

Fall 2022 EE361

HW1

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1 D1)

The wye connected circuit is constructed in Simulink environment. R_L and L_L values are selected as 28Ω and 38mH respectively, since my student number ends with 6.

2 D2)

Simulation is run and the results are obtained.

2.1 a)

$V_{line-line}$ and V_{phase} are presented in Figure 1

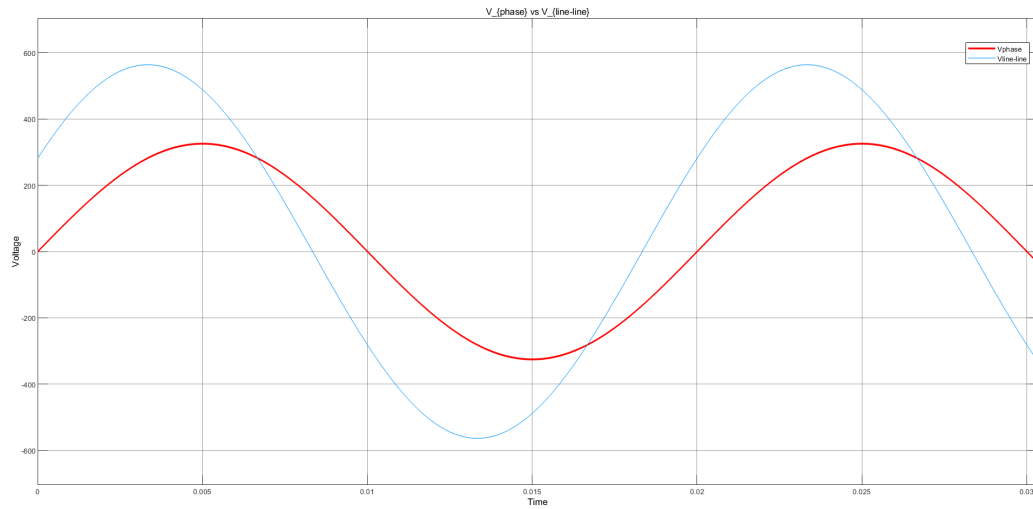


Figure 1: $V_{line-line}$ and V_{phase} vs Time

2.2 b)

I_{line} and I_{phase} are presented in Figure 2

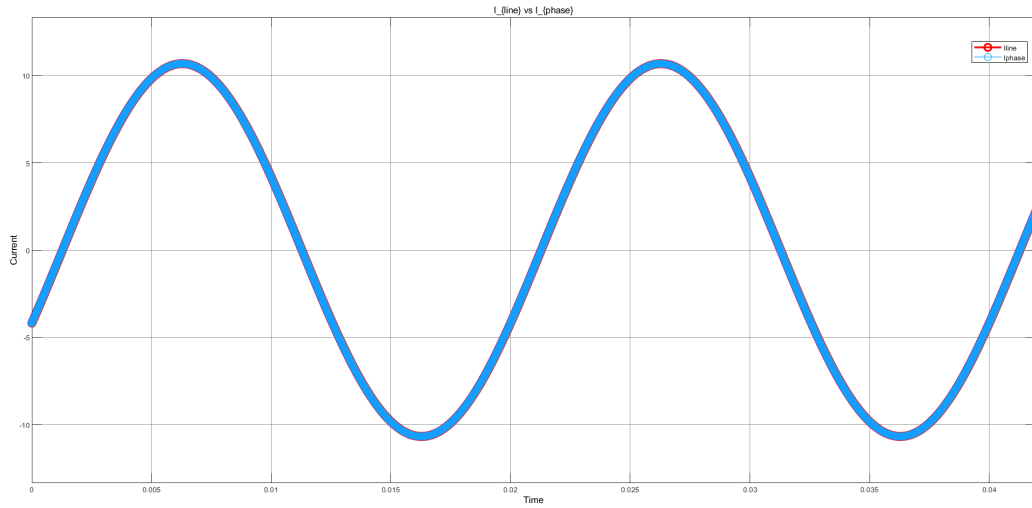


Figure 2: I_{line} and I_{phase} vs Time

2.3 c)

