ELECTRICAL AND COMPUTER ENGINEERING THE CITADEL

ELEC 302 Lab 4
Transformers in Three Phase Circuits

REFERENCE: Appropriate chapters of ELEC 316 text.

OBJECTIVE: The objective of this experiment is the experimental observation of the basic principals of balanced three-phase transformer circuits.

EQUIPMENT:

Power Supply Module (0-208Vac)	EMS 8821
Three Phase Transformer Module	EMS 8348
Resistance Module	EMS 8311
Inductance Module	EMS 8321
Data Acquisition Interface (DAI)	EMS 9062
DAI 24V Power Supply	EMS 30004

Notes: This entire experiment is conducted at 60 Hz. All of the currents and voltages in this experiment are RMS

INTRODUCTION:

In this experiment, you will use the three-phase transformer module EMS 8348, to connect the four possible delta-wye (Δ-Y) three-phase transformer connections. Each three-phase configuration will be used to supply power to a three-phase balanced wye connected load. A schematic representation of the three-phase transformer module is presented in Figure 1. This module contains three 208/208 volt, 40 VA single-phase transformers that can be connected in any of the four Δ-Y configurations.

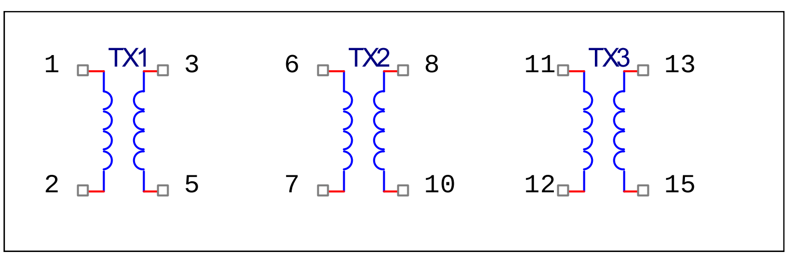


Figure 1: Schematic representation of the three-phase transformer module.

The three-phase wye connected load will be constructed using the installed EMS resistance and inductance modules as shown in Figure 2.

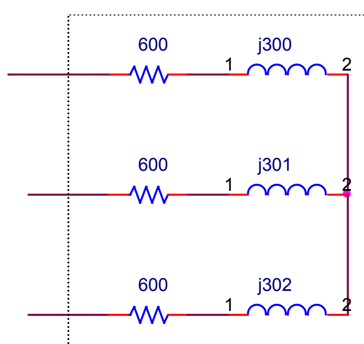


Figure 2: Schematic representation of the three-phase wye connected load.

PRIOR PREPARATION:

Complete the following at a time determined by the laboratory instructor.

1. For each of the four circuit configurations the primary line current is 120V, and the wye connected load is 600+j300 Ω. Compute the following and place your results in tables 1, 2, and 3.

a. Primary line-to-line and phase voltages, secondary line-line and phase voltages, and load phase voltage.
b. Primary line-to-line and phase currents, secondary line-line and phase currents, and load phase current.
c. Primary real-power, secondary real-power, and load real-power.

PROCEDURE:

WARNING!

High voltages are present in this laboratory experiment!

Do not make or modify any banana jack connections with the power on!

Prior to energizing any circuit, ensure that the supply voltage has been adjusted to zero; slowly increase the supply voltage to the desired value while continuously monitoring the circuit currents. Note the component maximum current ratings. DO NOT EXCEED THESE RATINGS.

PART ONE: The Three Phase Source

1. Verify the all components required in the equipment section are present at the EMS workstation.

2. Make sure the main power switch of the Power Supply is OFF and the voltage control knob is fully CCW. Set the voltmeter selector switch to position 4-5.

3. Ensure the DAI 24V supply is connected to the main Power Supply (turn it on), and that the DAI USB connector is attached to the computer.

4. Start the computer and the LVDAM EMS application. On the *File* menu open file C:\Program Files\Lab Volt\Samples\E302_4.dai. The Metering window should display meters for E1, I1, P1, E2, I2, 3 phase power, E3, I3 and E1 + E2 + E3.

5. Select focus to the metering window by clicking on it. Select *Options -> Acquisition Settings*, set the *Sample Window* dialog box to *extended*. Then click OK, and close the box. Select *View* -> check *continuous refresh.*

6. Construct the circuit of Figure 3a. The symbols E1, E2, and E3 refer to the DAI metering connections. The '+' symbol indicates the red meter connection.

