Introduction

During this exercise we will investigate the concept of a balanced three phase (3Φ) systems, specifically looking at the relationship between the phase and line voltages of a balanced, 3Φ wye-connected source, the currents flowing through and the complex power delivered to a balanced 3Φ load.

Procedure

1. Locate the **constant** 3Φ voltage supply on your lab bench. Configure the data acquisition system to measure each of the **phase voltages** of the constant 120/208V 3Φ supply (1-N, 2-N, and 3-N).

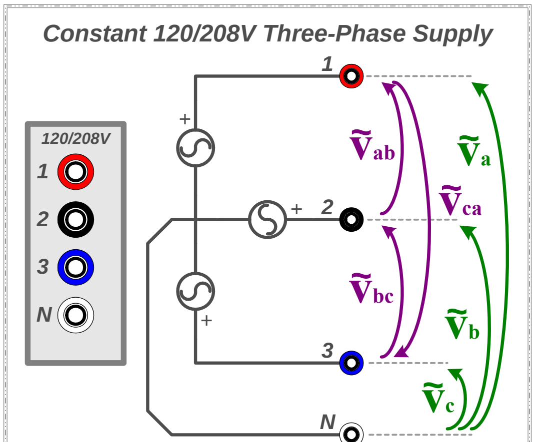


Figure 10.1

Balanced, Positive-Sequence, 3Φ voltage Source

Phase Voltages	**Line Voltages**
$\tilde{V}_a = V\angle\phi$	$\tilde{V}_{ab} = \sqrt{3}\cdot V\angle\phi + 30°$
$\tilde{V}_b = V\angle\phi - 120°$	$\tilde{V}_{bc} = \sqrt{3}\cdot V\angle\phi - 90°$
$\tilde{V}_c = V\angle\phi - 240°$	$\tilde{V}_{ca} = \sqrt{3}\cdot V\angle\phi - 210°$

Configure the ***Phasor Analyzer*** to display all three of the phase voltages simultaneously. Set the scale to **50V/div** and select **E1** as the ***reference phasor***.

Note – the reference phasor is the phasor to which the DAI assigns an arbitrary phase angle of 0º

2. Turn **ON** the main supply. Record the **magnitude and phase angle** of each of the **phase voltages** under the “Measured” columns in **Table 10.1**.

Although the data acquisition system can measure all three of the line voltages simultaneously, the angle relationship between the phase voltages and the line voltages would be lost if meter **E1**, the reference phasor, reconfigured such that it is no longer measuring **phase voltage $\mathbf{V_a}$**. For this reason, meter **E3** will be used to measure the line voltages one at a time.

3. Carefully <u>disconnect only meter **E3** from the 3Φ voltage supply</u> and configure meter **E3** to measure **line voltage $\mathbf{V_{ab}}$**. (Do <u>**NOT**</u> disconnect meters E1 and E2 from the 3Φ supply)

   Note the relationship between the **phase voltage $\mathbf{V_a}$ (E1)** and the **line voltage $\mathbf{V_{ab}}$ (E3)** as displayed on the phasor analyzer. The magnitude of $\mathbf{V_{ab}}$ should be $\sqrt{3}$ times greater than that of $\mathbf{V_a}$ and the phase angle of $\mathbf{V_{ab}}$ should be 30° greater than that of $\mathbf{V_a}$.

4. Record the **magnitude and phase angle** of **line voltage $\mathbf{V_{ab}}$** in **Table 10.1**.

5. Carefully reconfigure meter **E3** to measure **line voltage $\mathbf{V_{bc}}$** and note the relationship between the **phase voltage $\mathbf{V_b}$** (**E2**) and the **line voltage $\mathbf{V_{bc}}$** (**E3**) as displayed on the phasor analyzer.

6. Record the **magnitude and phase angle** of **line voltage $\mathbf{V_{bc}}$** in **Table 10.1**.

7. Carefully reconfigure meter **E3** to measure **line voltage $\mathbf{V_{ca}}$.** Record the **magnitude and phase angle** of **line voltage $\mathbf{V_{ca}}$** in **Table 10.1**. (Note – $\mathbf{V_{ca}}$ should appear in the upper-right quadrant of the display.)