All three phase currents are shown in Figure 3

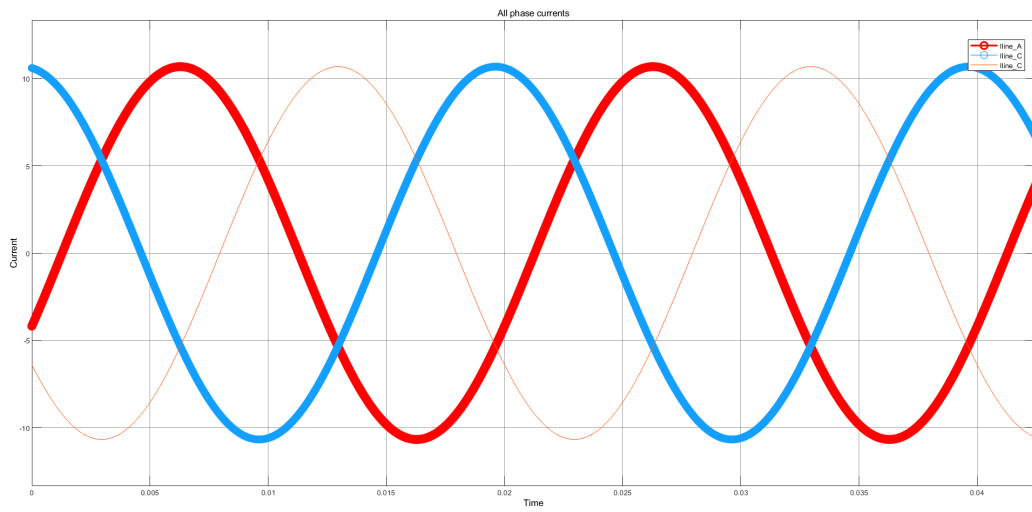


Figure 3: All three phase currents vs Time

2.4 d)

I_{phase} and V_{phase} are presented in Figure 2

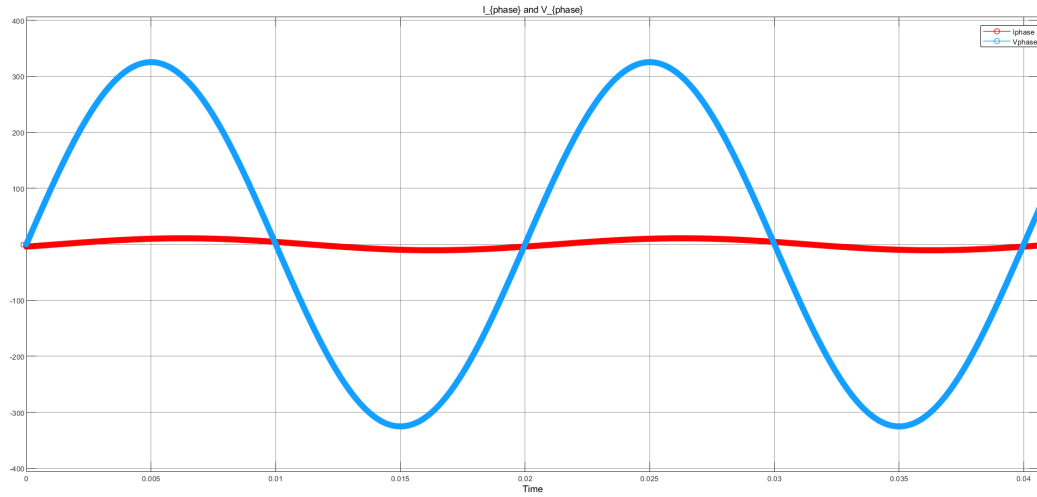


Figure 4: I_{phase} and V_{phase} of the wye-connected system vs Time

3 D3)

The instantaneous power is calculated according to the following expression.

