EE 330L Energy Systems Lab (Fall 2026)
Laboratory 7 Induction Motors

Introduction

The objective of this lab is to investigate the performance of an induction motor. The Four-Quadrant Dynamometer / Power Supply 8960-30 Electronics Module System (EMS) and Four-Pole Squirrel-Cage Induction Motor 8221-20 EMS will be used for this laboratory (see Figure 1). The equivalent circuit parameters of the induction motor will be found. In addition, the torque-speed characteristics of the motor will be examined.

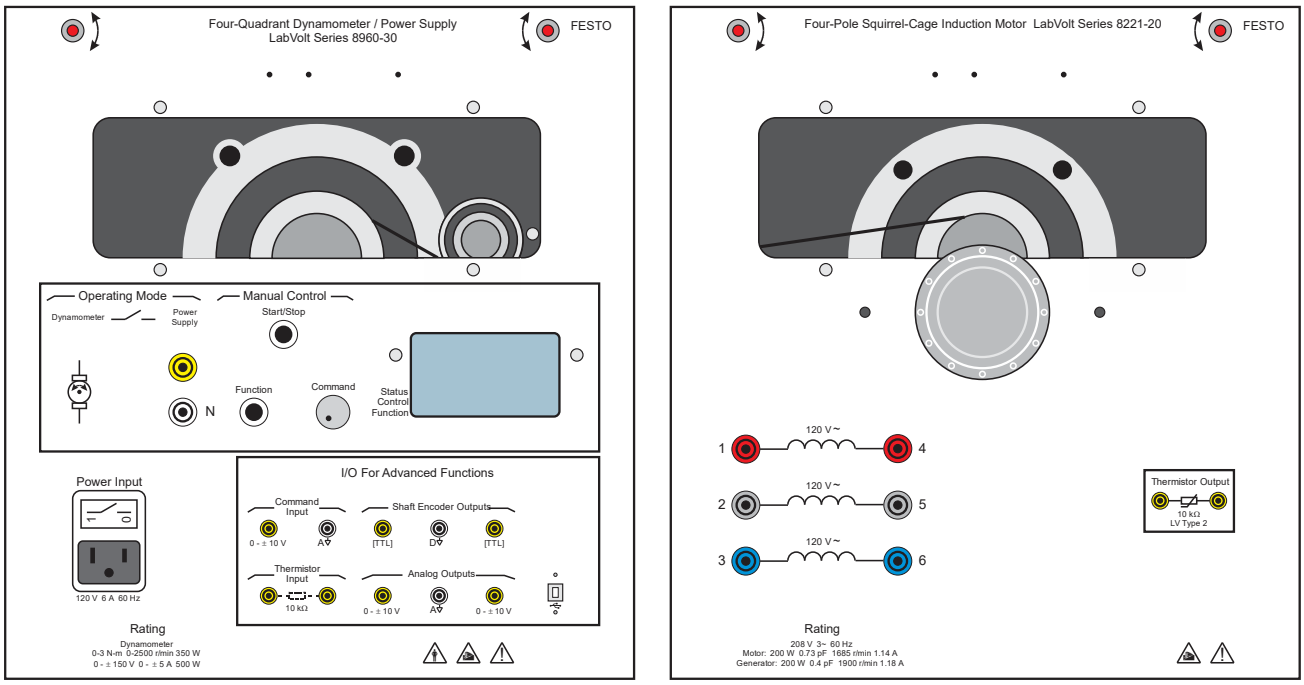


Figure 1 Four-Quadrant Dynamometer / Power Supply 8960-30 (left) and Four-Pole Squirrel-Cage Induction Motor 8221-20 (right) EMS

Preliminary

1) Determine the synchronous speed n_{synch} for this motor. Then, based on the ratings, fill in Table 1.

Table 1 Induction Motor Ratings

Config.	Rated P_{out} (W)	Rated P_{out} (hp)	Rated V_{LL} (V_{rms})	Rated V_{ϕ} (V_{rms})	Rated I_L (A_{rms})	Rated PF	n_{rated} (RPM)	s_{rated} (%)
Y								
Δ								

Experiment

Here, the user will connect their computer to the LabVolt system, perform various tests, and take measurements using the LVDAC-EMS software as well as Dynamometer / Power Supply 8960-30 EMS.

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 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. DC Test

1) To test the **red (phase a)** stator coil, set up the circuit shown in Figure 2 using the DACI EMS to implement the ammeter and voltmeter. For consistency, use voltmeter E1 and ammeter I1.

