EE 330L Energy Systems Lab (Fall 2026)
Laboratory 6 Three-Phase Transformers

Introduction

The objective of this lab is to investigate the performance of three-phase transformers in different configurations. The Three-Phase Transformer Bank 8348-40 Electronics Module System (EMS) (see Figure 1) will be used for this laboratory.

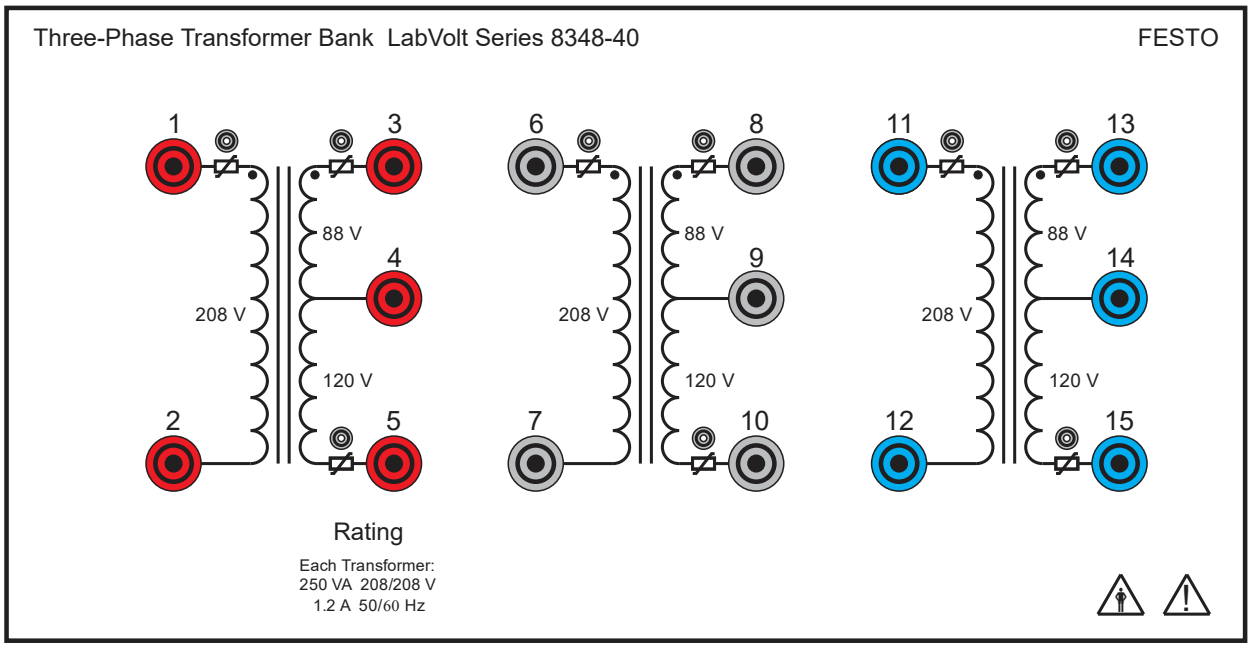


Figure 1 Three-Phase Transformer Bank 8348-40 EMS

Preliminary

Treat terminals 1-2, 6-7, & 11-12 on the Three-Phase Transformer Bank 8348-40 EMS as the primary coils and terminals 4-5, 9-10, and 14-15 as the secondary coils for three-phase transformers.

1) Assuming 100 V_{rms} is applied to the primary side coils, fill in Table 1 for the different three-phase transformer configurations.

Table 1 Transformer Values

Configuration	Primary V_ϕ (V_{rms})	Secondary V_ϕ (V_{rms})	a_ϕ*	Primary V_{LL} (V_{rms})	Secondary V_{LL} (V_{rms})	a_{LL}*
Y-Y						
Y-Δ						
Δ-Y						
Δ- Δ						

* Define phase turns ratio $a_\phi = V_{\phi,P} / V_{\phi,S}$ and line-to-line turns ratio $a_{LL} = V_{LL,P} / V_{LL,S}$.