$$p(t) = v(t) \times i(t)$$

When this calculation is done on Simulink, plot given in Figure 5

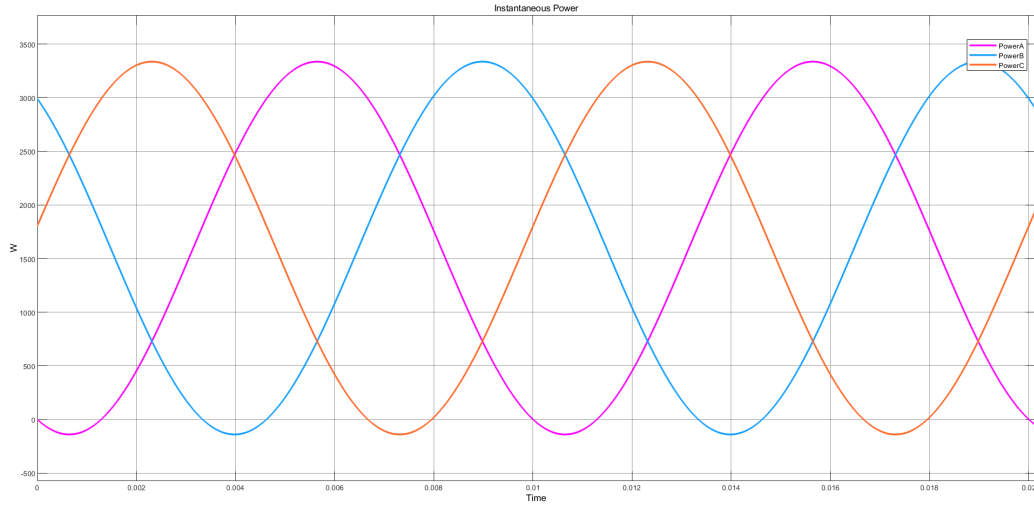


Figure 5: 3-phase instantaneous power

4 D4)

In this section three phase instantaneous power is measured using 2 voltmeters and 2 amperemeters according to the **two wattmeter method** described in section B/V. .

4.1 a)

The Simulink screenshot of the setup is given in Figure 6.

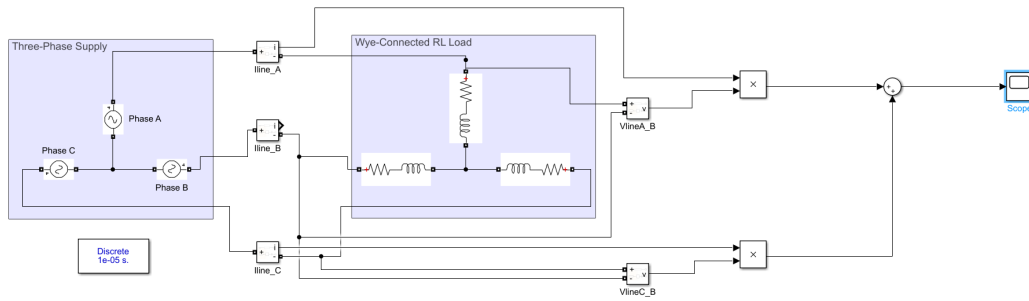


Figure 6: Simulink setup for two wattmeter method.

4.2 b)