7. Turn on the main voltage power supply and adjust the supply voltage to 120V line to line (e.g., 4-5 voltage should be 120V). Monitor both the installed EMS voltmeter, and the metering window for proper indications. If proper indications are not immediately established, turn the voltage control knob CCW and turn off the power supply. Obtain instructor assistance.

8. Record the measured line voltages below. Turn the voltage control knob CCW, and turn off the main power supply.

E1 = ________ E2 = __________ E3 = __________ E1 +E2 +E3__________

9. Observe the voltage phasors in the *Phasor Analyzer*. Does the display confirm the phasors are equal with 120 degrees phase shift?

10. Construct the circuit of Figure 3b. The '+' symbol indicates the red meter connection.

11. Turn on the main voltage power supply and adjust the supply voltage to 120V line to line (e.g., 4-5 voltage should be 120V). Record the measured phase voltages below. Turn the voltage control knob CCW, and turn off the main power supply.

    E1 = ________ E2 = __________ E3 = __________ E1 +E2 +E3__________

12. Observe the voltage phasors in the Phasor Analyzer. Does the display confirm the phasors are equal with 120 degrees phase shift?

In parts two through five of the procedure, each of the four transformer configurations will be constructed. **In all four cases, the supply voltage will be 120Vac line-to-line, and the wye-connected load will be 600 + j300 Ω.**

PART TWO: Y-Y Connected Transformer

13. Construct the circuit of Figure 4. Turn on the main voltage power supply and adjust the (line-to-line) supply voltage to 120V. Monitor both the installed EMS voltmeter, and the metering window for proper indications. If proper indications are not immediately established, turn the voltage control knob CCW and turn off the power supply. Obtain instructor assistance.

14. Utilizing Table 4, record the values of primary and secondary line voltage, primary and secondary line current, and primary input power. Measure and record the voltage across the load (move the E3 meter, or use one of the other AC meters in the lab). Turn the voltage control knob CCW, and turn off the main power supply.

Note: The four DAI meters (E1, I1, E2, and I2) are used to form a three-phase wattmeter to measure primary input power. This real power measurement is read on meter 'B' (3- phase power).

PART THREE: Y-Δ Connected Transformer

15. Repeat steps 13 and 14 using the circuit of Figure 5.

PART FOUR: Δ-Δ Connected Transformer

16. Repeat steps 13 and 14 using the circuit of Figure 6.

PART FIVE: Δ-Y Connected Transformer

17. Repeat steps 13 and 14 using the circuit of Figure 7.

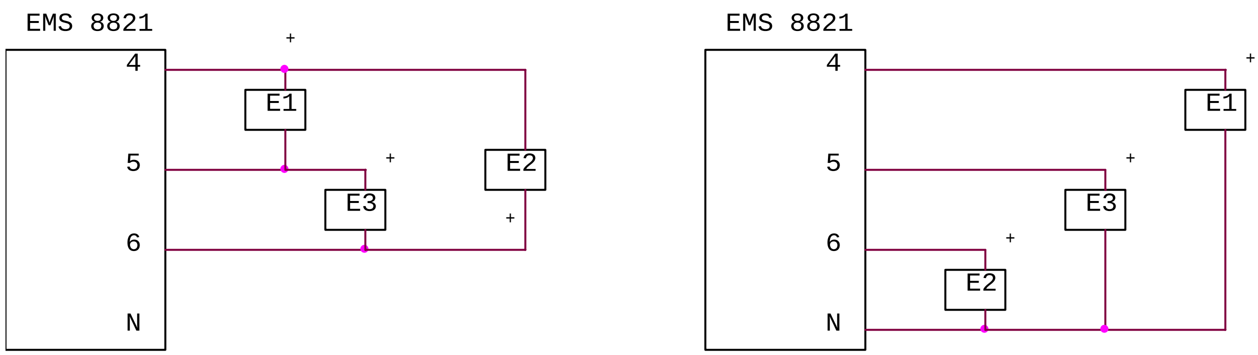
18. Use the fluke multi-meter to measure DC resistance of each transformer winding.

    1-2 _______ 6-7 _______ 11-12 _______ 3-5 _______ 8-10 _______ 13-15 _______

REPORT:

Your report should be completed in the format requested by the instructor. Specifically, it must contain the following items.

1. Compare the data collected in table 4 to those found for the pre-lab. Discuss any discrepancies.
2. Compute the transformer efficiency for each of the four cases.



a) Measuring Line Voltages b) Measuring Phase Voltages

Figure 3: Measuring source voltages for part one.

