KING FAHD UNIVERSITY OF PETROLEUM & MINERALS

Electric Engineering Department

EE 306 Electric Energy Engineering - Experiment#7

Determination of Parameters of Synchronous Generators

Objectives:

1. To determine the synchronous impedance of an alternator.
2. To determine its voltage regulation.

Apparatus

1 3Φ alternator
1 DC motor
1 AC Voltmeter
1 DC Ammeter
1 DC voltmeter
1 DC power supplies
1 Tachometer

Theory:

For a certain excitation the synchronous impedance per phase of a synchronous machine can be calculated as

$$Z_s = E_a / I_a \qquad (1)$$

Where E_a is the open circuit voltage per phase and I_a is the short circuit current. The synchronous reactance then can be calculated as

$$X_s = \sqrt{Z_s^2 - R_a^2} \qquad (2)$$

R_a is considered as 1.5 times the armature DC resistance R_{dc} .X_s is the saturated reactance when E_a is taken from the open circuit characteristics and
I_a is the corresponding short circuit current for the same excitation.
For a certain load current I_a, the internal voltage per phase can be written as

$$E_a = V_t + I_a (R_s + jX_s) \quad (3)$$

Where V_t is the terminal voltage per phase. Note, I_a is a complex number
The voltage regulation of the generator at the rated load is given as:

$$VR = (V_{NL}-V_{FL})/V_{FL} \text{ X } 100\% \quad (4)$$

Where, $V_{NL} = E_a$

and $V_{FL} = V_t$ (rated)

Procedure:

1. Note the rated values of current, voltage and speed of the synchronous generator as well as the motor that will drive the generator.
2. Connect the motor generator set as shown in fig.1 for the open circuit test.

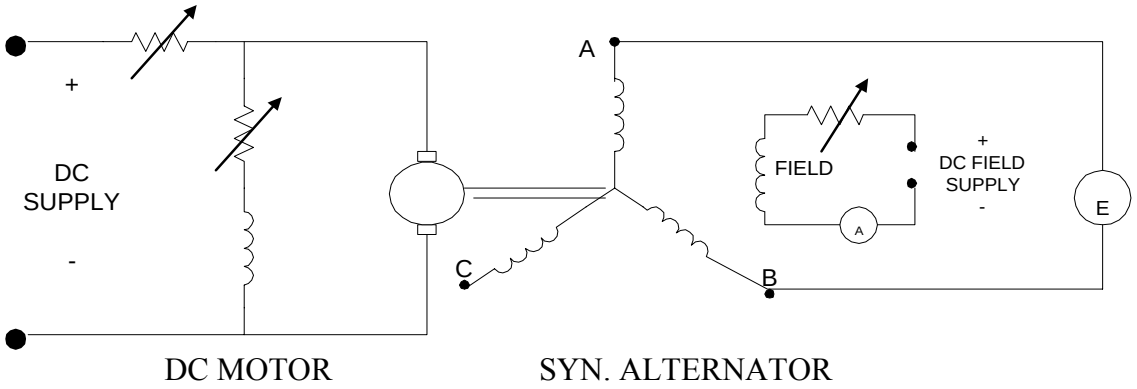
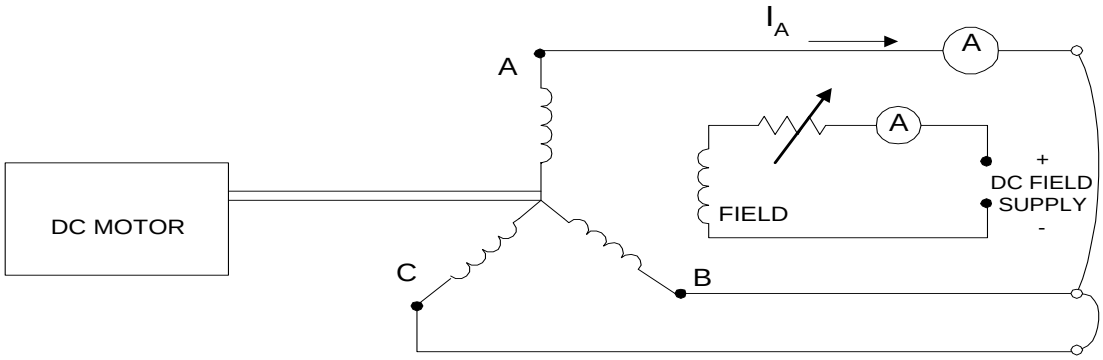