The result is obtained from the scopes and shown in Figure 7

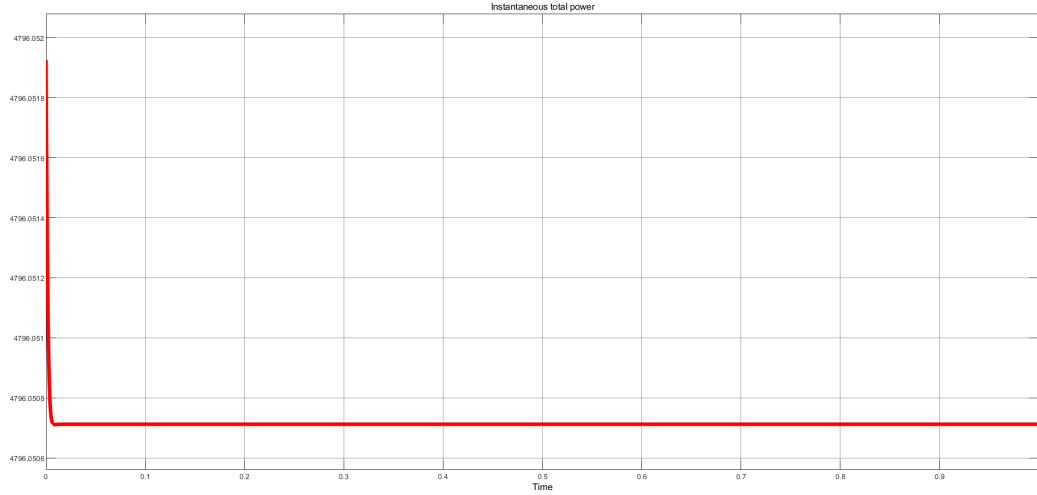


Figure 7: Total instantaneous power from two wattmeter

5 D5)

The phase angle is calculated from the plot given in section D5)d). The time difference between the peaks of the signals are obtained as 0.00125 seconds. The phase angle is calculated as follows.

$$\begin{aligned}\phi &= 360 \times f \times \Delta t \\ 22.5 &= 360 \times 50 \times 0.00125\end{aligned}\tag{1}$$

This phase angle may deviate from the actual value since the peak values are picked up by hand from the plot. Thus the power factor is obtained as

0.9238 . The power is calculated as follows;

$$V_{line-line} = 398.3717V_{rms}$$

$$So; V_{phase} = 230V_{rms}$$

$$I_{line} = 7.55A_{rms}$$

Thus the single phase apparent power is obtained as

$$\approx 1736.5$$

As we have found the power factor we can deduce complex power as:

$$1604.1787W + 664.8631VAR$$

Lastly the three phase complex power:

$$4812.5361W + 1994.5893VAR.$$

(2)

6 D6)

The values of the load resistance and inductance are doubled for just Phase-A. When the all phase current and voltages measured it is observed that for Phase-A voltage increases and the Phase-A current decreases.

