ECE 370
MACHINES & POWER

EXPERIMENT 2
THREE-PHASE AC CIRCUITS

Objective

The objectives of this laboratory experiment are summarized below:

1. Learn to perform voltage, current, and power measurements in three-phase ac circuits, using the Yokogawa digital meter.
2. Verify the phase and line relationships for the delta and wye-connected loads.
3. Observe the effect of various load combinations on the volt-ampere relationship in three-phase ac circuits.

Pre - Lab

Perform the required calculations in your lab notebook prior to attending the laboratory. These calculations will form the analytical (anticipated) results of your work.

Draw the appropriate circuit diagrams for Sections (a) and (b) of the laboratory procedure. Then calculate the following quantities for each circuit:

1. Line and phase voltage magnitude and angle
2. Line and phase current magnitude and angle
3. Total active power consumption of the load
4. Total reactive power consumption of the load
5. Source power factor

Finally, perform the analytical design for the reactive compensating circuit of Section (c).

Procedure

The following is the recommended procedure for performing this experiment.

Note that the load bank elements are rated for 120 V. Be sure that the supply voltage is properly set for the load configurations (delta or wye), such that the load bank voltage rating is not exceeded.

Set the variable ac supply on the left side of the bench to 208 V (line-to-line), and refer to Figure 1 for connecting the oscilloscope to the variable three-phase supply. This connection will display all three line-to-neutral voltages. Note that the voltages as marked on the benches <u>are not</u> the positive abc sequence. Your task is to identify true a, b, and c phases. ***Do not mark on the benches after you have identified the true a, b, and c phases.***

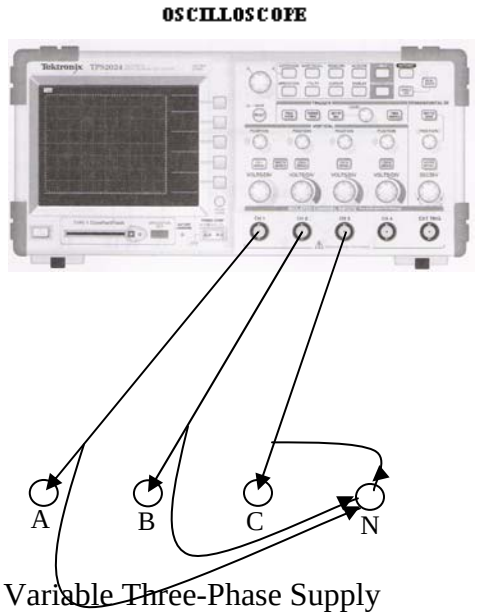

Figure 1. *Scope Connections for Measuring 3ϕ L-N Voltages.*

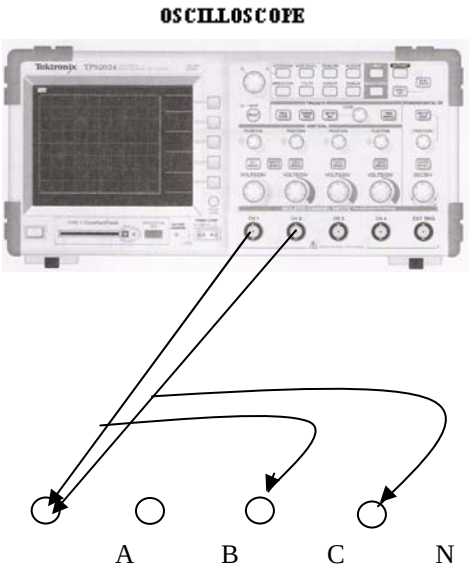

Figure 2. *Circuit Connections for Measuring L-L and L-N Voltages.*

Reconnect the oscilloscope to the variable three-phase power supply, as shown in Figure 2. This connection will allow you to display line-to-line and line-to-neutral voltages for phase "a". Observe and record the magnitude and phase angle for the two voltages.

Connect the Yokogawa digital meter to the three-phase power supply, using the three-phase four-wire system (measurement of 3 voltages and 3 currents) of Figure 3. Figure 3 shows true a, b, and c phases. Now you are prepared to record the voltages and currents that each Yokogawa channel is measuring.

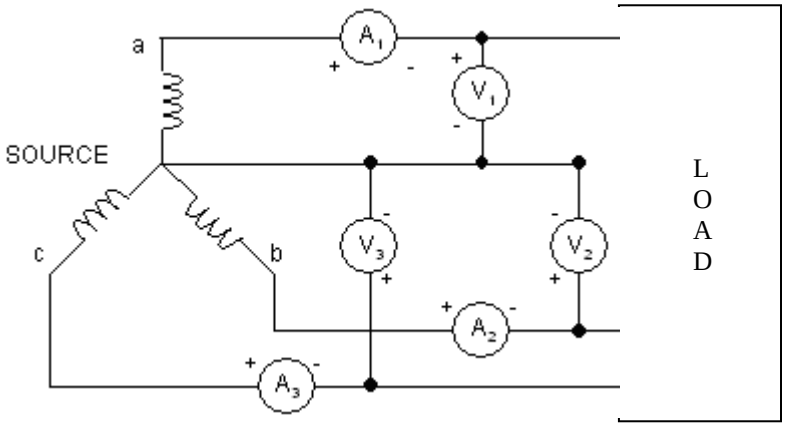

Figure 3. *Power Measurements with Yokogawa Digital Meter.*

(a) Make sure that the supply is set for 120 V (line-to-line). Connect a 300 Ω resistor and a 0.8 H inductor in parallel for each leg of a three-phase delta-connected load of Figure 4. Figure 4 shows true a, b, and c phases.

