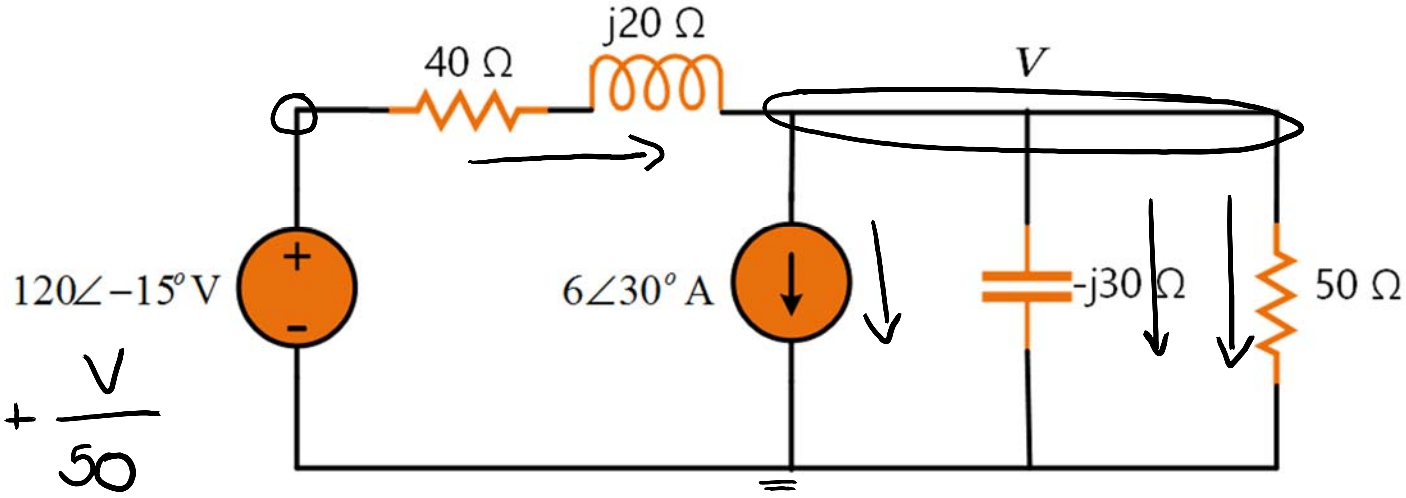
KCL at node:

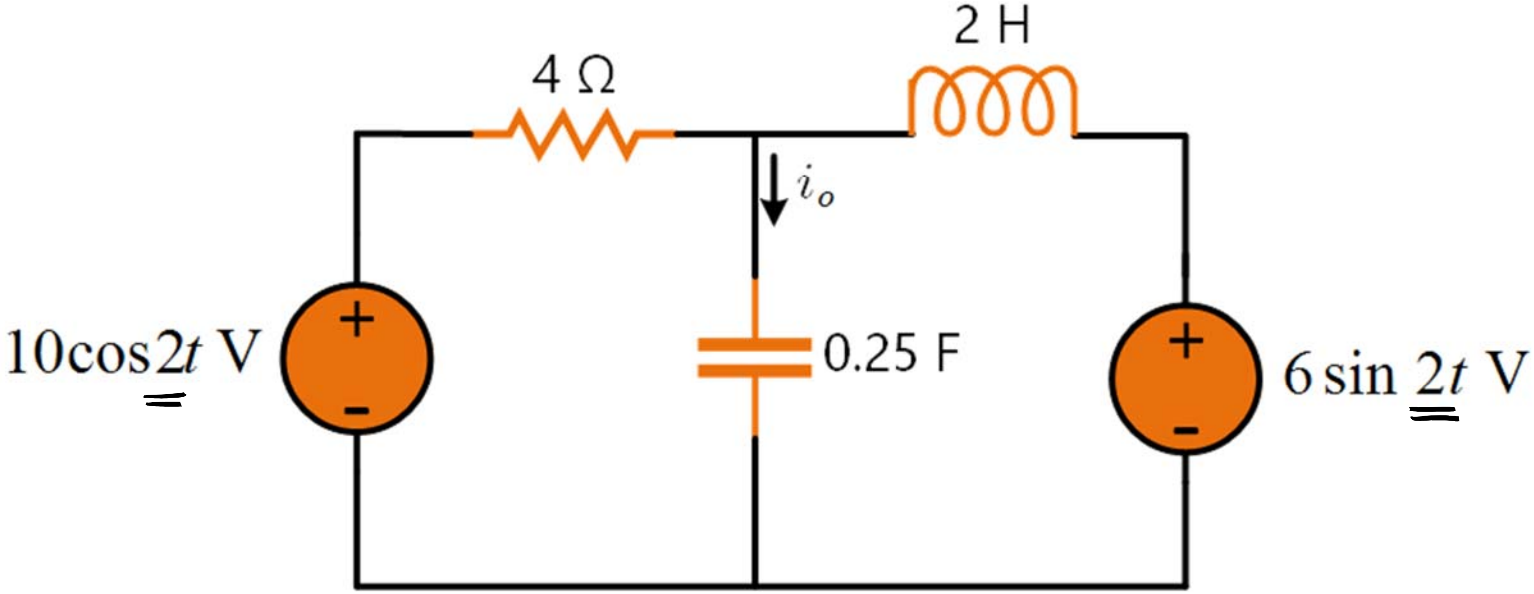



$$\frac{120\angle{-15^\circ} - V}{40 + j20} = 6\angle{30^\circ} + \frac{V}{-j30} + \frac{V}{50}$$