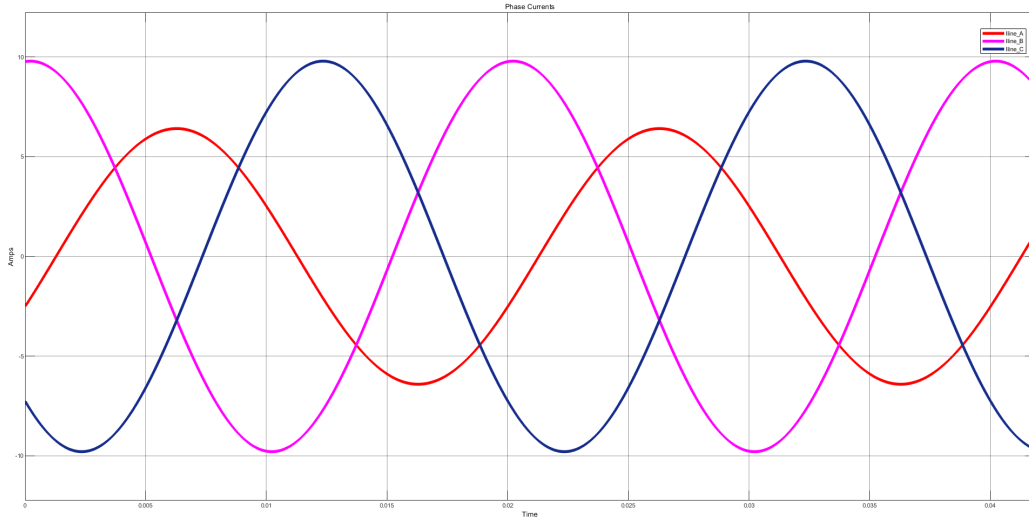


Figure 8: Unbalanced load phase currents

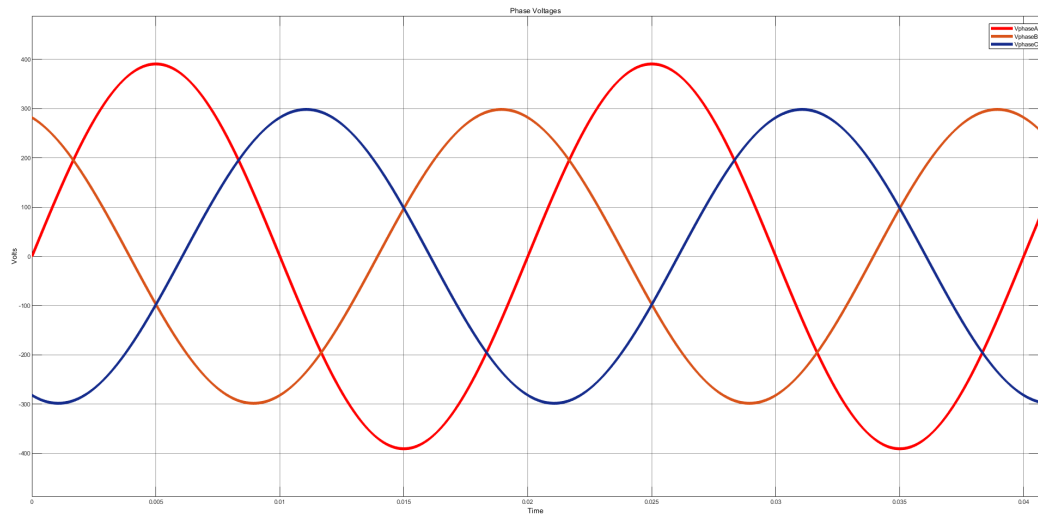


Figure 9: Unbalanced load phase voltages

7 D7)

The connection of the load is switched from wye to delta. The resultant configuration is given in Figure 10 .

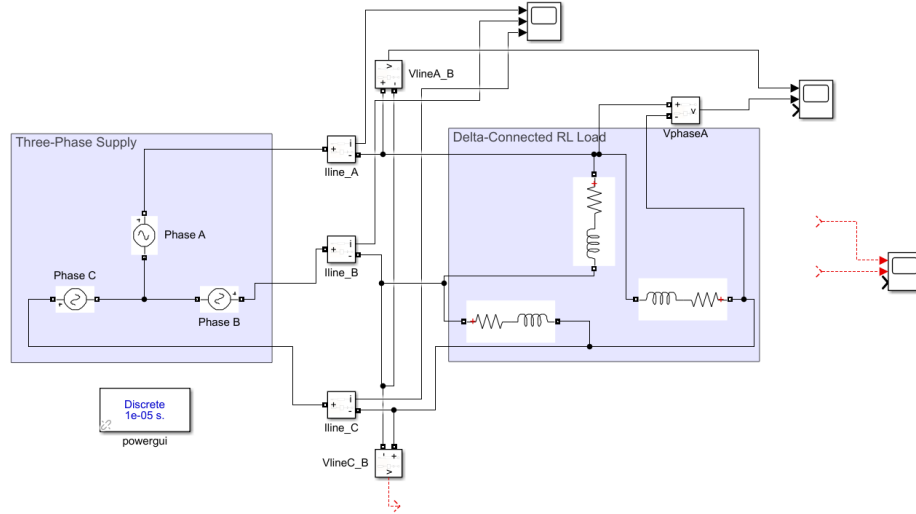


Figure 10: Δ connected load configuration in Simulink

7.1 a)