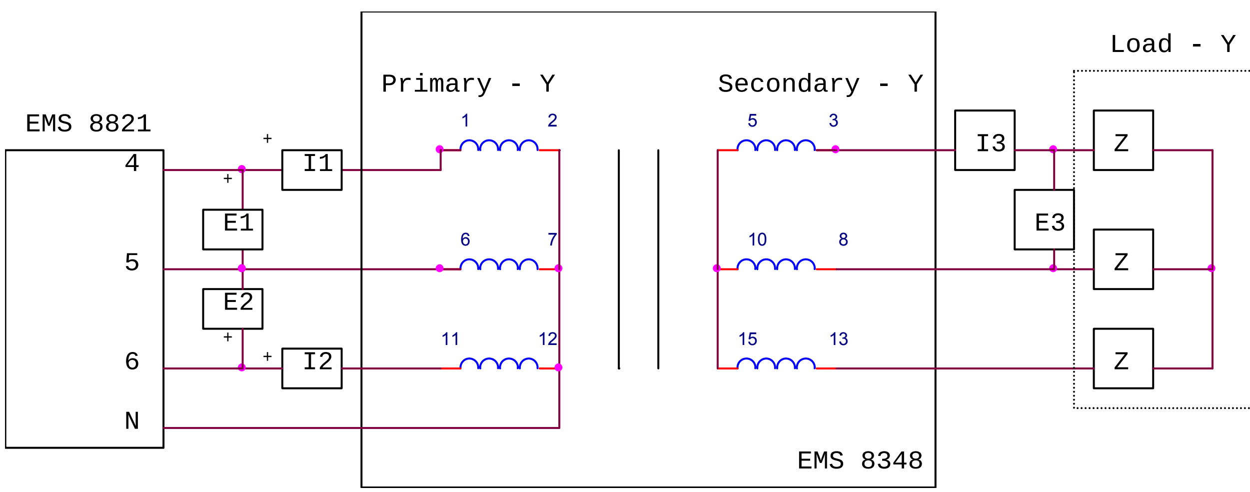


Figure 4: Y-Y connected three-phase transformer for part two. Note that primary winding connections 2, 7, and 12 are all connected to N., and that secondary winding connections 5, 10, and 15 are connected together but <u>not</u> to N.

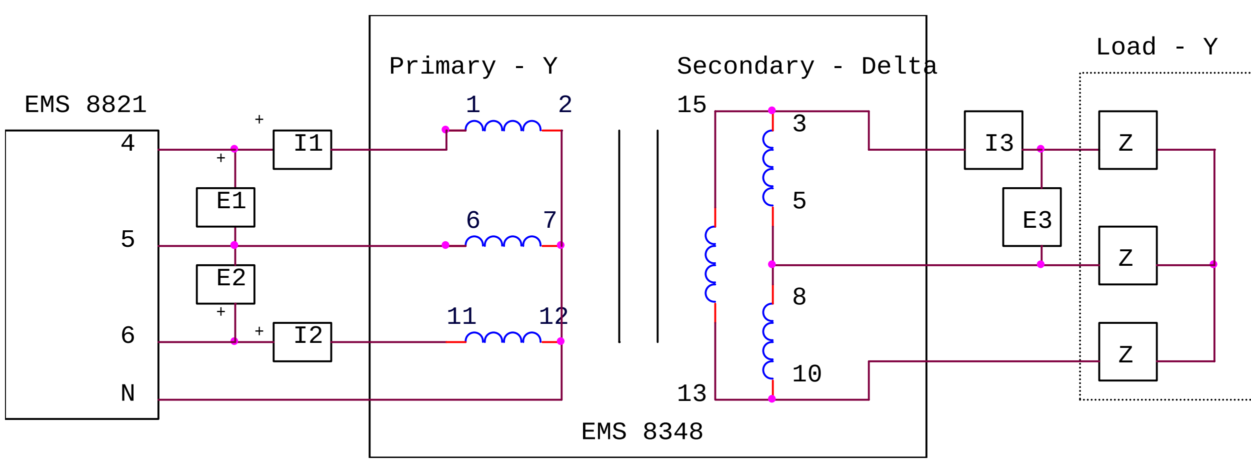


Figure 5: Y-Δ connected three-phase transformer for part three.

