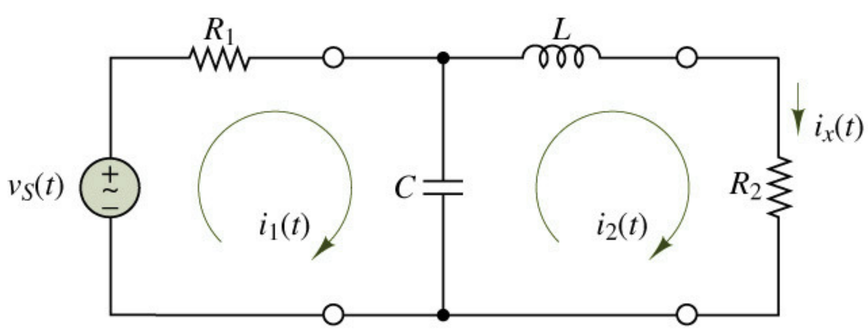
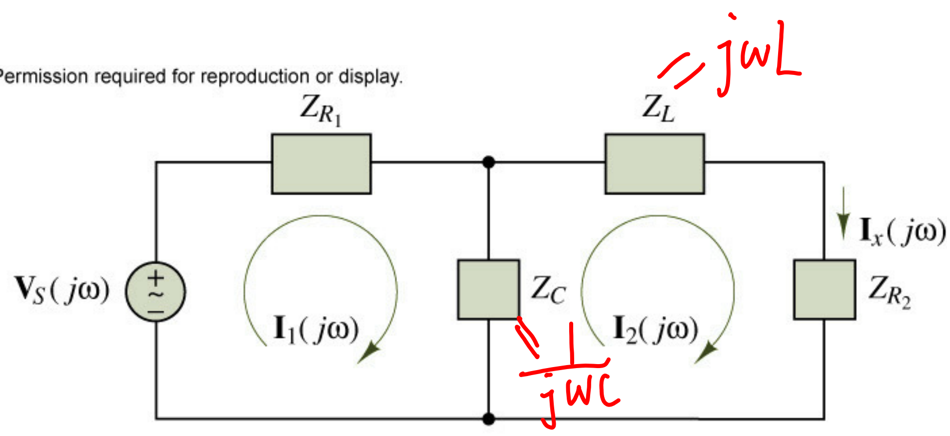
Class 10 (3/6) AC circuit analysis

- Procedure to solve a problem
  - Identify the sinusoidal and note the excitation frequency.
  - Covert the source(s) to phasor form
  - Represent each circuit element by its impedance
  - Solve the resulting phasor circuit using previous learnt analysis tools
  - Convert the (phasor form) answer to its time domain equivalent.

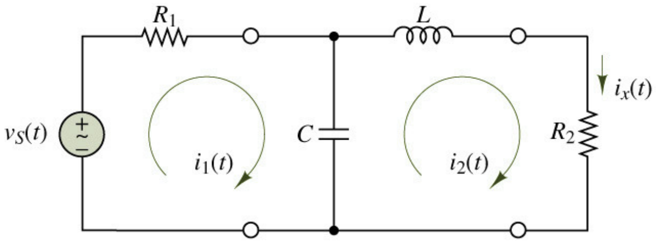


A sample circuit
for AC analysis

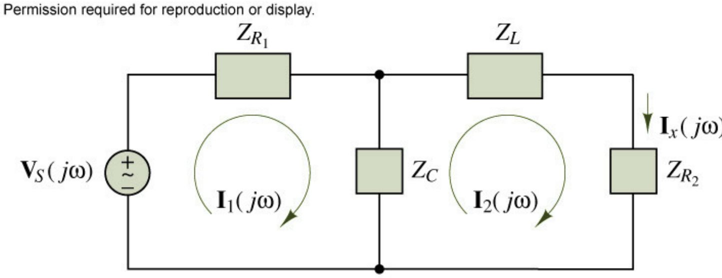


The same circuit
in phasor form

Ex. 4.21 P200



A sample circuit
for AC analysis



The same circuit
in phasor form

$= 10^{-6}$ F

R_1=100 Ω, R_2=75 Ω, C= 1μF, L=0.5 H, $v_S(t)$=15cos(1500t) V.
Determine $i_1(t)$ and $i_2(t)$.