$$\Rightarrow \frac{120\angle{-15^\circ}}{40+j20} - 6\angle{30^\circ} = V\left[\frac{1}{j50} + \frac{1}{-j30} + \frac{1}{40+j20}\right]$$

$$\Rightarrow -3.1885 - j4.7805 = (0.04 + j0.0233)V$$

$$\Rightarrow V = \frac{-3.1885 - j4.7805}{0.04 + j0.0233} = 124.08\angle{-154^\circ}\ V$$



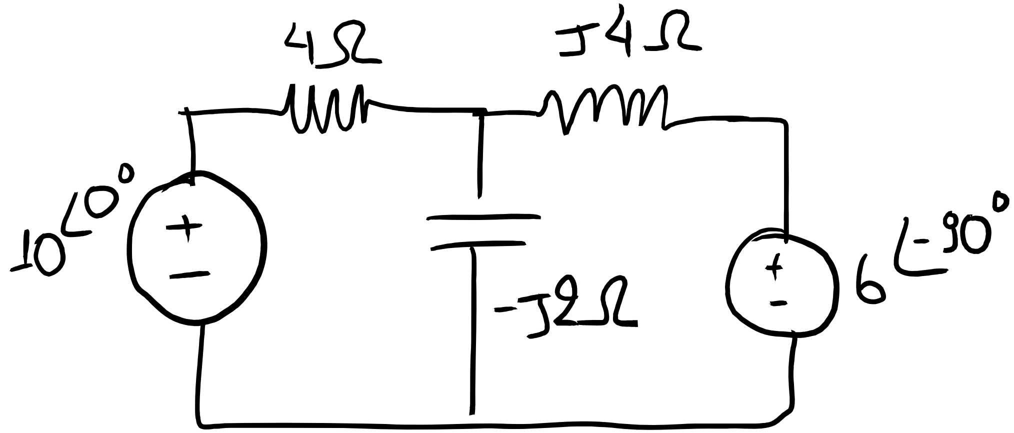

$\omega = 2$ rad/sec

$10\cos 2t \to 10\angle 0^\circ$ V

$6\sin 2t = 6\angle -90^\circ$ V

$2H \to j\omega L = j4\,\Omega$

$0.25F \to \dfrac{1}{j\omega C} = \dfrac{1}{j2 \cdot 0.25} = -j2\,\Omega$



Mesh Analysis:

Mesh 1: $-10 + 4I_1 + (-j2)(I_1 - I_2) = 0$

$$\Rightarrow (4 - j2)I_1 + j2 \cdot I_2 = 10 \quad (1)$$

Mesh 2: $(-j2)(I_1 - I_2) + j4 \cdot I_2 + (-j6) = 0$

$$\Rightarrow j2 \cdot I_1 + j2 \cdot I_2 = j6 \quad (2)$$

Solve the system of equations: → Substitution or Cramer's Rule

$$\begin{bmatrix} 2-j & j \\ 1 & 1 \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \end{bmatrix} = \begin{bmatrix} 5 \\ 3 \end{bmatrix}$$

