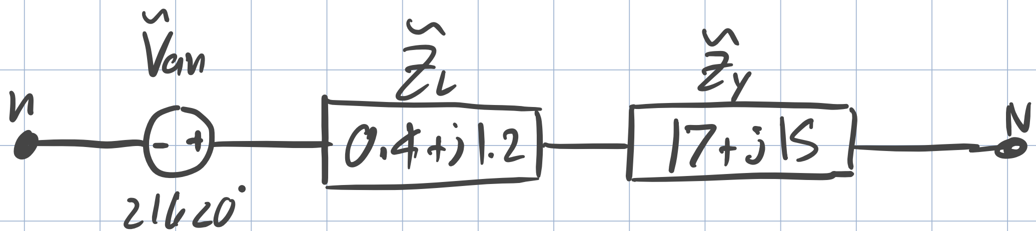
A balanced three-phase Y-Δ system has $V_{an} = 216 \angle 0°$ V and $Z_\Delta = (51 + j45)\ \Omega$. If the line impedance per phase is $(0.4 + j1.2)\ \Omega$, find the total complex power delivered to the load.

The total complex power delivered to the load S = (____ + j ____) kVA.

Convert Y-Δ to Y-Y

$$Z_Y = \frac{Z_\Delta}{3}$$

$$= 17 + j15$$



$$\tilde{I}_{1\phi} = \frac{\tilde{V}_{an}}{\tilde{Z}_L + \tilde{Z}_Y}$$

$$= 6.650 - j6.191 \text{ A}$$

$$S_{1\phi \text{ load}} = Z_Y |\tilde{I}_{1\phi}|^2$$

$$= 1403 + j1238 \text{ VA}$$

$$S_{3\phi \text{ load}} = 3\tilde{P}_{1\phi \text{ load}}$$

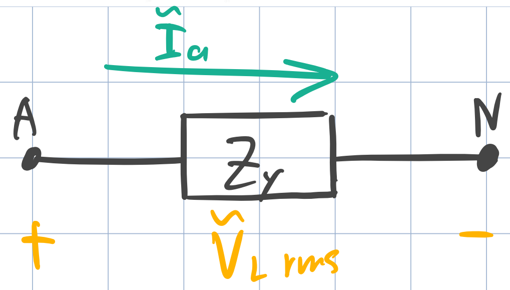
$$= 4210 + j3715 \text{ VA}$$

Required information

A three-phase source delivers 4.8 kVA to a wye-connected load with a phase voltage of 216 V and a power factor of 0.9 lagging. Calculate the source line current and the source line voltage.

Calculate the source line current.

The source line current is ______ A.



$|S_{3\phi}| = 4800$ VA

$\cos(\theta_s) = 0.9°$

$\tilde{V}_{L\,rms} = 216\angle 0$ V

$$|S_{1\phi}| = \frac{|S_{3\phi}|}{3}$$

$$= 1600 \text{ VA}$$

$$|S_{1\phi}| = |\tilde{V}_{L\,rms}||\tilde{I}^*_{L\,rms}|$$

$$|S_{1\phi}| = |\tilde{V}_{L\,rms}||\tilde{I}_{a\,rms}|$$

$$|\tilde{I}| = \frac{|S_{1\phi}|}{|\tilde{V}_{L\,rms}|}$$

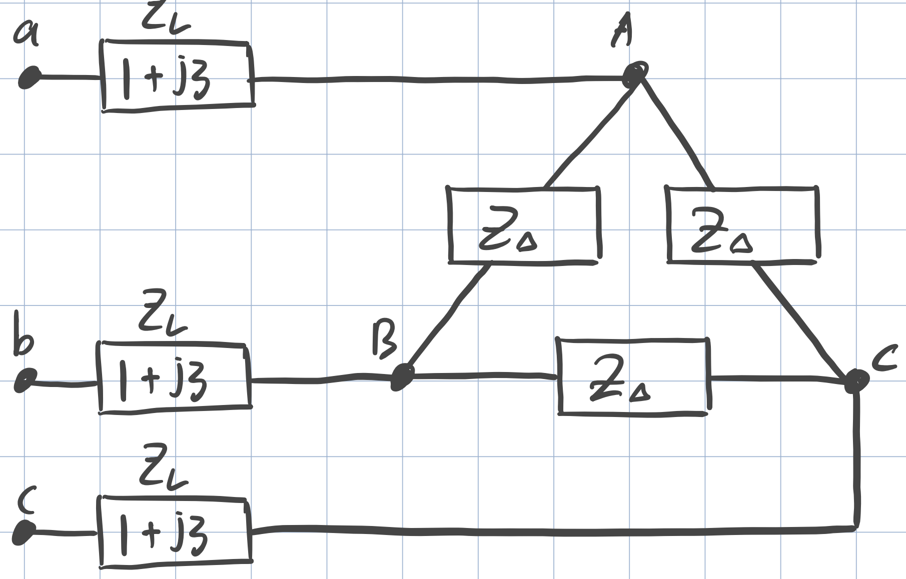
$$= 7.407 \text{ A}$$

Required information

A three-phase line has an impedance of 1 + *j*3 Ω per phase. The line feeds a balanced delta-connected load, which absorbs a total complex power of 12 + *j*5 kVA. The line voltage at the load end has a magnitude of 230 V.

