**Superposition Analysis Steps**

1. Set all independent sources to zero
   - $V$ source $\rightarrow$ short circuit
   - $I$ source $\rightarrow$ open circuit
2. Turn on each independent source, one at a time.
3. Calculate response due to each individual independent source.
4. For total response, add up individual contributions from each source.

**Superposition Cautions**

Only applies to linear systems!
Do not turn off dependent sources!

**Why Use Superposition?**

Usually simplifies analysis when circuit has many independent sources
Explicitly shows path from each source to output: "assign blame"
(signal, noise)

\[
\text{OUT} = \left( \text{signal FROM 1} \right) + \left( \text{interf FROM 2} \right) + \left( \text{noise FROM 3} \right)
\]
1. Determine $V_L$ for the following circuit:

2. Determine $V_L$ for the following circuit:

ECB2019 Quiz
1. Determine $V_L$ for the following circuit:

\[ V_L = \frac{2V \cdot 50 \Omega}{100 \Omega} = 1.0V \]

2. Determine $V_L$ for the following circuit:

\[ V_L = 2V \]
STEP 1: FIND OPEN CIRCUIT VOLTAGE

USE NODAL ANALYSIS

KCL AT \( V_1 \):
\[
\dot{i}_1 = 20 \text{mA} + \dot{i}_2 + \dot{i}_3
\]

OHM'S LAW
\[
\frac{5V-V_1}{50\Omega} = 20\text{mA} + \frac{V_1}{50\Omega} + 0
\]

SOLVE FOR \( V_1 \)
\[
5V-V_1 = 1V + V_1
\]
\[
(5V-1V) = 2V_1
\]
\[
V_1 = +2V
\]

KVL \( V_1 \rightarrow V_{OC} \): 0V DROP ON \( R_3 \)
\[
V_{OC} = V_1 = +2V
\]

STEP 2: FIND \( R_{eq} \) WITH ALL INDEPENDENT SOURCES = 0

V SOURCE: \( \Rightarrow \) 0V (SHORT)

I SOURCE: \( \Rightarrow \) 0A (OPEN)

REDRAW

REDRAW AGAIN

\[
\text{Re}_L = 25\Omega
\]

\[
50\Omega || 50\Omega = 25\Omega
\]

\[\text{Re}_L = 25\Omega + 25\Omega = 50\Omega\]
Find \( V_{OC} \) (for Thevenin) using Superposition

1. **Turn off 20 mA source**
   - **Voltage Divider**
     - \( V_{OC} = V_1 = +5V \left( \frac{50}{50 + 50} \right) = +2.5V \)
     - \( V_{OC} (+5V) = +2.5V \)
   - **ADD by Superposition**
     - \( V_{OC} = V_{OC} (+5V) + V_{OC} (20mA) \)

2. **Turn off +5V; Short**
   - **Parallel**: \( 50\Omega || 50\Omega = 25\Omega \)
     - \( V_{OC} = (20mA) (25\Omega) = -0.5V \)

\( V_{OC} = V_{OC} (+5V) + V_{OC} (20mA) = +2.5V + (-0.5V) = +2V \) \( \checkmark \)

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ECE2019 Superposition Example
WITH SYMBOLIC MATH

\[ V_{oc} = \left( \frac{R_2}{R_1 + R_2} \right)(+5V) + (R_1/R_2)(-20mA) \]

- \( R_1/R_2 \) RATIO
- TELLS HOW \(+5V\) INFLUENCES OUTPUT
- HOW \(20mA\) INFLUENCES OUTPUT

\[ R_{eq} = R_3 + R_1/R_2 \]

ANALYSIS: GIVEN \( R_1, R_2, R_3 \) VALUES FIND \( V, I, \ldots \)

DESIGN: CHOOSE \( R_1, R_2, R_3 \) TO GET A DESIRED \( V_{oc}, R_{eq} \) (OR \( V_L \) WITH \( R_L, \ldots \))
YO DAWG, I HERD YOU LIKE THEVENIN EQUIVALENTS

SO I PUT A THEVENIN EQUIVALENT IN YOUR THEVENIN EQUIVALENT SO YOU CAN SIMPLIFY WHILE YOU SIMPLIFY.

ECE2019 Repeated Thevenin Example