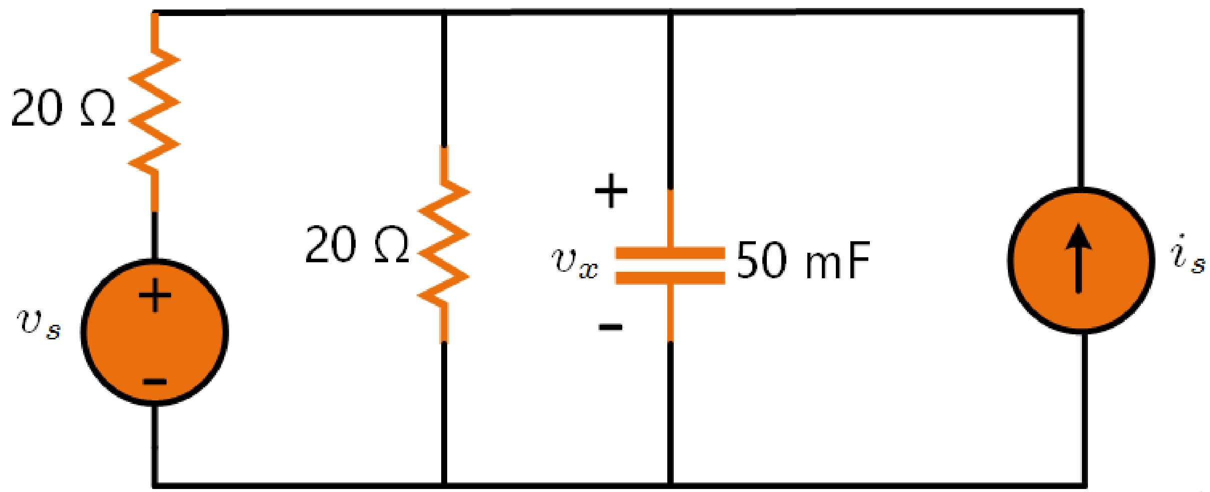
$\Delta = 2(1-j)$

$\Delta_1 = 5 - j3$

$\Delta_2 = 1 - j3$

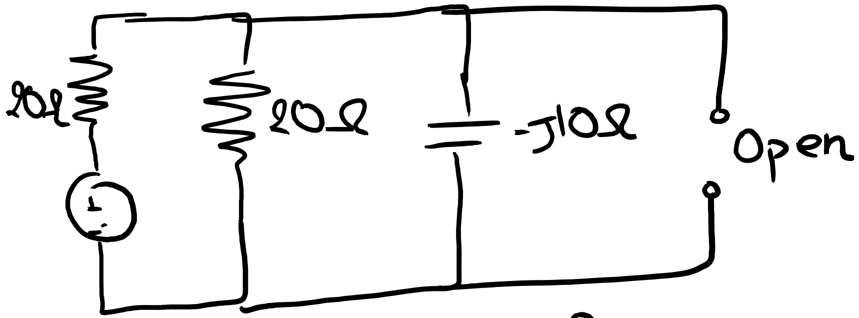
$$I_o = I_1 - I_2 = \frac{\Delta_1}{\Delta} - \frac{\Delta_2}{\Delta} = \frac{\Delta_1 - \Delta_2}{\Delta} = \frac{4}{2(1-j)} = 1 + j = 1.41\angle 45^\circ$$

$i_o(t) = 1.41 \cdot \cos(2t + 45^\circ)\ A$




Only $v_s$ $\quad \omega = 2$ rad/s

$$C \to \frac{1}{j\omega C} = -j10\,\Omega$$

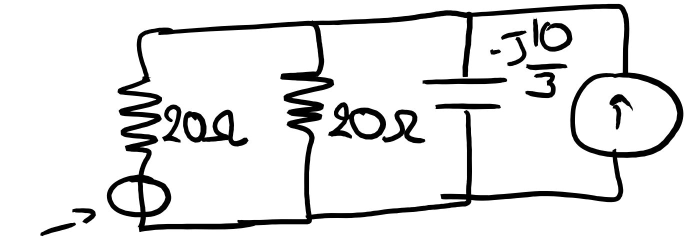



$$V_s \to 50\angle 0^\circ$$

for sin2ωt

Only $i_s$ $\quad \omega = 6$ rad/sec

$$C \to \frac{1}{j\omega C} = -\frac{j10}{3}\,\Omega$$




short circuit

$$i_s \to 12\angle{+10^\circ}\ \text{A}$$

for cos 6ωt

Nodal analysis:

$$\frac{V_1 - 50}{20} + \frac{V_1}{20} + \frac{V_1}{(-j10)} = 0$$

$$\Rightarrow [0.1 + j0.1]V_1 = 2.5$$

$$\Rightarrow V_1 = \frac{2.5}{0.1 + j0.1}$$

$$\Rightarrow V_1 = 17.67 \angle -45^\circ \text{ V}$$

$$v_1(t) = 17.67 \sin(2t - 45^\circ) \text{ V}$$

Nodal Analysis:

$$\frac{V_2}{20} + \frac{V_2}{20} + \frac{V_2}{\left(-j\frac{10}{3}\right)} = 12\angle 10^\circ$$

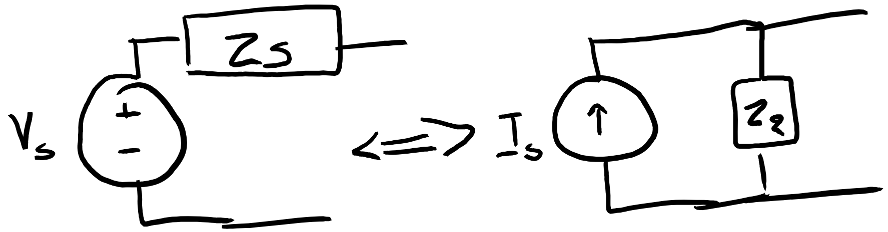
$$\Rightarrow (0.1 + j0.3)V_2 = 12\angle 10^\circ$$

