Electric Machines Laboratory (EE2P001)

EXPERIMENT-8

DIRECT AND QUADRATURE AXIS SYNCHRONOUS REACTANCE OF ALTERNATOR

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AIM OF THE EXPERIMENT:

Determination of the direct and quadrature axis synchronous reactance by slip test of synchronous machine.

EQUIPMENTS REQUIRED:

Instruments/Equipment:

Sl.No	Instruments/Equipments	Type	Specification	Quantity
1	Voltmeter	MI	0-100V	1
2	Ammeter	MI	0-10A	1
3	Rheostat	Tubular	500Ω, 3A	1
4	3- Φ Variac	Iron core	415 V, 10 A	1 No
5	Tachometer	Digital	0-2000rpm	1
6	Connecting wires	Cu	1.5 sq. mm	As required

Machines Required:

Sl. No.	Machine	Specification	Quantity
1.	D.C. Motor coupled with 3-Φ Alternator	**D.C. Shunt Motor:-6** HP , 1500 RPM 220 V, 24 A , Excitation- 220 V/ 2 A **3-Φ Salient Pole Type Alternator : -** 5 kVA, 415V,50Hz, Star, 7A,1500 RPM, 0.8 pf Excitation- 220 V/2 A	1 Set

THEORY:

From slip test the value of direct and quadrature axis synchronous reactance can be determined. The synchronous machine is driven by a separate prime- mover (in this case dc motor) at a speed slightly different from synchronous speed. The field winding is left open and positive sequence balanced voltage of reduced magnitude (around 25% of rated value) and rated frequency is impressed across the armature terminals. Under these conditions the relative velocity between the field poles and the rotating armature mmf wave is equalto the difference between synchronous speed and the rotor speed, i.e. the slipspeed. A small ac voltage across the open field winding indicates that the field poles and rotating mmf wave are revolving in the same direction and this is required in slip test. If field poles revolve in a direction opposite to therotating mmf wave negative sequence reactance would be measured.

At one instant when the peak of armature mm wave is in line with field pole or direct axis, the reluctance offered by the small air gap is minimum. At this instant the impressed terminal voltage per phase divided bythe corresponding armature current per phase gives d-axis synchronous reactance X_d.

After one quarter of slip cycle the peak of armature mmf wave acts onthe inter polar or q-axis of the magnetic circuit, and the reluctance offered bylong air gap is maximum. At this instant the ratio of armature terminal voltage per phase to the corresponding armature current per phase gives q- axis synchronous reactance X_q.