8. Turn **OFF** the main supply. Have the instructor verify your results **before** proceeding to the next step.

9. Disconnect the meters from the 3Φ supply and construct the circuit shown in **Figure 10.2**.

   In this circuit, a variable resistance box and a variable capacitance box are configured to form a balanced, Y-connected, R||C load that consists of **240Ω of resistance** (per-phase) in parallel with **240Ω of capacitive reactance**, all of which is supplied by the 3Φ voltage source.

   In addition to measuring the three the **phase voltages**, ammeters **I1-I3** of the data acquisition system are configured to measure the **line currents** flowing from the source to each phase of the load.

10. Configure the ***Phasor Analyzer*** to display the complete set of **phase voltages** and **line currents**. Set the scale for each to **50V/div** and **0.5A/div** respectively, and select **E1** as the ***reference phasor***.

    Additionally, configure the ***Digital Meters*** to display the complete set of the **phase voltages**, **line currents**, and **powers** (P,Q,S) supplied to the individual phases of the load.

11. Switch **OFF** all of the capacitors such that the load consists only of **240Ω of resistance** (per-phase).

12. Turn **ON** the main supply.

13. Using the ***Phasor Analyzer***, record the **magnitude and phase angle** of each of the **line currents** under the "Measured" columns in **Table 10.2**.

    Additionally, using the ***Digital Meters***, record the "Measured" **real power (P)**, **reactive power (Q)**, and **apparent power (S)**, being delivered to each phase of the load in **Table 10.3**.

14. Switch back **ON** the appropriate capacitors such that the load consists of **240Ω of resistance** in parallel with **240Ω of capacitive reactance** (per-phase).

15. Using the ***Phasor Analyzer***, record the **magnitude and phase angle** of each of the **line currents** under the "Measured" columns in **Table 10.4**.

    Additionally, using the ***Digital Meters***, record the "Measured" **real power (P)**, **reactive power (Q)**, and **apparent power (S)**, being delivered to each phase of the load in **Table 10.5**.

16. Switch **OFF** all of the resistors such that the load consists of **240Ω** of **capacitive reactance** (per-phase).

17. Using the ***Phasor Analyzer***, record the **magnitude and phase angle** of each of the **line currents** under the "Measured" columns in **Table 10.6**.

    Additionally, using the ***Digital Meters***, record the "Measured" **real power (P)**, **reactive power (Q)**, and **apparent power (S)**, being delivered to each phase of the load in **Table 10.7**.

18. Have your instructor verify your results **before** proceeding to the next step.

19. Turn **OFF** the main supply, disassemble the circuit, and neatly hang the wires in their correct locations.

Report Guide

You are required to complete the following tasks:

1. Copy the **phase voltages** recorded under the "Measured" columns of Table 10.1 to the "Calculated" columns of **Table 10.1**.

2. Using the **phase voltages** copied to the "Calculated" columns, calculate a set of **line voltages** for the source and record the results under the "Calculated" columns in **Table 10.1**.

3. Using the "calculated" phase voltages, calculate the theoretical set of **line currents** and the **real**, **reactive**, and **apparent powers** supplied to each phase of a Y-connected load that consists of **240Ω resistance** (per-phase). Record the results in the "Calculated" columns of **Tables 10.2 & 10.3**.

