 = V_1/R_1$ and $I_2 = V_2/R_2$ and show that $I_1 + I_2 = I_{expected}$.
6. Compare $I_1 = V_1/R_1$ and $I_2 = V_2/R_2$ with measured values.