Step 1: $v_S(t)$=15cos(1500t), ω=1500 rad/s.

Step 2: $\mathbf{V}_S(j\omega)=15\angle 0$

Step 3: $Z_{R1}=R_1$, $Z_{R2}=R_2$, $Z_C=1/j\omega C$, $Z_L=j\omega L$

Step 4: mesh equation

$$(Z_{R1}+Z_C)I_1(j\omega) \qquad -Z_C I_2(j\omega)=V_S(j\omega)$$

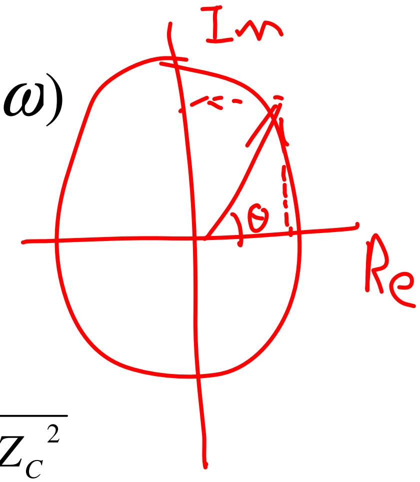
$$-Z_C I_1(j\omega)+(Z_C+Z_L+Z_{R2})I_2(j\omega)=0$$

In text book, mesh equations are written based on KVL

$$V_S(j\omega)-Z_{R1}I_1(j\omega)\ -Z_C\left(I_1(j\omega)-I_2(j\omega)\right)=0$$

$$(Z_{R1}+Z_C)I_1(j\omega) \qquad - Z_C I_2(j\omega) = V_S(j\omega)$$

$$-Z_C I_1(j\omega) + (Z_C + Z_L + Z_{R2})I_2(j\omega) = 0$$



$$I_1(j\omega) = \frac{\begin{vmatrix} V_S(j\omega) & -Z_C \\ 0 & Z_C + Z_L + Z_{R2} \end{vmatrix}}{\begin{vmatrix} Z_{R1}+Z_C & -Z_C \\ -Z_C & Z_C + Z_L + Z_{R2} \end{vmatrix}} = \frac{(Z_C + Z_L + Z_{R2})V_S(j\omega)}{(Z_{R1}+Z_C)(Z_C + Z_L + Z_{R2}) - Z_C^{\,2}}$$

R1=100 Ω, R_2=75 Ω,

$10^{-6}F$ = C= 1μF, L=0.5 H,

$v_S(t)$=15cos(1500t) V

$$Z_C = \frac{1}{j\omega C} = \frac{1}{j1500\times 10^{-6}} = \frac{66.7}{j} = -66.7\,j\Omega$$

$$Z_L = j\omega L = j1500\times 0.5 = 750\,j(\Omega)$$

$$I_1(j\omega) = \frac{(75+683\,j)15\angle 0}{(100-66.7\,j)(75+683\,j)+4450}$$

$$\sqrt{(57550)^2+(63300)^2}$$

$$7500+45600-5000\,j+68300\,j+4450 = 57550+63300\,j$$

$$= 85500\angle 47.8$$

$$\tan^{-1}\left(\frac{63300}{57550}\right)$$

$$I_1(j\omega) = \frac{687\angle 83.7 \bullet 15\angle 0}{85500\angle 47.8} = 0.012\angle 35.9^{0} = 0.012\angle 0.63$$

$$i_1(t) = 0.012\cos(1500t + 0.63)(A)$$

Norton & Thevenin

- Norton & Thevenin equivalent circuits are calculated the same way as before except using the phasor.

Superposition principle

- For multiple sources of the same or different frequencies, final results are the superposition of individual result from single source by setting all other sources to be zero