Fig.1: The Open Circuit Test

3. Adjust the alternator field rheostat to the maximum value and that for the motor to the minimum value.
4. Adjust the motor speed to the synchronous speed of the alternator. You can control the speed by the resistors in the line or in the motor field circuit.
5. Vary the field current in steps by varying the rheostat in the field circuit and/or the supply voltage. Record the line-to-line voltage (E) and the filed current I_f. Make sure that the speed remains constant through the whole test.
6. Take the readings upto 110 % of the rated voltage of the alternator.
7. Stop the motor and connect as in fig .2 for the short circuit test of the alternator



DC MOTOR SYN. ALTERNATOR

Fig.2 The Short Circuit Test

8. With the generator exciter off, bring DC motor upto synchronous speed. Close the 3Φ switch and gradually increase the excitation. Record the field current I_f and the armature current I_a. Take readings upto 120 % of the rated generator current.
9. Switch the alternator exciter off. Stop the motor and make connection as given in fig.3 for measurement of DC resistance of the armature.

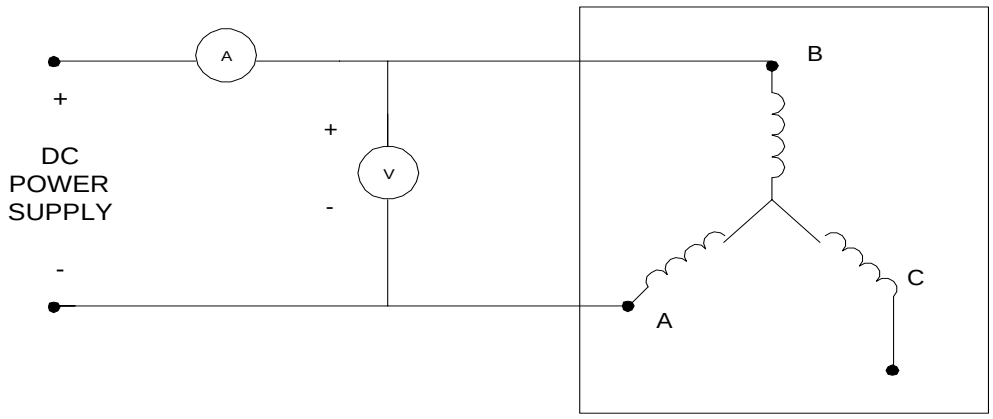


Fig.3: DC Resistance measurement Of The Alternator

10. Adjust the DC power supply so that the current flowing through the alternator winding does not exceed the rated value. The DC resistance is given as

$$R_{dc} = V_{dc} / 2I_{d\,c}$$

The armature resistance R_a can be considered to be 1.5 times R_{dc}

Note: the armature DC resistance can also be measured by an accurate millimeter, or by some resistance measurement bridge.

Report:

1. Using the OCC and SCC test results, plot E_A and I_A against I_f on the same graph paper.
2. From the plotted graphs, determine Z_s and X_s using equations (1) and (2). Calculate only the saturated value.
3. Calculate, analytically, the voltage regulation of the generator for the following loading conditions:

   One. Rated load, unity power factor
   Two. Rated load, 0.8 lagging p.f
   Three. Rated load, 0.8 leading p.f

   Use equations (3) and (4).

