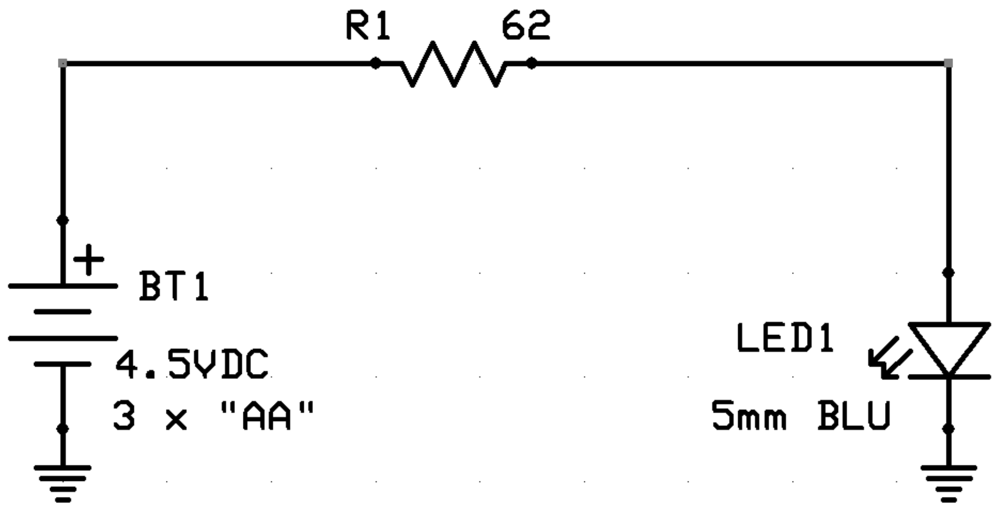
Basic Electronics Series

Series vs. Parallel -- Ohm's Law Applied

Series Circuits

- Only one path for the current to follow.
- Values of resistors add to get the total
- The same current flows through each and every resistor
- The total current is controlled by the total resistance
- The voltage drops proportionally across each of the resistances in the circuit.
- The sum of the individual voltage drops is equal to the source voltage.

Series Circuit

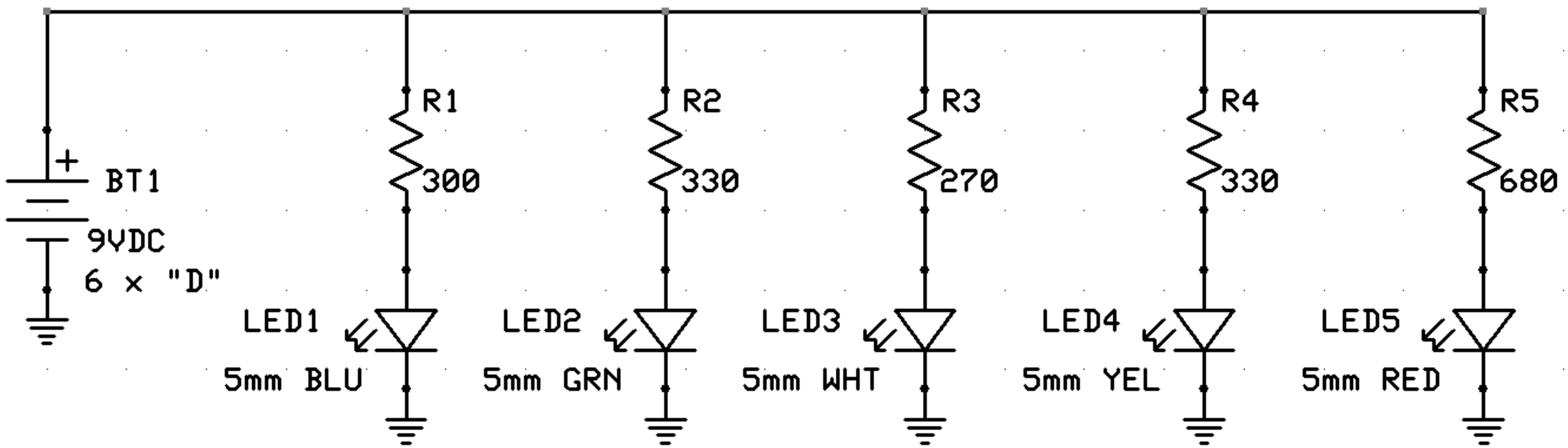


- Only one path for all current to follow.
- Voltage drops across each component.
- The same current flows through all components in the series path.
- LED_1 drops 3.2V, and R_1 drops balance (1.3V)
- LED_1 current 20.967mA (1.3V / 62Ω)

