Regulation Of Synchronous Generator :

The regulation of an alternator can be determined by various methods. In case of small capacity alternators it can be determined by direct loading test while for large capacity alternators it can be determined by synchronous impedance method.

The synchronous impedance method has some short comings. Another method which is popularly used is ampere-turns method. But this method also has certain disadvantages. The disadvantages of these two methods are overcome in a method called zero power factor method. Another important theory which gives accurate results is called Blondel's two reaction theory. Thus there are following methods available to determine the voltage regulation of an alternator,

1. Direct loading method
2. Synchronous impedance method or E.M.F. method
3. Ampere-turns method or M.M.F. method
4. Zero power factor method or potier triangle method
5. ASA modified from of M.M.F. method
6. Two reaction theory

Voltage Regulation by Direct Load

The Figure 1.19. shows the circuit diagram for conducting the direct loading test on the three phase alternator. The star connected armature is to be connected to a three phase load with the help of triple pole single throw (TPST) switch. The field winding is excited by separate d.c. supply. To control the flux i.e. the current through field winding, a rheostat is inserted in series with the field winding. The prime mover is shown which is driving the alternator at its synchronous speed.

Procedure : The alternator is first driven at its synchronous speed N_s by means of a prime mover. Now $E_{ph} \alpha \Phi$ .....(From e.m.f. equation)

By giving d.c. supply to the field winding, the field current is adjusted to adjust the flux so that rated voltage is available across the terminals. This can be observed on the voltmeter connected across the lines. The load is then connected by means of a TPST switch. The load is then increased so that ammeter reads rated value of current. This is full load condition of the alternator. Again adjust the voltage to its rated value by means of field excitation using a rheostat connected. The throw off the entire load by opening the TPST switch, without changing the speed and the field excitation.

Observe the voltmeter reading. As load is thrown off, there is no armature current and associated drops. So the voltmeter reading in this situation indicates the value of internally induced e.m.f. called no load terminal voltage. Convert both the reading to phase values. The rated voltage on full load is V_{ph} while reading when load is thrown off is E_{ph}.

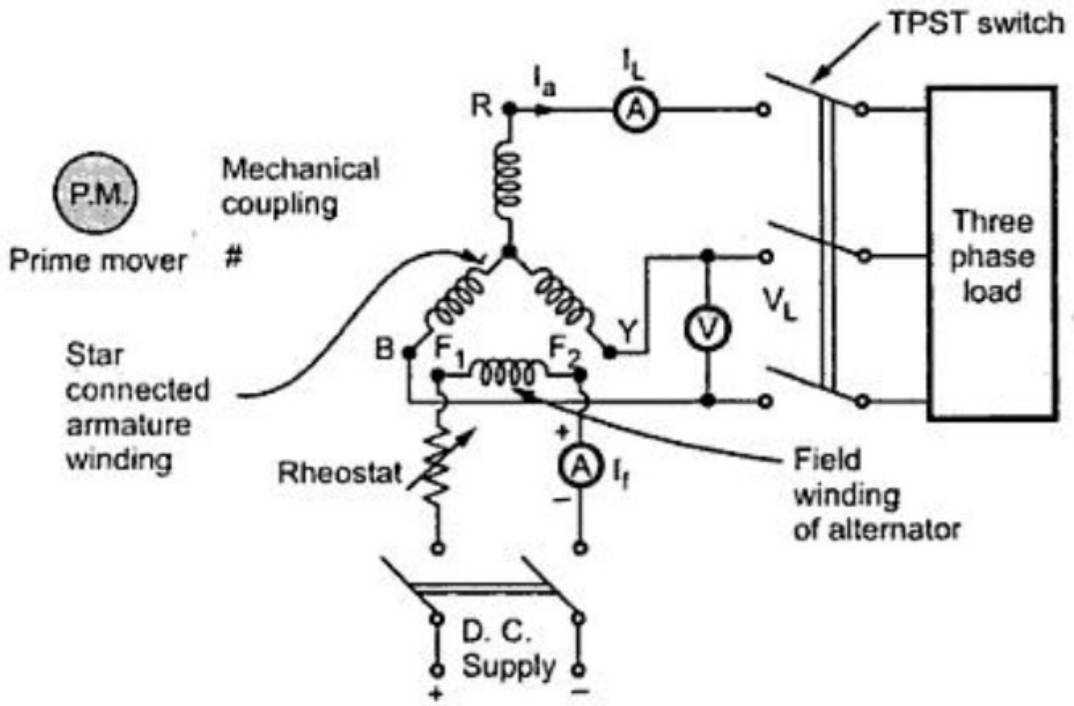

Figure 1.19 open circuit and short circuit test

Synchronous Impedance Method or E.M.F. Method

The method is also called E.M.F. method of determining the regulation. The method requires following data to calculate the regulation.

1. The armature resistance per phase (R_a).
2. Open circuit characteristics which is the graph of open circuit voltage against the field current. This is possible by conducting open circuit test on the alternator.
3. Short circuit characteristics which is the graph of short circuit current against field current. This is possible by conducting short circuit test on the alternator.

Let us see, the circuit diagram to perform open circuit as well as short circuit test on the alternator. The alternator is coupled to a prime mover capable of driving the alternator at its synchronous speed. The armature is connected to the terminals of a switch. The other terminals of the switch are short circuited through an ammeter. The voltmeter is connected across the lines to measure the open circuit voltage of the alternator.

