When to Use Nodal Analysis vs. Mesh Analysis

If non-purist circuit, we must use Nodal (KCL)

If N nodes, KCL will yield a max. of N equations, and each supernode reduces # of Eqs by 1.

If M distinct meshes, a max of M KVL equations, and each supermesh reduces # of Eqs by 1.

Best to find smallest number of Eqs.

Dependent Sources can influence our choice.

EX: A dependent Voltage Source controlled by a nodal Voltage does not require an additional equation in nodal analysis.

Similarly, a dependent current source controlled by a mesh current does not require an additional equation in mesh analysis.

Mesh analysis is easiest when current sources are on the periphery of the mesh.

Nodal analysis is easiest when voltage sources are connected to the reference (ground).

See Ch. 4.5.3 p.119

What will be fewer Eqs?

5 NODES \Rightarrow 4 Eqs \text{ but supernode}

3 MESHES \Rightarrow 5 Eqs \text{ but supernode}

Nodal \Rightarrow 2 Eqs

Mesh \Rightarrow 1 Eq

What if current sources stuffed in nodal? Then mesh only!
Ch 5 Superposition & Linearity

**Linear:** \( R = \frac{V}{I} \)

- **R** is a constant regardless of any values of \( V \) & \( I \)

such that \( V(t) = I(t) R \)

\[ \text{graph: } \begin{align*}
V(t) & \quad \text{R is a constant,} \\
I(t) & \quad \text{linear-slope}
\end{align*} \]

Superposition:

The addition of multiple inputs gives a result that is the same as the sum of the results of each input separately.

**Consider This:**

\[ \text{Diagram: } \begin{align*}
V_1 & \quad \text{M} \\
V_2 & \quad \text{N}
\end{align*} \]

- **Use Nodal Analysis**

2 independent sources \( \Rightarrow \) current is forced by 2 sources

\( V_1, V_2 \) are "responses"

**Node \( V_1 \):**

\( I_q = \frac{V_1}{2} + \frac{V_1 - V_2}{5} \)

\( I_b = \frac{V_2}{1} + \frac{V_2 - V_1}{5} \)

\( I_{eq} = 0.7V_1 - 0.2V_2 \)

\( I_b = -0.2V_1 + 1.2V_2 \)
If we change facing functions to \( i_{ax}, i_{bx} \), then the responses will possibly be different \( v_{1x}, v_{2x} \).

Then:

\[
\begin{align*}
    i_{ax} &= 0.7v_{1x} - 0.2v_{2x} \\
    i_{bx} &= -0.2v_{1x} + 1.2v_{2x}
\end{align*}
\]

Now change source currents to \( i_{ay}, i_{by} \):

\[
\begin{align*}
    i_{ay} &= 0.7v_{1y} - 0.2v_{2y} \\
    i_{by} &= -0.2v_{1y} + 1.2v_{2y}
\end{align*}
\]

3 different sets of source currents.

Let's superimpose the \( i_{ay}, i_{by} \) by equations:

\[
\begin{align*}
    i_{v1} &= v_1 \\
    i_{v2} &= v_2 \\
    0.7(v_{1x} - v_{1y}) &= 0.2(v_{2x} - v_{2y}) = i_{ax} - i_{ay} \\
    0.7v_1 - 0.2v_2 &= ia \\
    -0.2v_1 + 1.2v_2 &= ib
\end{align*}
\]

\[
\begin{align*}
    \text{Key: we can do experiments and look at separate results from independent sources, with all other sources turned off.}
\end{align*}
\]
A Voltage Source turned off is a short circuit (4V).
A Current Source turned off is an open circuit (0A).

We can perform N experiments with N independent sources (all dependent sources stay active in all experiments).

Just keep one active independent source, and short all other voltage sources and open all current sources.

Also, different experiments can change the values of the "unused" sources such that the sums equal the original circuit value.

Or, we can keep multiple sources on (super-source).

Example: Find I_x

\[ I_x = \frac{V}{R} = \frac{3}{15} = 0.2\, A \]

Then, set 3V source = 0

\[ I_x = \left(\frac{6}{15}\right)(2) = 0.8\, A \]

Thus, I_x = 0.2 + 0.8 = 1 A
Interesting:
What if 3V is doubled to 6V, then the superposition from voltage source is 0.4A, and the 2A current source still provides 0.8A, for a total of 1.2A

Superposition turns a multi-source circuit into a lot of single-source circuits.

**Practice Work Example 5.2**

Find the maximum positive current before they exceed its power rating for overloads.

What about dependent voltages?

Find $I_x$

![Circuit Diagram]

First: open the 3A current source, open the 10V source.

**Mesh:**

$10 = 2I_x + I_x + 2I_x$

Then, short the 10V source:

**Nodal:**

$3 = \frac{V}{2} + \frac{V - 2I_x}{2}$

where $V = 2(\frac{I_x}{2} + \frac{1}{2})$
\[
\frac{3}{2} V - 2 I_{\text{node}} = 3 \\
\text{and } V = -2 I_{\text{node}} \\
\Rightarrow \quad 2V = 6 \\
\Rightarrow \quad V = 3 \\
\frac{3}{2} V + V = 3 \\
\frac{3}{2} V = 3 \\
V = \sqrt{6/5} V \\
I_{\text{node}} = -\frac{V}{5} = \left(-\frac{3}{5}\right) A \\
I_X = I_{\text{mesh}} + I_{\text{node}} = 2 + \left(-\frac{3}{5}\right) = \frac{10}{4} A \\
\]

**Basic Superposition**

1) Select one independent source, set all others to zero

2) Relabel voltages & currents with suitable notation

3) Analyze simplified circuit

4) Repeat steps 1-3 for each independent source

5) Add up the partial values from the separate analysis

6) Only add currents or voltages, not power
Practical voltage sources cannot keep a voltage constant as current increases.

More practical if 100 A

Two ideas model
1. A real device (internal resistance)
2. A model of a real device

Practical current sources cannot source infinite current

Internal resistance very high value (1kΩ)?

Matched