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ME 6 — Homework 1

1 Problem Statement:

Determine the values of R_1, R_2, R_3

Given:

- The main fuse will burn if more than 1000mA is drawn

  $I_{battery} <= 1000mA$

  $R_{fuse} = 1.1\Omega$

- DV1, DV2, and DV3 have a rated voltage and wattage.

$$\begin{array}{ll} V_{DV1} = 8.0V & P_{DV1} = 3.0W \\ V_{DV2} = 16.0V & P_{DV2} = 4.4W \\ V_{DV3} = 10.0V & P_{DV3} = 2.0W \end{array}$$

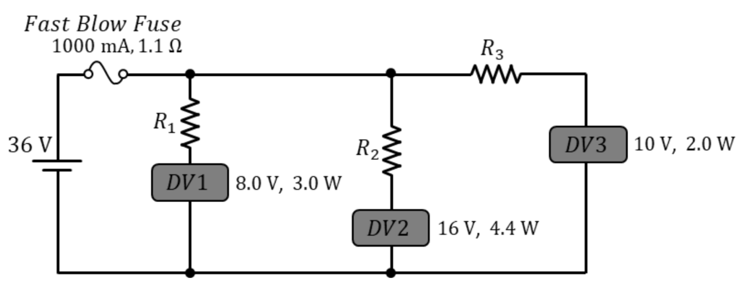

Figure 1: Circuit diagram of Problem 1

Solution:

The function of the resistors is to ensure that each transducer is functioning within its rated voltage and wattage. The circuit diagram shows that the 3 transducers are wired in parallel, each having a resistor wired in series. Since the 3 transducers are wired in parallel that means the voltage going to each transducer resistor branch is the same.

We are given the rated voltage and wattage of each transducer, from which we can find what amount of current the transducer needs using the following formula: $P = V * I \rightarrow I = \frac{P}{V}$ We can also use KCL to verify that the total current does not exceed the $1A$ rating of the fuse.

$$
\begin{aligned}
I_{DV1} &= \frac{3.0W}{8.0V} = 375mA \\
I_{DV2} &= \frac{4.4W}{16.0V} = 275mA \\
I_{DV3} &= \frac{2.0W}{10.0V} = 200mA \\
I_{DV1} + I_{DV2} + I_{DV3} &= 850mA \ \underline{\leq 1000mA}
\end{aligned}
$$

We can now use Kirchhoff's Voltage Law to create three loops with each transducer and find the required resistance value.

$$
\begin{aligned}
V_{fuse} &= R_{fuse} * (I_{DV1} + I_{DV2} + I_{DV3}) \\
V_{fuse} &= 0.935V
\end{aligned}
$$

$$
\begin{aligned}
-V_{battery} + V_{fuse} + R_1 * I_{DV1} &= 8.0V \\
R_1 &= \frac{8.0V - V_{battery} + V_{fuse}}{I_{DV1}} \\
R_1 &= 72.2\Omega
\end{aligned}
$$

$$
\begin{aligned}
-V_{battery} + V_{fuse} + R_2 * I_{DV2} &= 16.0V \\
R_2 &= \frac{16.0V - V_{battery} + V_{fuse}}{I_{DV2}} \\
R_2 &= 69.3\Omega
\end{aligned}
$$

$$
\begin{aligned}
-V_{battery} + V_{fuse} + R_3 * I_{DV3} &= 10.0V \\
R_3 &= \frac{10.0V - V_{battery} + V_{fuse}}{I_{DV3}} \\
R_3 &= 125.3\Omega
\end{aligned}
$$

$\boxed{R_1 = 72.2\Omega \ \ R_2 = 69.3\Omega \ \ R_3 = 125.3\Omega}$

2 Problem Statement:

Determine the values of

- I_1 - the current supplied by the battery when S1 is closed and S2 is open
- I_{12} - the current supplied by the battery when S1 is closed and S2 is closed
- R_{b15} and R_{b10} - the resistance of the 15 W and 10 W bulbs, respectively

Given:

- $V_{battery} = 12V$
- $P_{b15} = 15W$
- $P_{b10} = 10W$

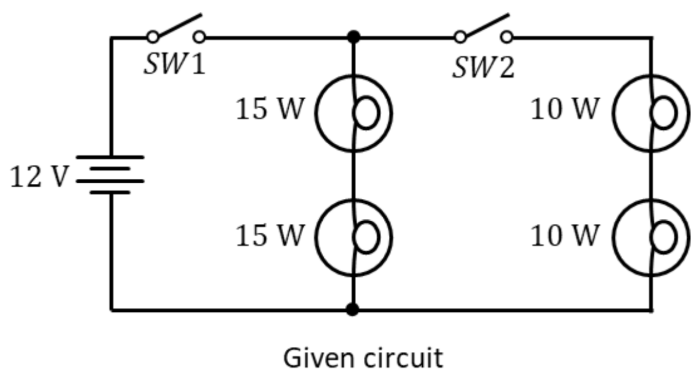

Figure 2: Circuit diagram of Problem 2

Solution:

The current supplied by the battery when S1 is closed and S2 is open can be found by calculating the total power of the bulbs that will be powered when S1 is closed. The two bulbs are wired in series so the current going through each bulb is the same. Each of the two bulbs pulls 15W, using the following formula: $P = V * I \rightarrow I = \frac{P}{V}$

$$
\begin{aligned}
I_1 &= \frac{P}{V} \\
I_1 &= \frac{P_{b15} + P_{b15}}{12} \\
I_1 &= 2.5A
\end{aligned}
$$

$\boxed{I_1 = 2.5A}$

The current supplied by the battery when S1 is closed and S2 is closed can be found by adding the current in each branch of the two sets of bulbs. The two bulbs in the first branch each pull 15W and the two bulbs in the other branch each pull 10W. The branches are in parallel so the voltage going to each branch is the same, so we can find the current in each branch using the total power and voltage. Then using KCL find the total current.

$$
\begin{aligned}
I_2 &= \frac{P}{V} \\
I_2 &= \frac{P_{b10} + P_{b10}}{12} \\
I_2 &= 1.\overline{7}A \\
I_{12} &= I_1 + I_2 = 4.1\overline{6}A
\end{aligned}
$$

$\boxed{I_{12} = 4.1\overline{6}A}$

To find the resistance of each type of bulb we can create two Kirchhoff loops, one with the two 15 W bulbs and one with the two 10 W bulbs. We know the current going into each branch so we can solve for the resistance of each bulb.

$$
\begin{aligned}
12V &= I_1 * R_{b15} + I_1 * R_{b15} \\
R_{b15} &= \frac{12V}{2 * I_1} \\
R_{b15} &= \frac{12V}{5A} \\
R_{b15} &= 2.4\Omega
\end{aligned}
$$

$$
\begin{aligned}
12V &= I_2 * R_{b10} + I_2 * R_{b10} \\
R_{b10} &= \frac{12V}{2 * I_2} \\
R_{b10} &= \frac{12V}{3.\overline{3}A} \\
R_{b10} &= 3.6\Omega
\end{aligned}
$$

$\boxed{R_{b15} = 2.4\Omega \;\; R_{b10} = 3.6\Omega}$