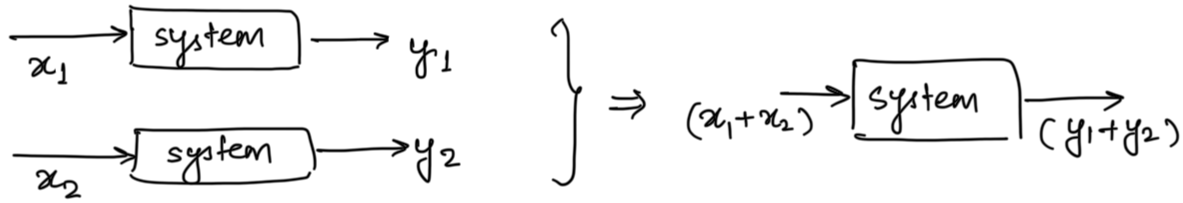
## Superposition Principle:—

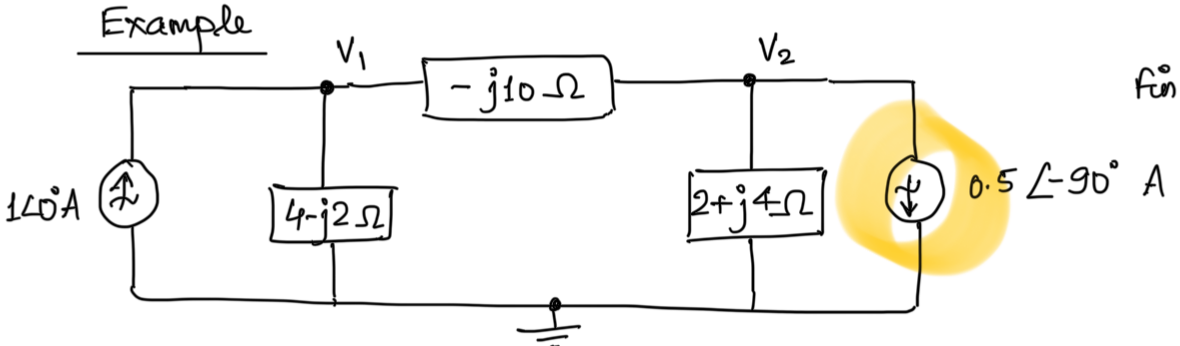
linearity ⟺ superposition




* Multiple independent sources

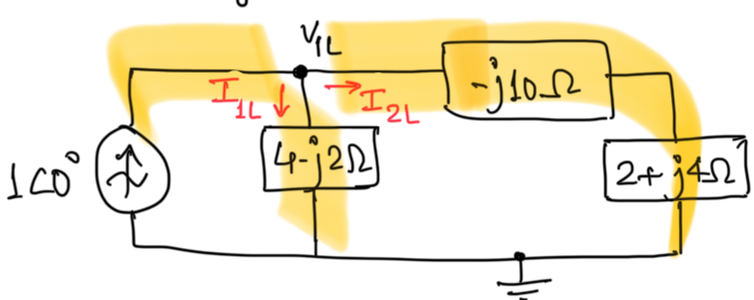
- consider seperate independent sources "acting alone"
- add all responses.

Example

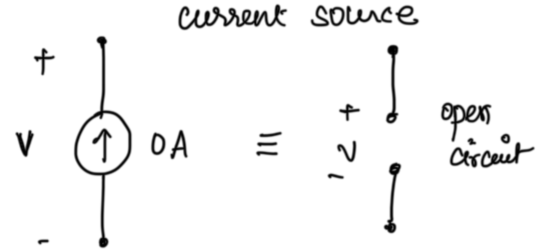



find $V_2$

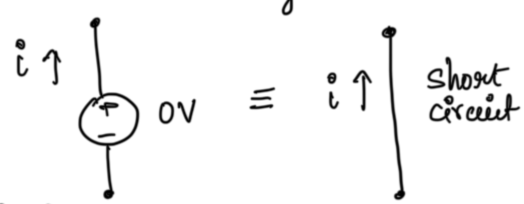
Consider left side source:




current source




voltage source




$V_{1L} = I_{1L}(4-j2)$ ← ohm's law

$$= \underbrace{1\angle 0^\circ \frac{(-j10+2+j4)}{(4-j2)+(-j10+2+j4)}}_{\text{current division}} (4-j2)$$