Parallel Circuits

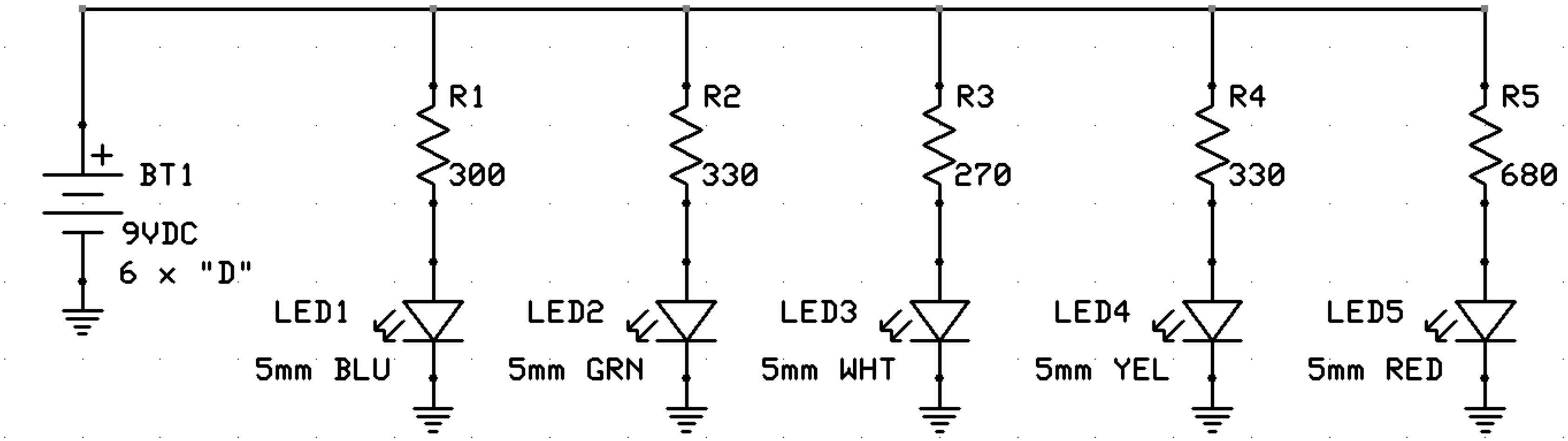
- Multiple paths for current to follow.
- The total resistance is *lower than the lowest resistance in the circuit.*
- The current splits proportionally among the parallel branches based on the resistance of each branch.
- The source voltage is applied to each parallel branch of the circuit.
- While the currents in the individual parallel branches may be different, the same current flows through each component in a series path in each parallel branch.

Parallel Circuit



- Multiple paths for current to follow
- Source voltage (9V) is applied to each branch
- Overall current divides by branch resistances
  - A different current flow will be present in each branch, based upon the resistance of the branch

Parallel Circuit

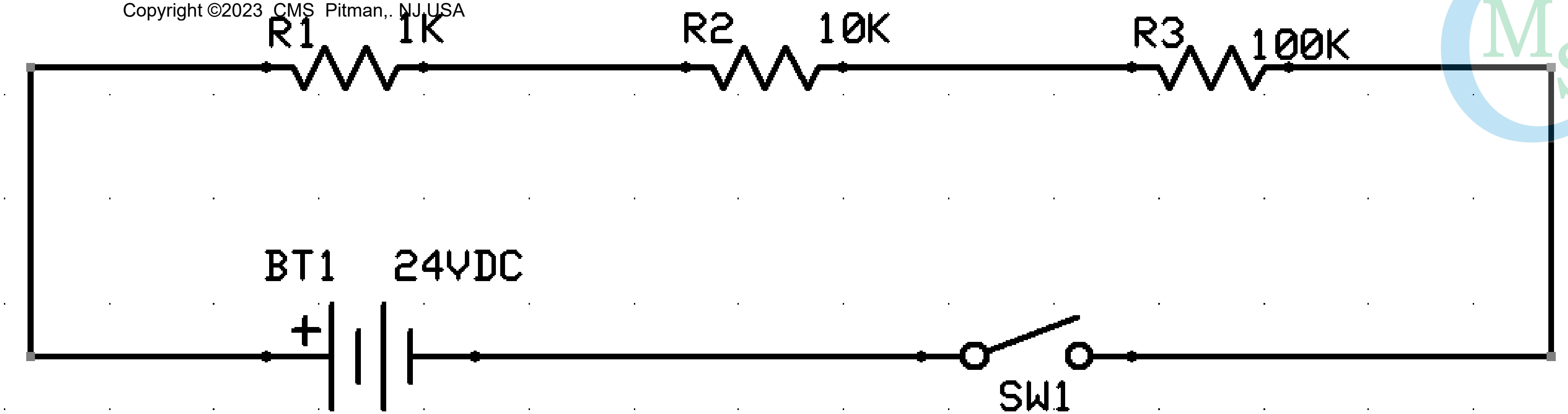


- LED_1 drops 3.2V – R_1 drops balance (5.8V)
  - LED_1 current = 19.333mA (5.8V / 300Ω)
- LED_2 drops 2.1V – R_2 drops 6.9V, current = 20.910mA
- LED_3 drops 3.6V – R_3 drops 5.4V, current = 20.000mA
- LED_4 drops 2.3V – R_4 drops 6.7V, current = 20.303mA
- LED_5 drops 1.7V – R_5 drops 7.2V, current = 10.588mA