2) Assume a standard *abc* phase sequence is applied to the primary side and wiring as shown in Figure 3-37 of the text. [Warning: Be careful with Δ-Y case.] For all four cases:

   - Are the phase angles of like (coil pair) phase voltages, i.e., $\overline{V}_{\phi,P}$ & $\overline{V}_{\phi,S}$, aligned or shifted? Describe in terms of magnitude of angular difference (deg), i.e., $|\angle V_{\phi,P} - \angle V_{\phi,S}|$, and whether secondary voltages lag/lead.
   - Are the phase & line-to-line primary voltages, i.e., $\overline{V}_{\phi,P}$ & $\overline{V}_{LL,P}$, aligned or shifted? Describe in terms of magnitude of angular shift (deg), i.e., $|\angle V_{\phi,P} - \angle V_{LL,P}|$, and whether the line-to-line voltages lag/lead.
   - Are the phase & line-to-line secondary voltages, i.e., $\overline{V}_{\phi,S}$ & $\overline{V}_{LL,S}$, aligned or shifted?
   - Are the line-to-line primary and secondary voltages, i.e., $\overline{V}_{LL,P}$ & $\overline{V}_{LL,S}$, aligned or shifted?

   Fill in Table 2 with results.

Table 2 Transformer Voltage Phase Shifts

Configuration	$\|\angle V_{\phi,P} - \angle V_{\phi,S}\|$ **(deg) & lead/lag**	$\|\angle V_{\phi,P} - \angle V_{LL,P}\|$ **(deg) & lead/lag**	$\|\angle V_{\phi,S} - \angle V_{LL,S}\|$ **(deg) & lead/lag**	$\|\angle V_{LL,P} - \angle V_{LL,S}\|$ **(deg) & lead/lag**
Y-Y				
Y-Δ				
Δ-Y				
Δ- Δ				

Experiment

Here, the user will connect their computer to the LabVolt system, wire various three-phase transformer circuits, and take measurements using the LVDAC-EMS software.

1) Check that the LabVolt system is in 'start-up' state by:

   - Verifying large power cord from back of the LabVolt system is plugged into 3-phase plug on wall. Alert instructor/TA if there is an issue, do **not** touch.
   - On the Power Supply 8525-20 EMS, ensure power switches located on left side are 0/OFF, turn small knob (upper center) to '**4-N**' position, and turn large knob (upper right) all the way counterclockwise (CCW) to '0'.
   - Ensuring all toggle switches on the Resistive Load 8311-00 EMS, Inductive Load 8321-00 EMS, and Capacitive Load 8331-00 EMS are in the down/0/OFF position.
   - Ensuring 'Power Input' jacks on the lower right of the Data Acquisition And Control Interface (DACI) EMS are disconnected.
   - Ensuring 'Power Input' switch is 0/OFF and no AC power cord is connected on lower left of the Four-Quadrant Dynamometer / Power Supply EMS 8960-30.

2) Plug JAMECO AC Adaptor (i.e., 'wall wart') into a 120 V wall outlet and plug cord into one of the 'Power Input' jacks located on the lower right of the DACI 9063-00 EMS. Connect USB cable (USB-A to USB-B) to your computer and the USB jack on the DACI EMS.

3) Start the LVDAC-EMS software on your computer. When the 'LVDAC-EMS Launcher' screen pops up, select 'Connected Mode'. When the 'LVDAC-EMS Start-up' screen pops up, verify 'Local Network Voltage and Frequency' has '120 V - 60 Hz' selected and click 'OK'. The 'LVDAC-EMS - Document 1' screen should now appear.

A. Y-Y Configuration

1) Set up the circuit shown in Figure 2 using the Data Acquisition And Control Interface (DACI) 9063-00 EMS to implement the voltmeters.

2) Have instructor/TA inspect and approve the completed wiring connections. **Take picture.**

3) On the 'LVDAC-EMS - Document 1' software screen on your computer, activate/select the 'Metering' instrument.

4) By default, meters 'M1' - 'M4' in first row show AC RMS voltages from 'E1' - 'E4' on the DACI EMS. Rename the meters to match the quantities being measured. Deactivate unused meters.

5) On the Power Supply EMS, toggle the 'Power' switch to ON. Then, slowly turn the large knob until the **primary transformer phase voltage** (i.e., voltage across terminals 1-2, 6-7, & 11-12) is ~100 V_{rms}.