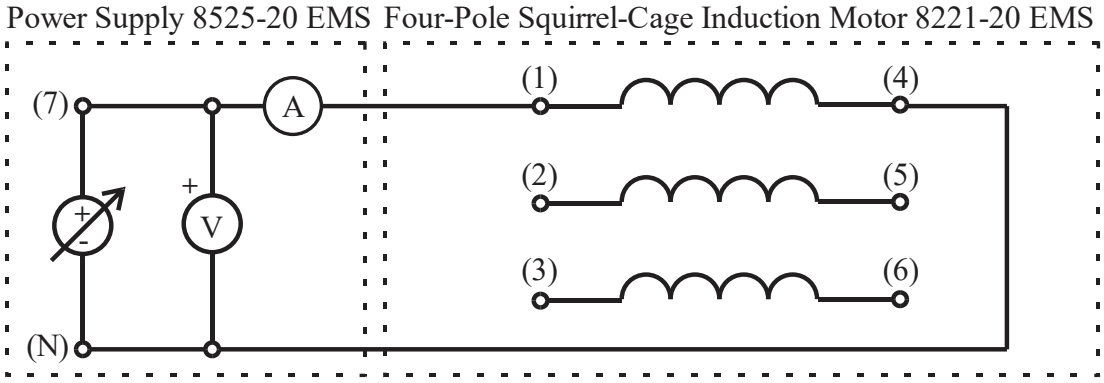


Figure 2 Circuit for DC Test (phase a)

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) Use meter 'M1' in the first row to show **DC voltage** from 'E1' on the DACI EMS. Use meter 'M7' in the second row to show **DC current** from 'I1' on the DACI EMS. Rename the meters to 'Vdc' and 'Idc' respectively. Deactivate unused meters.

5) On the Power Supply EMS, turn small knob (upper center) to '**7-N**' position and toggle the 'Power' switch **ON**. Then, very slowly turn the large knob CW until I1 shows about the **rated current**.

6) Click 'Single Refresh' icon to freeze the measured values. **Save a screenshot** of the 'Metering' instrument (e.g., DC_meter_phase_a.jpg). Click 'Continuous Refresh' icon. On the Power Supply EMS, **turn large knob CCW to 0**, and **toggle 'Power' switch OFF.**

7) To test the **black (phase b)** stator coil, connect the ammeter to terminal (2) and the power supply neutral wire to terminal (5) on the induction motor. On the Power Supply EMS, toggle the 'Power' switch **ON**, and very slowly turn the large knob CW until I1 shows about the **rated current**. Click 'Single Refresh' icon to freeze the measured values. **Save a screenshot** of the 'Metering' instrument (e.g., DC_meter_phase_b.jpg). Click 'Continuous Refresh' icon. On the Power Supply EMS, **turn large knob CCW to 0**, and **toggle 'Power' switch OFF.**

8) To test the **blue (phase c)** stator coil, connect the ammeter to terminal (3) and the power supply neutral wire to terminal (6) on the induction motor. On the Power Supply EMS, toggle the 'Power' switch **ON**, and very slowly turn the large knob CW until I1 shows about the **rated current**. Click 'Single Refresh' icon to freeze the measured values. **Save a screenshot** of the 'Metering' instrument (e.g., DC_meter_phase_c.jpg). Click 'Continuous Refresh' icon. On the Power Supply EMS, **turn large knob CCW to 0**, and t**oggle 'Power' switch OFF**. Disconnect all wires.

B. No-Load Test

1) As shown on Figure 1, there are rotating lock buttons on the upper left and right of the Four-Quadrant Dynamometer / Power Supply 8960-30 and Four-Pole Squirrel-Cage Induction Motor 8221-20 EMS. Rotate them to the unlocked position and tip the front panels down to access the pulleys and timing belt. To disconnect the timing belt, pull it out from one of the tensioner pulleys and then slip the belt off the dynamometer and induction motor shaft pulleys. Remove the belt, tip up the front panels and relock the buttons. [The instructor/TA will demonstrate.]

2) Set up the circuit shown in Figure 3 for a Y-connected induction motor using the DACI EMS to implement the ammeters and voltmeters (and power meters). You will use the two power meter method to measure $P_{\text{in,NL}}$. Therefore, **use DACI input 'E1' for V_{ab}, 'E2' for V_{cb}, and 'E3' for V_{ca}. Use DACI input 'I1' for I_a, 'I2' for I_c, and 'I3' for I_b.** [Be careful to get correct polarity on the voltmeters and have currents from the power supply EMS enter the red terminals for the ammeters to ensure correct two power meter results.]