$$= \frac{-4-j28}{6-j8} = 2-j2 \quad V$$

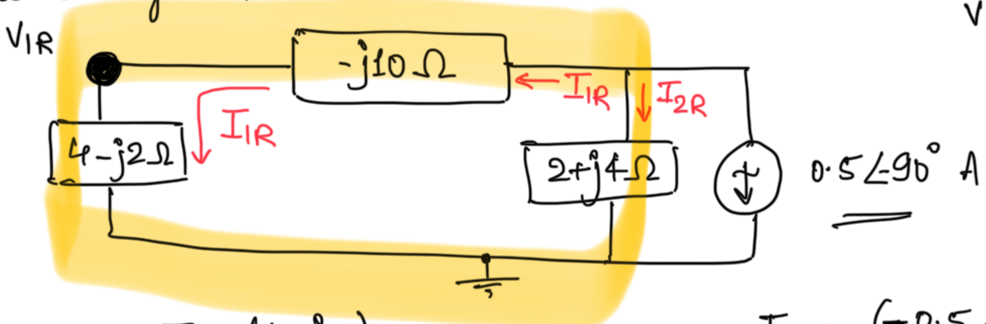
$1\angle 0^\circ$

$= 1\cos 0^\circ + 1\sin 0^\circ$

$= 1$

Consider right side source

$V_1 = V_{1L} + V_{1R}$

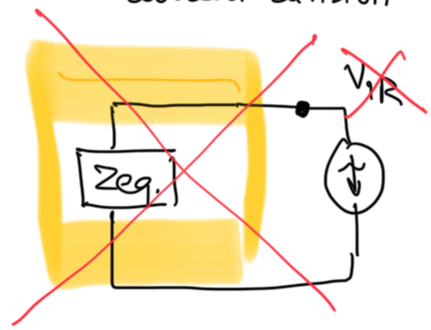



$$I_{1R} = \underbrace{\frac{(-0.5\angle -90^\circ)(2+j4)}{(-j10+4-j2+2+j4)}}_{\text{current division}}$$

$$V_{1R} = I_{1R}(4-j2)$$

$$= \frac{(j0.5)(2+j4)(4-j2)}{(6-j8)}$$

$$= -1\text{ V}$$




Applying superposition: $V_1 = V_{1L} + V_{1R}$

$$= 2-j2-1$$

$$= 1-j2 \quad \text{V}$$

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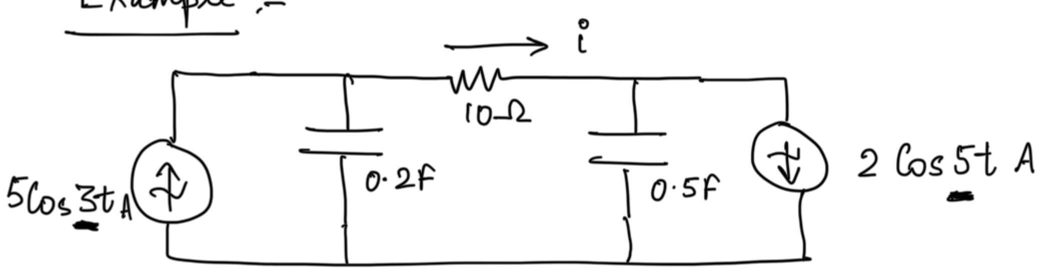
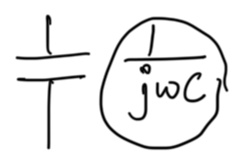
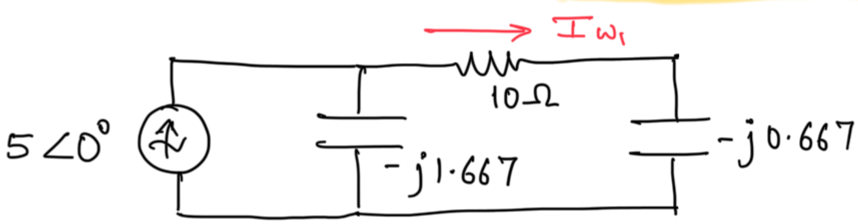
Example :-

find $i(t)$




Consider left source: $\omega_1 = 3$ rad/s

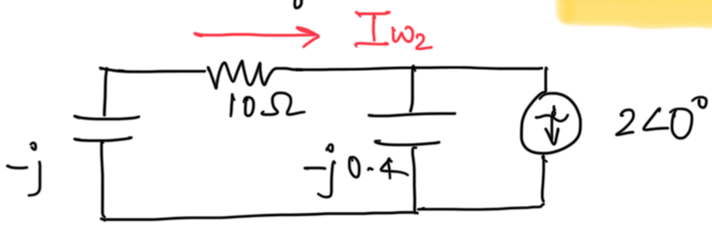



$$\frac{1}{j(3)(0.2)} = \frac{-j}{0.6}$$

$$\frac{1}{j(3)(0.5)} = \frac{-j}{1.5}$$

$$I_{\omega_1} = 5\angle 0^\circ \left(\frac{-j1.667}{-j1.667+10-j0.667}\right) = 811.7\angle -76.86^\circ \text{ mA}$$