$V_{line-line}$ and V_{phase} versus time is plotted and given in Figure 11

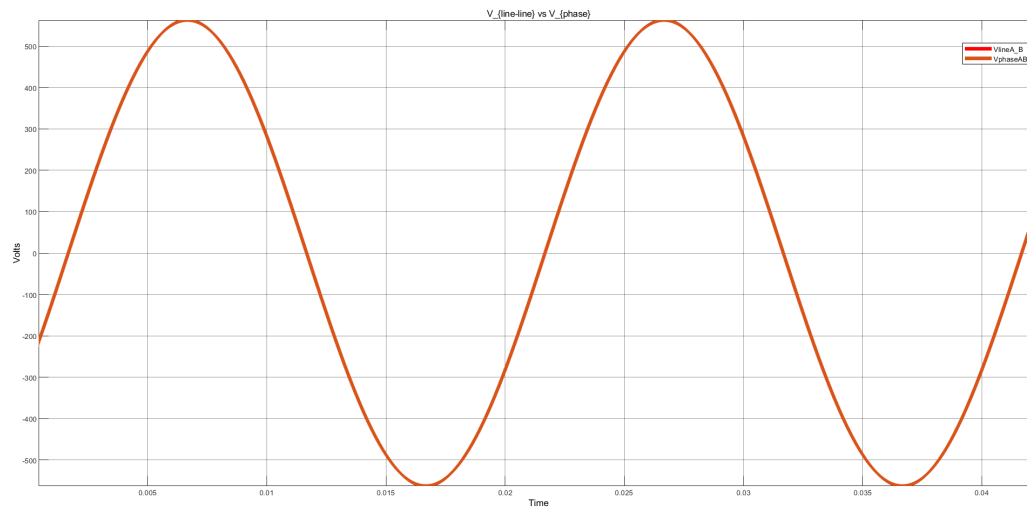


Figure 11: $V_{line-line}$, V_{phase} vs Time

7.2 b)

I_{line} and I_{phase} versus time is plotted and given in Figure 12

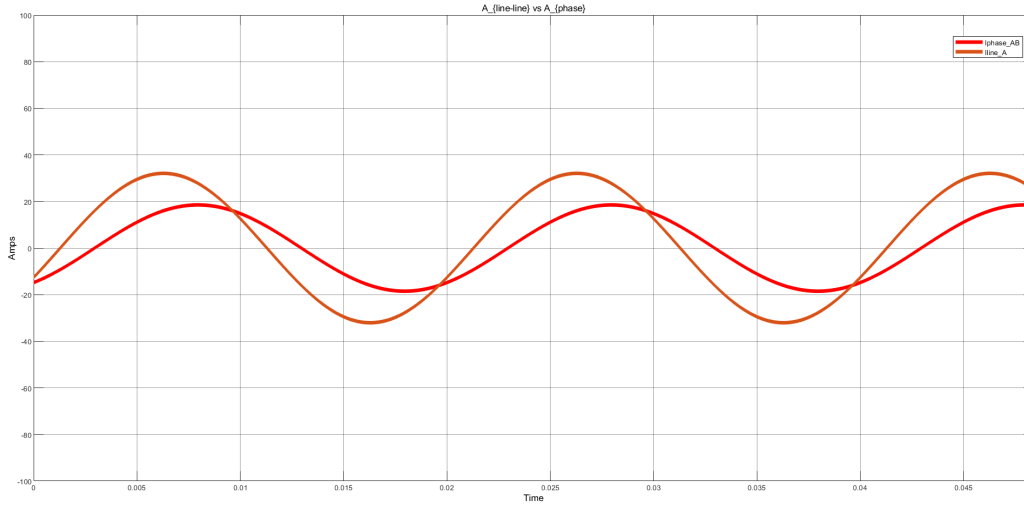


Figure 12: I_{line} , I_{phase} vs Time

7.3 c)

I_{phase} and V_{phase} versus time is plotted for Δ connected load and given in Figure 13.

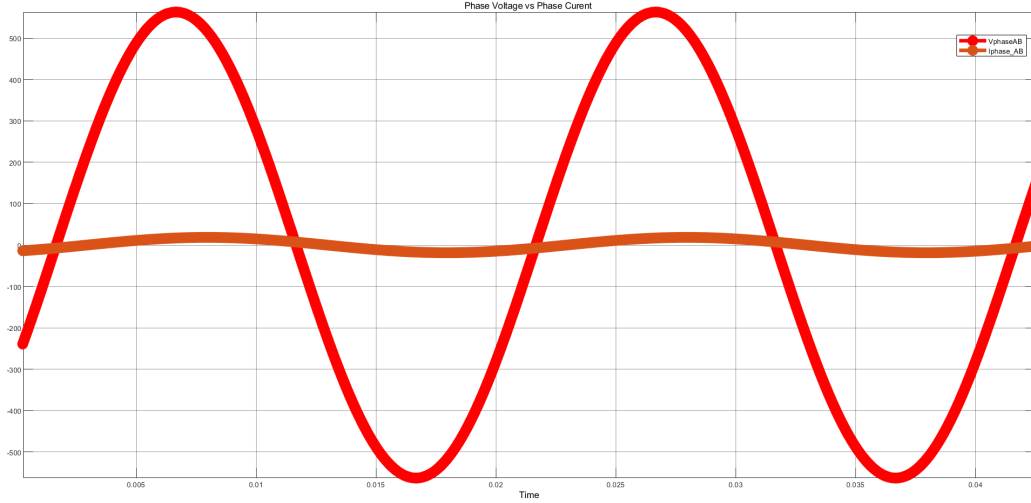


Figure 13: I_{phase} , V_{phase} of Δ connected system.

