Fall 2011

EE320 CIRCUIT ANALYSIS II
Laboratory Experiment #8
"Synchronous Machine Parameter Determination"

Background: The synchronous machine model requires us to determine three parameters: r_s, X_s, and L_{sf}. The stator resistance can be evaluated by applying a reduced DC voltage to the machine stator until rated current flows, then employing Ohm's Law. We will establish L_{sf} using measurements from an open-circuit test (stator windings open circuited and the induced voltage is measured for different amounts of DC field current). The synchronous reactance X_S will then be computed from data recorded from both the open-circuit test and the short-circuit test (stator terminals are short circuited and the induced current is measured at different amounts of DC field current).

Part 1. Open-Circuit Characteristic

1. Connect the circuit shown in Figure 1.
    a. Make sure to couple the four pole squirrel cage induction machine (8221-00) to the synchronous machine (8241-00) with the timing belt. Use the handheld DMM to measure DC current.
    b. Set the synchronous machine field rheostat (exciter) at its full CW position (for maximum resistance).
    c. Set the power supply voltage control knob for 0V (zero field current)
    d. Close the switch located on the synchronous machine faceplate to complete the field circuit.
    e. Have the instructor verify your setup: _____
2. Turn on the power supply (the motor should be turning). What is the anticipated no-load speed of a 4-pole, 60Hz induction machine?

$$N_{no-load-theo} = _____$$

3. Measure the rotor speed with the hand tachometer: $N_{no-load-act}$ = _____
4. Measure and record the voltmeter readings to complete table 1 on the following page. ***Gradually*** increase the DC voltage applied to the rotor to ***slowly*** increase the field current in 100mA increments.
5. Are these line-to-line or line-to-neutral voltages? _____
6. Complete the table for the remaining values of I_F. The column V_{ave} is the average of channels 1 and 2 while V_{phase} is the voltage across the phase coil (from terminals 1 to 4 for instance, you can calculate this value)
7. Reduce the applied field voltage to more precisely determine the required field current to produce a measured voltage of 208V (rated)