$$\Rightarrow V_2 = \frac{12\angle 10^\circ}{0.316\angle 71.57^\circ}$$

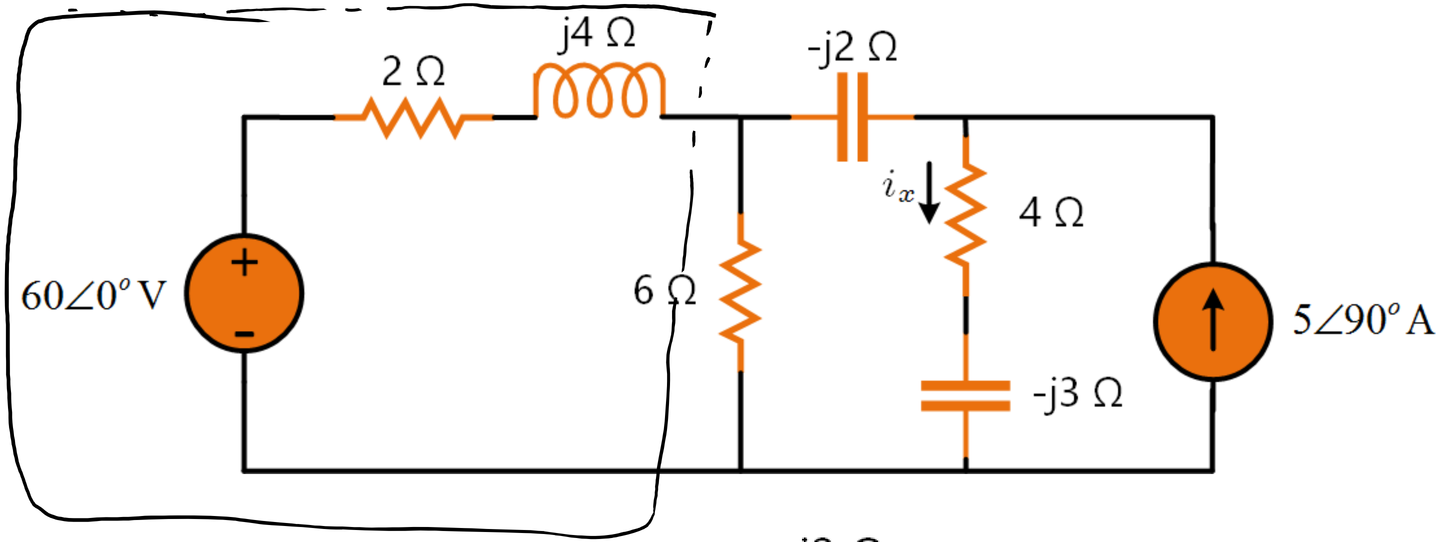
$$\Rightarrow V_2 = 37.95 \angle -61.57^\circ \text{ V}$$