6) Click the 'Single Refresh' icon to freeze the measured values. **Save a screenshot** of the 'Metering' instrument (e.g., Y_Y_meter.jpg). Click 'Continuous Refresh' icon.

7) Activate the 'Phasor Analyzer' instrument. In 'Phasor Analyzer Settings', set all 'Currents' to 'Off', set all 'Voltages' (e.g., E1-E4) to 'On', and set the 'Scale' for the voltages to 50 V/div'. **Save a screenshot of the 'Phasor Analyzer' instrument** (e.g., Y_Y_phasor.jpg). Close the 'Phasor Analyzer' instrument.

8) On Power Supply EMS, **turn large knob CCW to 0**, and toggle 'Power' switch to OFF.

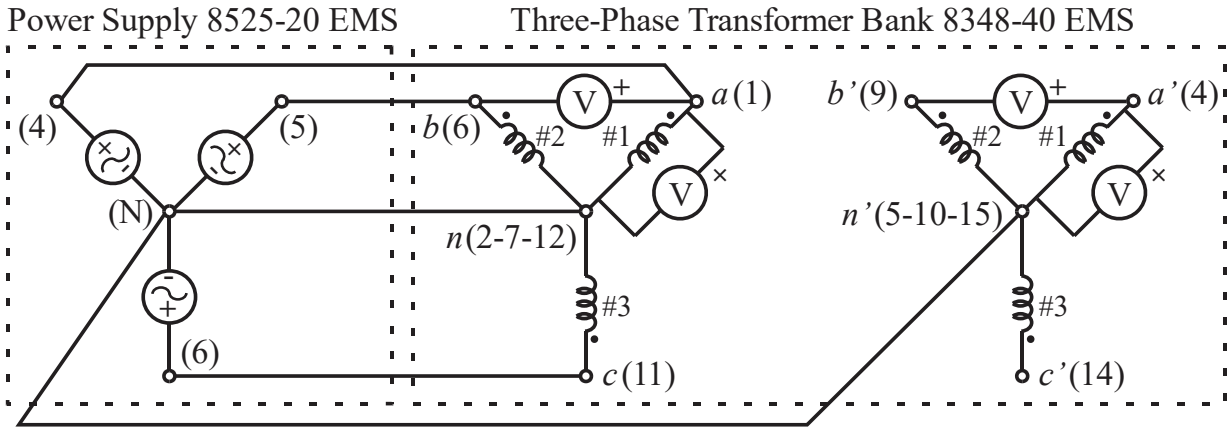


Figure 2 Circuit for Y-Y Configuration Three-Phase Transformer

B. Y-Δ Configuration

1) Set up the circuit shown in Figure 3 using the DACI EMS to implement the voltmeters.
2) Have instructor/TA inspect and approve the completed wiring connections. **Take picture.**
3) On the 'Metering' instrument, meters 'M1' - 'M4' show AC RMS voltages from 'E1' - 'E4' on DACI EMS. Rename meters to match quantities being measured. Deactivate unused meters.
4) On the Power Supply EMS, toggle the 'Power' switch to ON. Then, slowly turn the large knob until the **primary transformer phase voltage** is ~100 V_{rms}.
5) Click the 'Single Refresh' icon to freeze the measured values. **Save a screenshot** of the 'Metering' instrument (e.g., Y_D_meter.jpg). Click 'Continuous Refresh' icon.
6) Activate the 'Phasor Analyzer' instrument. Set unused E4 to 'Off'. Remaining settings should stay the same. **Save a screenshot of the 'Phasor Analyzer' instrument** (e.g., Y_D_phasor.jpg). Close the 'Phasor Analyzer' instrument.
7) On Power Supply EMS, **turn large knob CCW to 0**, and toggle 'Power' switch to OFF.

