SUPERPOSTION PRINCIPLE

If a circuit is linear it obeys

Superposition + homogeneity.
(additivity) (scaling)

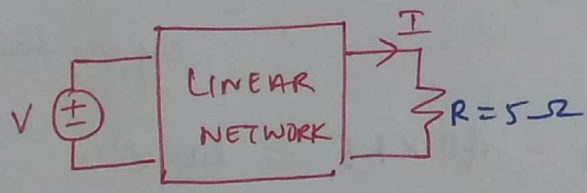
LINEAR

Output ∝ input.

In a dc circuit, $V \propto I$. Linear.

But $P = i^2R = \frac{V^2}{R}$ (non-linear).

Example



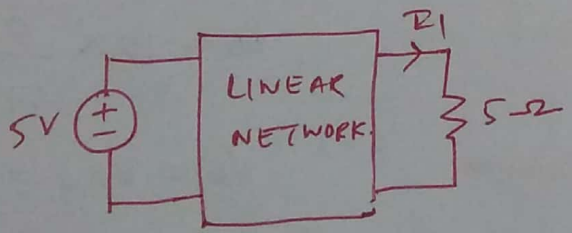
V = Input
I = Output.

If V = 10 V $I = \frac{10}{5} = 2A$

If V = 1 V $I = \frac{1}{5} = 0.2A$

If V = 100V $I = \frac{100}{5} = 20A$

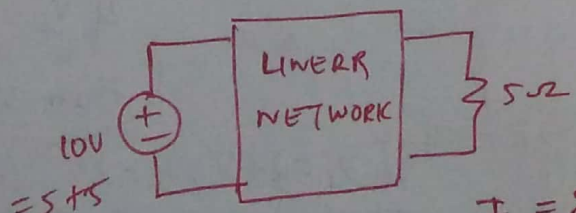
} Scaled by same factor.
(HOMOGENITY)



$I_1 = 1A$

+

$I_2 = 1A$.



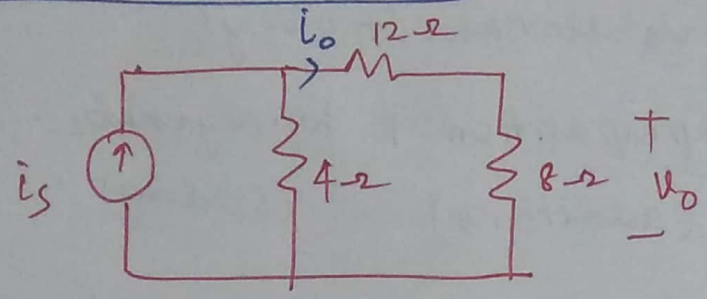
$I = 2A = I_1 + I_2$

(SUPERPOSTION - ADDITIVITY)

(2)

LINEARITY EXAMPLE

(1)



Find V_o, when

$i_s = 30A$

$i_s = 45A$.

when $i_s = 30A$,

$$i_o = 30 \times \frac{4}{4+8+12} = 5A.$$

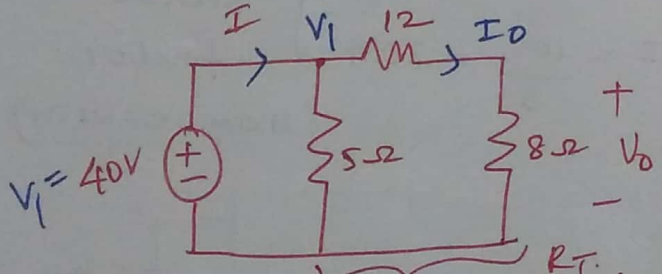
$$V_o = 8 \times 5 = 40V.$$

when $i_s = 30A$, $V_o = 40V$. $\quad \frac{45}{30} = 1.5$

By linearity when $i_s = 45A$ (current increased by a factor 1.5)

