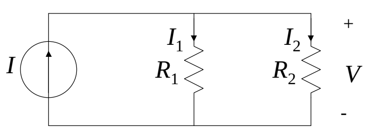
# Single Node-Pair Circuits and Current Division



## Example: 2 Light Bulbs in Parallel




How do we find $I_1$ and $I_2$?



## Apply KCL at the Top Node

$$I_1 + I_2 = I$$

$$I_1 = \frac{V}{R_1}$$

$$I_2 = \frac{V}{R_2}$$

## Solve for $V$

$$I = \frac{V}{R_1} + \frac{V}{R_2} = V\left(\frac{1}{R_1} + \frac{1}{R_2}\right)$$

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



## Equivalent Resistance

If we wish to replace the two parallel resistors with a single resistor whose voltage-current relationship is the same, the equivalent resistor has a value of:

$$R_{eq} = \frac{R_1 R_2}{R_1 + R_2}$$



## Now to find $I_1$

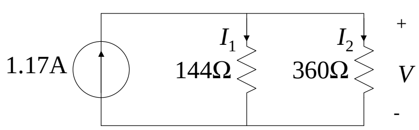
$$I_1 = \frac{V}{R_1} = I\frac{R_2}{R_1 + R_2}$$

- This is the current divider formula.
- It tells us how to divide the current through parallel resistors.

## What is the formula for $I_2$?



## Example: 2 Light Bulbs in Parallel




Find $I_1$ and $I_2$

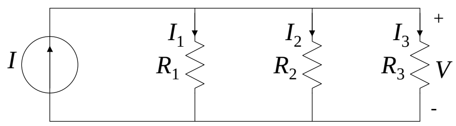


## $I_1$ and $I_2$

$$I_1 = 1.17\text{A}\,\frac{360\Omega}{144\Omega + 360\Omega} = 0.836\text{A}$$

$$I_2 = 1.17\text{A}\,\frac{144\Omega}{144\Omega + 360\Omega} = 0.334\text{A}$$

## Example: 3 Light Bulbs in Parallel




How do we find $I_1$, $I_2$, and $I_3$?



## Apply KCL at the Top Node

$$I_1 + I_2 + I_3 = I$$

$$I_1 = \frac{V}{R_1} \qquad I_2 = \frac{V}{R_2}$$

$$I_3 = \frac{V}{R_3}$$



## Solve for $V$

$$I = \frac{V}{R_1} + \frac{V}{R_2} + \frac{V}{R_3} = V\left(\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}\right)$$

$$V = I\frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}}$$

## $R_{eq}$

$$R_{eq} = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}}$$

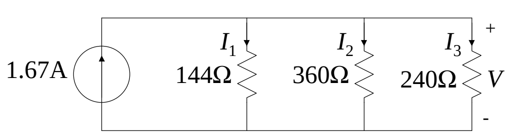


## No Current Divider!

- We cannot make a simple current divider equation for three or more parallel resistors.
- We have to solve for *V*, then solve for the current(s) of interest.



## Example: 3 Light Bulbs in Parallel




Find $I_1$

## Compute $V$, then $I_1$

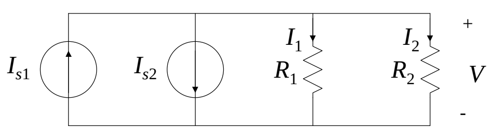
$$R_{eq} = \frac{1}{\frac{1}{144\Omega} + \frac{1}{360\Omega} + \frac{1}{240\Omega}} = 72\Omega$$

$$V = IR_{eq} = 1.67\text{A} \cdot 72\Omega = 120\text{V}$$

$$I_1 = \frac{V}{R_1} = \frac{120\text{V}}{144\Omega} = 0.833\text{A}$$



## More Than One Source




How do we find $I_1$ or $I_2$?



## Apply KCL at the Top Node

$$I_1 + I_2 = I_{s1} - I_{s2}$$

$$I_{s1} - I_{s2} = \frac{V}{R_1} + \frac{V}{R_2} = V\left(\frac{1}{R_1} + \frac{1}{R_2}\right)$$

$$V = \left(I_{s1} - I_{s2}\right)\frac{R_1 R_2}{R_1 + R_2}$$

## Multiple Current Sources

- We find an equivalent current source by algebraically summing current sources.
- We find an equivalent resistance.
- We find *V* as equivalent *I* times equivalent *R*.
- We then find any necessary currents using Ohm's law.