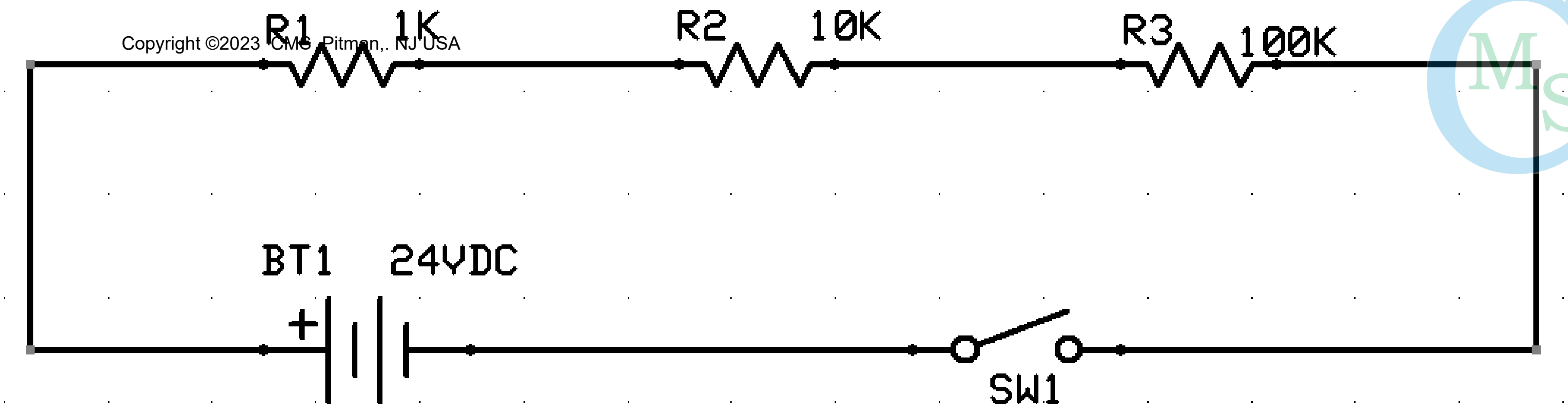
NOTE: Forward voltage of each LED is found on LED datasheet.

Resistance Formulas

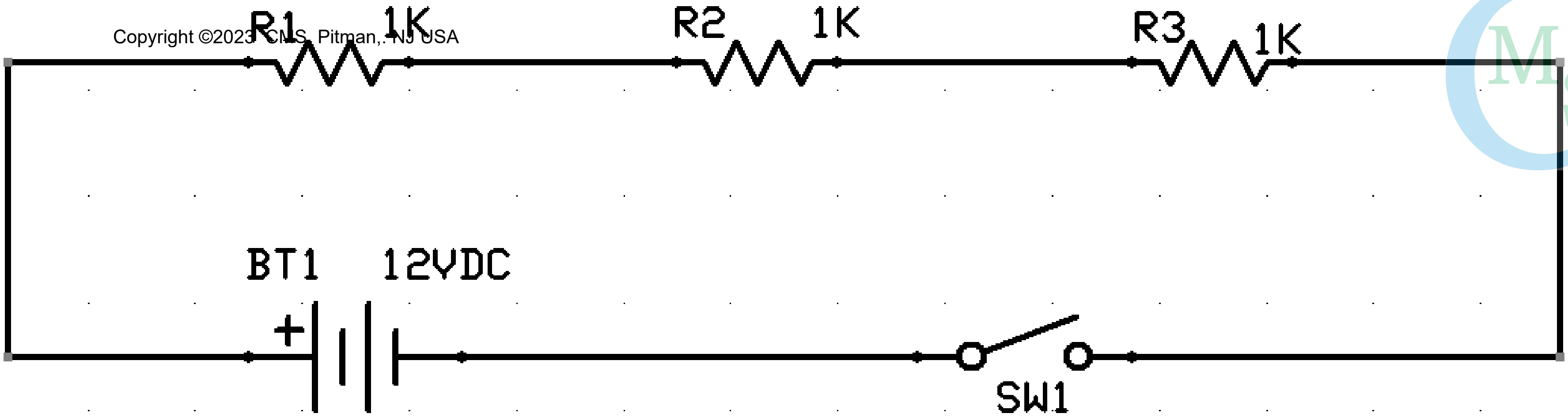
- Series resistances
  - $R_T = R_1 + R_2 + R_3$... *etc.*
- Parallel resistances
  - If only two resistances – product over sum
    - $R_T = (R_1 \text{ x } R_2) / (R_1 + R_2)$
  - If more than two resistances…
    - $1/R_T = 1/R_1 + 1/R_2 + 1/R_3$...*etc.* or
    - $R_T = 1/(1/R_1 + 1/R_2 + 1/R_3$...*etc.*)
- *If combination of series and parallel, work out parallel resistance first, then add that to the series resistance.*