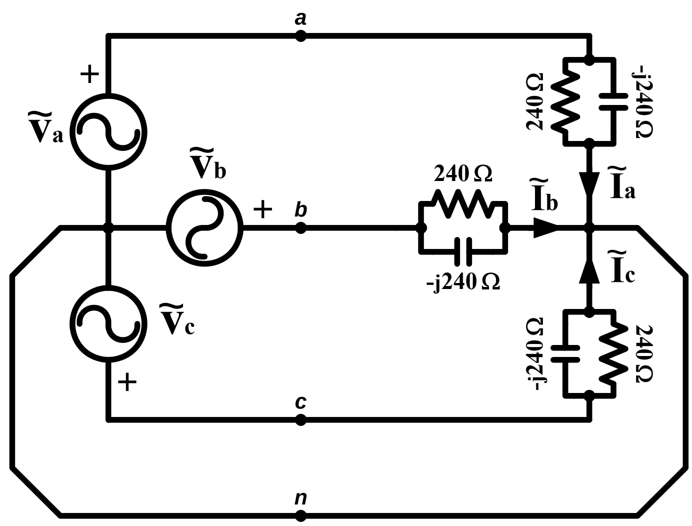
4. Using the "calculated" phase voltages, calculate the theoretical set of **line currents** and the **real**, **reactive**, and **apparent powers** supplied to each phase of a Y-connected load that consists of **240Ω of resistance** in parallel with **240Ω of capacitive reactance** (per-phase). Record the results in the "Calculated" columns of **Tables 10.4 & 10.5**.

5. Using the "calculated" phase voltages, calculate the theoretical set of **line currents** and the **real**, **reactive**, and **apparent powers** supplied to each phase of a Y-connected, **240Ω capacitive reactance** (per-phase). Record the results in the "Calculated" columns of **Tables 10.6 & 10.7**.

6. Compare the "Calculated" results to the "Measured" results from this experiment.

Submit your results using the "ECET3000 Lab 10 Results" sheet provided in lab as the cover page with all of your calculations stapled to the back.

Note – You must show all of the work required to obtain the "calculated" results, and all calculations must be completed neatly, single-sided, on blank paper.



