\[ i = i_1 + i_{sc} \]

\( i_1 \) is produced by the voltage source \( V \) with all independent sources in a \( \text{ckt. lead} \).

\( i_{sc} \) is the short circuit current produced by any sources inside ckt A with \( V \) 'killed'.

If we have

\[ i = i_2 \text{ for the circuit diagram above} \]

If all sources 'killed', then ckt A purely resistive. Therefore

\[ i_1 = \frac{-V}{R_\text{th}} \]
Now

\[ \text{isc due to all source in \text{ckt A.}} \]

\[ I = -\frac{V}{R_{th}} + \text{isc} \quad \text{general equation} \]

holds for values of \( I \)

in particular \( I = 0 \), open ckt \( V_{oc} \)

\[ V = -\frac{V_{oc}}{R_{th}} + \text{isc} \]

\[ \text{isc} = \frac{V_{oc}}{R_{th}} \]

\[ V_{oc} = R_{th} \times \text{isc} \]

get rid of \( I \)

\[ V = -R_{th} \times I + V_{oc} \]

\[ \text{isc general eq} \]
\[ i = -\frac{v}{R + h} + i_{sc} \]

\[ V = -R + h i + V_{oc} \]

\[ V_{oc} \]

Norton

Thévenin
Examples

\[ \begin{align*}
6V & \quad 2 \Omega & \quad R \\
| & \quad \downarrow & \quad \downarrow |
\end{align*} \]

\[ \begin{align*}
2A & \quad 6 \Omega & \quad 3 \Omega
\end{align*} \]

Replace by

Thevenin and then Norton eq.

Kill all independent sources and find the equivalent resistance looking in from a - b

\[ 2 \Omega + \frac{3(6)}{9} = 4 \Omega \]

Now open the current and find Vo

\[ \begin{align*}
V_1 & \quad 6V & \quad V_2 \\
\text{2A} & \quad \downarrow & \quad \downarrow \\
6 \Omega & \quad 3 \Omega
\end{align*} \]

Then

\[ \frac{V_1}{6} - 2 + \frac{V_2}{3} = 0 \]

\[ -V_1 - 6 + V_2 = 0 \]

\[ V_1 = V_2 - 6 \]
Therefore

\[
\frac{V_1}{6} - 2 + \frac{V_2}{3} = 0
\]

\[V_2 = V_{oc}\]

\[V_1 = V_{oc} - 6\]

\[
\frac{V_{oc} - 5}{6} - 2 + \frac{V_{oc}}{3} = 0
\]

\[V_{oc} - 6 - 12 + 2V_{oc} = 0\]

\[3V_{oc} = 18\]

\[V_{oc} = 6 V\]

Thevenin equiv.
Look at Norton

Rth is the same -
Final I_{sc} instead of V_{oc}.

\[ I_{sc} = \frac{V_{oc}}{R_{th}} = \frac{6V}{4\Omega} \]

\[ I_{sc} = 1.5A \]

\[-6 + 3(I_2 - I_{sc}) + 6(I_2 - 2) = 0 \]

\[ 9I_2 - 3I_{sc} = 15 \]

\[ 2I_{sc} + 3(I_{sc} - I_2) = 0 \]

\[ -3I_2 + 5I_{sc} = 0 \]

\[ I_2 = 2.5A \]

\[ I_{sc} = 1.5A \]
\[ 8 \left[ 2i_x + i_x \right] + 2i_x - 10 = 0 \]

How?

\[ 16i_x + 8i_x + 2i_x = 0 \]

\[ 26i_x = 0 \]

\[ i_x = \frac{10}{26} \, \text{A} \]

\[ R_{th} = \frac{10 \, \text{V}}{\frac{10}{26} \, \text{A}} = 26 \, \Omega \]

\[ 26 \, \Omega \]

\[ \begin{array} {c}
26 \\
\hline
\end{array} \]

\[ 6 \]
Is this the same as the original circuit?

\[ I = \frac{25}{31} = 0.8065 \text{ A} \]

\[ V_{ab} = 25 (0.8065) \]

\[ V_{ab} = 20.92 \text{ V} \]

\[ 8 [2i_c + i_k] + 7i_x - 25 = 0 \]

\[ 3i_k = 25 \]

\[ i_k = \frac{25}{31} = 0.8065 \text{ A} \]

What about \( V_{ab} \)

\[ V_{ab} = 25 + 5(0.8065) = 0 \]

\[ V_{ab} = 25 - 5(0.8065) = 20.92 \text{ V} \]

That's good!
Find Thevenin eq circuit looking into ports (a, b).
Since there is a dependent source we must find V_{oc} and I_{sc}.

Set up mesh equation use \( I \) as mesh current
\[ I_x = I_1 + 2 \]

\[-24 + 4 I_1 + 2 [I_1 + 2] + 4 [I_1 + 2] = 0 \]
\[10 I_1 - 24 + 4 + 8 \]
\[10 I_1 = 12 \]
\[I_1 = \frac{12}{10} = 1.2 \text{ A} \]

\[ V_{oc} = -24 + 4 I_1 = 0 \]
\[ V_{oc} = 24 - 4 \times 1.2 = 24 - 4(1.2) \]
\[ V_{oc} = 19.2 \text{ V} \]
\[ I_1 = \frac{2V}{4} = 0.5A \quad V_b = 8V. \]

Also,
\[ 2i_x + 4i'_x = 0 \]
\[ i'_x = 0 \]

**Supermode I Current**

\[ -6 + I_5 - 1 + 1 - 2 + 0 = 0 \]

\[ I_5 = 8A \]

\[ R \times I_5 \]
\[ \frac{V_{oa}}{I_5} = \frac{19.2}{8} = 2.4 \Omega \]
The Thevenin equivalent circuit is:

\[ V_1 = \frac{19.2}{6.4} (19.2) = 12 \text{ volts} \]
Let $I_S$ be the unknown current through the dependent voltage source.

Dependency Eq.: $i_X = \frac{V_2}{4}$

Constraint:

\[-V_1 + 2i_X + V_2 = 0\]
\[-V_1 + \frac{V_2}{2} + V_2 = 0\]
\[-2V_1 + V_2 + 2V_2 = 0\]
\[-2V_1 + 3V_2 = 0\]

Note:

\[\frac{V_1 - 24}{4} + \frac{V_2}{4} - 1 + I_S = 0\]
\[-2 + 1 + \frac{V_2}{4} - I_S = 0\]
\[\frac{V_1 - 24 + \frac{V_2}{4} + 0 - 2 + + \frac{V_2}{4}}{4} = 0\]
\[V_1 - 24 + V_1 - 8 + V_2 = 0\]
\[2V_1 + V_2 = 32\]
Constraint: 
\[-2V_1 + 3V_2 = 0\]
\[2V_1 + V_2 = 32\]

From constraint: 
\[4V_2 = 32\] 
\[V_2 = 8\] 
\[V_1 = 12\] volts