

Experiment-6: Characteristics of a Self-excited DC Shunt Generator

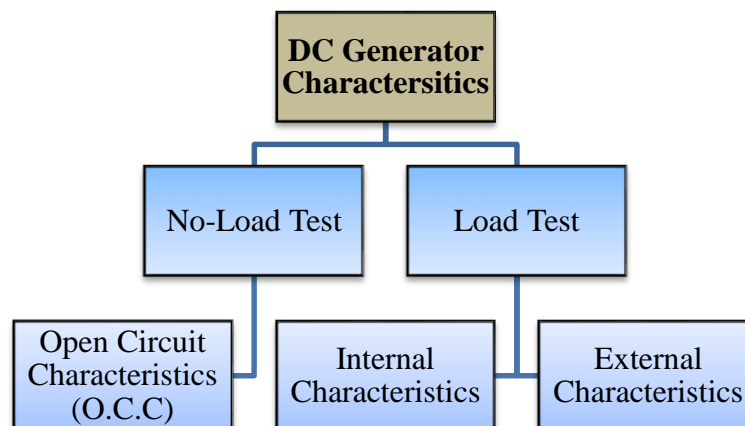
1. Objective

The objective of this experiment is to study the following characteristics of a DC shunt generator.

- Open Circuit Characteristics (O.C.C) through no-load test to determine the critical field resistance and critical speed.
- External Characteristics through load test.

2. Theory of DC Shunt Generator Characteristics

For a self-excited DC shunt generator, the field excitation is provided by the generator output voltage itself. The armature e.m.f starts building with the help of the residual magnetism in the ferromagnetic core. Generally, it is seen that when load on generator increases from no-load to full load, the terminal voltage will decrease due to armature reaction and voltage drop in armature, which are practically absent under no-load conditions. Hence it is necessary to study the performance characteristics under these two condition. The following are the characteristics of DC generators are taken into consideration:



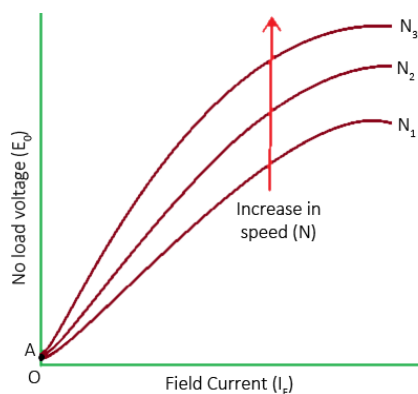


Fig.a: O.C.C.

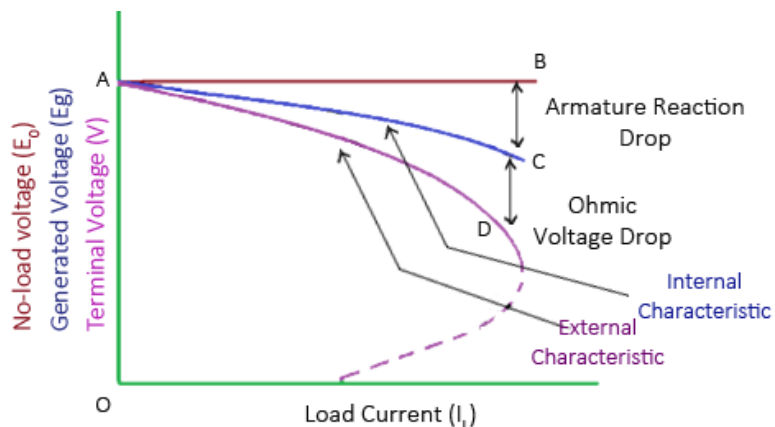


Fig.b: Internal and External characteristics

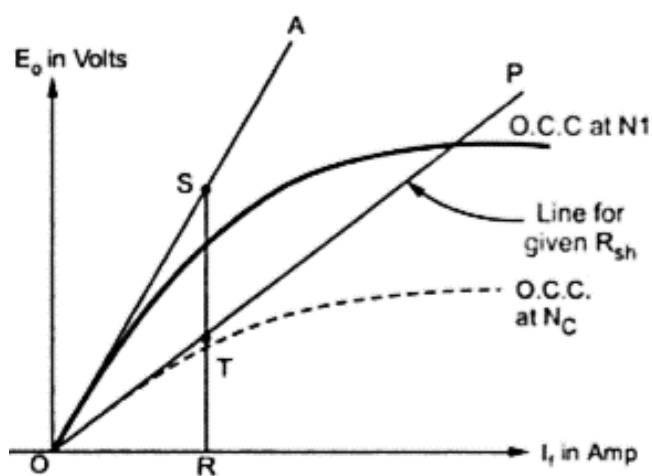


Fig.c: Calculation of critical resistance and speed

2.1 Open Circuit Characteristic (O.C.C.) (E_0/I_f)

Open circuit characteristic is also known as magnetic characteristic or no-load saturation characteristic. This characteristic shows the relation between generated emf at no load (E_0) and the field current (I_f) at the given fixed speed. The O.C.C. curve is just the magnetization curve and it is practically similar for all type of generators. The data for O.C.C. curve is obtained by operating the generator at no load and keeping speed constant. Field current is varied and the corresponding terminal voltage is recorded.