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

4) On the 'Metering' instrument, ensure meters 'M1' - 'M4' show **AC** RMS voltages from 'E1' - 'E4' on DACI EMS. Rename meter 'M1' for 'E1' to 'Vab', meter 'M2' for 'E2' to 'Vcb', and 'M3' for 'E3' to 'Vca' to match quantities being measured. Deactivate 'M4'.

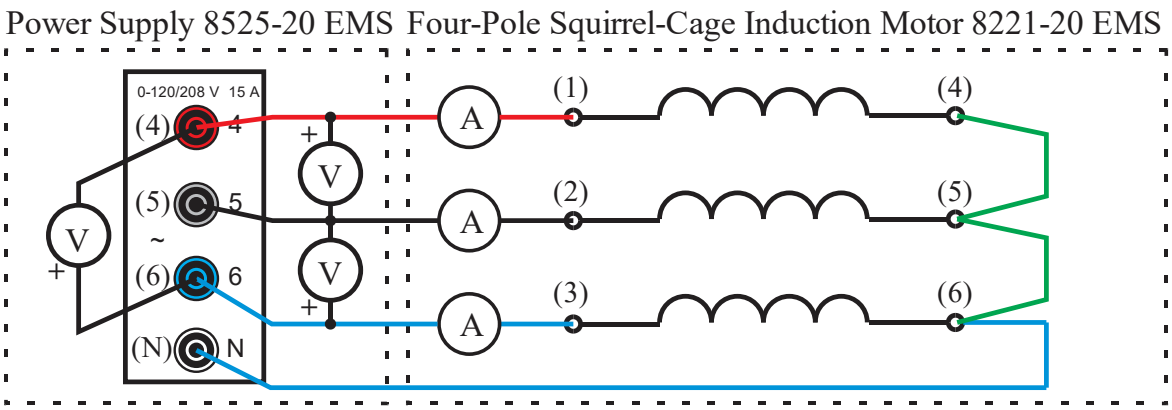


Figure 3 Circuit for No-Load Test

5) On the 'Metering' instrument, ensure meters 'M7' - 'M10' show **AC** RMS voltages from 'I1' - 'I4' on DACI EMS. Rename meter 'M7' for 'I1' to 'Ia', meter 'M8' for 'I2' to 'Ic', and 'M9' for 'I3' to 'Ib' to match quantities being measured. Deactivate 'M10'.

6) On the 'Metering' instrument, meter 'M13' should be measuring 'PQS1(E1,I1)' and meter 'M14' should be measuring 'PQS2(E2,I2)' by default. Rename meter 'M13' to 'PQS_VabIa' and meter 'M14' to 'PQS_VcbIc'. Deactivate meter 'M15'.

7) On the Power Supply EMS, turn small knob to '**4-5**' position toggle 'Power' switch to ON. Then, slowly turn the large knob until the **line-to-line/terminal voltages** are about the **rated voltage**.

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

9) On Power Supply EMS, **turn large knob CCW to 0**, and toggle 'Power' switch to OFF. Do NOT change any wiring connections or 'Metering' instrument settings.

C. Locked-Rotor Test

1) As shown on Figure 1, there are rotating lock buttons on the upper left and right of the Four-Quadrant Dynamometer / Power Supply 8960-30 and Four-Pole Squirrel-Cage Induction Motor 8221-20 EMS. Rotate them to the unlocked position and tip the front panels down to access the pulleys. To reconnect the timing belt, slip the belt on to the dynamometer and induction motor shaft pulleys outside the tensioner pulleys. Then, work the belt between the tensioner pulleys one side at a time. [The instructor/TA can/will demonstrate.]

2) Plug the AC power cord into the lower left of the Four-Quadrant Dynamometer / Power Supply 8960-30 EMS and then into a wall outlet. Toggle the 'Power Input' switch to 1/ON. Toggle the 'Operating Mode' switch to 'Dynamometer'. Push the 'Function' button until the LCD screen reads '2Q CT Brake' in the lower left corner. Turn the 'Command' knob until the 'Torque' reads 3 N-m in the upper right corner of the LCD screen.

3) On the Power Supply EMS, toggle the 'Power' switch to ON. Then, slowly turn the large knob CW to increase the line voltages until the ammeters show about the **rated current**. [If the induction motor starts rotating, turn the large knob CCW to stop it. Then, try again.]

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

5) On Power Supply EMS, turn large knob CCW to zero (0), and toggle 'Power' switch to OFF.

6) On the Four-Quadrant Dynamometer / Power Supply 8960-30 EMS, toggle the 'Power Input' switch to 0/OFF. Then, unplug the AC power cord (wall outlet end first).

