Electrical Machines (EE3500) EE19BTECH11041

Experiment 5: characteristics of a Self-Exited DC Shunt Generator.

Aim:

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

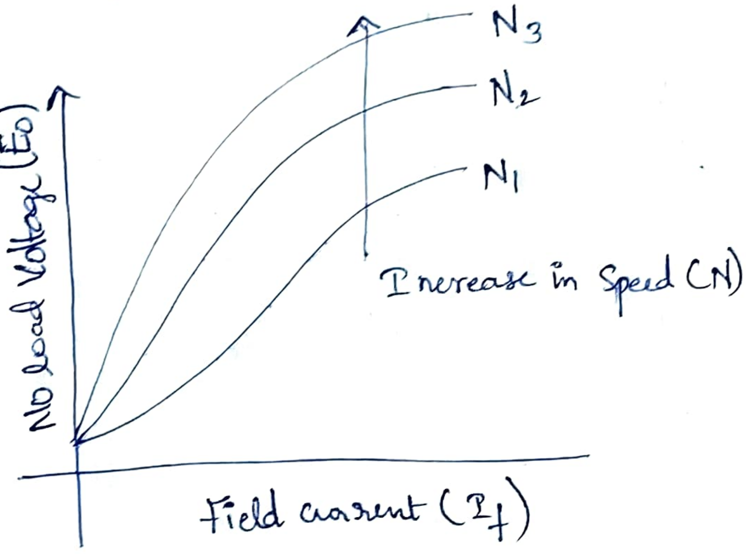
* open circuit Characteristics (O.C.C) through no-load test to determine the critical field resistance and Critical Speed.
* External characteristics through load test.

Theory:

For a self-exited 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 the two condition → No-load Test, ~~Load Test~~.

Open circuit characteristic (O.C.C) (E_0/I_f):

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 types 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 corresponding terminal voltage is recorded.



O.C.C

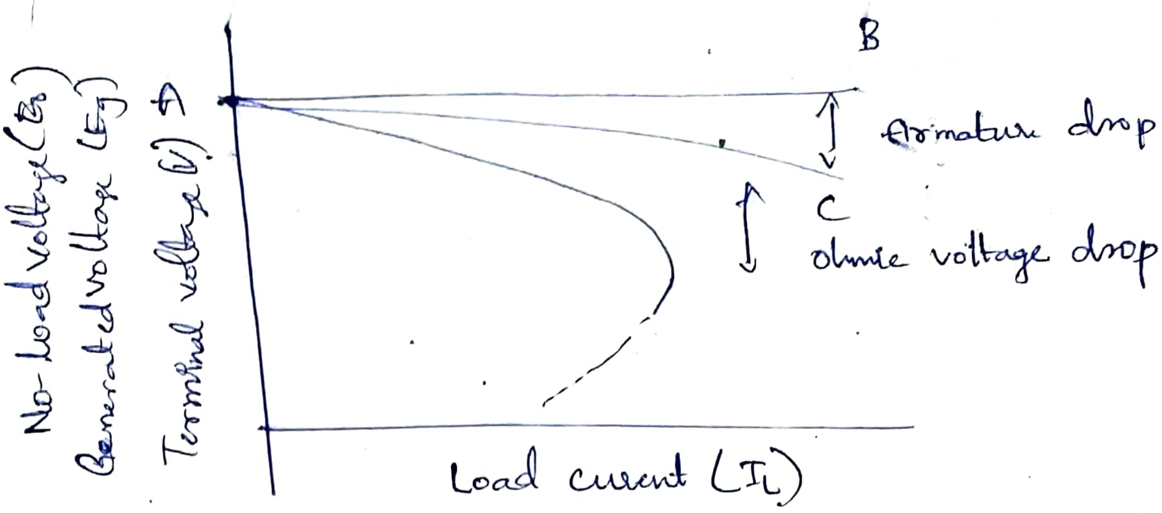
Internal characteristic (E/I_a):

This 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.

External characteristic (V/I_L):

This 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 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 and terminal voltage.



Internal and External characteristics

Critical Resistance and Critical Speed:

The Critical field resistance is defined as the maximum field resistance 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 ~~rotator~~ 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):