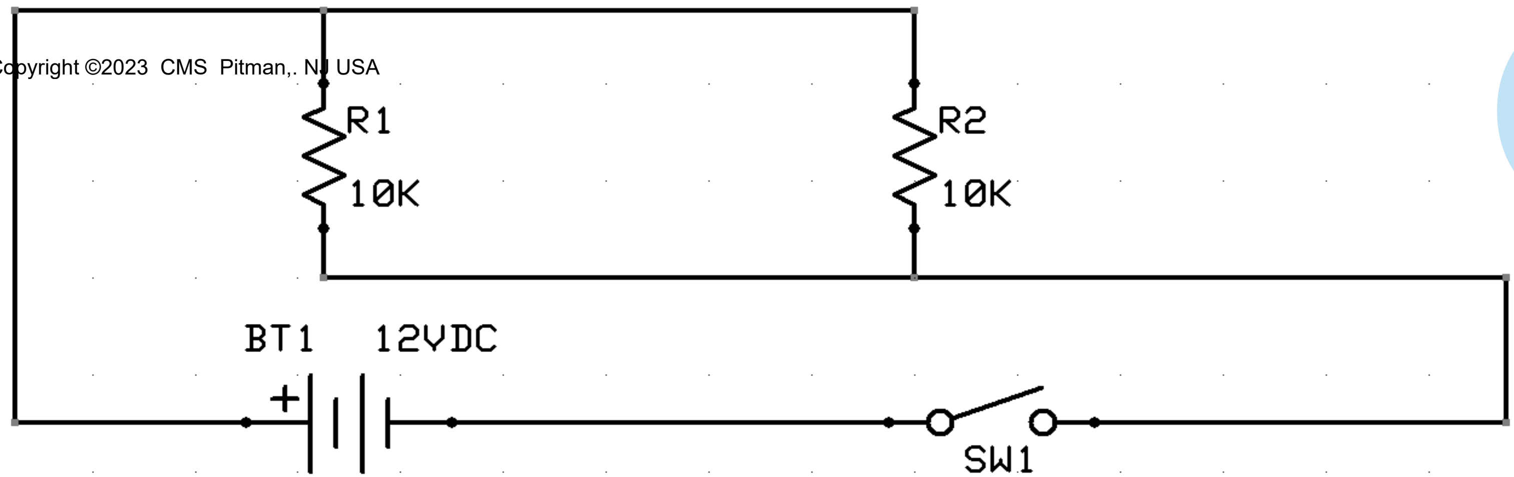
- What is the total resistance?
  - $R_T = R_1 + R_2 + R_3 \ldots$
  - $R_T = 111{,}000\Omega$
- What is the current through R2?
  - $I = E / R$
  - $I = 24/111{,}000 = 0.0002162162A$
  - $I = 0.21262162mA$



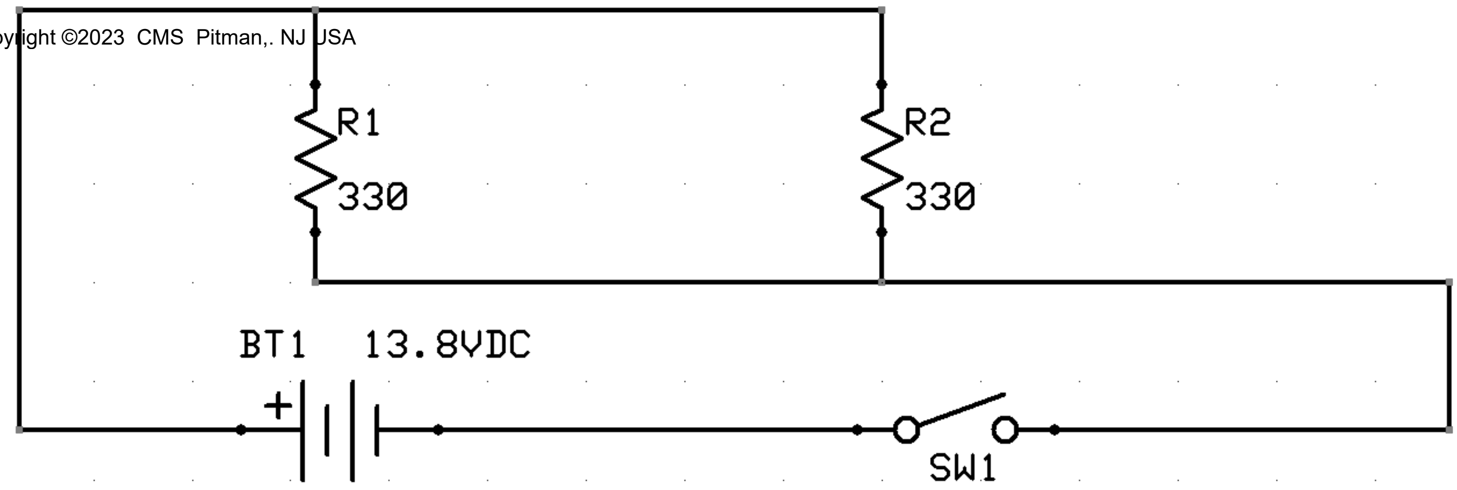
- What is the voltage drop across R_1, R_2, & R_3?
  - $I = 24/111{,}000 = 0.0002162162A$
  - $E_{R1} = I \times R_{R1} = 0.0002162162 \times 1{,}000$
  - $E_{R1} = 0.2162162V$
  - $E_{R2} = I \times R_{R2} = 0.0002162162 \times 10{,}000$
  - $E_{R2} = 2.162162V$
  - $E_{R3} = I \times R_{R3} = 0.0002162162 \times 100{,}000$
  - $E_{R3} = 21.62162V$



