EE 340L

EXPERIMENT # 3

SYNCHRONOUS GENERATORS

A. EQUIVALENT CIRCUIT PARAMETERS

A.1. OPEN CIRCUIT TEST

(a) Mechanically couple the generator with a shunt-excited DC motor as shown in figure 4(a).

(b) With the field rheostat in its maximum resistance (fully CCW position), increase the DC supply to 115 V. Then bring the motor speed to its rated value (1800 RPM) by varying the field rheostat. Make sure that the generator IND.START-SYNC.RUN switch is in the SYNC.RUN position.

(c) Energize the generator exciter, then increase the field current in discrete steps until the generator line voltage reaches 208 V or the field current reaches 1A. Record the field current and the induced line voltage at each step.

(d) When finished, reduce the field current back to zero, the motor field rheostat back to its maximum value, then shut down the power supply.

A.2. SHORT-CIRCUIT TEST

(a) Repeat steps (a) and (b) above. Then short-circuit the output terminals of the generator as shown in figure 4(b).

(b) Energize the generator exciter. Increase the field current in discrete steps. Record the short-circuit current and field current at each step, until the short-circuit current reaches 2 A.

A.3. DC TEST

(a) Connect a variable DC supply across two phases of the synchronous generator.

(b) Start with 0 V then increase the DC voltage until the DC current reaches 2A. Record the corresponding voltage.

B. ISOLATED OPERATION

- Repeat steps (a) and (b) of the open-circuit test, energize the exciter and increase the field current until the line voltage reaches 208 V.
- Connect a 3-phase Y-connected resistive load (600Ω in each phase) across the generator terminals as illustrated in Figure 4(d). Re-adjust the speed back to 1800 RPM. Record the line voltage and load current. Note the drop in voltage.

- Repeat the above step for loads of 300Ω, 200 Ω, 150 Ω, 100 Ω and 85 Ω.
- Repeat Steps 2 and 3 for and R-L load, by starting with 208V under no-load (with 600 Ω in parallel with 1.6 H, 300 Ω in parallel with 0.8 H, 200 Ω in parallel with .533 H, 150 Ω in parallel with .4 H, 100 Ω in parallel with .266 H, 85 Ω in parallel with .228 H).
- Repeat Steps 2 and 3 for and R-C load by starting with 208V under no-load (with 600 Ω in parallel with 4 uF, 300 Ω in parallel with 8 uF, 200 Ω in parallel with 12uF, 150 Ω in parallel with 16uF , 100 Ω in parallel with 20uF, 85 Ω in parallel with 24uF).
- Decrease the motor speed to minimum value, disconnect the resistive load from the generator terminals, decrease the generator field current to zero, then turn off the power supply.

C. PARALLEL OPERATION

C.1. SYNCHRONIZATION

(a) Connect the DC-motor, synchronous machine, three light bulbs, and measuring meters as shown in figure 4(e) below.

(b) Make sure that the three light bulb switch is OPEN. Start the motor and bring its speed to near 1800 RPM.

(c) Energize the generator exciter and adjust the field current until the terminal voltage of the synchronous generator reaches 208V. Bring the rotor speed back to 1800 RPM.

(d) Connect the other terminals of the three light bulbs to the 3-Φ power supply.

(e) Adjust the generator phase sequence, rotor speed, and field current until all the light bulbs are dark. Then increase the rotor speed slightly so that the light bulbs flash at a very low frequency (few flashes/minute). Move the three bulb switch to CLOSE position when the light bulbs are all dark.

(f) Check the synchronous speed of the rotor with a stroboscope.

IMPORTANT NOTE: During the next two sections, if for some reason the generator loses synchronism, move the three light bulb switch to OPEN position **immediately.**

C.2. REAL POWER CONTROL

(a) Vary the mechanical power supplied to the synchronous generator P_{in} by slowly varying the DC-motor field current until the real output power P_{out} is zero, then adjust the torque angle $\delta = 0°$.

(b) Increase P_{in} slowly, then record P_{out}, Q_{out} and δ.

(c) Repeat step 2 several times until the line current is greater than 1A.

C.3. REACTIVE POWER CONTROL

(a) Reduce P_{in} until P_{out} and δ are zero.

(b) Increase the internal voltage of the synchronous generator by slowly varying the generator field current. Record the field current I_f, P_{out} and Q_{out}.

(c) Repeat step 2 several times until the line current is equal to 1 A.

QUESTIONS

Equivalent Circuit:

1. Plot the generator saturation curve from the open-circuit test.

2. Plot the short-circuit current versus the field current from the short circuit test.

3. Use the results of the no-load, short-circuit and DC tests to find the internal impedance of the generator.

4. Suppose that the generator under test is short-circuited when the line voltage is 208 V. Determine an approximate value of the short-circuit current under this condition.