7) Close the 'Metering' instrument. Then, close the LVDAC-EMS software.

8) Lastly, finish shutting down the LabVolt system by:
   - Disconnecting all cords and return to rack on side of the LabVolt system.
   - Disconnecting 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

1) Use saved screenshots from the DC Test to compute average DC voltage V_{DC} and current I_{DC}. Then, compute the terminal resistance R_T and resistance R_1. Complete Table 2.

Table 2 DC Test Results

V_{DC} (V)	I_{DC} (A)	R_T (Ω)	R_1 (Ω)

2) Use saved screenshots from the No-Load Test to find average line current $I_{L,NL} = I_{1,NL}$ and line-to-line voltage $V_{LL,NL}$. Then, compute the average no-load phase voltage $V_{\phi,NL}$ as well as the stator coil losses P_{SCL}, rotational losses P_{rot}, and combined reactance $X_1 + X_M$. Complete Table 3.

Table 3 No-Load Test Results

$I_{1,NL}$ (Arms)	$V_{LL,NL}$ (Vrms)	$V_{\phi,NL}$ (Vrms)	$P_{in,NL}$ (W)	P_{SCL} (W)	P_{rot} (W)	$X_1 + X_M$ (Ω)

3) Use saved screenshots from the Locked-Load Test to find average line current $I_{L,LR} = I_{1,LR}$ and line-to-line voltage $V_{LL,LR}$. Then, compute the average locked-rotor phase voltage $V_{\phi,LR}$, power factor PF_{LR}, impedance magnitude Z_{LR}, resistance R_{LR}, and reactance X_{LR}. Complete Table 4.

Table 4 Locked-Rotor Test Results

$I_{1,LR}$ (Arms)	$V_{LL,LR}$ (Vrms)	$V_{\phi,LR}$ (Vrms)	PF_{LR}	θ_{LR} (deg)	Z_{LR} (Ω)	R_{LR} (Ω)	X_{LR} (Ω)

4) Use data from Tables 2 - 4, to compute resistance R_2 as well as reactances X_1, X_2, and X_M. Assume induction motor is design class A/D. Complete Table 5.

Table 5 Induction Motor Equivalent Circuit Parameters

R_1 (Ω)	R_2 (Ω)	X_1 (Ω)	X_2 (Ω)	X_M (Ω)

5) Draw per-phase equivalent circuit for this induction motor (separate R_2 and R_{conv}).

6) Assuming the induction motor is supplied with the rated line-to-line voltage, find and draw the fully-labeled simplified equivalent circuit (form shown in Figure 7-16c of text).

7) Compute the starting torque τ_{start}, slip s_{start}, and speed n_{start}. Then, compute the pullout torque τ_{max}, slip s_{max}, and speed n_{max}. Also, at the rated speed n_{rated}, find the slip s_{rated} and torque τ_{rated}. Complete Table 6.

Table 6 Induction Motor Speed-Torque Values

n_{start} (RPM)	s_{start}	τ_{start} (N-m)	n_{max} (RPM)	s_{max}	τ_{max} (N-m)	n_{rated} (RPM)	s_{rated}	τ_{rated} (N-m)

8) Use MATLAB to plot the induced torque τ_{ind} versus speed n_m curve as well as the power converted P_{conv} versus speed n_m curve from 0 to n_{synch}. From the τ_{ind} versus n_m curve, which design class best describes this induction motor?

9) Assuming the induction motor is supplied with the rated line-to-line voltage, find and draw the fully-labeled equivalent circuit (separate R_2 and R_{conv}) at the rated speed/slip. Use this circuit to find the **rated** line current I_{rated}, power factor PF_{rated}, input power $P_{in,rated}$, converted power $P_{conv,rated}$, output power $P_{out,rated}$, output torque $\tau_{out,rated} = \tau_{load,rated}$, and motor efficiency η_{rated} (%). Complete Table 7.

Table 7 Induction Motor Rated Quantities

I_{rated} (A_{rms})	PF_{rated}	$P_{in,rated}$ (W)	$P_{conv,rated}$ (W)	$P_{out,rated}$ (W)	$\tau_{out.rated}$ (N-m)	η_{rated} (%)

10) How do the computed I_{rated} and PF_{rated} compare with the nameplate values? Is the nameplate power $P_{in,rated}$ or $P_{out,rated}$? Why?

Each group should write and submit one hard copy of a lab report on Lab 7 to the instructor following guidelines given in lab syllabus.

Due Tuesday November 24, 2026 by 4 pm to instructor's office or EECS mailbox.