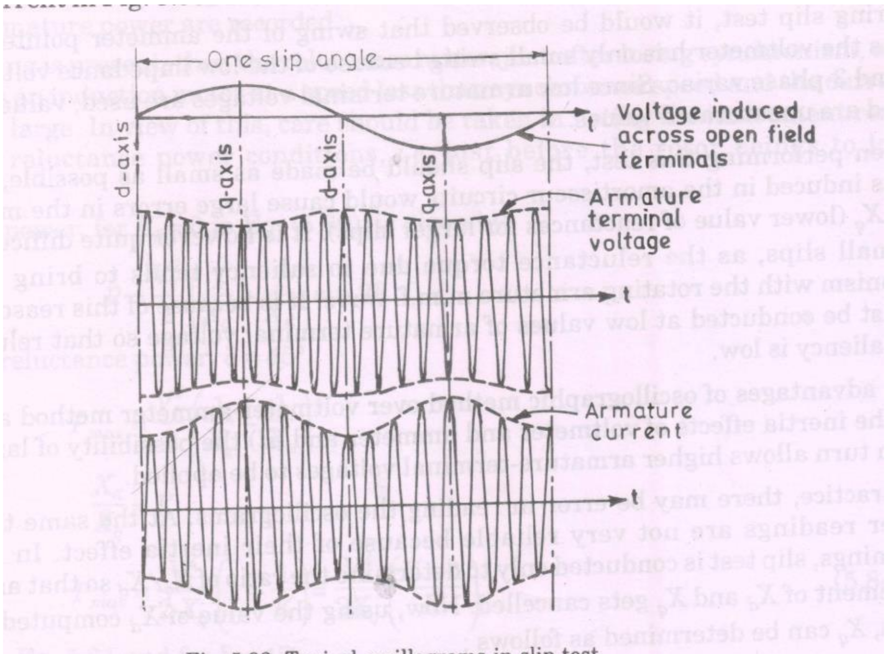


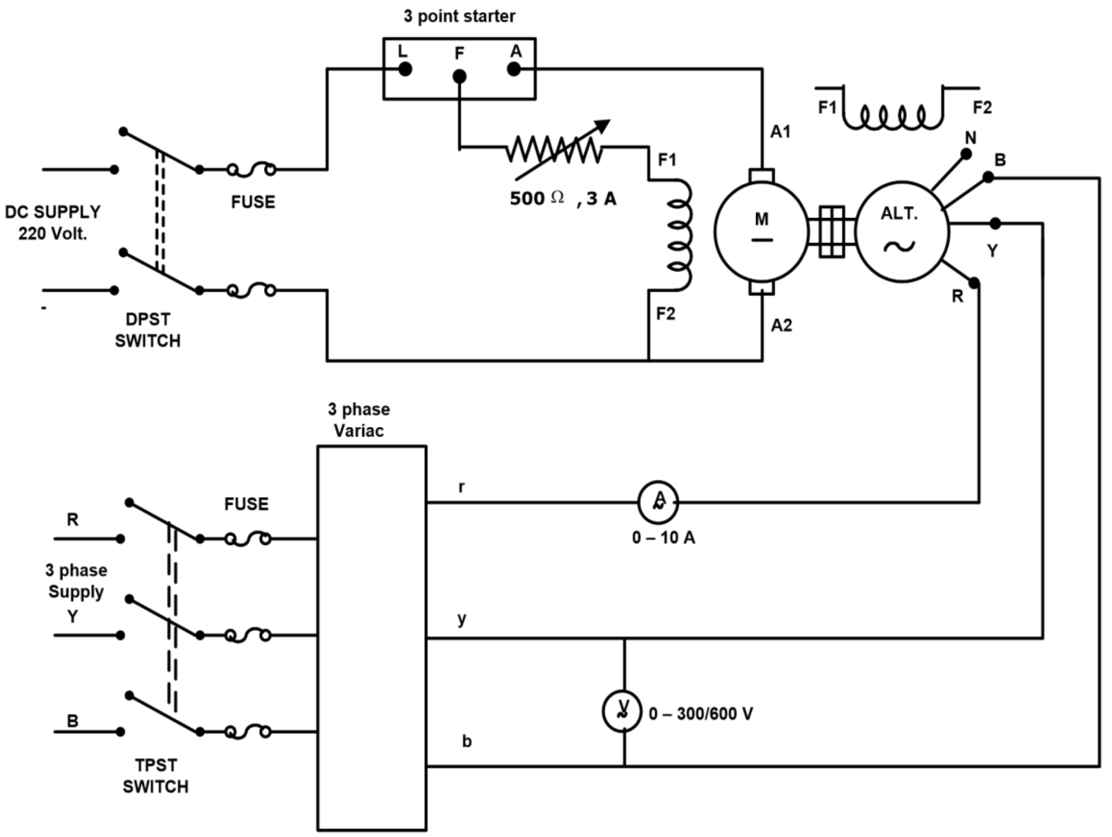
Fig. 5.93. Typical oscillograms in slip test.

FORMULAE USED:

$$\text{Direct axis unsaturated reactance} = \frac{\text{Maximum armature terminal voltage per phase}}{\text{Minimum armature current per phase}}$$

$$\text{Quadrature axis unsaturated reactance} = \frac{\text{Minimum armature terminal voltage per phase}}{\text{Maximum armature current per phase}}$$

CIRCUIT DIAGRAM:



PRECAUTION:

1. Connection should be right and tight.
2. Check the circuit connection thoroughly before switching on thesupply.
3. Instruments should be connected in proper polarity and range.
4. Do not touch any non-insulated part of any instrument or equipment.
5. Be ensured the zero setting of instrument is on right position. Avoid parallax error.

6. Before switching on the supply, be sure that variable point of Variac should be at zero.

PROCEDURE:

1. Make the field circuit open.
2. Set the speed of the alternator slightly less than the synchronous speed(1480 to 1490 rpm) by dc motor.
3. Apply reduced voltage (around 25% of rated value) to the armatureterminals by the 3-phase autotransformer.
4. Note down the maximum and minimum readings of the ammeter andvoltmeter deflections.

OBSERVATIONS: -

Sl. No.	**V_{ph} maximum/minimum(V)**	**I maximum/minimun(A)**	**Xd (Ω)**	**Xq (Ω)**
1.	100.1/100.9	1 /2.6	58.25	22.228

CALCULATIONS:

Xd=100.9/(√3 x 1)=58.25 Ω;

Xq=100.1/(√3 x 2.6)=22.228 Ω

CONCLUSION

Thus, we successfully calculated Direct Axis Unsaturated Reactance (Xd) as 58.25 Ω and Quadrature Axis Unsaturated Reactance (Xq) as 22.228 Ω of an alternator from the corresponding maximum and minimum phase voltages and currents.

DISCUSSION

1. Will you get X_d and X_q in case of cylindrical rotor type alternator? If notwhy? Discuss.

   Ans: No, we cannot get Xd and Xq in case of cylindrical rotor because incase of a cylindrical rotor there exist a uniform air gap across the rotorperiphery. Which implies that the reluctance is constant across the rotor periphery.
   So, the method that we follow to find the Xd and Xq will fail as the reluctance will be same throughout so the voltage will not vary as in theabove case and the current will also not vary.

2. What is the difference between synchronous reactance, leakage reactanceand armature reactance? Do they have any relation among themselves?

   Ans: The reactance of the Synchronous Machine is known as the Synchronous Reactance Xs=Leakage Reactance X+Armature Reactance Xa;
   Leakage reactance X is a reactance which is put up in a circuit to include theeffects of flux leakage. The Armature reactance Xa is the inductive reactance due to the flux produced by the armature current and enclosed by the conductors in the armature slots and the end connections.

3. What is the salience factor of an alternator?
   Ans: saliency-factor= L_d / L
   The d-axis is when the rotor is aligned with the poles. It is also the orientation with highest inductance. The q-axis is when the rotor is alignedwith the gaps. It has the lowest inductance. It can be shown that reluctancemotors work best when you maximize the saliency ratio.