$$I_{F,rated_V} = _____$$

8. Return the voltage control knob to zero and de-energize the power supply

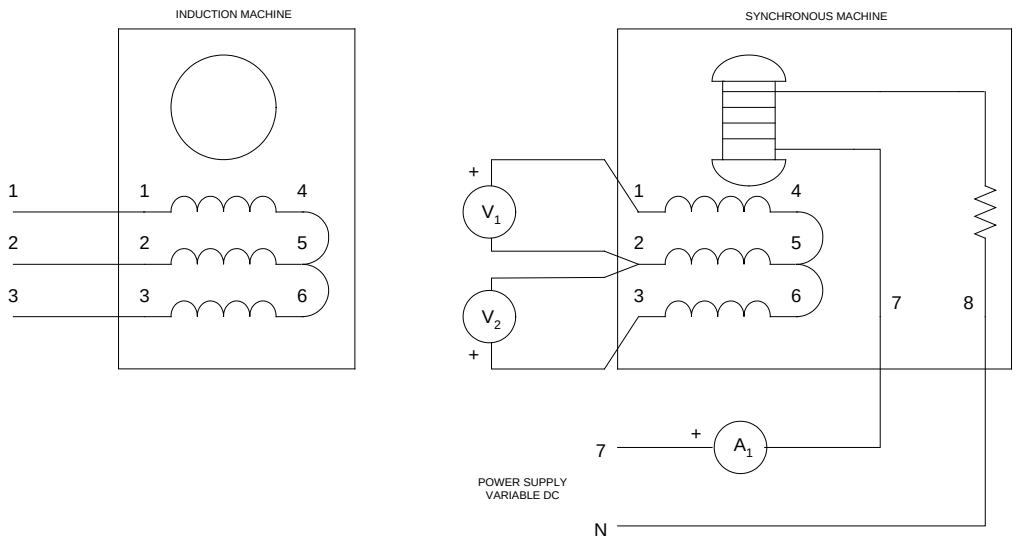
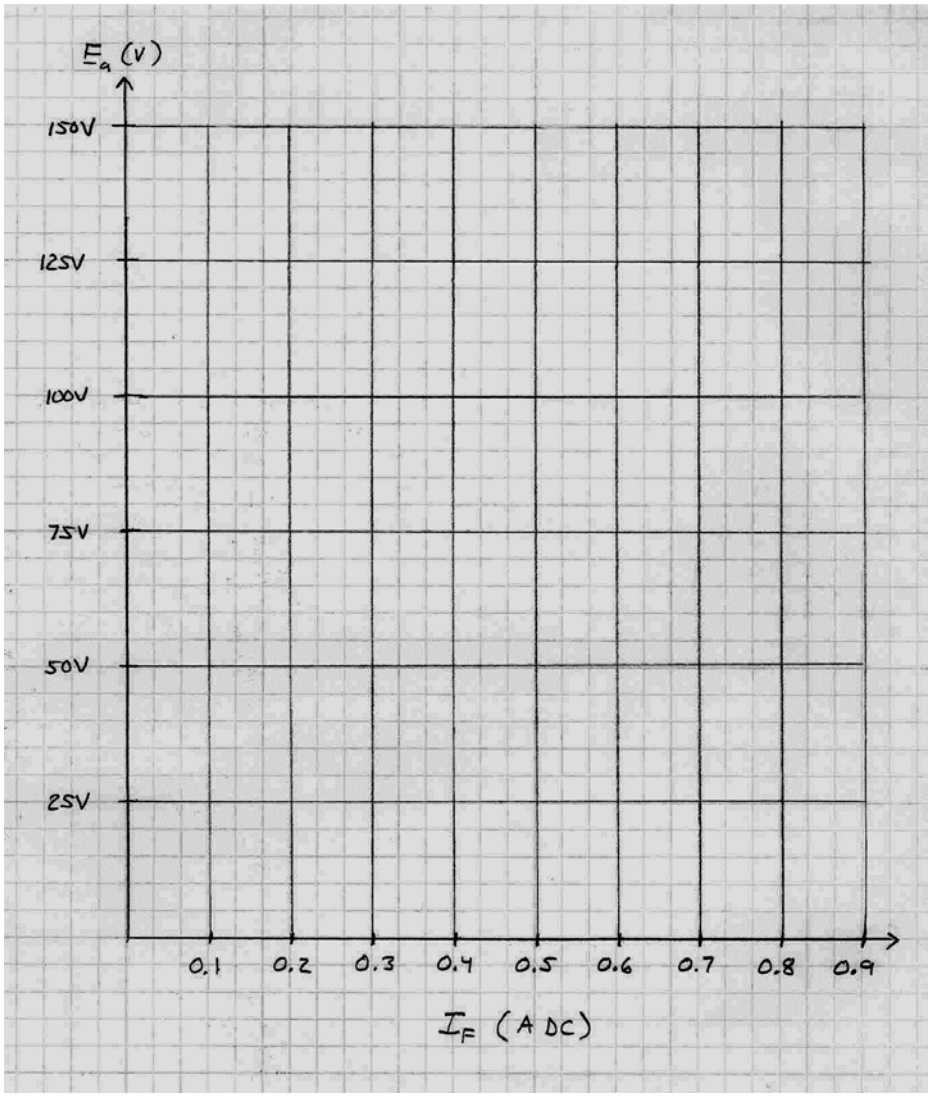


Figure1. Open-Circuit Characteristic

Table 1

I_F (A)	$I_{F,act}$ (A)	V_1	V_2	V_{ave}	V_{phase}
0					
0.1					
0.2					
0.3					
0.4					
0.5					
0.6					
0.7					
0.8					
0.9					

9. Plot the open circuit characteristic



10. Calculate the slope of the linear part of the curve.

11. From the slope and the definition of E_a, calculate the parameter L_{sf}

12. If your machine yielded a non-zero voltage at zero field current, explain how this could happen (and no, the voltmeter is NOT the reason)

13. At what values of E_a and I_F does the machine start exhibiting magnetic saturation

Part 2. Short-Circuit Characteristic

1. Modify the circuit setup to the one shown in Figure 2. Note this entails removing the voltmeters, connecting an ammeter between terminals 1 and 2 of the synchronous machine, and introducing a short between terminals 2 and 3. Continue to use the handheld meter for the DC field current.