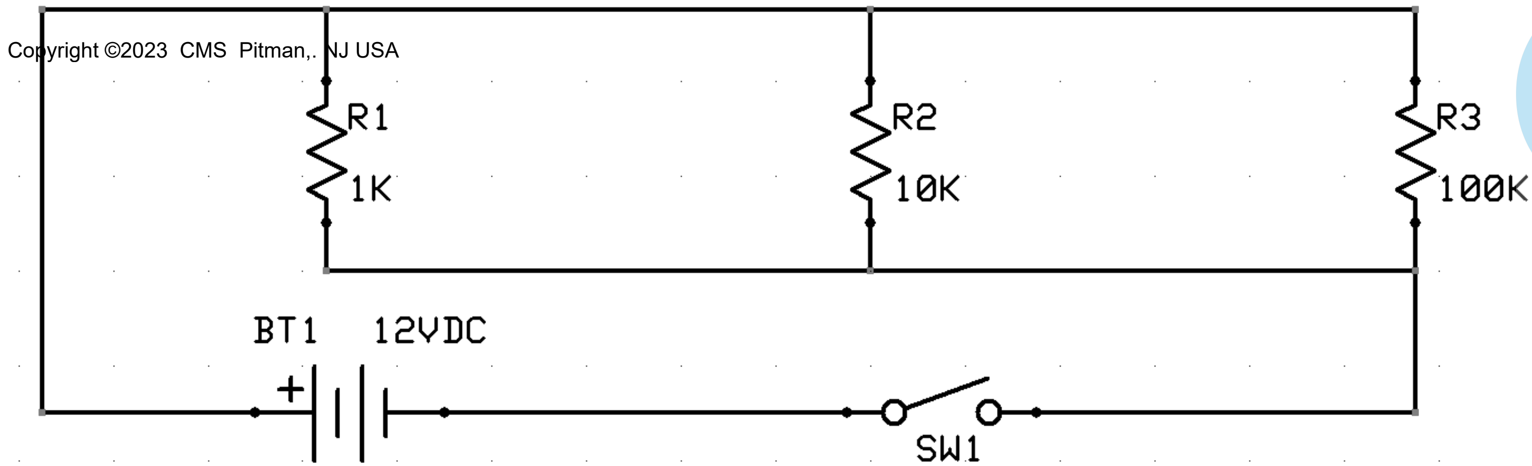
- What is the total resistance?
  - $R_T = R_1 + R_2 + R_3 \ldots$
  - $R_T = 3{,}000\Omega$
- What is the current through R_2?
  - $I = E \,/\, R$
  - $I = 12/3{,}000 = 0.004A$
  - $I = 4mA$