$$v_2(t) = 37.95 \cos(6t -$$

# Source Transformation:

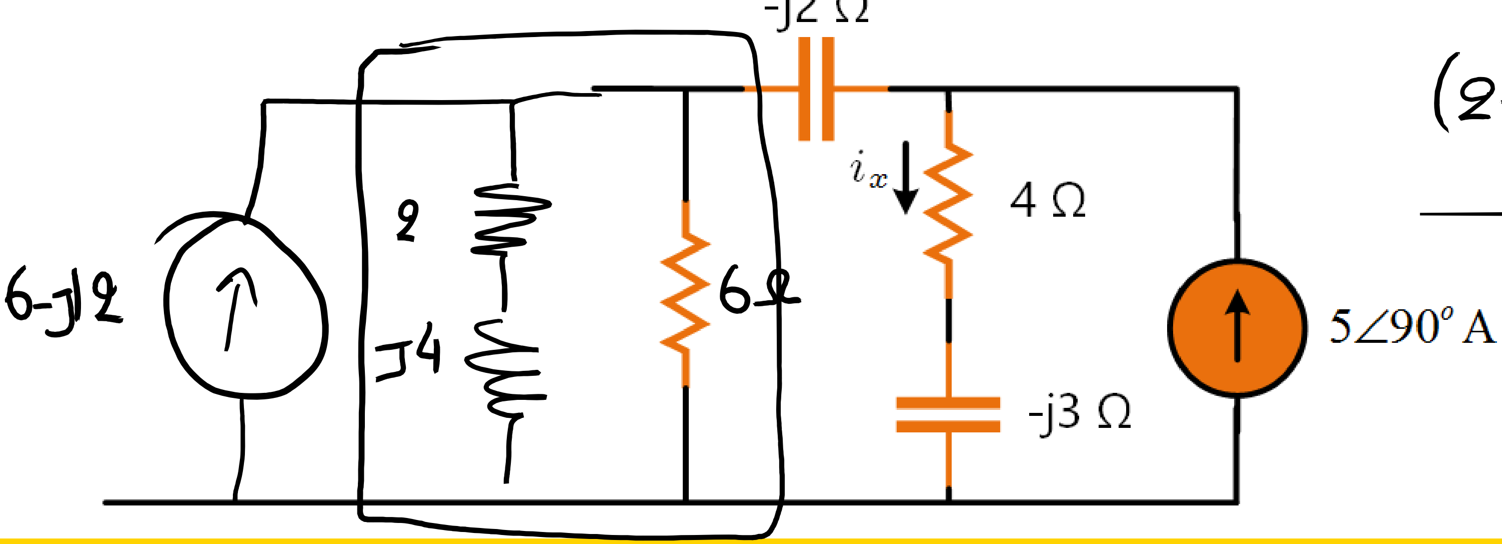



$$I_s = \frac{V_s}{Z_s}$$




$$I_s = \frac{60\angle 0^\circ}{2+j4}$$

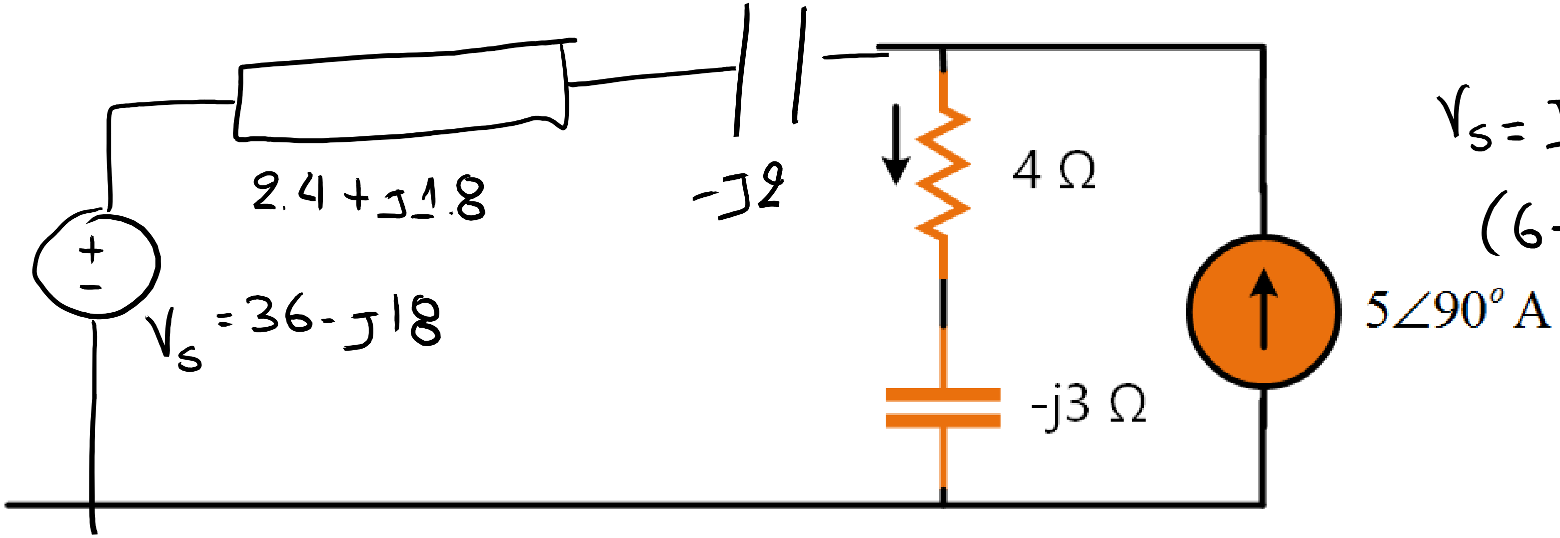
$$= 6 - j12\ \text{A}$$




$$(2+j4) \parallel 6$$

$$= \frac{6(2+j4)}{8+j4}$$

$$= 2.4 + j1.8\ \Omega$$



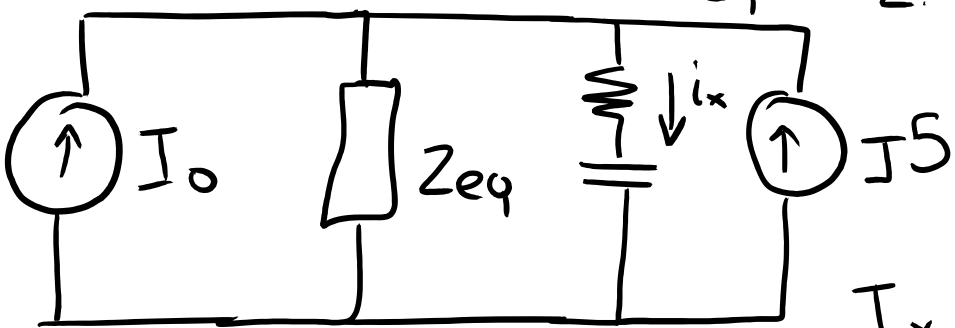

$V_s = I_s . Z_s =$

$(6 - j12)(2.4 + j1.8)$

$= 36 - j18 \text{ V}$

$$Z_{eq} = 2.4 + j1.8 - j2 = 2.4 - j0.2 \ \Omega$$

