EE4226- Power Engineering Lab

Experiment #6

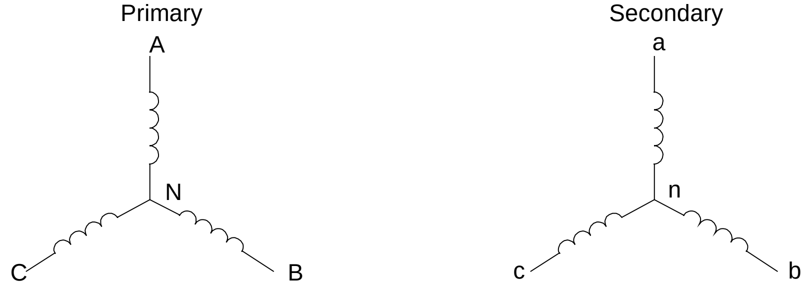
Three Phase Transformers

The purpose of this experiment is to understand different transformer connections and to verify the relationships of phase and line values of currents and voltages.

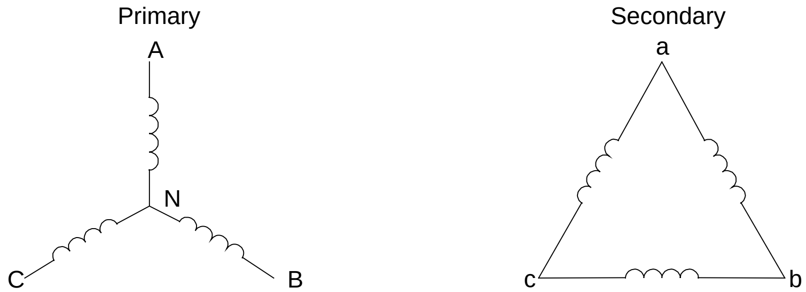
Background:

There are many three-phase transformer connections and each has its own set of advantages and disadvantages. These are only a few of the possible connections:

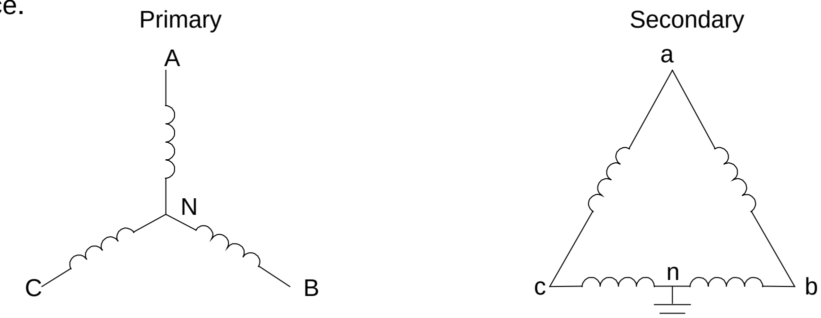
Wye-Wye: This connection can provide two output voltages using the line-to-line or line-to-neutral voltages. Due to this voltage relationship, a wye-wye connection is a good option for high voltage, low current secondary. Both the primary and secondary neutrals can be grounded.



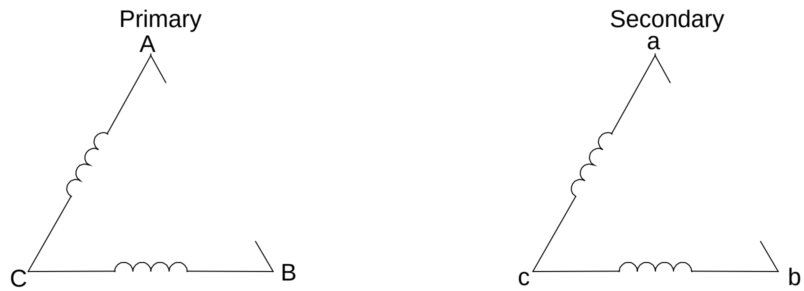
Wye-Delta: A wye-delta connection is good connection for lower voltage, higher current applications. This connection eliminates third-harmonic voltages by allowing them to circulate through the secondary delta. The delta secondary does not allow for a neutral point on the load side.