Isolated Operation:

1. Calculate the internal voltage phasor E for each resistive load. Plot the voltage regulation curve (terminal voltage versus load current).

2. Repeat 1 above for both the inductive and capacitive loads.

Parallel Operation:

1. Use the data recorded in Part C.2 to plot the change of P_{out} and Q_{out} in terms of torque angle δ. Note that the reactive power is not very sensitive to the change in input power.

2. Use the data recorded in Part C.3 to plot the change of P_{out} and Q_{out} in terms of the field current. Note that the active power is not very sensitive to the change in generator filed current.

3. After the synchronous generator has been synchronized with the power system, explain what happens if the prime mover (i.e., motor driving the shaft) is shut-down.

4. Explain why a small change in the motor field current does not result in a change of rotor speed, and a small change in the generator field current does not result in a change of terminal voltage (i.e., unlike the case of isolated operation).

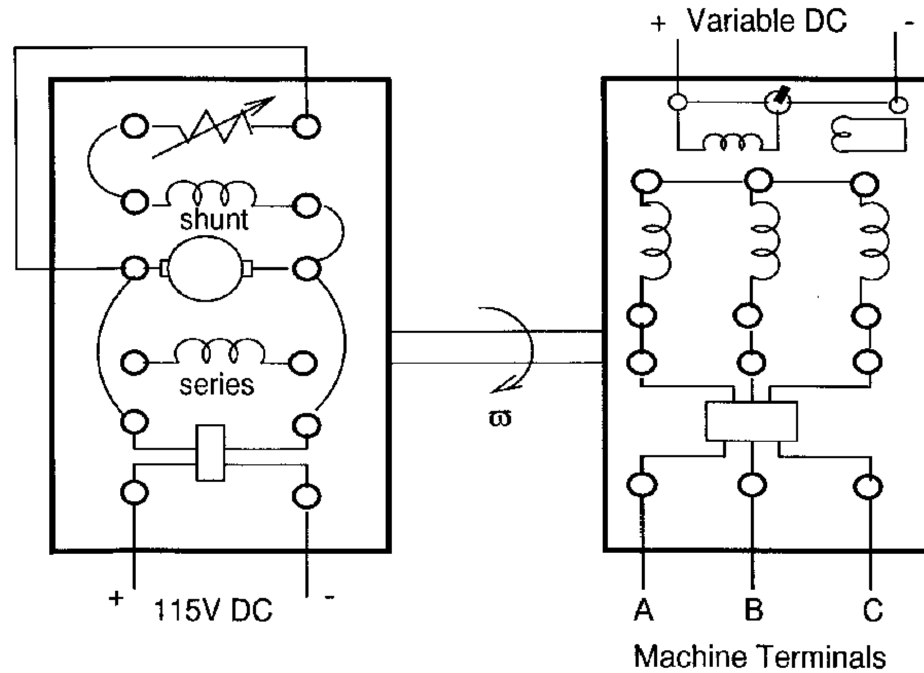

Figure 4(a)

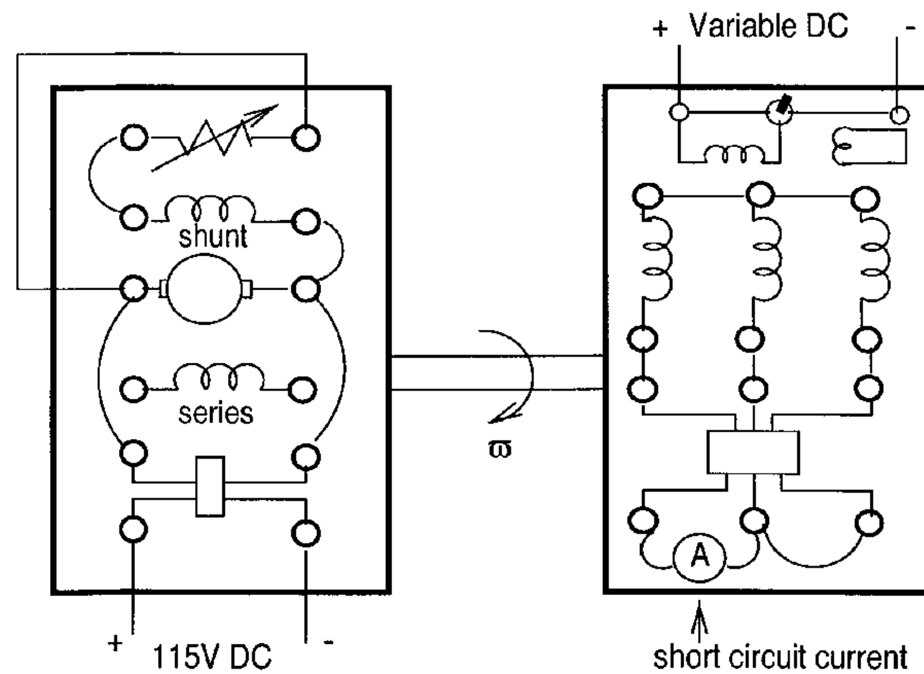

Figure 4(b)

