Synchronous Generator – Lab experiment required for the assignment

Objective:

To measure the characteristics of a three phase synchronous generator under open, short and loaded circuits.

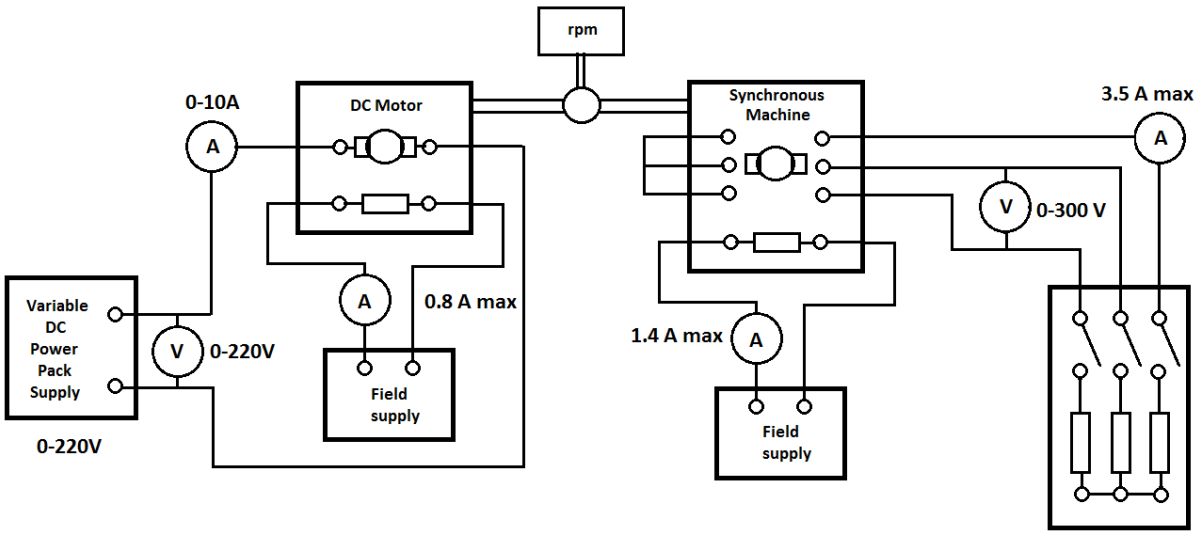

Figure 1 Experimental set up

Apparatus with range (you can put it in the figure itself)

- Synchronous Machine Number Plate
- DC Motor MV Number plate
- Terco Power Supply unit
- Volt meter , Ammeter AC
- Volt meter , Ammeter DC
- Wattmeter – Metrix PX120
- Terco Load Switch Box
- Variable Resistive Load, L &C load

Table 1 – Specifications / Ratings of DC Motor & Synchronous generator

	DC Motor	Synchronous Generator	
		Star	Delta
Power Rating (kW)			
Rated Speed (RPM)			
Supply Frequency (Hz)			
Rated Voltage (Volts)			
Rated Current (Amps)			
Rated Field Current (Amps)			

Procedure:

Tests to find Circuit Parameters

Considering the armature per-phase circuit diagram, the following information is required to be able to analyze machine performance:

a. Armature resistance, R_A
b. Voltage induced by the field winding, **E**
c. Synchronous reactance, X_S

Armature resistance is often neglected, as in large machines it is small relative to synchronous reactance. If needed, armature resistance can be obtained by a DC resistance test.

Open Circuit Voltage test

The open circuit test is carried out with the terminals of the machine disconnected from any external circuit. The basic test procedure is:

1. Open circuit the generator terminals
2. Drive the machine at synchronous speed using an external mechanical system
3. **Slowly increase the field current and measure the open circuit terminal voltage at constant speed.**

As there is no armature current, the measured terminal voltage is the induced voltage:

$$V_{oc} = E_{oc}$$

If the machine is wye connected, the measure voltage will be a line-line voltage and the per-phase induced voltage can be found from

$$V_{LL_{oc}} = \sqrt{3}E_{oc}$$

Remember the induced voltage vs. field current plot will have a similar shape to the flux vs. field current plot. At higher field current levels, the iron in the machine saturates and the percentage of field mmf applied to the air gap is reduced. As a result, the induced voltage falls below the air gap line.

As synchronous machines operate at effectively constant speed, the open circuit voltage test provides the relationship between field current and induced voltage for all load conditions. The induced open circuit voltage is sometimes known as the "excitation voltage", or even simply as the "excitation".

Open circuit test: speed kept constant at 1500 rpm

I_f (A)	V_L (V)	V_{ph} (V)

Table 2 – Open Circuit Test: Generator Field Current vs Induced Voltage

Short-Circuit Test

As the name suggests, the short circuit test is carried out with the terminals of the machine short circuited. The basic test procedure is as follows:

1. Set the field current to zero
2. Short circuit the armature terminals
3. Drive the generator at synchronous speed with external mechanical system
4. Slowly increase the field winding current **until the short circuit armature current reaches the rated design value**

Note that very low field current levels are required to achieve rated short circuit armature current.

When short circuited, armature reaction prevents the machine from saturating. The short-circuit per-phase equivalent circuit and phasor diagrams are shown below.

Short circuit test: speed kept constant at 1500 rpm

I_f (A)	I_S (A)

Table 3 – Short Circuit Test: Generator Stator Current vs Field Current

Load tests: (hint) Constant SPEED

1. Fix I_f at 3 different values (rated, under excited, over excited) and take readings of V_{load} and I_{load}. Note the power factors . This will help you to draw the phasors.

2. Do the same for Inductive and capactive loads. (try to take the same If values to compare).

*Table 4 – Load Test with Resistive Load & **Under Excited Condition***
*Table 5 – Load Test with Resistive Load & **Rated Voltage Condition***
*Table 6 – Load Test with Resistive Load & **Over Excited Condition***
*Table 7 – Load Test with Inductive Load & **Under Excited Condition***
*Table 8 – Load Test with Inductive Load & **Rated Voltage Condition***
*Table 9 – Load Test with Inductive Load & **Over Excited Condition***
*Table 10 – Load Test with Capacitive Load & **Under Excited Condition***
*Table 11 – Load Test with Capacitive Load & **Rated Voltage Condition***
*Table 12 – Load Test with Capacitive Load & **Over Excited Condition***

speed kept constant at 1500 rpm for each reading & FIX the I_f as per the requirement

I_a (A)	V_L (V)	V_{ph} (V)	P (W)	Power Factor	VA	Var

Table 4 – 12 Load test under different conditions