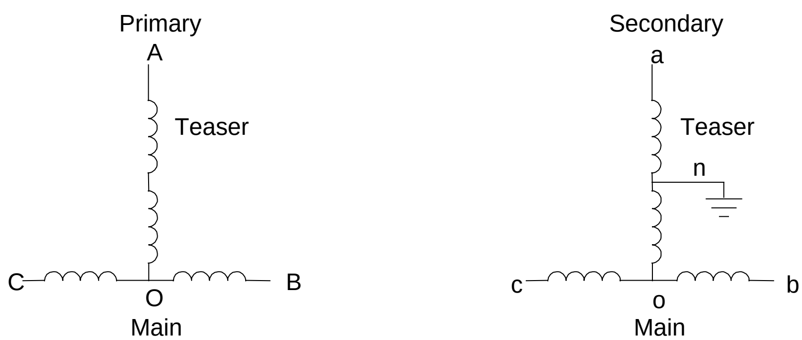
Wild Leg Delta: This connection has similar advantages and disadvantages as a normal wye-delta connection. The main difference is that a neutral point is now available. This allows for three and single phase loads to be connected using a single set of transformers. The line-to-line voltages are equal, however, the line-to-neutral voltages are not. This means that only two phases can be loaded, resulting in an inherent system imbalance.



Open Delta: The only real advantage of this connection has over a delta-delta connection is an initial cost savings in only buying two transformers instead of three. Each transformer must bear a much larger load when compared to an equivalent delta-delta connection. If a load is predicted to gradually grow, then a third transformer could be installed later to complete a delta-delta connection. An open delta connection may also be used temporarily if a single transformer in a delta-delta connection becomes damaged.



T-T: A T-T connection is another way of providing three phase power using only two transformers. It also allows for three, two, and single phase loads to be supplied at the simultaneously. The two transformers each have a name, main and teaser. The main transformer has a center tap that connects to the teaser transformer. The teaser transformer must have a turns ratio √3/2 times that of the main transformer in order to provide a balanced set of line-to-line voltages. A tap 2/3 of the way down the teaser transformer is necessary to provide a balanced neutral point for grounding as shown below. The two transformers can be interchangeable if both transformers have the correct taps.



Procedure:

Part 1 - Wye - Wye Connection

1. Connect the load cart as seen in Figure 1, the load will remain in this connection throughout the lab. Connect the three, single-phase transformers as shown in Figure 2. **Have the Instructor check your circuit**.

2. Adjust the variable three-phase supply to give 208 V_{L-L} on the primary. Load the secondary with a balanced resistive load to give approximately 4.0 amperes of secondary current. Measure and record all the voltages and currents. Use the clamp-on ammeter for your current measurements and the digital voltmeter with a pair of long banana jack leads for your voltage measurements.

3. De-energize the circuit starting with the triple switch and next the power pedestal switches.

Part 2 - Wye - Delta Connection

4. Connect the three, single-phase transformers as shown in Figure 3. **Have the Instructor check your circuit**.

5. Adjust the variable three-phase supply to give 208 V_{L-L} on the primary. Load the secondary with a balanced resistive load to give approximately 4.0 amperes of secondary current. Measure and record all the voltages and currents.

6. De-energize the circuit starting with the triple switch and next the power pedestal switches. Do not dismantle your circuit, you will use it in the following section

Part 3 - Wild Leg Delta Connection

7. Add the neutral connection to your circuit as seen in Figure 4. **Have the Instructor check your circuit**.

8. Adjust the variable three-phase supply to give 208 $V_{L\text{-}L}$ on the primary. Load the secondary with a balanced resistive load to give approximately 4.0 amperes of secondary current on the C phase. The highest load current on any phase should be 4A. If another phase has more than 4A, you have made a wiring mistake. Measure and record all the voltages and currents.

9. De-energize the circuit starting with the triple switch and next the power pedestal switches.

Part 4 - Open Delta Connection

10. Connect the two, single-phase transformers as shown in Figure 5 (Note you need only two, single-phase transformers.) **Have the Instructor check your circuit**.

