Superposition Principle

Total voltage at a node or current in a branch is superposition of independent sources acting one at a time.

\[ i_2 = \frac{V_2}{R_2} \]

Current through \( R_1 \):

\[ i = \left[ \frac{V_1}{R_2} + \frac{V_2}{R_2} \right] \]

\[ V_2 = V - R_1 \left[ \frac{V_2}{R_2} \right] = V + R_1 i - \frac{R_0 (1+k) V_2}{R_2} \]

\[ \Rightarrow V_2 \left[ 1 + \frac{R_0 (1+k)}{R_2} \right] = V + R_1 i \]

\[ \Rightarrow V_2 = V \left( \frac{R_2}{R_2 + R_1 + R_0} \right) + i \left( \frac{R_1 R_2}{R_2 + R_1 + R_0} \right) \]

Remove voltage source ⇒ short ckt at \( i \) (so voltage is zero)

\[ V' = \left( \frac{R_2}{R_2 + R_1 + R_0} \right) \]

\[ \Rightarrow i' = \frac{R_1 R_2}{R_2 + R_1 + R_0} \]

Remove current source ⇒ open ckt at \( i \) (so current is zero)

\[ V'' = V - (1+k) i'' R_0 = R_2 i'' \]

\[ \Rightarrow i'' = \frac{V}{R_2 + (1+k) R_0} \]

Thus, \( V_2 = V' + V'' \) (This is superposition principle).

Superposition applies to ckt containing linear elements.
Wheatstone Bridge

- Device to measure resistance does not require calibration since only need to detect presence/absence of current, and not value of it.

\[ V = \left( \frac{R_3}{R_1 + R_3} \right) \left( \frac{R_2}{R_2 + R_3} \right) \Rightarrow R_2 + R_2 = R_1 + R_3 \Rightarrow R_2 = \frac{R_2 R_3}{R_1} \]

- Adjust \( R_2 \) until no current flows through detector (balanced condition). Voltage across detector is zero.

Using superposition to solve circuit:

Contribution of only the voltage source:

\[ V' = 15 \left( \frac{5}{5+10} \right) = 5 \text{ V} \]

Contribution of only current source:

\[ V'' = \left( \frac{50}{15} \right) \times 2 = \left( \frac{100}{15} \right) = 20 \frac{2}{3} \text{ V} \]

So, \( V = V' + V'' = 5 + 20 \frac{2}{3} = 25 \frac{3}{3} = 28 \frac{2}{3} \text{ V} \).