The field winding is connected to a suitable d.c. supply with rheostat connected in series. The field excitation i.e. field current can be varied with the help of this rheostat. The circuit diagram is shown in the Figure 1.19

Open Circuit Test

Procedure to conduct this test is as follows :

i) Start the prime mover and adjust the speed to the synchronous speed of the alternator.

ii) Keeping rheostat in the field circuit maximum, switch on the d.c. supply.

iii) The T.P.S.T switch in the armature circuit is kept open.

iv) With the help of rheostat, field current is varied from its minimum value to the

rated value. Due to this, flux increasing the induced e.m.f. Hence voltmeter reading, which is measuring line value of open circuit voltage increases. For various values of field current, voltmeter readings are observed.

The observation for open circuit test are tabulated as below :

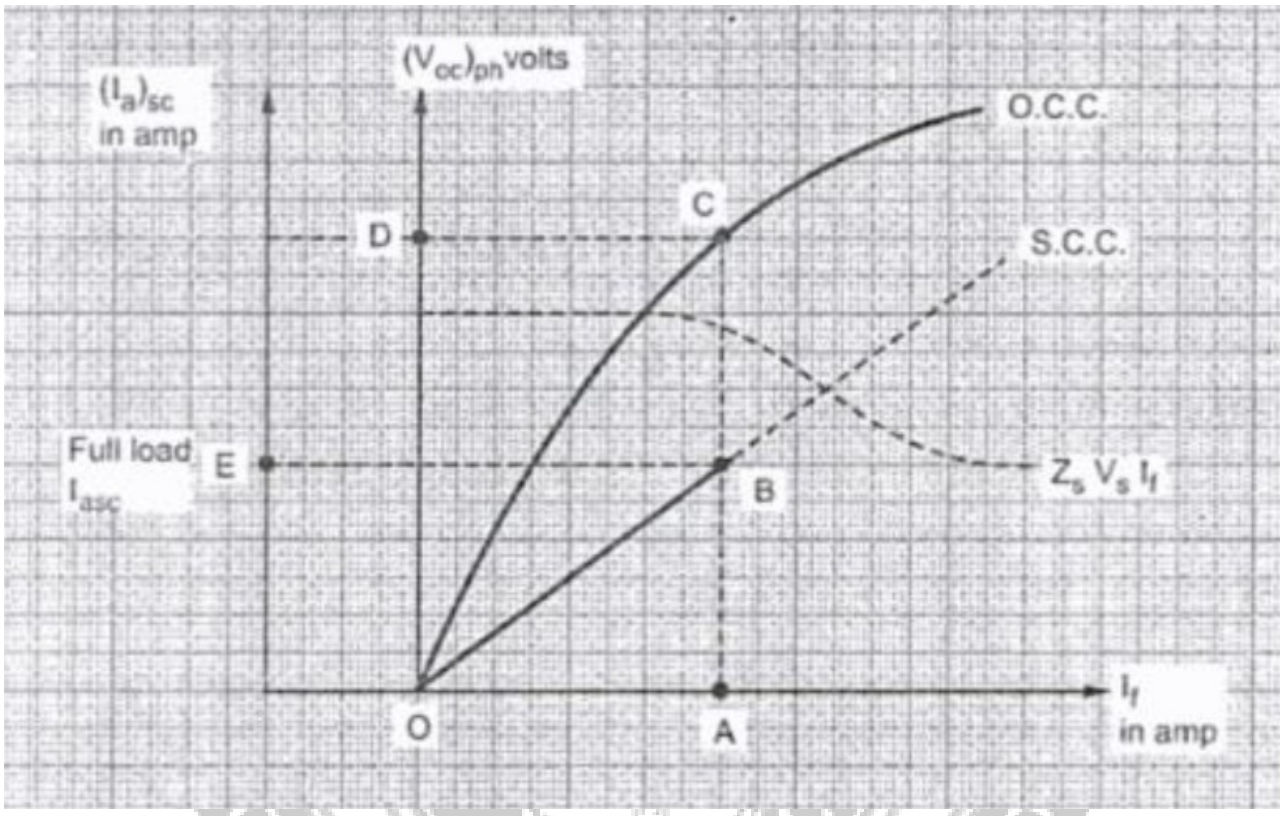

Figure 1.20 OC & SC characteristics

Short Circuit Test

After completing the open circuit test observation, the field rheostat is brought to maximum position, reducing field current to a minimum value. The T.P.S.T switch is closed. As ammeter has negligible resistance, the armature gets short circuited.

Then the field excitation is gradually increased till full load current is obtained through armature winding. This can be observed on the ammeter connected in the armature circuit. The graph of short circuit armature current against field current is plotted from the observation table of short circuit test. This graph is called short circuit characteristics, S.C.C. This is also shown in the Figure 1.20.

Advantages and Limitations of Synchronous Impedance Method

The main advantages of this method is the value of synchronous impedance $Z_s$for any load condition can be calculated. Hence regulation of the alternator at any load condition and load power factor can be determined. Actual load need not be connected to the alternator and hence method can be used for very high capacity alternators

The main limitation of this method is that the method gives large values of synchronous reactance. This leads to high values of percentage regulation than the actual results. Hence this method is called pessimistic method