11. Adjust the variable three-phase supply to give 208 $V_{L\text{-}L}$ on the primary. Load the secondary with a balanced resistive load to give approximately 4.0 amperes of secondary current. Measure and record all the voltages and currents.

12. De-energize the circuit starting with the triple switch and next the power pedestal switches.

Part 5 - T - T Connection

13. Using a Type I and a Type II, construct the circuit shown in Figure 6. Use shorting strips to connect X_3 and X_4. **Have the Instructor check your circuit**.

14. Adjust the variable three-phase supply to give 208 $V_{L\text{-}L}$ on the primary. Load the secondary with a balanced resistive load to give approximately 4.0 amperes of secondary current. Measure and record all the voltages and currents.

15. De-energize the circuit starting with the triple switch and next the power pedestal switches. Remove all wiring, loads, and instrumentation.

16. Write down the turns ratios of both transformer types to use in the post lab before leave.

EE4226 - EXPERIMENT #6

THREE PHASE TRANSFORMERS

Lab Section: ______________ Name: ______________________________

Date: ____________________ Lab Partners: ________________________

____

Part 1: Primary Secondary

2. V_{AB} ______ V_{BC} ______ V_{CA} ______ V_{ab} ______ V_{bc} ______ V_{ca} ______

V_{AN} ______ V_{BN} ______ V_{CN} ______ V_{an} ______ V_{bn} ______ V_{cn} ______

I_{AN} ______ I_{BN} ______ I_{CN} ______ I_{an} ______ I_{bn} ______ I_{cn} ______

I_n ______

Part 2:

5. V_{AB} ______ V_{BC} ______ V_{CA} ______ V_{ab} ______ V_{bc} ______ V_{ca} ______

V_{AN} ______ V_{BN} ______ V_{CN} ______ I_a ______ I_b ______ I_c ______

I_{AN} ______ I_{BN} ______ I_{CN} ______ I_{ab} ______ I_{bc} ______ I_{ca} ______

Part 3:

8. V_{AB} ______ V_{BC} ______ V_{CA} ______ V_{ab} ______ V_{bc} ______ V_{ca} ______

V_{AN} ______ V_{BN} ______ V_{CN} ______ V_{an} ______ V_{bn} ______ V_{cn} ______

I_{AN} ______ I_{BN} ______ I_{CN} ______ I_a ______ I_b ______ I_c ______

I_{ab} ______ I_{bc} ______ I_{ca} ______

I_n ______

Part 4:

11. V_{AB} ______ V_{BC} ______ V_{CA} ______ V_{ab} ______ V_{bc} ______ V_{ca} ______

I_A ______ I_B ______ I_C ______ I_a ______ I_b ______ I_c ______

I_{AB} ______ I_{BC} ______ I_{CA} ______ I_{ab} ______ I_{bc} ______ I_{ca} ______

Part 5:

14. V_{AB} ______ V_{BC} ______ V_{CA} ______ V_{ab} ______ V_{bc} ______ V_{ca} ______

V_{AO} ______ V_{BO} ______ V_{CO} ______ V_{no} ______ V_{bo} ______ V_{co} ______

I_A ______ I_B ______ I_C ______ V_{an} ______ V_{bn} ______ V_{cn} ______

I_a ______ I_b ______ I_c ______

I_n ______

Post Lab Questions:

Given a balanced input where V_{AB} 200V at 0˚, determine the theoretical voltages and phase angles of each other element in the circuit using what you know about three-phase and ideal transformer relationships. Show your work.

Primary — Secondary

Wye-Wye:

Primary		Secondary	
V_{AB} *200* θ *0*	V_{AN} ______ θ ______	V_{ab} ______ θ ______	V_{an} ______ θ ______
V_{BC} ______ θ ______	V_{BN} ______ θ ______	V_{bc} ______ θ ______	V_{bn} ______ θ ______
V_{CA} ______ θ ______	V_{CN} ______ θ ______	V_{ca} ______ θ ______	V_{cn} ______ θ ______

Wye-Delta:

Primary		Secondary
V_{AB} *200* θ *0*	V_{AN} ______ θ ______	V_{ab} ______ θ ______
V_{BC} ______ θ ______	V_{BN} ______ θ ______	V_{bc} ______ θ ______
V_{CA} ______ θ ______	V_{CN} ______ θ ______	V_{ca} ______ θ ______

Wild Leg Delta:

Primary		Secondary	
V_{AB} *200* θ *0*	V_{AN} ______ θ ______	V_{ab} ______ θ ______	V_{an} ______ θ ______
V_{BC} ______ θ ______	V_{BN} ______ θ ______	V_{bc} ______ θ ______	V_{bn} ______ θ ______
V_{CA} ______ θ ______	V_{CN} ______ θ ______	V_{ca} ______ θ ______	V_{cn} ______ θ ______

Open Delta:

Primary	Secondary
V_{AB} *200* θ *0*	V_{ab} ______ θ ______
V_{BC} ______ θ ______	V_{bc} ______ θ ______
V_{CA} ______ θ ______	V_{ca} ______ θ ______

T-T:

Primary		Secondary		
V_{AB} *200* θ *0*	V_{AO} ______ θ ______	V_{ab} ______ θ ______	V_{ao} ______ θ ______	V_{an} ______ θ ______
V_{BC} ______ θ ______	V_{BO} ______ θ ______	V_{bc} ______ θ ______	V_{bo} ______ θ ______	V_{bn} ______ θ ______
V_{CA} ______ θ ______	V_{CO} ______ θ ______	V_{ca} ______ θ ______	V_{co} ______ θ ______	V_{cn} ______ θ ______
			V_{no} ______ θ ______	