Consider right source: $\omega_2 = 5$ rad/s




$$\frac{1}{j(5)(0.2)} = -j$$

$$\frac{1}{j(5)(0.5)} = -j0.4$$

$$I_{\omega_2} = +2\angle 0^\circ \left( \frac{-j0.4}{-j + 10 - j0.4} \right) = 79.2 \angle -82.03^\circ \text{ mA}$$

Applying superposition:

$$\cancel{I = \underbrace{I_{\omega_1}}_{3\text{rad/s}} + \underbrace{I_{\omega_2}}_{5\text{rad/s}}}$$

**Phasor**

$$i(t) = I_m \cos(\omega t + \phi)$$
$$= \text{Re}\{I_m e^{j\omega t + j\phi}\}$$
$\downarrow$ Remove $e^{j\omega t}$, Re{ }
$$I_m e^{j\phi} = I_m \angle \phi$$

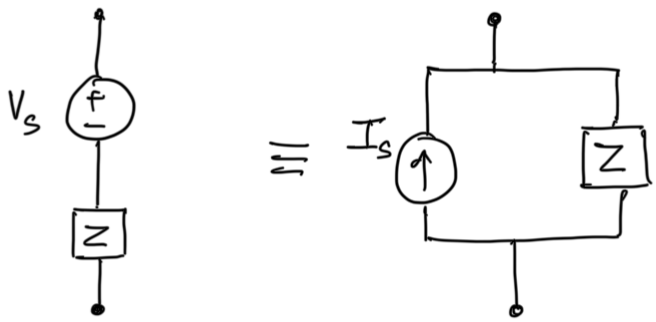
$$i(t) = i_{\omega_1}(t) + i_{\omega_2}(t)$$

$$i_{\omega_1}(t) = 811.7 \cos(3t - 76.86^\circ) \text{ mA}$$
$$i_{\omega_2}(t) = 79.23 \cos(5t - 82.03^\circ) \text{ mA}$$

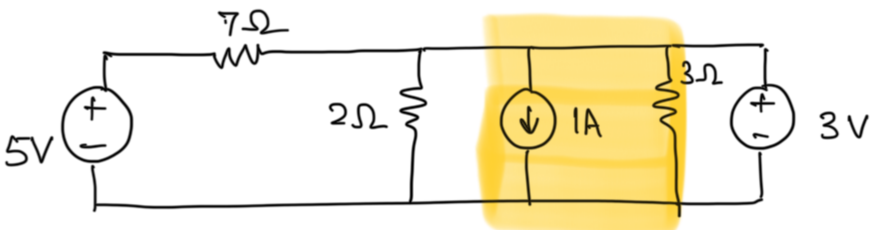
$$i(t) = [811.7 \cos(3t - 76.86^\circ) + 79.23 \cos(5t - 82.03^\circ)] \text{ mA}$$

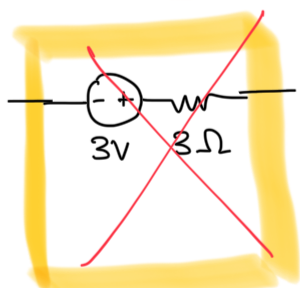
Phasors can only be added when they correspond to same frequency