$\therefore$ voltage $V_o = 40 \times 1.5 = 60V$

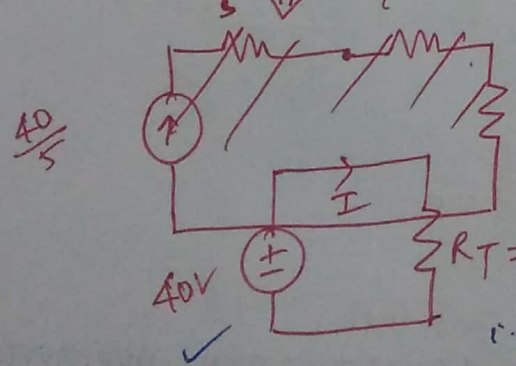
(2) Assume $V_o = 1V$, using linearity calculate the actual value of V_o in the circuit.



$$\therefore I = \frac{40}{4} = 10A$$

$$I_o = 10 \times \frac{5}{5+20} = 2A.$$

$$V_o = 8 \times 2 = \underline{16V}.$$



$$R_T = \frac{20 \times 5}{20+5} = 4\Omega$$ ✓

By linearity,

If $V_o = 1V \rightarrow I_o = \frac{1}{8}A$

then $V_1 = \frac{1}{8} \times 20 = \frac{5}{2}$

$V_1 = 2.5V$

If $V_1 = 2.5V$, $V_o = 1V$

i.e If $V_1 = 40V$, $V_o = ?V$

$V_o = 16V$

SUPERPOSITION

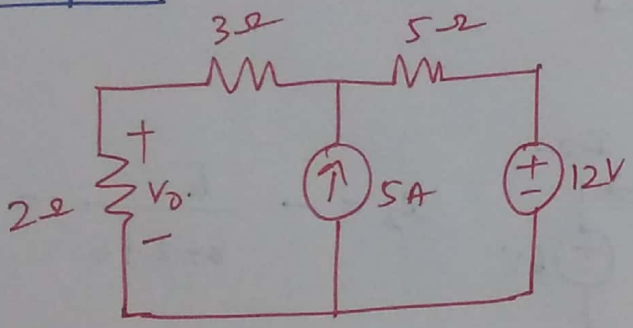
1. In a given circuit, consider one source at a time and solve.
2. Net Result = Sum of individual output.

When considering one source, turn off all other independent sources.

i.e OC – current source, SC – voltage source.

Example

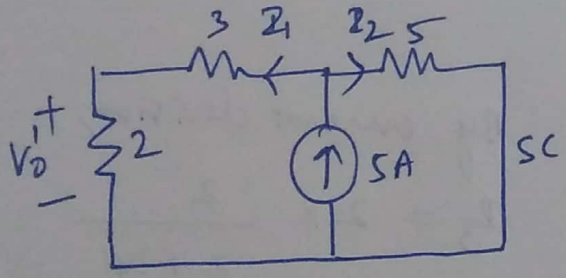
(1)



Find V_o using Superposition.

$V_o = V_o^1 + V_o^2$

due to two sources.