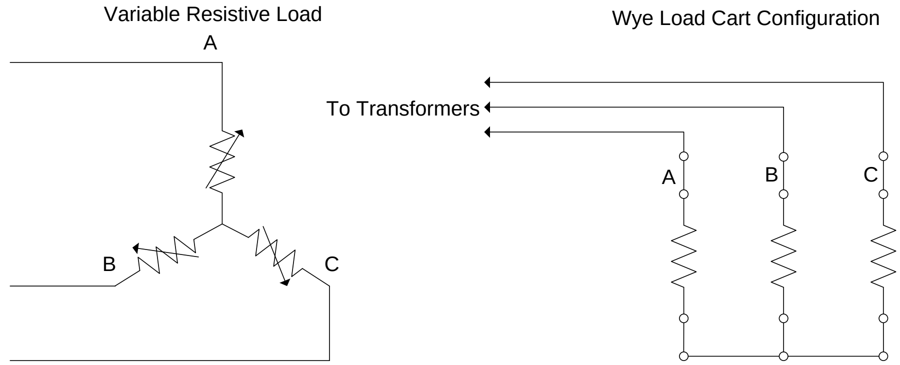


Figure 1- Load Cart Configuration

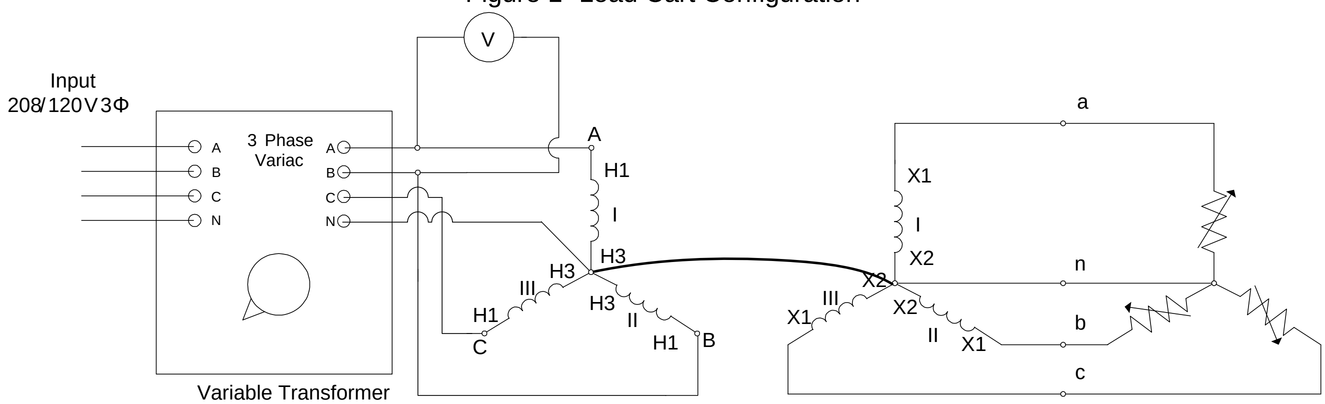


Figure 2- Wye-Wye Connection

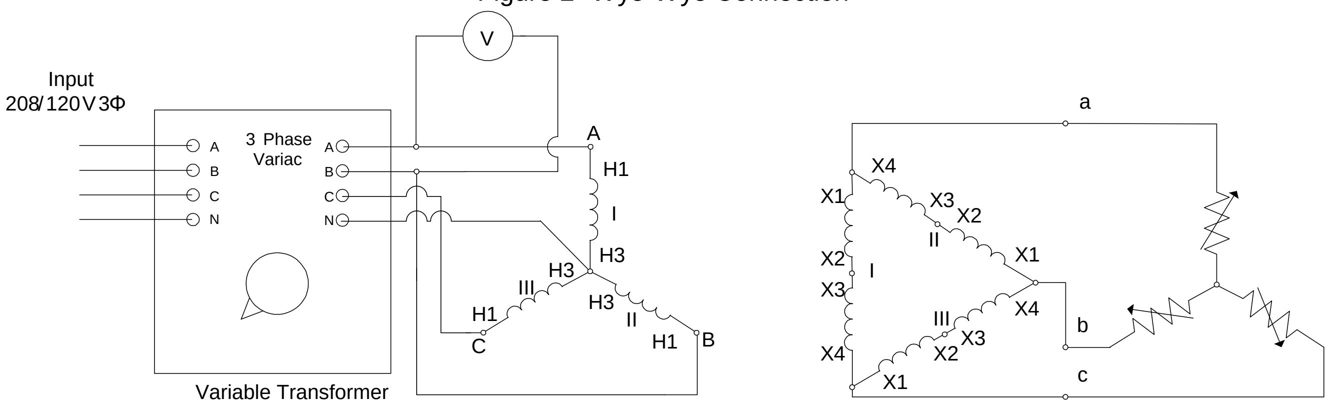


Figure 3- Wye-Delta Connection

