Example 2-18

Find the current $i_x$.

Reduce this circuit to

The problem now is to calculate $R_{eq}$ for

These two are in series and can simply be added together.

$$R'_{eq} = 5 + 5 = 10 \Omega$$

This is now a parallel circuit. The equivalent resistance is given by

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

$$R_{eq} = \frac{R_1R_2}{R_1 + R_2} = \frac{(20 \times 10)}{20 + 10} = 6.67 \Omega$$

Now use a current divider to find $i_x$

$$i_x = \frac{R_{eq}}{20 + R_{eq}} \times 5A = \frac{6.67}{20 + 6.67} (5A) = 1.25 \text{ Amperes}$$
Two allowable values for $R_x$:

$$R_x = \frac{V}{I} = \frac{0.1\text{ V}}{0.1\text{ mA}} = 1000\text{ ohms}.$$

Applying KCL at A gives:

$$\sum I = 0 \\
\frac{V_x}{R_1} + 10\text{ mA} - I_x - 1\text{ mA} = 0 \\
\left(\frac{V_x}{R_1}\right) = 9\text{ V}$$

The same volt appears across $R_1$ and $R_x$.

The current thru $R_1$ is then:

$$I_1 = \frac{V_x}{R_1} = \frac{9\text{ V}}{1000\text{ ohms}} = 9\text{ mA}$$

This is an extensive device you want to protect. It cannot receive more than 1 mA.

This is a current division problem. The fuse plus 90Ω resistor are in series and can be replaced by a $R_{eq} = R_1 + R_2 = 10 + 90 = 100\Omega$ since there is a 1 mA current through $R_{eq}$ the voltage across $R_{eq}$ is $V_{eq} = 100\Omega \times 1\text{ mA} = 100\text{ V}$. You protect the device with a 15 mA fuse which looks like a

Exercise 2-12

1. 100Ω resistor
2. 1 mA required
3. Calculate $R_x$ so that only 1 mA goes to the device.
Example 2-20

Use series and parallel equivalence to find the output voltage and the input current in the circuit shown below.

\[ i_s \]
\[ V_s \]
\[ 2R \]
\[ R \]
\[ + \]
\[ 3R \]
\[ - \]
\[ 0 \]

Solution approach:

a. combine parallel resistors \( R \) and \( 2R \)

b. calculate \( V_o \) using voltage divider

c. combine all resistances to determine input current \( i_s \)

\[ R_{eq} = 2R \parallel R = \frac{(2R)(R)}{2R + R} = \frac{2R^2}{3R} = \frac{2}{3}R \]

From (2-31)

\[ V_K = \frac{R_K}{R_{eq}} V_{TOTAL} \]

\[ V_o = \frac{2}{3} \frac{R}{R + \frac{2}{3}R} \]

\[ V_s = \frac{2 \frac{3}{3} R}{\frac{5}{3} R} \]

\[ V_3 = \frac{2}{5} V_s \]

Resistors in series add.

\[ V_s = R + \frac{2}{3}R = \frac{5}{3}R \]

Using Ohm's Law

\[ i_s = \frac{V_s}{R_{eq}} = \frac{\frac{2}{3} V_s}{\frac{5}{3} R} = \frac{3}{5} \frac{V_s}{R} \]
Example 2-21
Use source transformations to find the output voltage $V_o$ and the input current $i_s$ in the circuit shown below.

\[
\begin{align*}
V_s & \quad \text{parallel} \quad 2R \quad \text{parallel} \quad R \\
\text{a. apply a source transformation to} \quad & V_s - R \quad \text{left side} \quad X \rightarrow Y \\
b. \text{combine the two parallel resistors} \quad & R_{\text{eq}} = \frac{2R \cdot R}{2R + R} = \frac{2R^2}{3R} = \frac{2}{3}R \\
c. \text{use current division to find } i_s \\
d. \text{calculate } V_o
\end{align*}
\]

\[
\begin{align*}
\text{a.} & \quad i = \frac{V_s}{R} \\
\text{b.} & \quad R_{\text{eq}} = \frac{2R \cdot R}{2R + R} = \frac{2R^2}{3R} = \frac{2}{3}R \\
\text{c. using current divider} & \quad i_s = \frac{R}{R + R_{\text{eq}}} \quad i = \frac{R}{R + \frac{2}{3}R} \quad \frac{V_s}{R} = \frac{3}{5} \frac{V_s}{R} \\
\text{d. calculate } V_o \text{ using Ohm's Law} & \quad V_o = i_s R_{\text{eq}} = \left( \frac{3}{5} \frac{V_s}{R} \right) \left( \frac{2}{3}R \right) = \frac{2}{5}V_s
\end{align*}
\]
Example 2-22
Find $V_x$ in the circuit below.

\[ i = \frac{15}{20} \text{ A} \]
\[ i = \frac{3}{4} \text{ A} \]

\[ R_{eq} = 10 + 10 = 20 \Omega \]

\[ R_{eq1} = \frac{(20)(20)}{20 + 20} = 10 \]
\[ R_{eq2} = \frac{(20)(20)}{20 + 20} = 10 \]

\[ R_{eq3} = 10 + 10 = 20 \Omega \]

\[ i = \frac{3}{4} \text{ A} \]

\[ \text{using current divider: } i_x = \frac{10}{10 + R_{eq3}} \cdot i \]
\[ i_x = \frac{10}{10 + 20} \left(\frac{3}{4}\right) = \frac{1}{4} \cdot \frac{3}{4} = \frac{1}{4} \]

\[ V_x = i_x (10 \Omega) = \frac{1}{4} (10) = 2.5 \text{ volts} \]