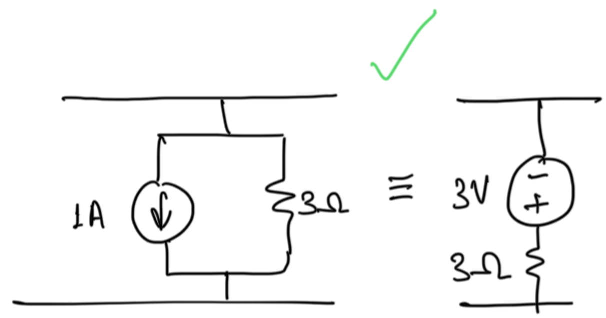
# Source Transformation :-



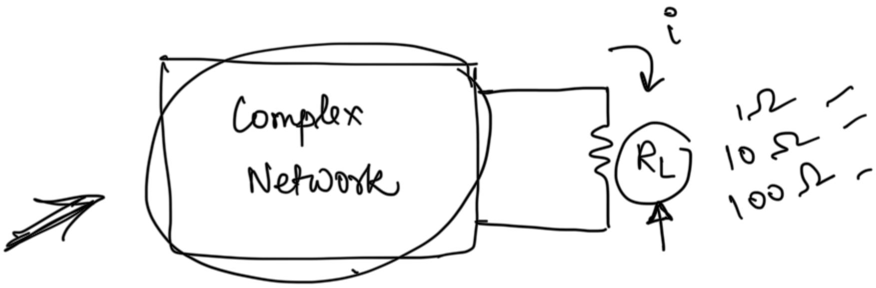

$I_s = V_s / Z$

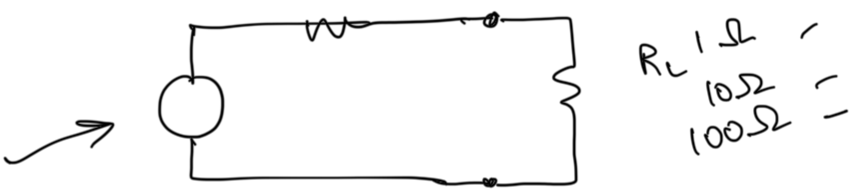


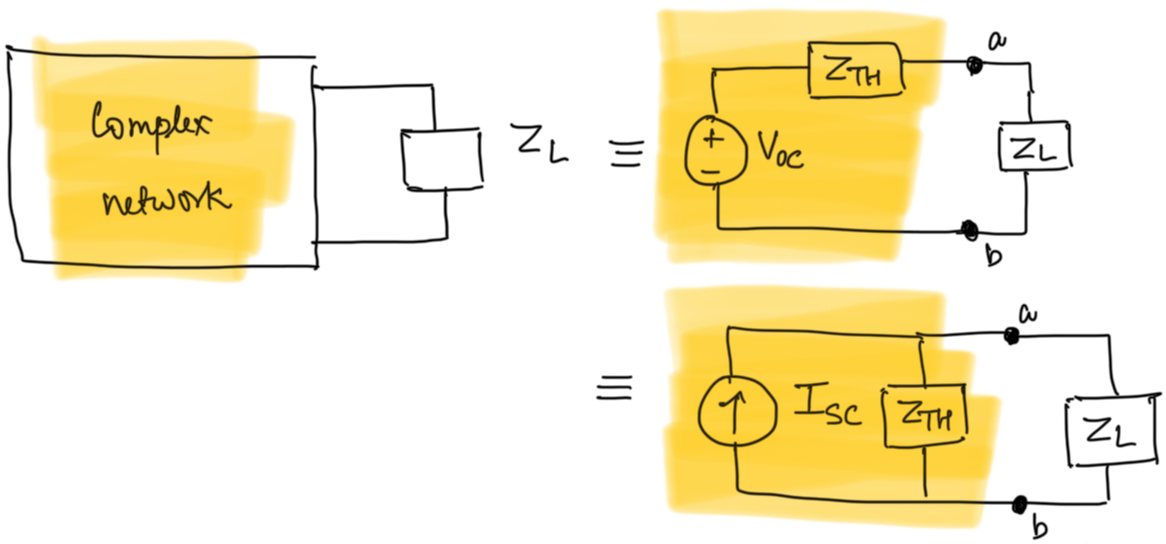



# Thevenin & Nortan Equivalent Circuits :

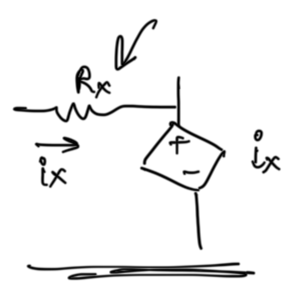


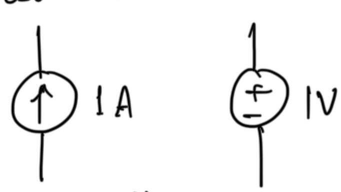




$$V_{oc} = I_{sc} \cdot Z_{TH}$$

| | $V_{oc}$ | $I_{sc}$ | $Z_{TH}$ |
|---|---|---|---|
| 1) Independent sources only | ✓ | ✓ | ✓ |
| 2) Independent + dependent sources | ✓ | ✓ | ✓ |