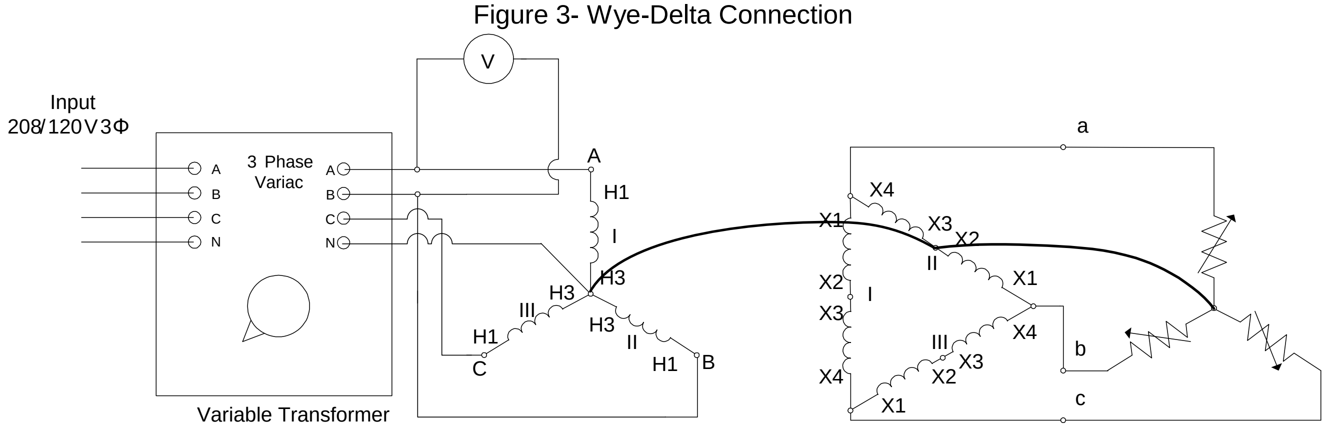


Figure 4- Wild Leg Delta Connection

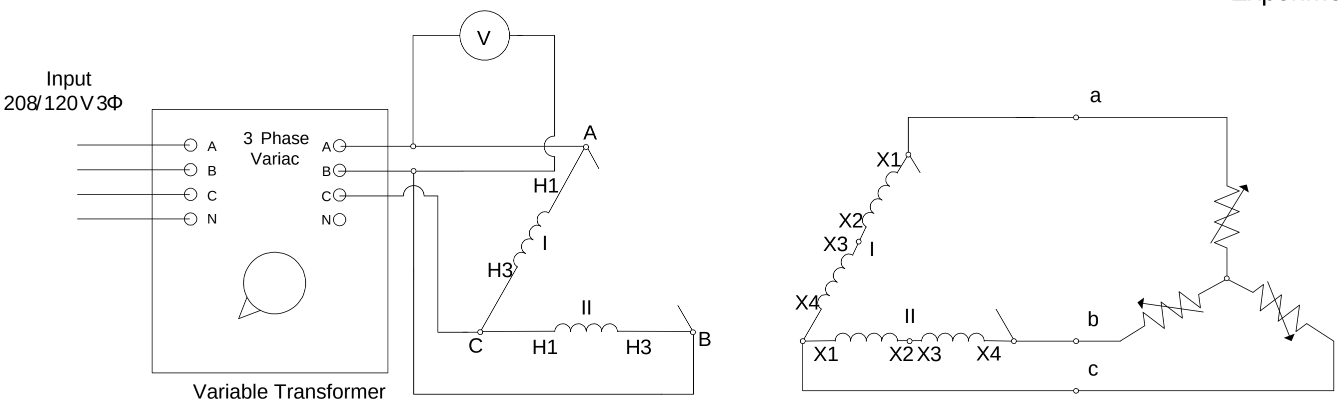


Figure 5- Open-Delta Connection

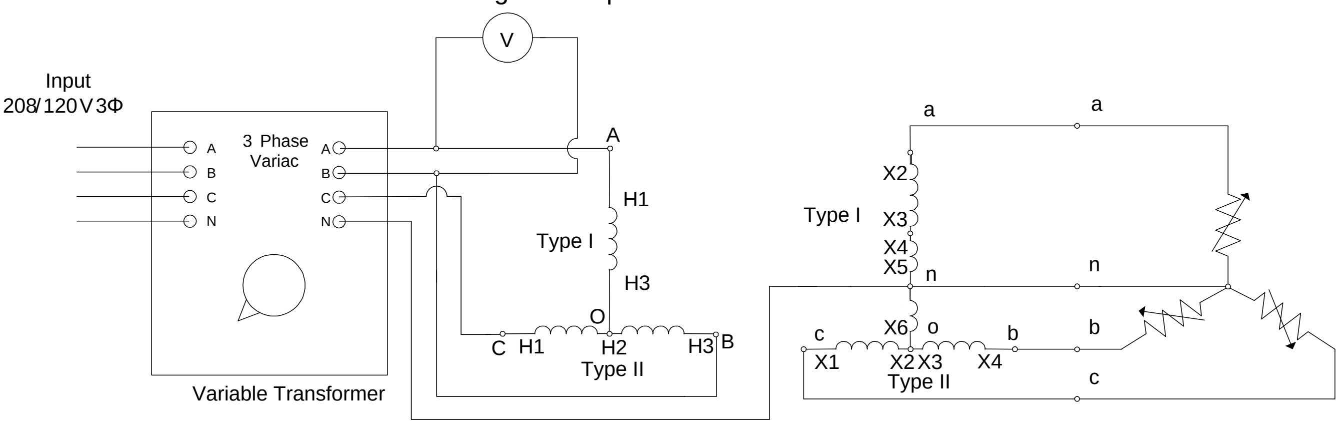


Figure 6- T-T Connection