8 D8)

The phase angle is calculated from the plot given in section D7)c). The time difference between the peaks of the signals are obtained as 0.00125 seconds. The phase angle is calculated as follows.

$$\begin{aligned}\phi &= 360 \times f \times \Delta t \\ 22.5 &= 360 \times 50 \times 0.00125\end{aligned}\tag{3}$$

Thus the power factor is obtained as 0.9238 (same with the wye-connected configuration) . The power is calculated as follows;

$$\begin{aligned}V_{line-line} &= 398.3717V_{rms} \\ So; V_{phase} &= 230V_{rms} \\ I_{line-line} &= 22.06A_{rms}\end{aligned}$$

From this information 3 phase apparent power directly calculated as

$$398.3717 \times 22.06 \times \sqrt{3} = 15221.869$$

Lastly the three phase complex power:

$$14061W + 5824.82VAR.\tag{4}$$

9 E1)

It is impossible to get constant instantaneous power with a regular single-phase system. This is due to the fact that in single-phase there are no other line to balance the sinusoid signal in instantaneous manner.

10 E2)

Using wye-connected and Δ -connected systems provide an advantage of less wire connection. Since the systems are balanced there are no neutral wires or very thin neutral wires compared to the phase lines. Thus, wye and Δ -connected systems reduces cost.

11 E3)

In Figure 14 the per-phase representation and the calculations are provided.

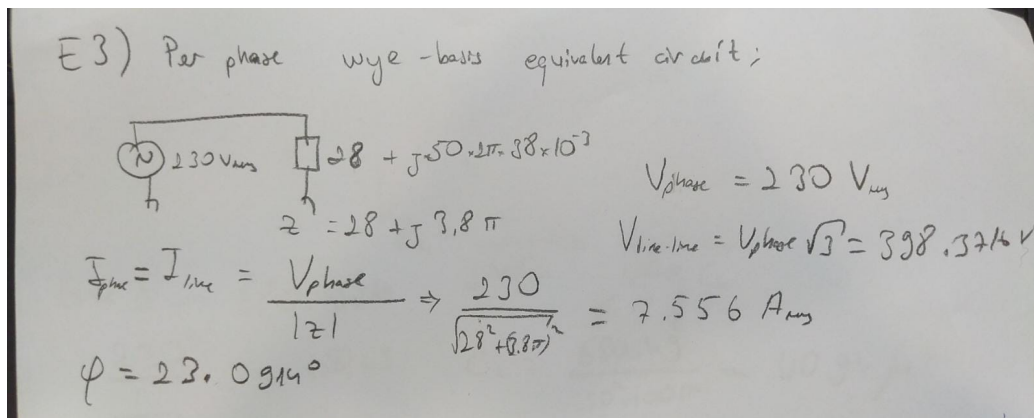


Figure 14: Per phase wye-basis calculations

12 E4)

It can be said that the simulation results are quite close to the calculation as expected.

13 E5)

In Figure 15 the phasor diagram of the per phase wye-basis circuit is provided.