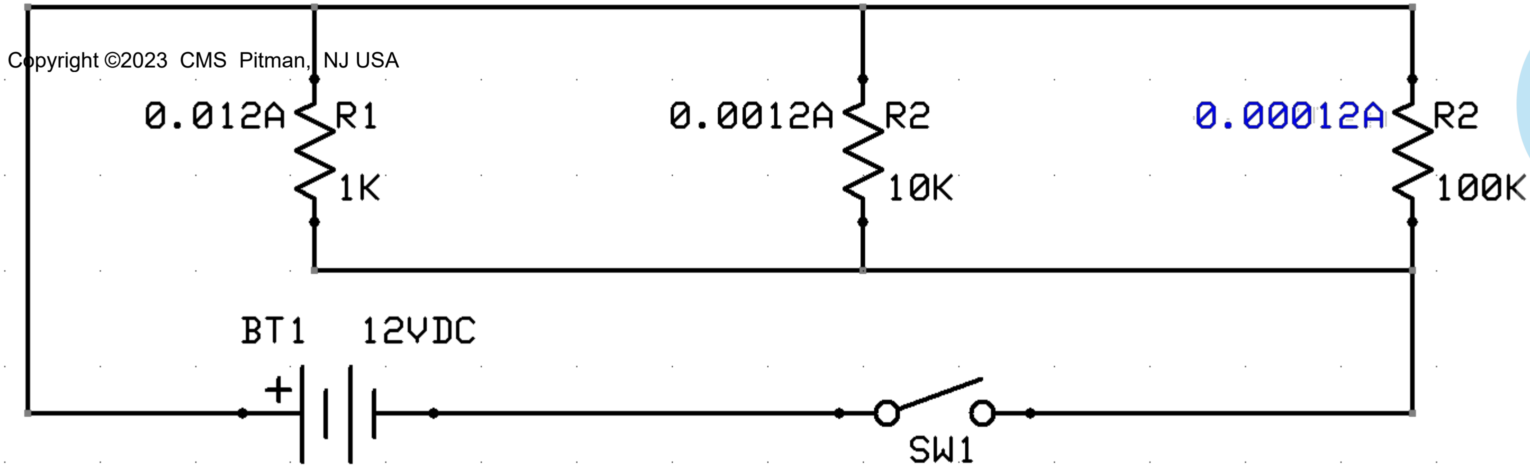
- What is the total resistance?
  - $R_T = (R_1 \text{ x } R_2) / (R_1 + R_2) = 100{,}000 / 20{,}000...$
  - $R_T = 5{,}000\Omega$
- What is the current through R_1?
  - $I = E / R$
  - $I_T = 12/5{,}000 = 0.0024A$
  - $I = 1.2mA$
  - R_1 and R_2 are same value – current splits evenly



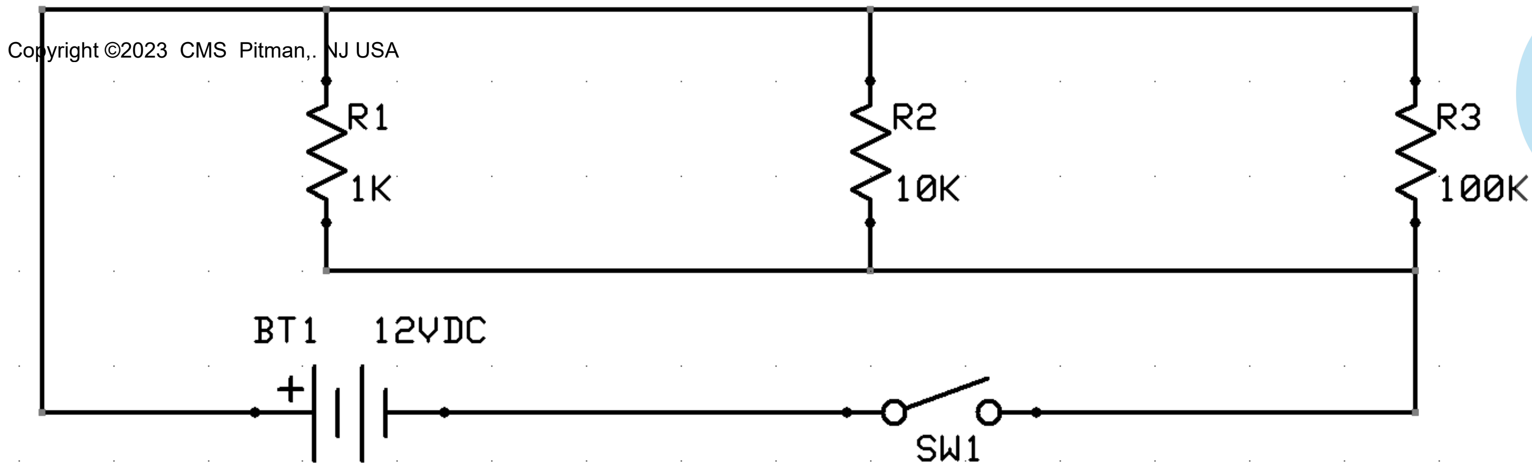
- What is the total resistance?
  - $R_T = (R_1 \times R_2) / (R_1 + R_2) = 108{,}900 / 660$
  - $R_T = 165\Omega$
- What is the current through R_2?
  - $I = E / R$
  - $I = 13.8/330 = 0.0418181818$
  - $I = 41.81818mA$
  - $I_{R2} = 41.81818mA / 2$, as $R_1 = R_2$ so current splits evenly between the two resistive paths
  - $I_{R2} = 20.90909mA$