2.2 Internal or Total Characteristic (E/I_a)

The internal characteristic curve shows the relation between the on-load generated emf (E_g) and the armature current (I_a). The on-load generated emf E_g is always less than E_0 due to

armature reaction. E_g can be determined by subtracting the drop due to demagnetizing effect of armature reaction from no-load voltage E_0 . Therefore, internal characteristic curve lies below O.C.C. curve.

2.3 External Characteristic (V/I_L)

The external characteristic curve shows the relation between the terminal voltage (V) and load current (I_L). The terminal voltage V is less than generated emf E_g due to voltage drop in the armature circuit. Therefore, the external characteristic curve lies below the internal characteristic curve. External characteristics are very important to determine the suitability of a generator for a given purpose.

When load resistance is decreased in DC shunt generator, the load current increases. But, load resistance can be decreased up to a certain limit, beyond this limit any further decrease in load resistance results in decreasing load current and terminal voltage. Consequently, the external characteristic curve turns back as shown by dotted line in above figure.

2.4 Critical Resistance and Critical Speed

The critical field resistance is defined as the maximum field circuit resistance (for a given speed) with which the shunt generator would excite. The shunt generator will build up voltage only if field circuit resistance is less than critical field resistance. For a given speed of rotation, the output voltage of the generator fails to reach the desired level in the case the resistance of the field circuit exceeds an upper limit. The respective upper limit defines the critical resistance of the field circuit of the generator.

In the same way, for a particular field resistance, the generator fails to excite when the generator speed falls below a lower limit. The respective lower limit defines the critical speed of the generator. It is to be noted that the critical resistance varies with the generator speed as shown in above figure (O.C.C.) and the critical speed varies with the generator field resistance.

CRITICAL RESISTANCE (R_C):

Draw the tangent (shown by OA in above Fig.c), to the initial part of this O.C.C. then the slope of this line is the critical resistance for that particular speed.

Note: If speed changes, then the O.C.C. changes hence the value of R_C will also change.

CRITICAL SPEED (N_c):

It is known that as speed changes, the open circuit characteristics also changes, similarly for different shunt field resistances, the corresponding lines are also different. For the calculation of critical speed follow the below procedure.

- 1) Take a particular value of R_{sh} (E_0/I_f) and draw a line from origin connecting to that point (shown by OP in Fig.c).
- 2) Select any field current say point R.
- 3) Draw vertical line from R to intersect OA at S and OP at T.
- 4) Then the critical speed N_c is,

$$N_c = N_{\text{nominal}} \times \frac{RT}{RS}$$

3. Circuit Arrangement

The circuit arrangements are shown in the following Figures. Here, A and AA are the terminals of the armature winding; F and FF are the terminals of the field winding. Resistance $R_{f,ex}$ is the external resistances connected in series with the field winding. Care should be taken for the connection for armature and field terminals. A wrong connection will cause demagnetization of the residual magnetism making the DC generator fail to excite. The DC generator is mechanically coupled with synchronous motor which acts as prime mover.

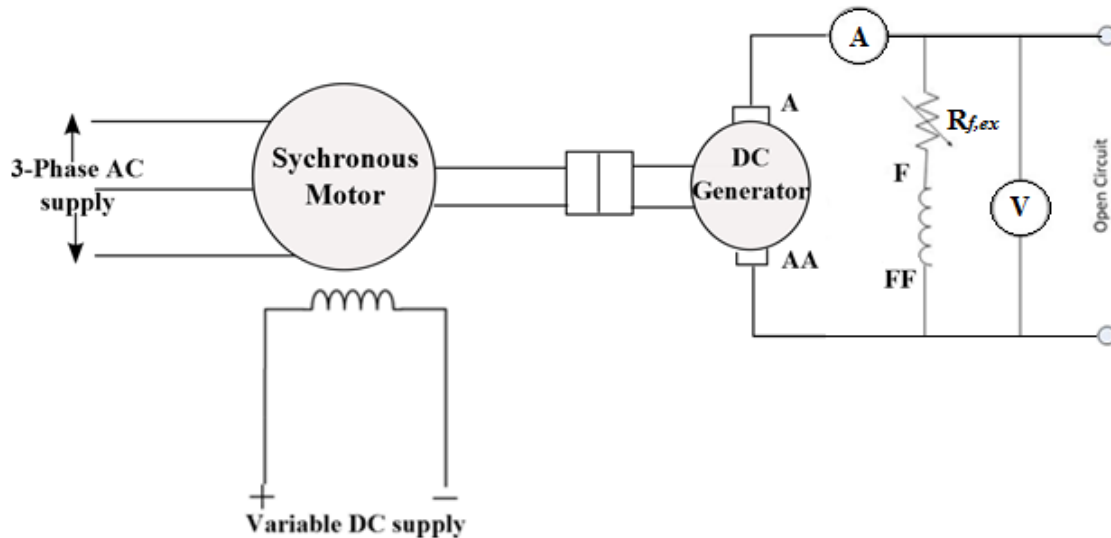


Fig. Circuit arrangement to obtain no-load characteristics.