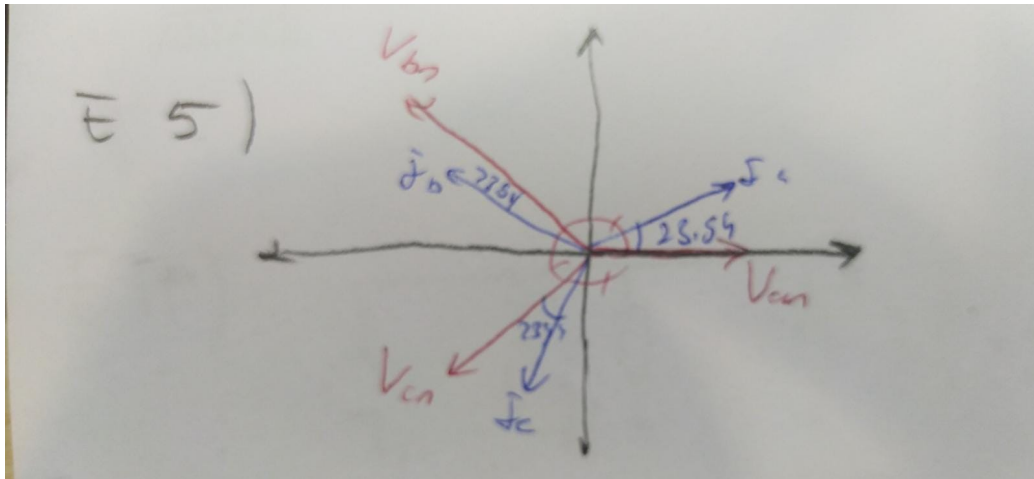


Figure 15: Phasor diagram

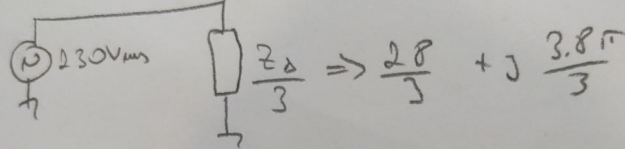
14 E6)

By comparison it can be said that the results are quite close, however not identical. These deviations may stem from some non-idealities of my measurement method and my calculation approach. For example some of the significant figures are ignored through my calculations.

15 E7)

The wye-basis equivalent circuit is given in Figure 16 with the equivalent R and L values.

E 7)



$$V_{\text{phase}} - V_{\text{line}} = 230\sqrt{3} = 398.3716 \text{ V}$$

$$I_{\text{line}} = \frac{230}{\sqrt{\left(\frac{28}{3}\right)^2 + \left(\frac{3.8\pi}{3}\right)^2}} = 22.67 \text{ A}_{\text{rms}} \quad I_{\text{phase}} = 13.0876$$

$$\varphi = 23.0914^\circ$$

Figure 16: Per phase delta-basis calculations

16 E8)

When the line currents calculated with wye and *Delta* connected loads are compared the following statement can be made:

$$I_{\text{line}\Delta} = \sqrt{3}I_{\text{line}_{\text{wye}}}$$

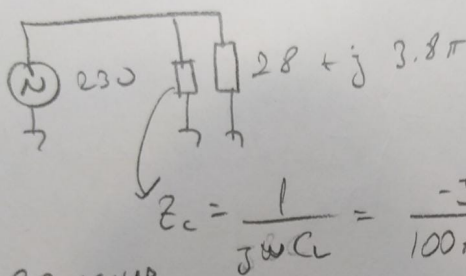
17 E9)

Overall power delivered to the load does change when the RL load connection is changed from wye to Δ . Indeed, the Q part is increased significantly.

18 E10)

The power factor correction calculations for wye-connected load are given in Figure 17.

E10)



$$Z_c = \frac{1}{j\omega C_L} = \frac{-j}{100\pi C_L}$$

Since Q was 680.43 VAR

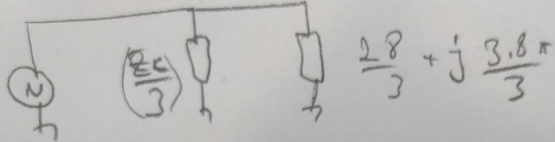
$$\frac{230^2}{\frac{1}{100\pi C_L}} = 680.43 \quad C_L = \frac{680.43}{230^2 \times 100\pi} = 40.94 \mu F$$

Figure 17: Power factor correction for wye-basis

19 E11)

The power factor correction calculations for delta-connected load are given in Figure 18.

E11)



Since Q was 1941.6 VAR

$$\frac{Z_c}{3} = \frac{1}{j\omega C \cdot 3} = \frac{-j}{300\pi C} \Rightarrow \frac{230^2}{\frac{1}{300\pi C}} = 1941.6$$

$$\therefore C = 38.94 \mu F$$

Figure 18: Power factor correction calculations for delta-connected load

20 Conclusion

In this document results of the first homework of fall semester are presented.