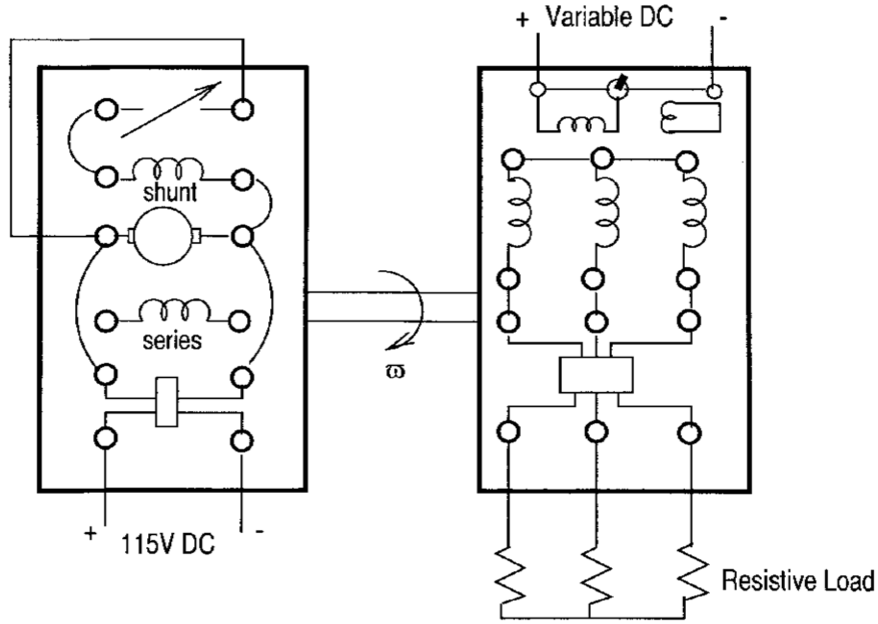

Figure 4(d)

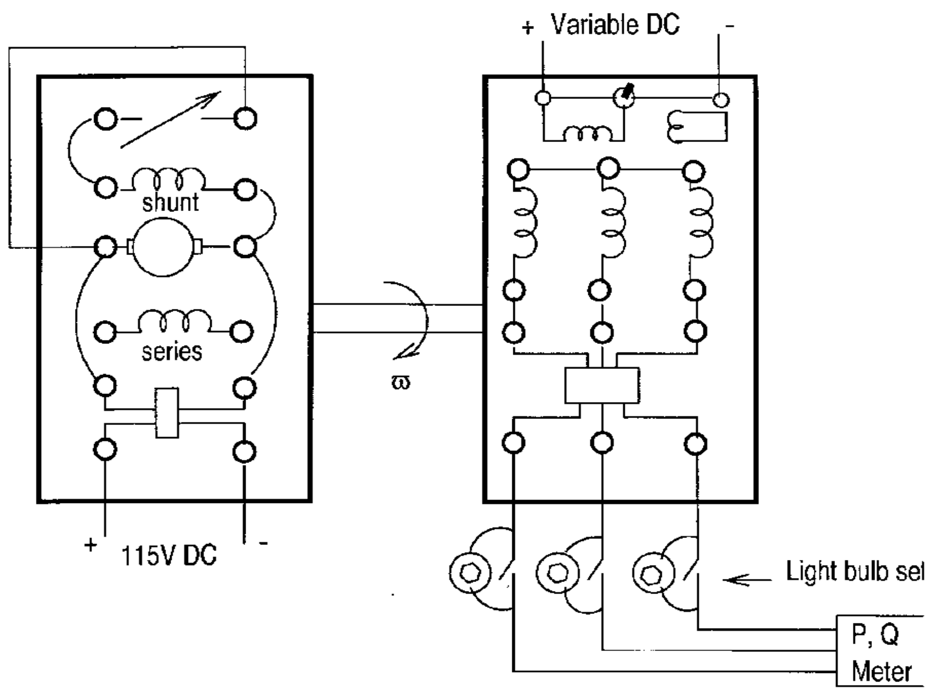

Figure 4(e)