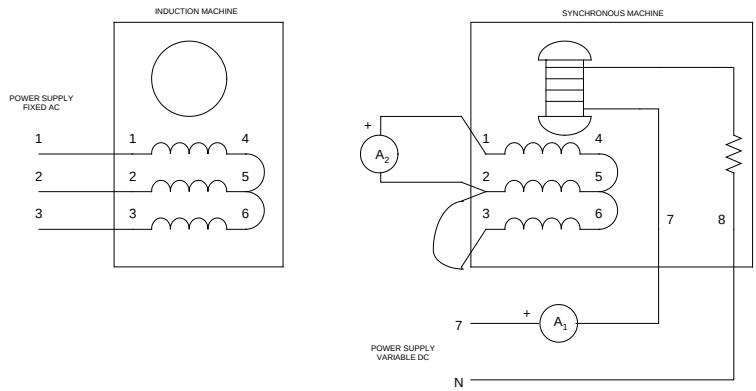


Figure 2. Short-Circuit Characteristic

2. **Have the instructor verify your circuit**: _____
3. Energize the power supply (the motor should be spinning). Gradually increase the field excitation (voltage control knob) and complete the following table.

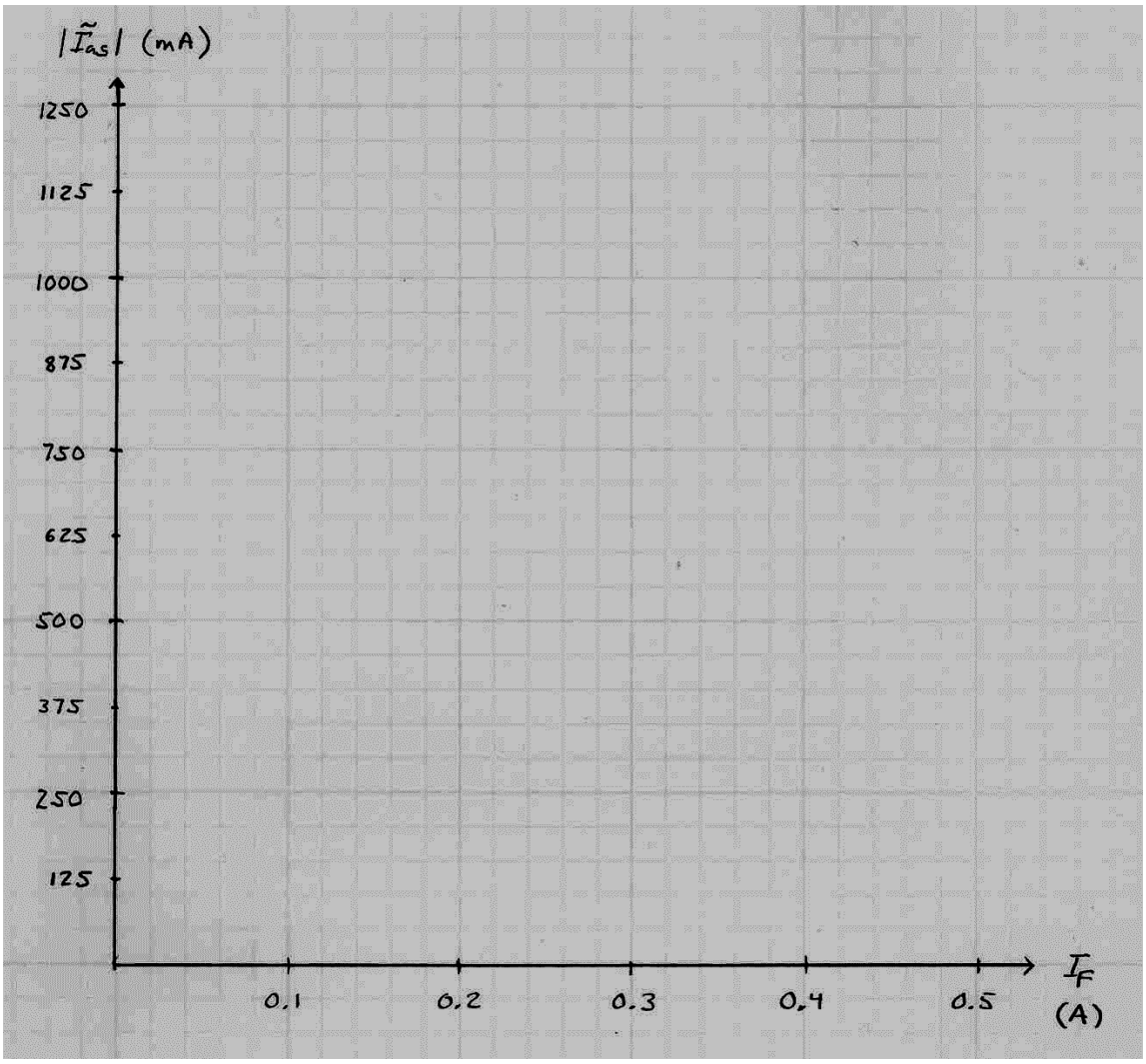
Table 2

I_F (A)	$I_{F,act}$ (ADC)	$\lvert\tilde{I}_{as}\rvert$ (Arms)
0		
0.1		
0.2		
0.3		
0.4		
0.5		

4. Reduce the applied field voltage to more precisely determine the required field current to produce a measured stator current of 1Arms (rated):

$$I_{F,rated_I} = _____$$

5. Return the voltage control knob to zero and de-energize the power supply.
6. Plot the short-circuit characteristic



7. Determine the slope of this characteristic

Part 3. Stator Resistance Measurement