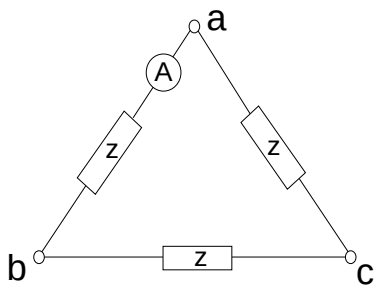

Figure 4. *Delta-Connection with Embedded Ammeter.*

Use the voltmeters and ammeters (Fluke or Yokogawa) to measure the magnitude of the line voltage (V_{ab}), phase voltage (V_{ab}), line current (I_a), and phase current (I_{ab}). Use the oscilloscope and the current probe to measure the phase angle of the I_{ab} with respect to V_{ab}. Use the line voltage, line current, and the power factor angle to calculate the three-phase active and reactive powers. Compare these values with the readings of the Yokogawa digital meter. Make a table and show the analytical and the experimental values.

(b) Set the supply to 120 V line-to-neutral. Connect a 300 Ω and a 0.8 H inductor in parallel for each leg of a wye-connected three-phase load, as shown in Figure 5. Figure 5 shows true a, b, and c phases. Note that your load is now a three-wire, three-phase wye-connected load. This means that there is no connection between the neutral of the load and the neutral of the supply.

Use the voltmeters and ammeters (Fluke or Yokogawa) to measure the magnitude of the phase voltage (V_{an}), line voltage (V_{ab}), and the line and phase currents (I_a). Use the oscilloscope and the current probe to measure the phase angle of the I_a with respect to V_{an}. Use the phase voltage, line current, and the power factor angle to calculate the three-phase active and reactive powers. Compare these values with the readings of the Yokogawa digital meter. Make a table and show the analytical and the experimental values.

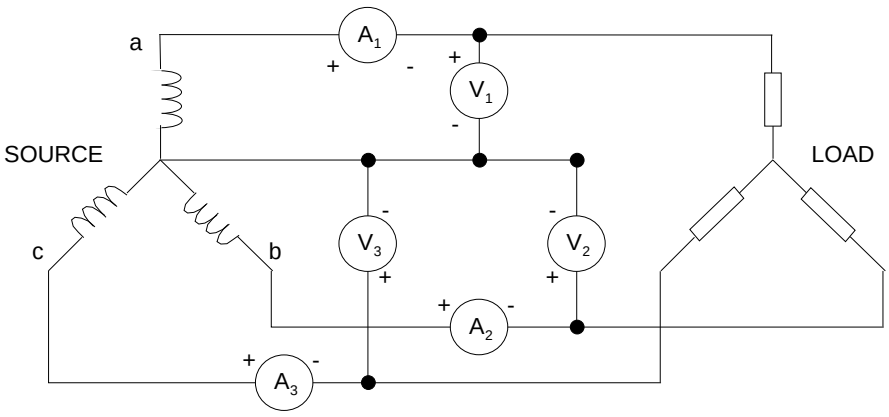

Figure 5. *Power Measurements with Yokogawa Digital Meter for Wye-Connected Load.*

(c) Analytically design a three-phase wye-connected reactive power compensating circuit (shunt capacitor banks) to achieve a source power factor of 0.938 leading for the circuit of Figure 5. Verify the adequacy of your design experimentally by connecting the capacitor banks and recording the values of active power, reactive power, and the power factor. Perform the necessary percent error calculations. What would be the capacitance of each phase, if you could connect the capacitors in delta configuration? Why can't you connect the capacitor banks in a delta configuration?

(d) Remove the capacitor banks and set the supply voltage to 130 V line-to-neutral. In addition to the 300 Ω resistor and the 0.8 H inductor, connect a 0.4 H inductor in parallel for each leg of the three-phase wye-connected load. Now, connect a wire between the neutral point of the load and the neutral point of the supply. Use the current probe to observe the distorted neutral current waveform. What is the frequency of the neutral current? Use the **APPLICATION** button and select the **HARMONICS** function of the oscilloscope to answer this question.

Documentation

The experiment should be documented in your lab notebook in a lab log format. Your documentation should be complete and clear, so you would be able to write a formal report based on the logged information.

The pre-lab calculations for the two load configurations and the design of Section (c) will form the analytical (anticipated) results. The laboratory measurement will establish your experimental results. There will be a discrepancy between your analytical and experimental results. The discrepancies should described and explained in the conclusion section of your lab notebook.