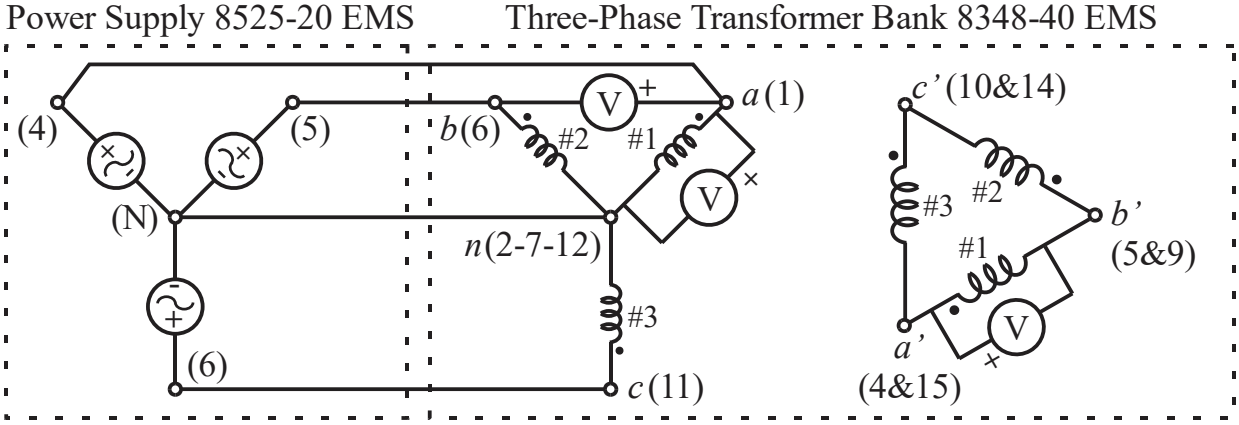


Figure 3 Circuit for Y-Δ Configuration Three-Phase Transformer

C. Δ-Y Configuration

1) Set up the circuit shown in Figure 4 using the DACI EMS to implement the voltmeters. **Note: The terminals called *b*' and *c*' have swapped to be consistent with Figure 3-37c of text!**
2) Have instructor/TA inspect and approve the completed wiring connections. **Take picture.**
3) On the 'Metering' instrument, meters 'M1' - 'M4' show AC RMS voltages from 'E1' - 'E4' on DACI EMS. Rename meters to match quantities being measured. Deactivate unused meters.
4) On the Power Supply EMS, toggle the 'Power' switch to ON. Then, slowly turn the large knob until the **primary transformer phase voltage** is ~100 V_{rms}.
5) Click the 'Single Refresh' icon to freeze the measured values. **Save a screenshot** of the 'Metering' instrument (e.g., D_Y_meter.jpg). Click 'Continuous Refresh' icon.
6) Activate 'Phasor Analyzer' instrument. Settings should not change. **Save a screenshot of the 'Phasor Analyzer' instrument** (e.g., D_Y_phasor.jpg). Close the 'Phasor Analyzer' instrument.
7) On Power Supply EMS, **turn large knob CCW to 0**, and toggle 'Power' switch to OFF.