Find the source power factor.

The source power factor pf = ______ .



$S_{load} = 12000 + j5000$ VA

$|\tilde{V}_{AB\,rms}| = 230$ V

$$S_{load} = \frac{|\tilde{V}_{AB\,rms}|^2}{Z_\Delta^*}$$

$$Z_\Delta^* = \frac{|\tilde{V}_{AB\,rms}|^2}{S_{load}}$$

$$= 3.756 - j1.565\ \Omega$$

$$Z_\Delta = 3.756 + j1.565\ \Omega$$

$$S_s = S_L + S_{load}$$

Because $S = Z|\tilde{I}|^2$ and absolute value ignores the phase of whatever is inside of it, the phase of Z is equal to the phase of S.

So we can solve for the phase of Z

$$Z_s \cancel{|\tilde{I}_{a\,rms}|}^2 = Z_L \cancel{|\tilde{I}_{a\,rms}|}^2 + Z_{load} \cancel{|\tilde{I}_{a\,rms}|}^2$$

$$Z_s = Z_L + Z_\Delta$$

$$= 4.756 + j4.565$$

$$= 6.593 \angle 43.825^\circ$$

$$PF = \cos(43.825)$$

$$= 0.721^\circ$$

Required information

A three-phase line has an impedance of 1 + *j*3 Ω per phase. The line feeds a balanced delta-connected load, which absorbs a total complex power of 12 + *j*5 kVA. The line voltage at the load end has a magnitude of 230 V.

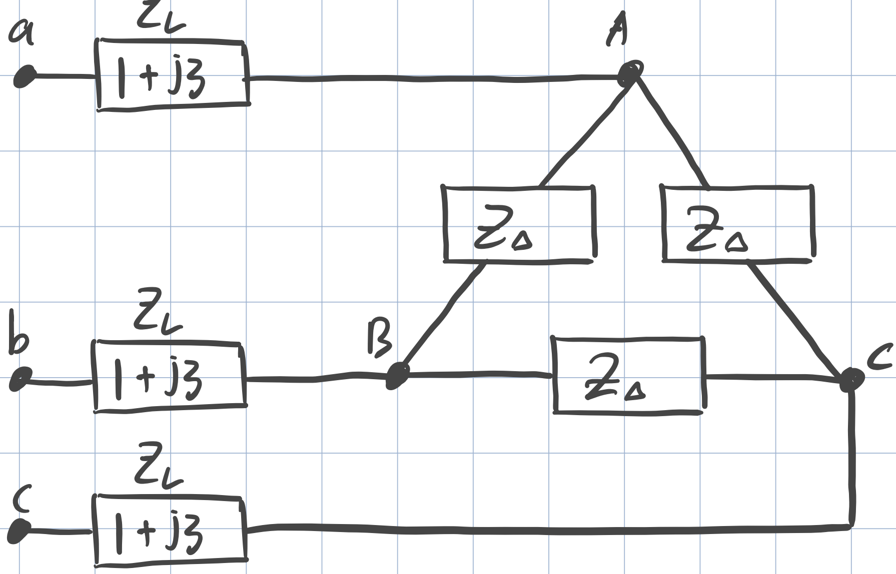
Calculate the magnitude of the line voltage at the source end.

The magnitude of the line voltage at the source end is ______ V.