$$I_o = \frac{V_s}{Z_{eq}} = \frac{36 - j18}{2.4 - j0.2} = 15.517 - j6.207$$

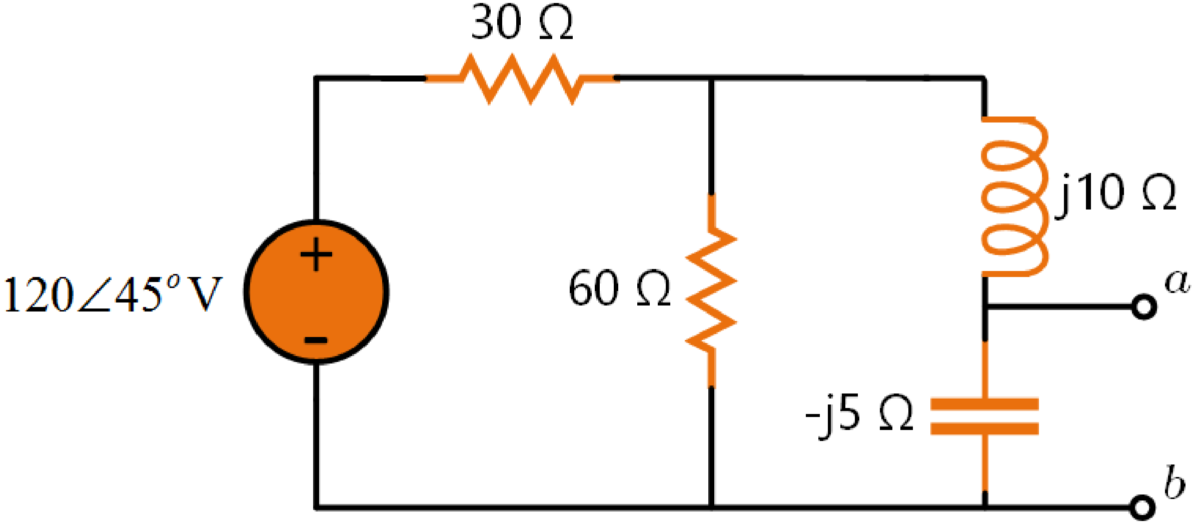


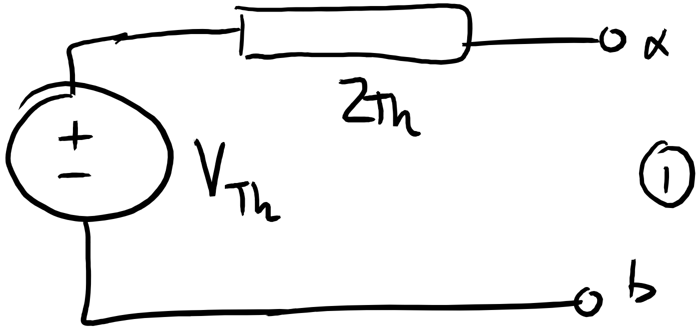

To find $I_x$:

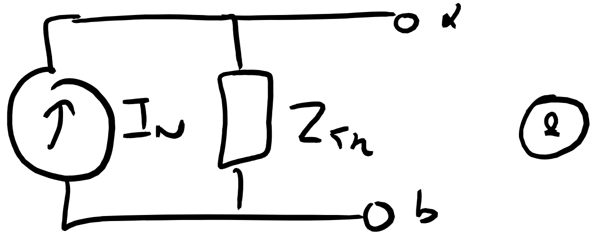
current division

$$I_x = \frac{Z_{eq}}{Z_{eq} + (4 - j3)} \cdot (I_o + j5) =$$

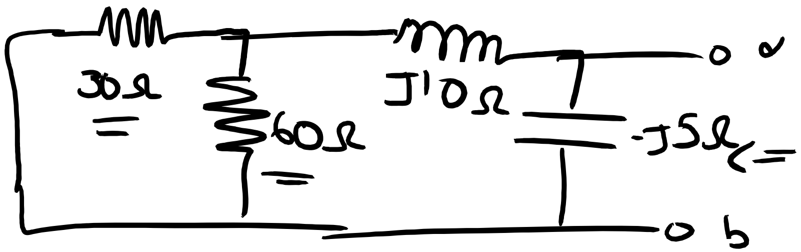
$$= \frac{2.4 - j0.2}{6.4 - j3.2} (15.517 - j1.207) = 5 + j1.5625 = 5.238 \angle 17.35^\circ \text{ A}$$