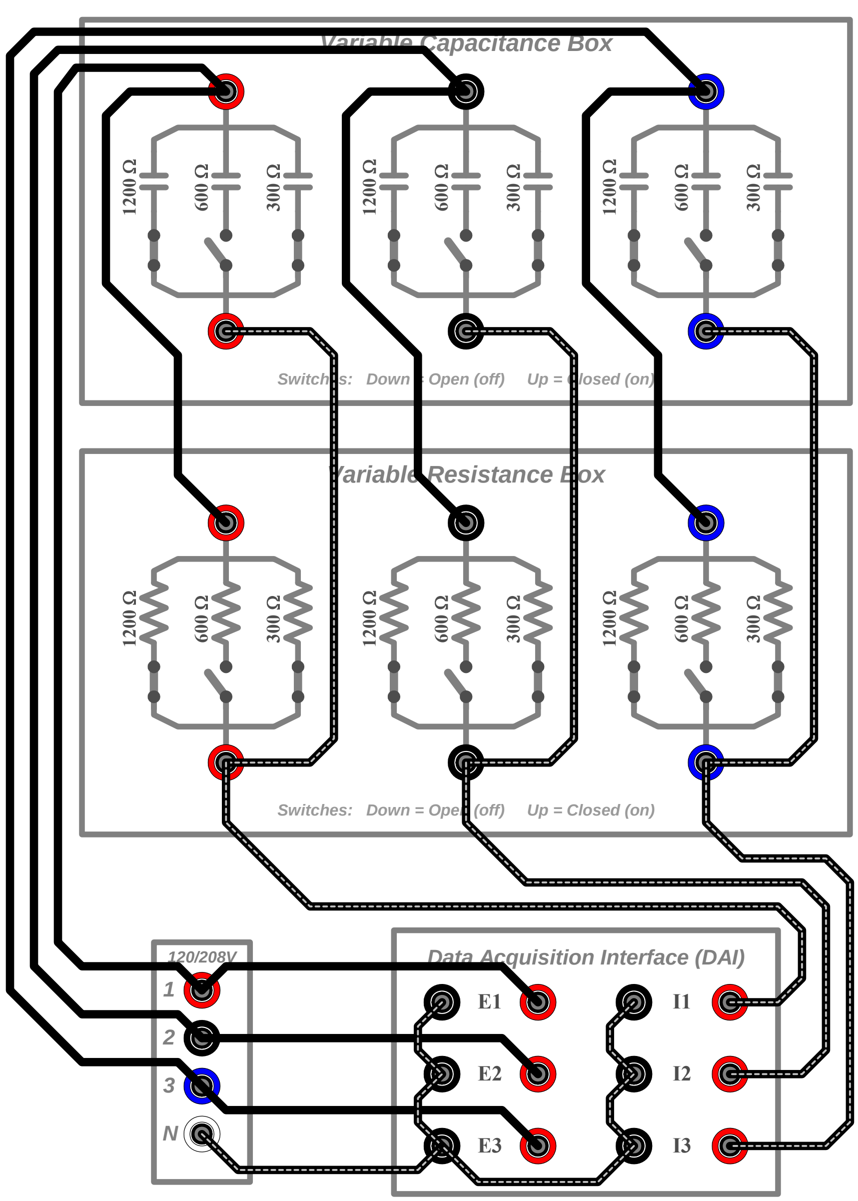


Figure 10.2 – Balanced 3Φ Circuit with Y-connected Load

ECET 3000 Lab 10 Results   Name: ______________________________
(Last Name First)

Instructions: Record both your measured values and calculated values into the tables shown below.

Be sure to neatly record the values as you will eventually be required to submit this sheet, along with a complete set of calculations stapled to the back, in order to fulfill the requirements of this experiment.

Part 1 – 3Φ Supply Phase and Line Voltages:

	Measured		**Calculated**	
	Magnitude	**Phase Angle**	**Magnitude**	**Phase Angle**
$\tilde{V}_a$ **(volts)**				
$\tilde{V}_b$ **(volts)**				
$\tilde{V}_c$ **(volts)**				
$\tilde{V}_{ab}$ **(volts)**				
$\tilde{V}_{bc}$ **(volts)**				
$\tilde{V}_{ca}$ **(volts)**				

Table 10.1 – Balanced 3Φ Y-connected Source Voltages

Part 2 – 3Φ Y-connected Resistive Loads – Line Currents and Powers:

	Measured		**Calculated**	
	Magnitude	**Phase Angle**	**Magnitude**	**Phase Angle**
$\tilde{I}_a$ (amps)				
$\tilde{I}_b$ (amps)				
$\tilde{I}_c$ (amps)				

Table 10.2 – Line Currents into a 3Φ Y-connected Resistive Load

	Measured			**Calculated**		
	Phase A	**Phase B**	**Phase C**	**Phase A**	**Phase B**	**Phase C**
P (W)						
Q (Var)						
|S| (VA)						

Table 10.3 – Power Measurements into the 3Φ Resistive Load

 Name: ______________________________

Part 3 – 3Φ Y-connected Resistive/Capacitive Loads – Line Currents and Powers:

	Measured		Calculated	
	Magnitude	**Phase Angle**	**Magnitude**	**Phase Angle**
$\tilde{I}_a$ (amps)				
$\tilde{I}_b$ (amps)				
$\tilde{I}_c$ (amps)				

Table 10.4 – Line Currents into a 3Φ Y-connected R-C Load

	Measured			Calculated		
	Phase A	**Phase B**	**Phase C**	**Phase A**	**Phase B**	**Phase C**
P (W)						
Q (Var)						
|S| (VA)						

Table 10.5 – Power Measurements into the 3Φ R-C Load

Part 4 – 3Φ Y-connected Capacitive Loads – Line Currents and Powers:

	Measured		Calculated	
	Magnitude	**Phase Angle**	**Magnitude**	**Phase Angle**
$\tilde{I}_a$ (amps)				
$\tilde{I}_b$ (amps)				
$\tilde{I}_c$ (amps)				

Table 10.6 – Line Currents into a 3Φ Y-connected Capacitive Load

	Measured			Calculated		
	Phase A	**Phase B**	**Phase C**	**Phase A**	**Phase B**	**Phase C**
P (W)						
Q (Var)						
|S| (VA)						

Table 10.7 – Power Measurements into the 3Φ Capacitive Load

Verified by (instructor): ________________