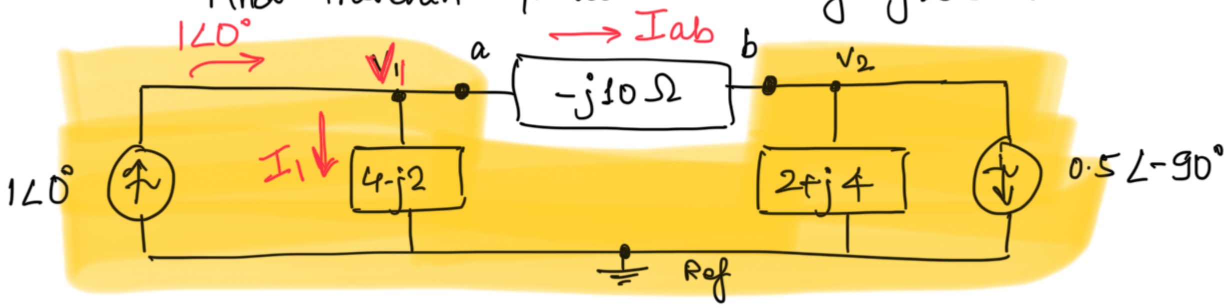

3) Dependent sources only ⇒ Test sources



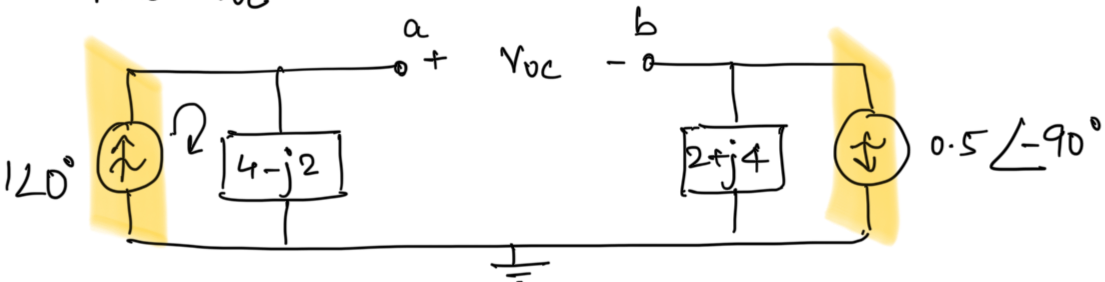

$V_{oc}$, $I_{sc}$, $Z_{TH} = V_{oc}/I_{sc}$

## Example :

Find Thevenin Equivalent seen by $-j10\,\Omega$ . Find $V_1$ .




Find $V_{oc}$



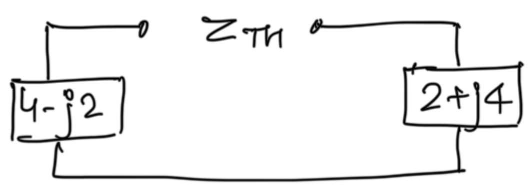

$$V_{oc} = V_a - V_b = 1\angle 0^\circ(4-j2) - (-0.5\angle -90^\circ)(2+j4)$$

$$= 4-j2 + 2-j1 = 6-j3\ \text{V}$$

Find $Z_{TH}$

$V_s \rightarrow$ short circuit

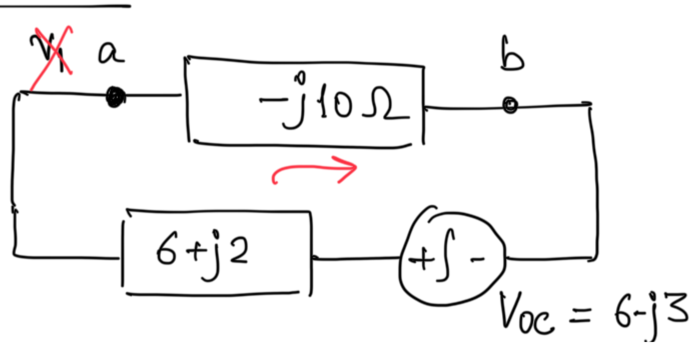
$I_s \rightarrow$ open circuit




$$Z_{TH} = (4-j2) + (2+j4)$$

$$= 6+j2\ \Omega$$

## Equivalent Circuit



$$I_{ab} = \frac{V_{oc}}{(6+j2)+(-j10)}$$

$$I_1 = 1\angle 0^\circ - I_{ab}$$

Then $V_1 = I_1(4-j2) = 1-j2 \quad V$