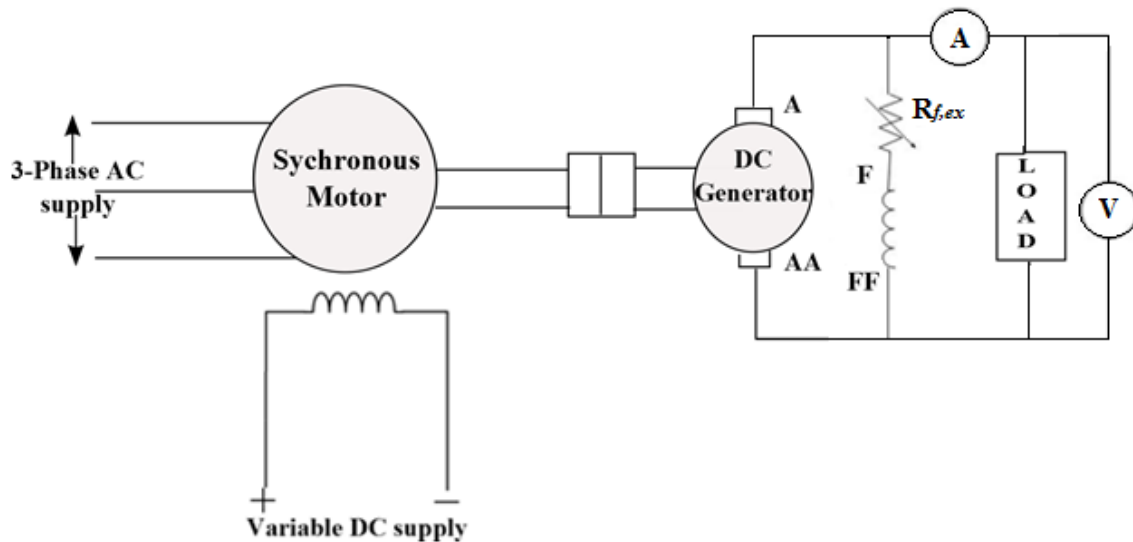


Fig. Circuit arrangement to obtain load characteristics.

4. Test Procedure

Open Circuit Characteristic (O.C.C.) (E_0/I_f):

- 1) The rheostat in the field circuit should first be set at the maximum position.
- 2) Bring the synchronous motor speed to the nominal value by adjusting 3-Ph variable AC supply and variable DC field supply. The speed of the motor can be measured by using a tachometer.
- 3) Now, the resistance of the rheostat is to be gradually reduced while continuously monitoring the voltage reading across the terminals of the DC generator. It can be observed that the output voltage of the DC generator is initially very small, but will suddenly start building as resistance of the rheostat is gradually reduced. (If this does not happen reduce the prime-mover input and switch off the supply. Interchange the field terminals of the generator and repeat the same procedure).
- 4) Tabulate the readings of E_0 and I_f for different rheostat positions (at least 10 positions).
- 5) Plot the graph between E_0 and I_f which gives the O.C.C.
- 6) Calculate critical field resistance and critical speed from the plot.

External Characteristics (V/I_L):

- 1) The rheostat in the field circuit should first be set at the maximum position.
- 2) Bring the synchronous motor speed to the nominal value by adjusting 3-Ph variable AC supply and variable DC field supply. The speed of the motor can be measured by using a tachometer.
- 3) Now, the resistance of the rheostat is to be gradually reduced while continuously monitoring the voltage reading across the terminals of the DC generator. It can be

observed that the output voltage of the DC generator is initially very small, but will suddenly start building as resistance of the rheostat is gradually reduced. (If this does not happen reduce the prime-mover input and switch off the supply. Interchange the field terminals of the generator and repeat the same procedure).

- 4) Once, the generator output reaches to the nominal value, take the readings of terminal voltage by increasing the load current, while keeping field current constant.
- 5) Plot the graph between V and I_L which gives the external characteristics.

5. Results

O.C.C.:

S.No	No-Load Voltage (E_0)	Field current (I_f)
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		

External characteristics:

S.No	Load Current (I_L)	Terminal Voltage (V)
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		

6. Conclusions

1. Plot the O.C.C and External characteristics.

Nominal speed = ----- (rpm)

Critical speed = ----- (rpm)

Critical resistance = ----- (rpm)

2. Comment on the concept of Residual Magnetism and Residual Voltage. Identify the Residual Voltage observed for the machine used in the experiment.

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