$$S_{3\phi} = 12000 + j5000$$

$$S_{1\phi} = \frac{S_{3\phi}}{3}$$

$$= 4000 + j\frac{5000}{3} \text{ VA}$$



$$Z_\Delta^* = \frac{|V_{AB\,rms}|^2}{S_{1\phi}}$$

$$= 11.269 - j4.695\ \Omega$$

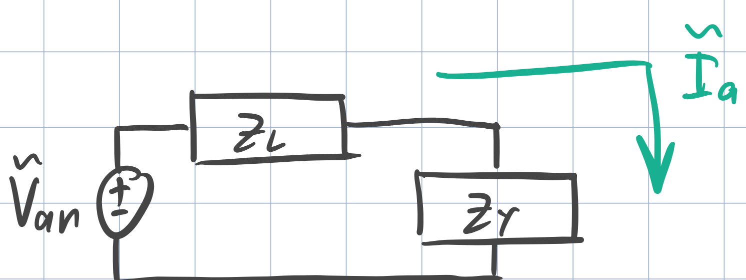
$$Z_\Delta = 11.269 + j4.695\ \Omega$$

$$Z_Y = \frac{Z_\Delta}{3}$$

$$= 3.756 + j1.565\ \Omega$$

$$\tilde{I}_a = \frac{\tilde{V}_{AB}/\sqrt{3}}{Z_Y}$$

$$= 32.632\ A$$



$$\tilde{V}_{an} = \tilde{I}_a (Z_L + Z_Y)$$

$$= 155.202 + j148.969 \text{ V}$$

$$\tilde{V}_{ab} = \sqrt{3} \cdot \tilde{V}_{an}$$

$$= 268.817 + j258.022 \text{ V}$$

$$|\tilde{V}_{ab}| = 372.610 \text{ V}$$

Required information

The total power measured in a three-phase system feeding a balanced wye-connected load is 12 kW at a power factor of 0.6 leading.

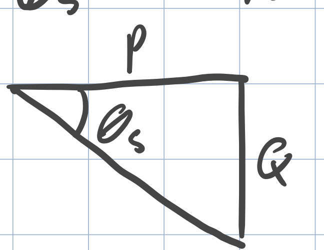
If the line voltage is 420 V, calculate the line current I_L.

The line current I_L = ____ A.

$$P_{3\phi} = 12000 \text{ W}$$

$$\cos(\theta_S) = 0.6$$

$$\theta_S = 53.13$$



$$Q = -P\tan(\theta_S)$$

$$= -16000$$

$$\tilde{V}_{AB} = 420 \text{ V}$$

$$|\tilde{V}_{AN}| = \frac{\tilde{V}_{AB}}{\sqrt{3}}$$

$$= 242.487 \text{ V}$$

$$S_{3\phi} = 12000 - j16000 \text{ VA}$$

$$S_{1\phi} = 4000 - j\frac{16000}{3} \text{ VA}$$

$$\tilde{I}_a^* = \frac{S_{1\phi}}{|\tilde{V}_{AN}|}$$

$$= 16.496 + j21.994 \text{ A}$$

$$|\tilde{I}_a| = 27.493 \text{ A}$$

Required information

The total power measured in a three-phase system feeding a balanced wye-connected load is 12 kW at a power factor of 0.6 leading.

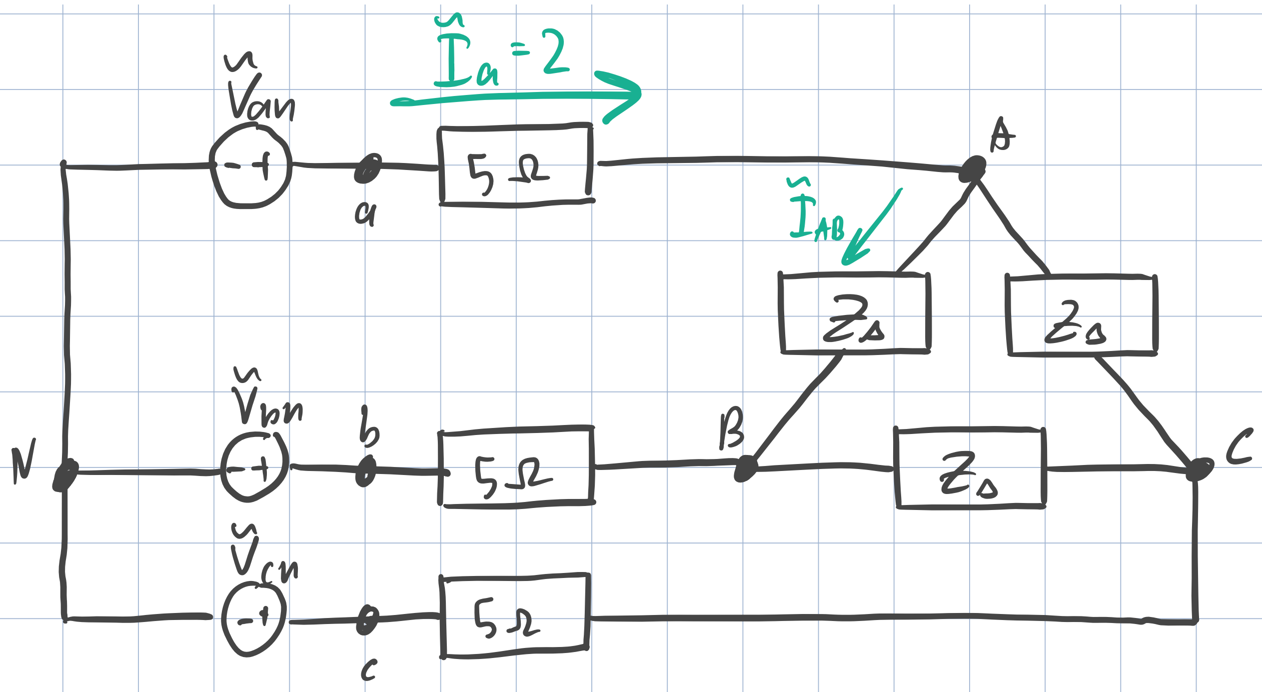
If the line voltage is 420 V and the line current is 27.49 A, calculate the load impedance.