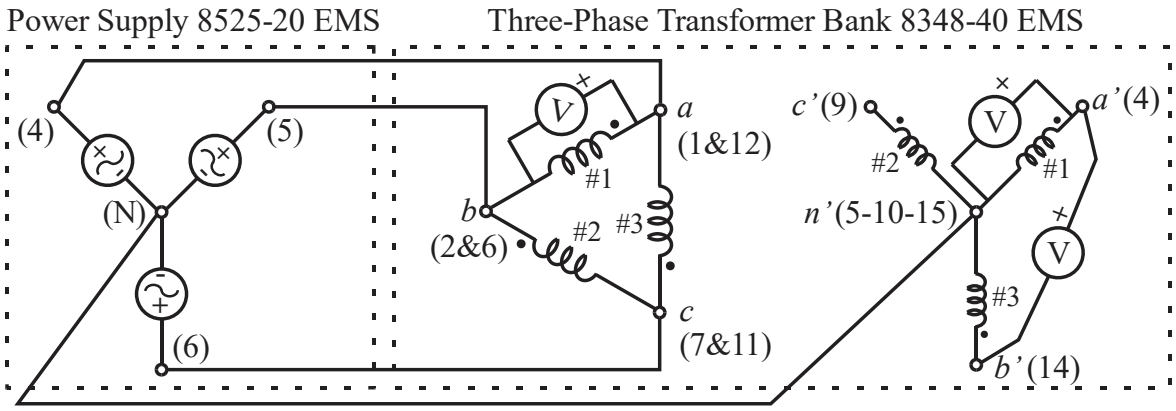


Figure 4 Circuit for Δ-Y Configuration Three-Phase Transformer

D. Δ-Δ Configuration

1) Set up the circuit shown in Figure 5 using the DACI EMS to implement the voltmeters.
2) Have instructor/TA inspect and approve the completed wiring connections. **Take picture.**
3) On the 'Metering' instrument, meters 'M1' - 'M4' show AC RMS voltages from 'E1' - 'E4' on DACI EMS. Rename meters to match quantities being measured. Deactivate unused meters.
4) On the Power Supply EMS, toggle the 'Power' switch to ON. Then, slowly turn the large knob until the **primary transformer phase voltage** is ~100 V_{rms}.
5) Click the 'Single Refresh' icon to freeze the measured values. **Save a screenshot** of the 'Metering' instrument (e.g., D_D_meter.jpg). Click 'Continuous Refresh' icon.
6) Activate the 'Phasor Analyzer' instrument. Set unused E3 to 'Off'. Remaining settings should stay the same. **Save a screenshot of the 'Phasor Analyzer' instrument** (e.g., D_D_phasor.jpg). Close the 'Phasor Analyzer' instrument.

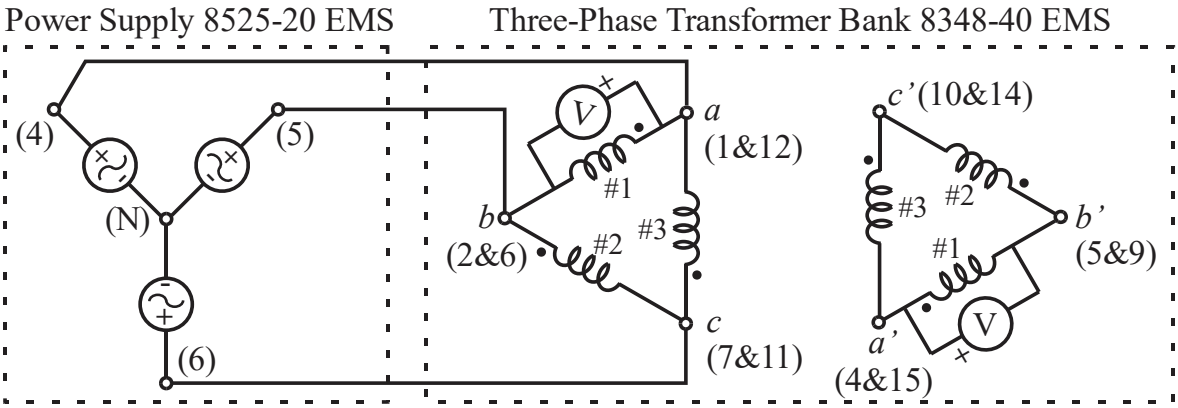


Figure 5 Circuit for Δ-Δ Configuration Three-Phase Transformer

7) Close the 'Metering' instrument. Then, close the LVDAC-EMS software.
8) Lastly, shut down the LabVolt system by:
   - On Power Supply EMS, **turn large knob CCW to 0**, and toggle 'Power' switch to OFF.

- Disconnect all cords and return to rack on side of the LabVolt system.
- Disconnect DACI EMS as a USB device from your computer. Then, disconnect USB cable from the computer and DACI EMS.
- Unplug JAMECO AC Adaptor from wall outlet and 'Power Input' jack on DACI EMS.

9) **Make an 'Equipment List' table** (include descriptions, model #s, & brands; only list EMS used).

Post Lab Analysis

A. Y-Y Configuration

1) Use saved screenshots to fill in Table 3. Compare results with Table 1.

Table 3 Measured Values for Y-Y Configuration

Primary V_ϕ **(V$_{rms}$)**	**Secondary** V_ϕ **(V$_{rms}$)**	a_ϕ	**Primary** V_{LL} **(V$_{rms}$)**	**Secondary** V_{LL} **(V$_{rms}$)**	a_{LL}

2) Insert phasor analyzer screenshot. Fill in Table 4. Compare results with Table 2.

