VE215 2024FA Assignment 5

JOINT INSTITUTE 交大密西根学院

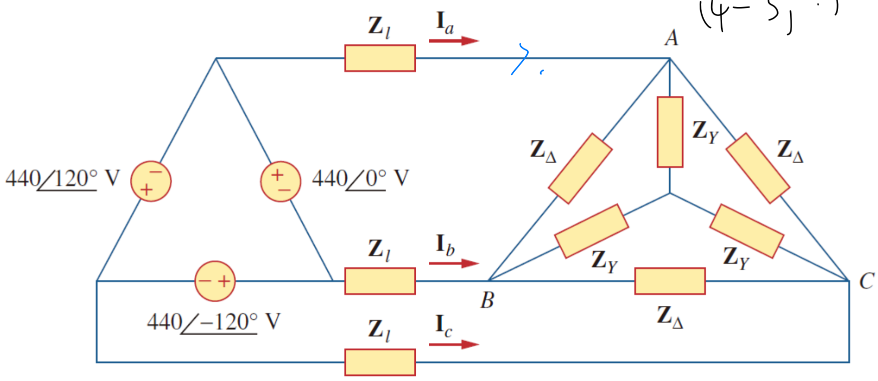
Due Date: 23:59, Dec.9th, 2024

In order to get full marks (60 points), you shall write all the intermediate steps of calculation or proof unless otherwise indicated. This assignment covers content of chapter 12.

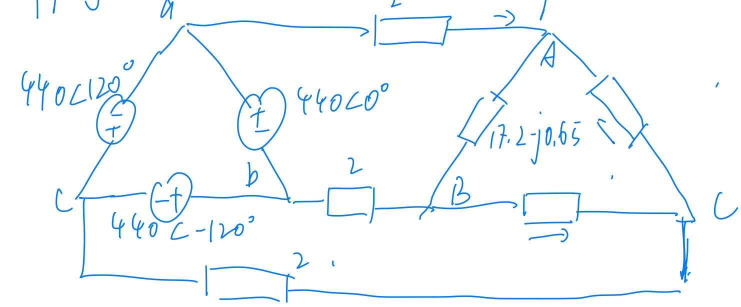
Exercise 5.1 (20%)

Find the line currents in the three-phase network. Take $Z_\Delta = 12 - j15\,\Omega$, $Z_Y = 4 + j6\,\Omega$, $Z_L = 2\,\Omega$.

$(4-5j\cdot)$



Apply Y-Δ, we can get the equivalent circuit.



$$\begin{cases} 440\angle 0^\circ + I_b\cdot 2 - V_{ab} - I_a\cdot 2 = 0 \\ I_a = \dfrac{V_{ab}}{Z_\Delta} - \dfrac{V_{ab}\angle 240^\circ}{Z_\Delta} \\ I_b = I_a\angle -120^\circ \end{cases}$$

$$I_a\left(2 + \frac{Z_\Delta}{1-\angle 240^\circ} - 2\angle -120^\circ\right) = 440\angle 0^\circ$$

$$\boxed{\begin{aligned} I_a &= 33.0\angle -28.5^\circ \text{ A} \\ I_b &= 33.0\angle -148.5^\circ \text{ A} \\ I_c &= 33.0\angle 91.7^\circ \text{ A} \end{aligned}}$$

Exercise 5.2 (20%)

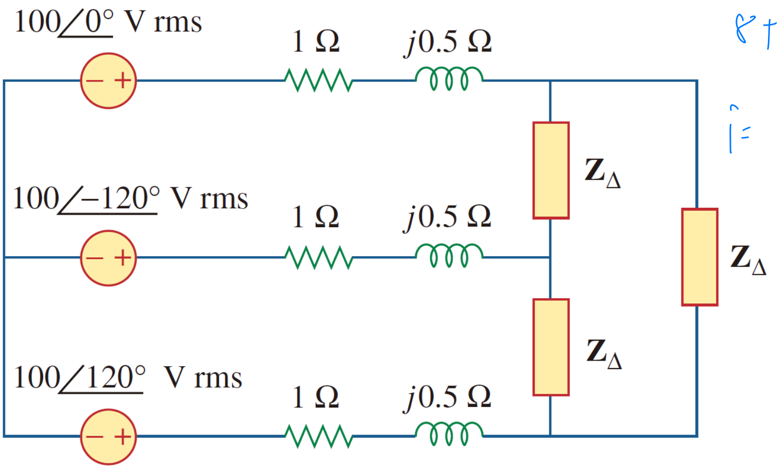
For the three-phase circuit below, find the average power absorbed by the delta-connected load with

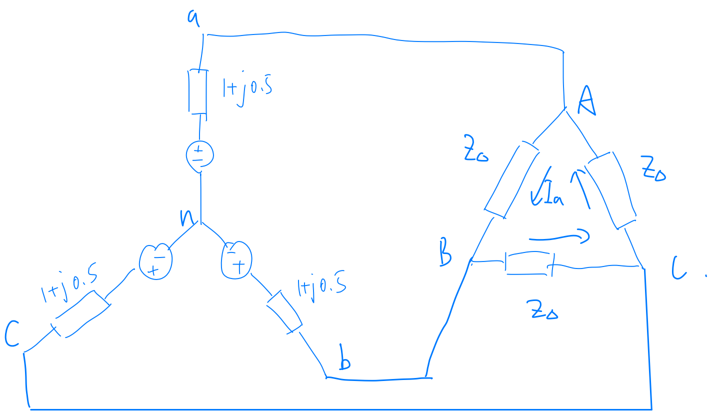
$$Z_\Delta = 21 + j24\,\Omega.$$

$7 + 8j$.