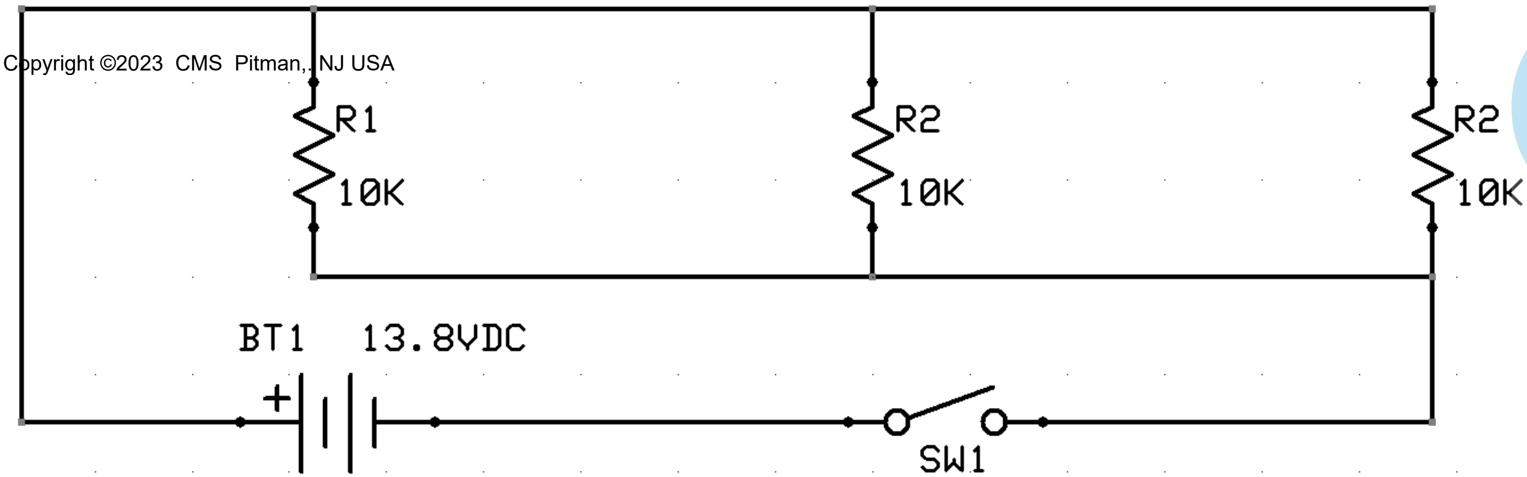
- What is the total resistance?
  - $1/R_T = 1/R_1 + 1/R_2 + 1/R_3$
  - $1/R_T = 0.001 + 0.0001 + 0.00001 = 0.00111$
  - $R_T = 1/\ 0.00111 = 900.9009\Omega$
- What is the total current in the circuit?
  - $I = E\ /\ R$
  - $I_T = 12/900.9 = 0.01332A$
  - $I_T = 13.32mA$



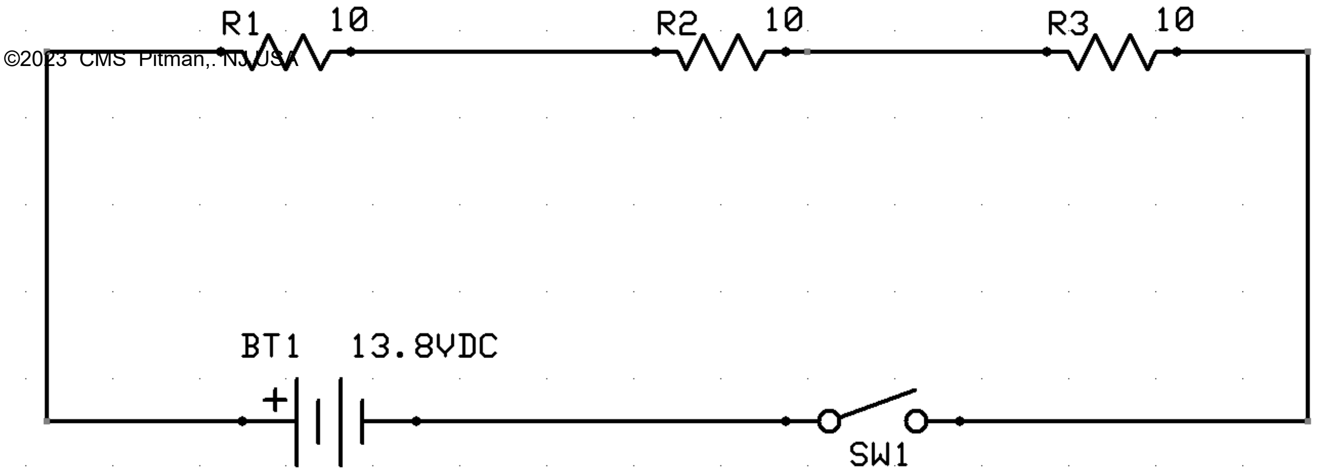
- What is the total current in the circuit?
  - $I_T = I_{R1} + I_{R2} + I_{R3} = 0.01332A$
- What is the power consumed in the circuit?
  - $P = I \text{ x } E$
  - $P = 12 \text{ x } 0.01332$
  - $P = 0.15984W$
  - $P = 159.84mW$