Table 4 Transformer Voltage Phase Shifts for Y-Y Configuration

$\lvert\angle V_{\phi,P} - \angle V_{\phi,S}\rvert$ **(deg) & lead/lag**	$\lvert\angle V_{\phi,P} - \angle V_{LL,P}\rvert$ **(deg) & lead/lag**	$\lvert\angle V_{\phi,S} - \angle V_{LL,S}\rvert$ **(deg) & lead/lag**	$\lvert\angle V_{LL,P} - \angle V_{LL,S}\rvert$ **(deg) & lead/lag**

B. Y-Δ Configuration

1) Use saved screenshots to fill in Table 5. Compare results with Table 1.

Table 5 Measured Values for Y-Δ Configuration

Primary V_ϕ **(V$_{rms}$)**	**Secondary** V_ϕ **(V$_{rms}$)**	a_ϕ	**Primary** V_{LL} **(V$_{rms}$)**	**Secondary** V_{LL} **(V$_{rms}$)**	a_{LL}

2) Insert phasor analyzer screenshot. Fill in Table 6. Compare results with Table 2.

Table 6 Transformer Voltage Phase Shifts Y-Δ Configuration

$\lvert\angle V_{\phi,P} - \angle V_{\phi,S}\rvert$ **(deg) & lead/lag**	$\lvert\angle V_{\phi,P} - \angle V_{LL,P}\rvert$ **(deg) & lead/lag**	$\lvert\angle V_{\phi,S} - \angle V_{LL,S}\rvert$ **(deg) & lead/lag**	$\lvert\angle V_{LL,P} - \angle V_{LL,S}\rvert$ **(deg) & lead/lag**

C. Δ-Y Configuration

1) Use saved screenshots to fill in Table 7. Compare results with Table 1.

Table 7 Measured Values for Δ-Y Configuration

Primary V_ϕ **(Vrms)**	**Secondary** V_ϕ **(Vrms)**	a_ϕ	**Primary** V_{LL} **(Vrms)**	**Secondary** V_{LL} **(Vrms)**	a_{LL}

2) Insert phasor analyzer screenshot. Fill in Table 8. Compare results with Table 2.

Table 8 Transformer Voltage Phase Shifts Δ-Y Configuration

$\lvert\angle V_{\phi,P} - \angle V_{\phi,S}\rvert$ **(deg) & lead/lag**	$\lvert\angle V_{\phi,P} - \angle V_{LL,P}\rvert$ **(deg) & lead/lag**	$\lvert\angle V_{\phi,S} - \angle V_{LL,S}\rvert$ **(deg) & lead/lag**	$\lvert\angle V_{LL,P} - \angle V_{LL,S}\rvert$ **(deg) & lead/lag**

D. Δ-Δ Configuration

1) Use saved screenshots to fill in Table 9. Compare results with Table 1.

Table 9 Measured Values for Δ-Δ Configuration

Primary V_ϕ **(Vrms)**	**Secondary** V_ϕ **(Vrms)**	a_ϕ	**Primary** V_{LL} **(Vrms)**	**Secondary** V_{LL} **(Vrms)**	a_{LL}

2) Insert phasor analyzer screenshot. Fill in Table 10. Compare results with Table 2.

Table 10 Transformer Voltage Phase Shifts Δ-Δ Configuration

$\lvert\angle V_{\phi,P} - \angle V_{\phi,S}\rvert$ **(deg) & lead/lag**	$\lvert\angle V_{\phi,P} - \angle V_{LL,P}\rvert$ **(deg) & lead/lag**	$\lvert\angle V_{\phi,S} - \angle V_{LL,S}\rvert$ **(deg) & lead/lag**	$\lvert\angle V_{LL,P} - \angle V_{LL,S}\rvert$ **(deg) & lead/lag**

Each group should write and submit one hard copy of a lab report on Lab 6 to the instructor following guidelines given in lab syllabus.

Due Monday November 2, 2026 by 4 pm to instructor's office or EECS mailbox.