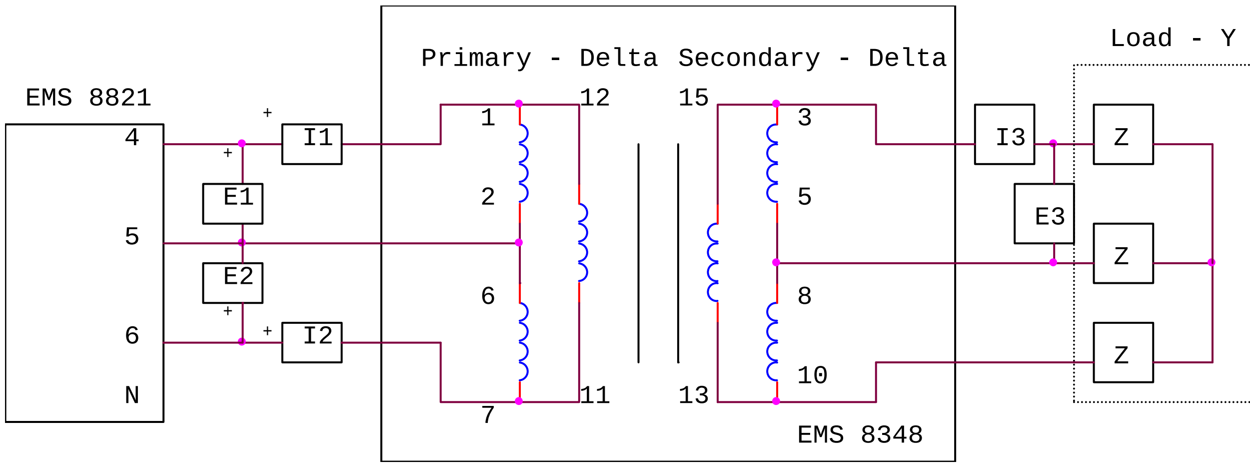


Figure 6: Δ-Δ connected three-phase transformer for part four.

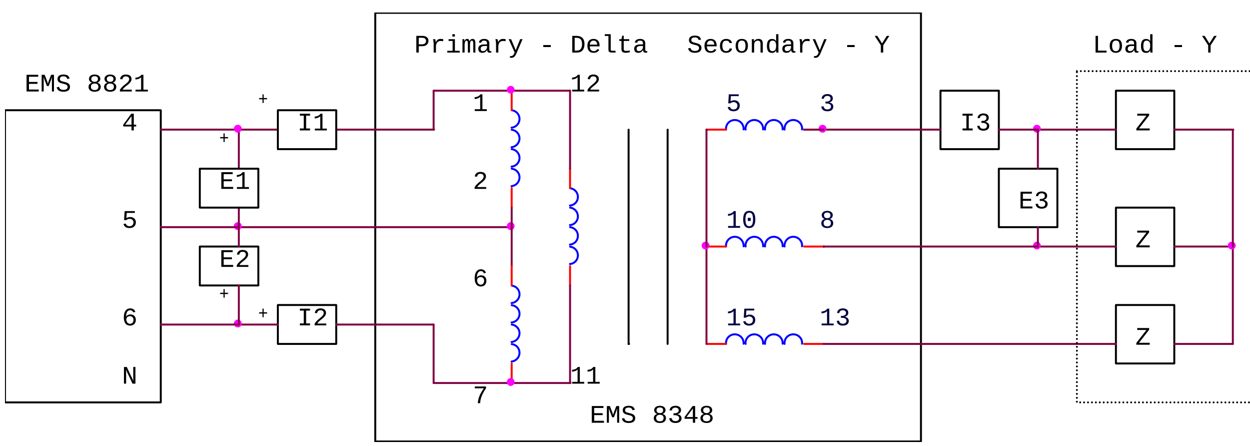


Figure 7: Δ-Y connected three-phase transformer for part five.

VOLTAGES

Case	Primary Line V	Primary Phase V	Secondary Phase V	Secondary Line V	Load Phase V
Y-Y					
Y-Δ					
Δ- Δ					
Δ -Y					

Table 1: Computed Voltages

CURRENTS

Case	Load Phase A	Secondary Line A	Secondary Phase A	Primary Phase A	Primary Line A
Y-Y					
Y-Δ					
Δ- Δ					
Δ -Y					

Table 2: Computed Currents

REAL POWERS

Case	Primary Power $\sqrt{3} \cdot V_{LL} I_L \cos(26.56)$ W	Secondary Power $\sqrt{3} \cdot V_{LL} I_L \cos(26.56)$ W	Load Power $3 \cdot V_P I_P \cos(26.56)$ W
Y-Y			
Y-Δ			
Δ- Δ			
Δ -Y			

Table 3: Computed Powers

MEASURED VALUES

Case	Primary Voltage E1 V	Primary Current I1 A	3 φ Input Power 'B' W	Secondary Voltage E3 V	Secondary Current I3 A	Load Voltage E3 V
Y-Y						
Y-Δ						
Δ- Δ						
Δ -Y						

Table 4: Measured Values