The load impedance is [ ] − *j* [ ] Ω.

$$Z_Y = \frac{S_{1\phi}}{|\tilde{I}_a|^2}$$

$$= 5.292 - j7.056 \ \Omega$$

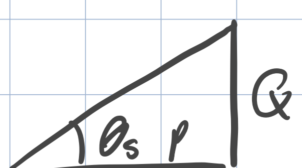
1. Given a balanced 3Ø Y connected source with line current 2 Arms delivers 300 W @ pf = .91 lagging to a Δ connected load. The line impedance is 5 Ω. Determine the Δ connected load impedance + the phase voltage at the source.



$P_{3\phi} = 300$ W

$\cos(\theta_s) = 0.91$

$\theta_s = 24.495°$



$$Q = P\tan(\theta_s)$$

$$= 136.684 \text{ VAR}$$

$$S_{3\phi} = 300 + j136.684 \text{ VA}$$

$$S_{1\phi} = 100 + j45.561 \text{ VA}$$

$$\tilde{I}_a = \tilde{I}_{AB}\sqrt{3}\angle -30^\circ$$

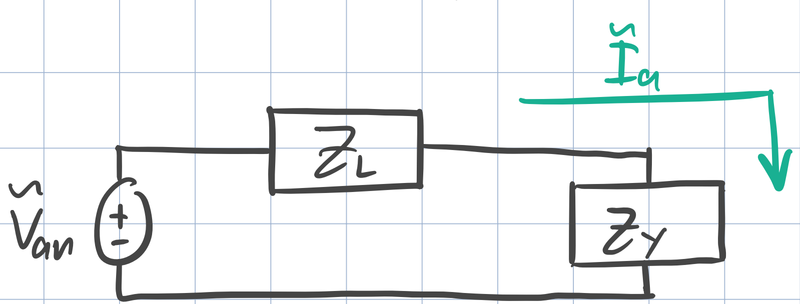
$$|\tilde{I}_{AB}| = \frac{\tilde{I}_a}{\sqrt{3}}$$

$$= 1.154 \text{ A}$$

$$S_{1\phi} = Z_\Delta |\tilde{I}_{AB}|^2$$

$$Z_\Delta = \frac{S_{1\phi}}{|\tilde{I}_{AB}|^2}$$

$$= 75 + j34.171 \ \Omega$$



$$Z_Y = \frac{Z_\Delta}{3}$$

$= 25 + j11.39\ \Omega$

KVL on loop

$-\tilde{V}_{an} + Z_L \tilde{I}_a + Z_Y \tilde{I}_a = 0$

$\tilde{V}_{an} = \tilde{I}_a (Z_L + Z_Y)$

$= 60 + j22.781\ V$

2. The complex pwr per phase of a balanced load is 384+j288 KVA. The line voltage at the load is 4160Vrms. Solve for the magnitude of the line current & the load impedance per phase assuming a Y connected load, R+jX.

$S_{1\phi} = 384000 + j288000\ VA$

$\tilde{V}_{AB} = 4160\ V_{rms}$

$S_{1\phi} = \tilde{V}_{AN} \tilde{I}_a^*$

$\tilde{I}_a^* = \dfrac{S_{1\phi}}{\tilde{V}_{AN}}$

$$= \frac{S_{1\phi}}{\hat{V}_{AB}/\sqrt{3}\angle 30^\circ}$$

$$|\hat{I}_a| = \left| \frac{S_{1\phi}\sqrt{3}}{\hat{V}_{AB}} \right|$$

$$= |159.882 + 119.911|$$

$$= 119.852 \text{ A}$$

$$S_{1\phi} = Z_Y |\hat{I}_a|^2$$

$$Z_Y = \frac{S_{1\phi}}{|\hat{I}_a|^2}$$

$$= 9.614 + j7.211 \ \Omega$$