1. Connect the circuit shown in Figure 3 (Note, we are now connected to the power supply variable DC terminals, 7 and N)

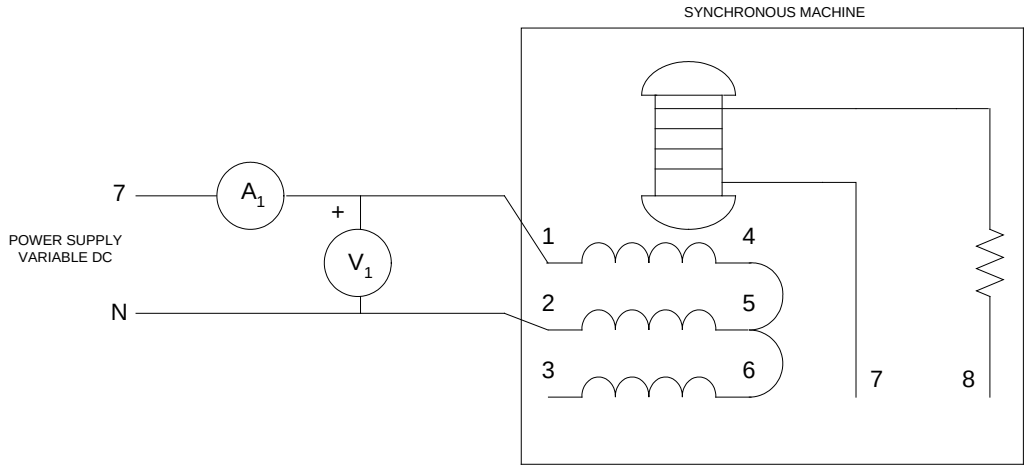


Figure 3. Stator Resistance Measurement

2. Energize the power supply and gradually increase the DC voltage until the measured DC current is 1A. Record the values below and calculate the stator resistance.

V_{DC} = _____

I_{DC} = _____

r_S = _____ = _____

Formula Used Value

3. Reduce the variable voltage control knob to zero. De-energize the power supply. Disconnect the circuit and return cabling to the rack.

Part 4. Questions

1. Evaluate the Synchronous Reactance X_S using the slopes calculated from the open-circuit and short-circuit data (NOTE, this will be the *unsaturated* value of synchronous reactance). Evaluate X_S by both including and excluding the stator resistance in your calculation.