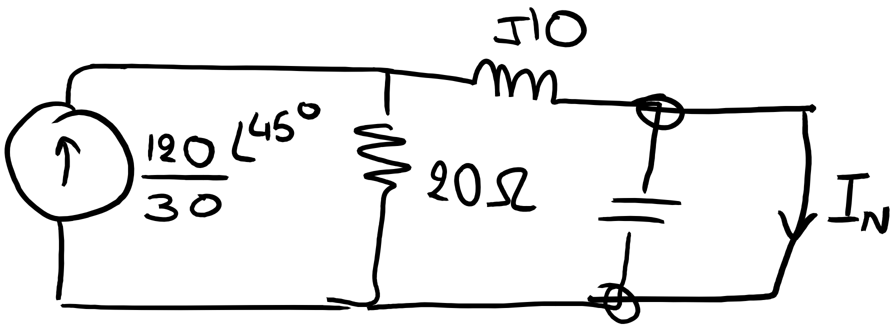




1) $Z_{Th}$ → short circuit voltage source



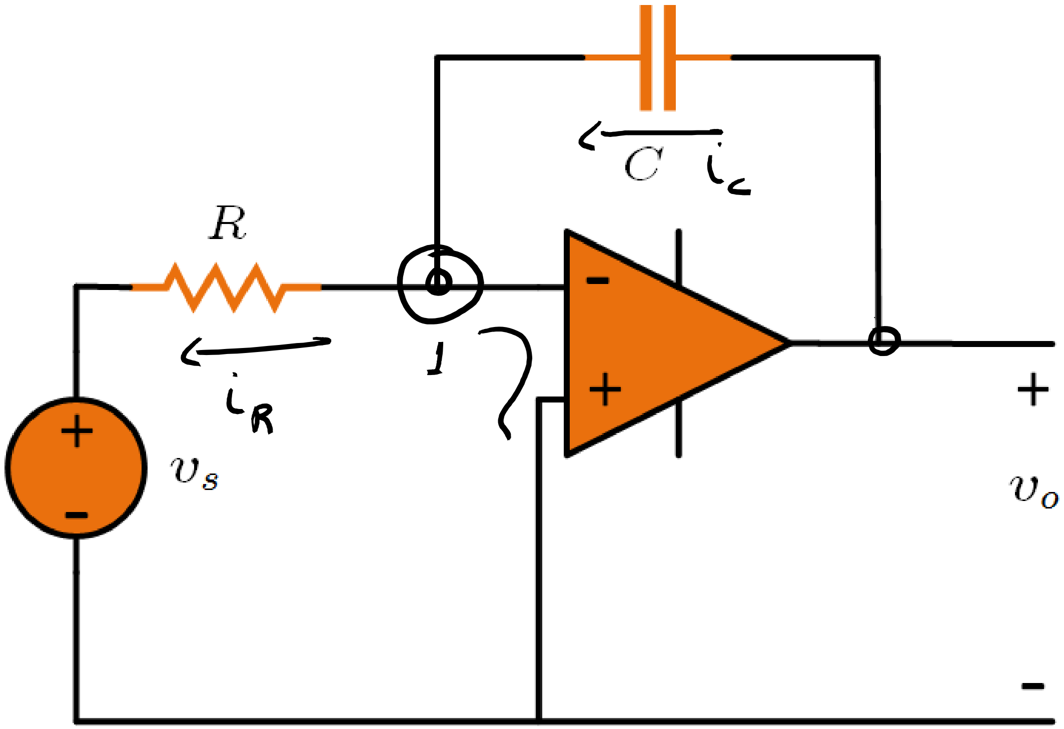

$$Z_{Th} = (-j5) \,||\, (j10 + 20) = \frac{(-j5)(20+j10)}{20+j5} = 5.493\angle{-77.47^\circ}\ \Omega$$

2) $V_{Th}$ and $I_N$. Source transformation




$$I_N = \frac{20}{20+j10}\, 4\angle 45^\circ = 3.578\angle 18.43^\circ\ \text{A}$$

$$V_{Th} = Z_{Th} \cdot I_N = 19.4\angle{-59^\circ}\ \text{V}$$




Find $\frac{V_o}{V_s}$

i) When in time domain:

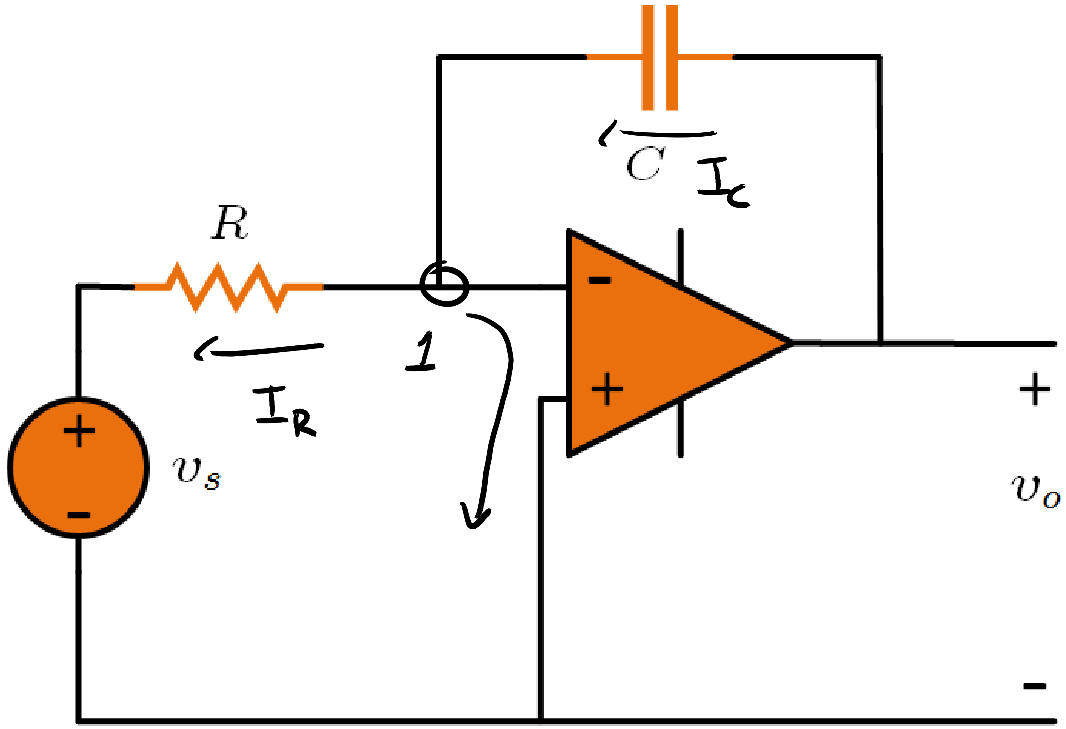
KCL at node 1

$i_c = i_R \Rightarrow$

$$C \cdot \frac{d(V_o - 0)}{dt} = \frac{0 - V_s}{R}$$

$$\Rightarrow dV_o = -\frac{V_s}{RC} dt \Rightarrow V_o(t) = -\frac{1}{R \cdot C} \int_0^t V_s(t) dt + V_c[0]$$

general integrator transfer function




In frequency domain

$$C \to \frac{1}{J\omega C}$$

$$I_c = I_R \Rightarrow$$

$$\frac{V_o}{Z_c} = \frac{0 - V_s}{R} \Rightarrow$$

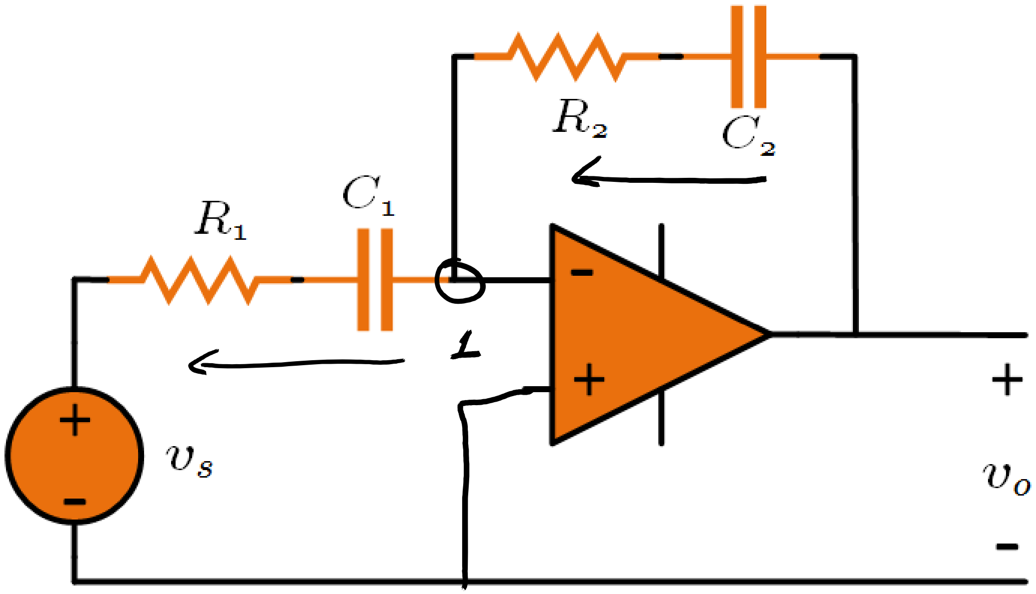
$$\Rightarrow \frac{V_o}{\frac{1}{J\omega C}} = -\frac{V_s}{R}$$

$$\Rightarrow V_o (J\omega C) = -\frac{V_s}{R} \quad \Rightarrow V_o = -\frac{V_s}{J\omega R C}$$

and $\dfrac{V_o}{V_s} = -\dfrac{1}{J\omega R C} = \dfrac{J}{\omega R C}$

Remember $J = 1 \angle 90^\circ$

phase shift of phasor




KCL at node 1:

$$Z_1 = R_1 + \frac{1}{j\omega C_1}$$

$$Z_2 = R_2 + \frac{1}{j\omega C_2}$$

$$\frac{V_o}{Z_2} = \frac{0 - V_s}{Z_1} \Rightarrow \frac{V_o}{V_s} = -\frac{Z_2}{Z_1} = \frac{R_2 + \frac{1}{j\omega C_2}}{R_1 + \frac{1}{j\omega C_1}}$$

$$= \frac{\frac{(j\omega R_2 C_2 + 1)}{j\omega C_2}}{\frac{j\omega R_1 C_1 + 1}{j\omega C_1}} = -\frac{\cancel{j\omega} C_1}{\cancel{j\omega} C_2} \cdot \frac{j\omega C_2 R_2 + 1}{j\omega C_1 R_1 + 1}$$

at $\omega = 0$ $\quad \frac{V_o}{V_s} = -\frac{C_1}{C_2}$ $\qquad$ at $\omega = \infty$ $\quad \frac{V_o}{V_s} = -\frac{R_2}{R_1}$