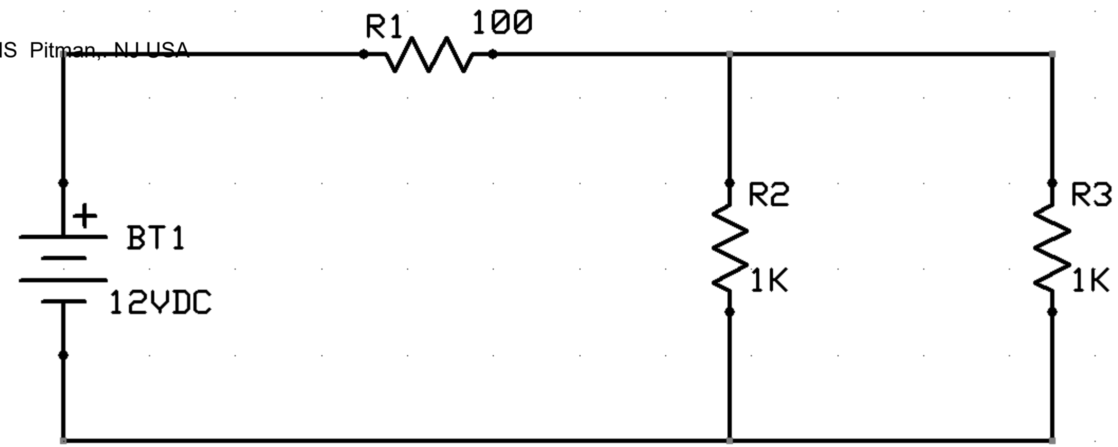
- What is the total resistance?
  - $1/R_T = 1/R_1 + 1/R_2 + 1/R_3$
  - $1/R_T = 0.001 + 0.0001 + 0.00001 = 0.00111$
  - $R_T = 1/\ 0.00111 = 900.9009\Omega$
- What is the current through R3?
  - $I = E\ /\ R$
  - $I_{R3} = 12/100{,}000 = 0.00012A$
  - $I_{R3} = 0.12mA$



- What is the total resistance?
  - $1/R_T = 1/R_1 + 1/R_2 + 1/R_3$
  - $1/R_T = 0.0001 + 0.0001 + 0.0001 = 0.0003$
  - $R_T = 1/\ 0.0003 = 3{,}333.3333\Omega$
- What is the total current in the circuit?
  - $I = E\ /\ R$
  - $I_T = 13.8/3{,}333.3333 = 0.00414A$
  - $I_T = 4.14mA$



- What is the power consumed in this circuit?
  - $P = I \text{ x } R...$ *or* $P = E^2 / R$
    - $E = 13.8V$ and $R = 30\Omega$
  - $P = (13.8 \text{ x } 13.8) / 30$
  - $P = 190.44 / 30$
  - $P = 6.348W$



- What is the total resistance in this circuit?
  - Solve for parallel resistance first…
    - $R_{(R2+R3)} = 1{,}000{,}000 / 2{,}000 = 500\Omega$
  - Then add series resistance…
    - $R_T = R_1 + (R_2 + R_3) = 100 + 500$
    - $R_T = 600\Omega$
- Most working circuits are combinations of series and parallel circuits in some form.

Capacitance Formulas

- Parallel Capacitances
- $C_T = C_1 + C_2 + C_3 \ldots \textit{etc.}$
- Series Capacitances
  - If only two capacitances – product over sum
    - $C_T = (C_1 \text{ x } C_2) / (C_1 + C_2)$
  - If more than two capacitances…
    - $1/C_T = 1/C_1 + 1/C_2 + 1/C_3 \ldots \textit{etc.}$, or
    - $C_T = 1/(1/C_1 + 1/C_2 + 1/C_3 \ldots \textit{etc.})$
- *If combination of series and parallel, work out series capacitance first, then add that to the parallel capacitance.*

Inductance Formulas

- Series inductances
  - $L_T = L_1 + L_2 + L_3 ... \textit{etc.}$
- Parallel inductances
  - If only two inductances – product over sum
    - $R_T = (L_1 \text{ x } L_2) / (L_1 + L_2)$
  - If more than two inductances…
    - $1/L_T = 1/L_1 + 1/L_2 + 1/L_3 ... \textit{etc.}$ or
    - $L_T = 1/(1/L_1 + 1/L_2 + 1/L_3 ... \textit{etc.})$
- *If combination of series and parallel, work out parallel inductance first, then add that to the series inductance.*

ANY QUESTIONS?