$8 + 8.5j$.

$I = 5.8 - 6.2j$.





$$\begin{cases} V_a - V_b + I_b \cdot Z_s - V_{ab} - I_a \cdot Z_s = 0. \\ V_{AB} = I_{AB} \cdot Z_\Delta \\ I_a = I_{AB} \sqrt{3} \angle -30^\circ . \end{cases}$$

$$100\angle 0^\circ - 100\angle -120^\circ + I_{AB}\sqrt{3}\angle 150^\circ \cdot Z_s - I_{AB} Z_\Delta - I_{AB}\sqrt{3}\angle 30^\circ Z_3 = 0$$

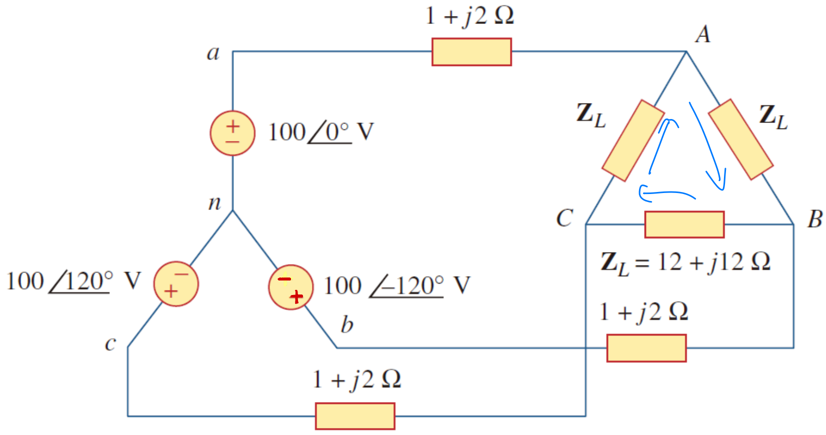
$$I_{AB} = \frac{100\angle 0^\circ - 100\angle -120^\circ}{(-\sqrt{3}\angle -150^\circ + \sqrt{3}\angle -30^\circ) Z_3 + Z_\Delta}.$$

$$I_{AB} : 4.95\angle -16.7^\circ$$

$$\boxed{P_A = 3 I_{AB}^2 \cdot R = 4.95^2 \cdot 21 = 1543.68 \cdot W}.$$

Exercise 5.3 (20%)

Obtain the line currents in the three-phase circuit



$$\begin{cases} V_a - V_b + I_b \cdot Z_s - I_{AB} \cdot Z_L - I_a \cdot Z_s = 0. \\ I_b = I_a \angle -120^\circ \\ I_a = \sqrt{3}\, I_{AB} \angle -30^\circ \end{cases}$$

$$100\angle 0^\circ - 100\angle -120^\circ - I_{AB} \cdot Z_L + \sqrt{3}\, I_{AB} \angle -150^\circ Z_s - \sqrt{3}\, I_{AB}\, {-30^\circ}\, Z_s = 0.$$

$$I_{AB} = \frac{100\angle 0^\circ - 100\angle -120^\circ}{\sqrt{3}\,(\angle -30^\circ - \angle -150^\circ) Z_s + Z_L}$$

$$= 7.4\angle -20.2^\circ$$

$$\boxed{\begin{aligned} I_a &= \sqrt{3}\, I_{ab} \angle -30^\circ = 12.82\angle -50.2^\circ \\ I_b &= 12.82 \angle -170.2^\circ \\ I_c &= 12.82 \angle 69.8^\circ \end{aligned}}$$

Additional Question (will not be marked)

Please derive the real power, reactive power, and complex power delivered to the load for four kinds of a-b-c sequence, balanced source and balanced load three-phase circuits (Y-Y, Y-Δ, Δ-Y, Δ-Δ). The RMS phase voltages for all four circuits are equal to $\mathbf{V_S}\angle\theta$ (for source-a, $\theta = 0°$) and the impedances connected in each phase for all four circuits are $\mathbf{Z} = \mathbf{R} + \mathbf{jX}$. All sources are ideal ones and all line voltage drops are equal to zero.

Y-Y

Real Power: $Re\left(3\left|\frac{V_s\angle 0}{R+jX}\right|^2\cdot(R+jX)\right)$.

Power: $Im\left(3\left|\frac{V_s\angle 0}{R+jX}\right|^2\cdot(R+jX)\right)$.

Complex power $3\left|\frac{V_s\angle 0}{R+jX}\right|^2\cdot(R+jX)$

Y-Δ $\left(\frac{\sqrt{3}V_s\angle 30°}{R+jX}\right)^2(R+jX)$

Δ-Δ $\left(\frac{V_s}{R+jX}\right)^2(R+jX)$

Δ-Y $\left(\frac{V_s\angle -30°}{\sqrt{3}(R+jX)}\right)^2(R+jX)$.