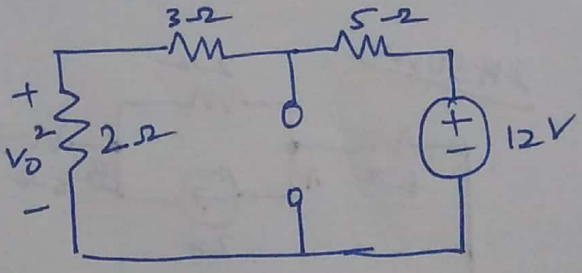
By current division,

$$Z_1 = 5 \times \frac{5}{5+2+3}$$

$$Z_1 = 2.5A$$

$$V_o^1 = 2 \times 2.5$$

$$V_o^1 = 5V$$



By voltage division,

$$V_o^2 = 12 \times \frac{2}{2+3+5}$$

$$V_o^2 = 2.4A$$

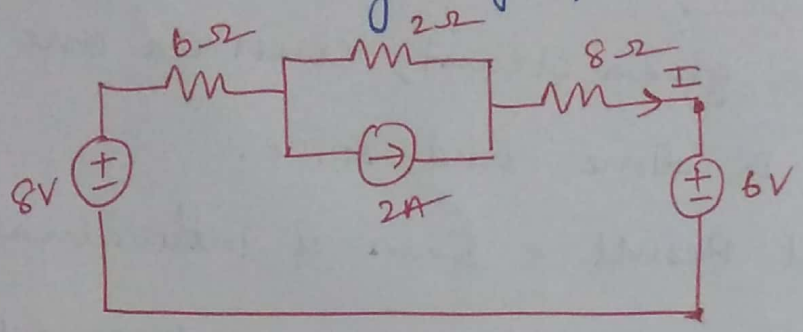
By superposition

$$V_o = 5 + 2.4 = 7.4V$$

$$V_o = 7.4V$$

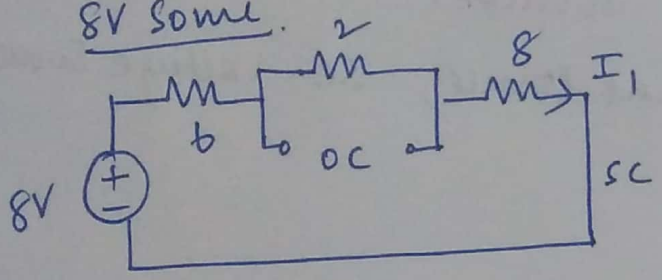
(4)

(2) Find I using Superposition.



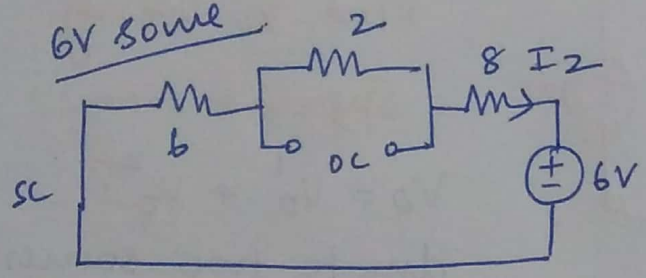
Solve considering 1 source at a time. $I = I_1 + I_2 + I_3$

8V source.



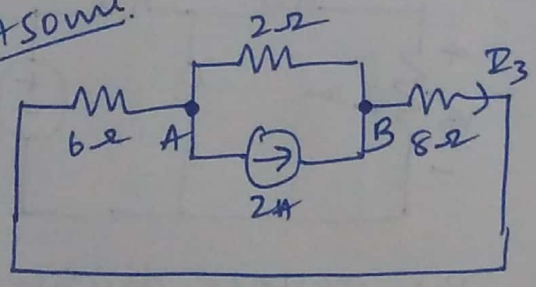
$$I_1 = \frac{8}{8+2+6} = 0.5\ A$$

6V source



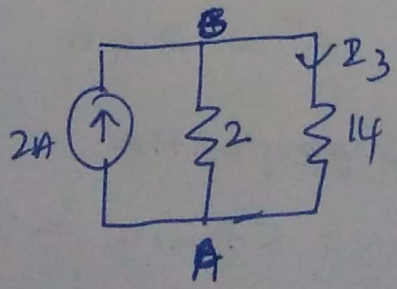
$$I_2 = -\frac{6}{8+2+6} = -0.375\ A$$

2A source.



6, 8 series $\Rightarrow$ 14

14 in parallel to 2Ω



By current division,

$$I_3 = 2 \times \frac{2}{2+14}$$

$$I_3 = 0.25\ A.$$

By superposition,

$$I = 0.5 - 0.375 + 0.25$$

$$I = 0.375\ A$$