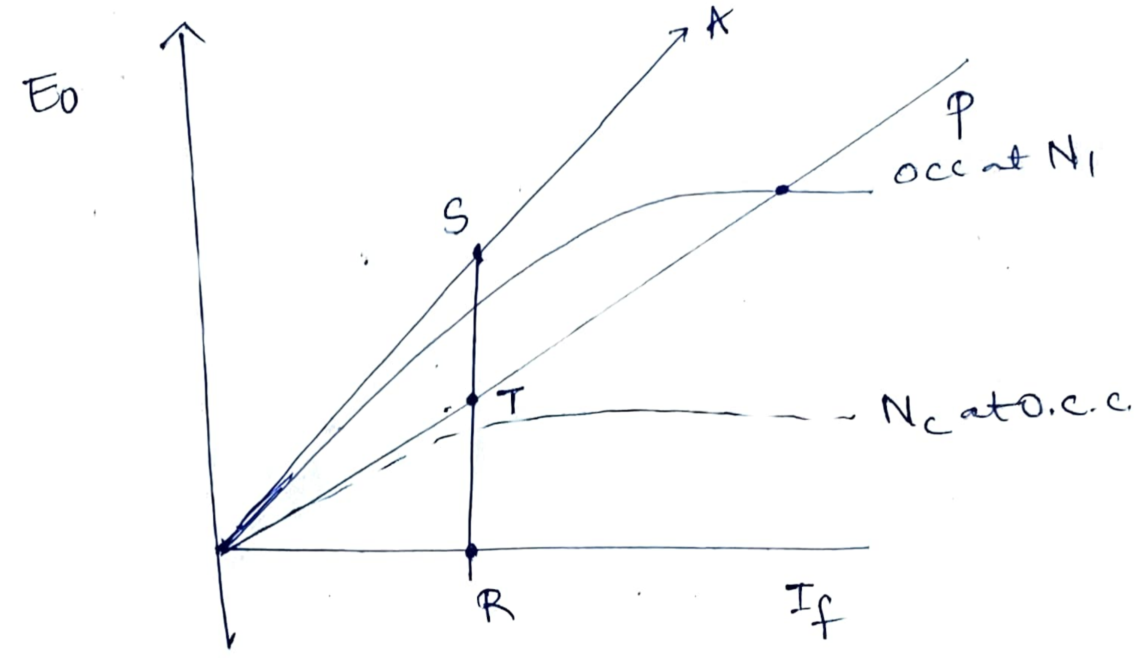
Draw the tangent to the initial part of this O.C.C then the slope of this line is the critical resistance for that particular speed.

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)
2. Select any field current say point R.
3. Draw vertical line from R to intersect at S and OP at T.
4. Then the critical speed N_c is

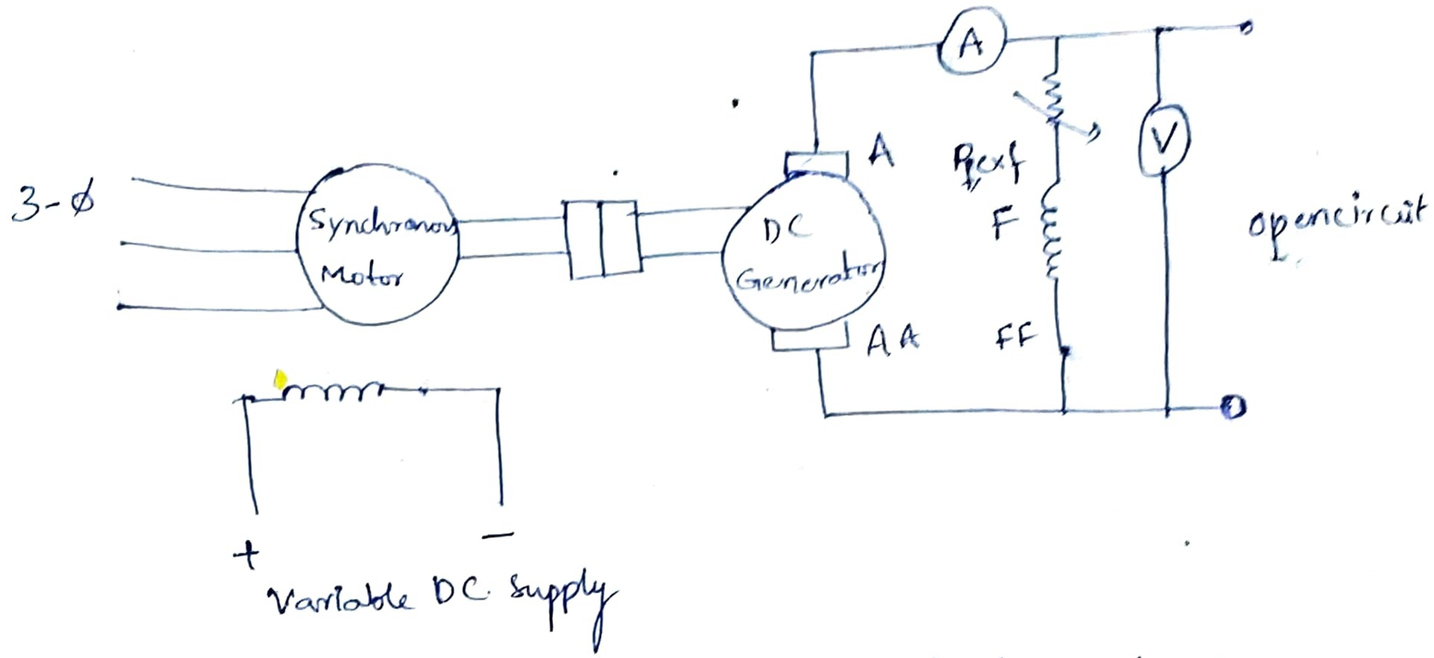
$$N_c = N_{nominal} \times \frac{RT}{RS}$$



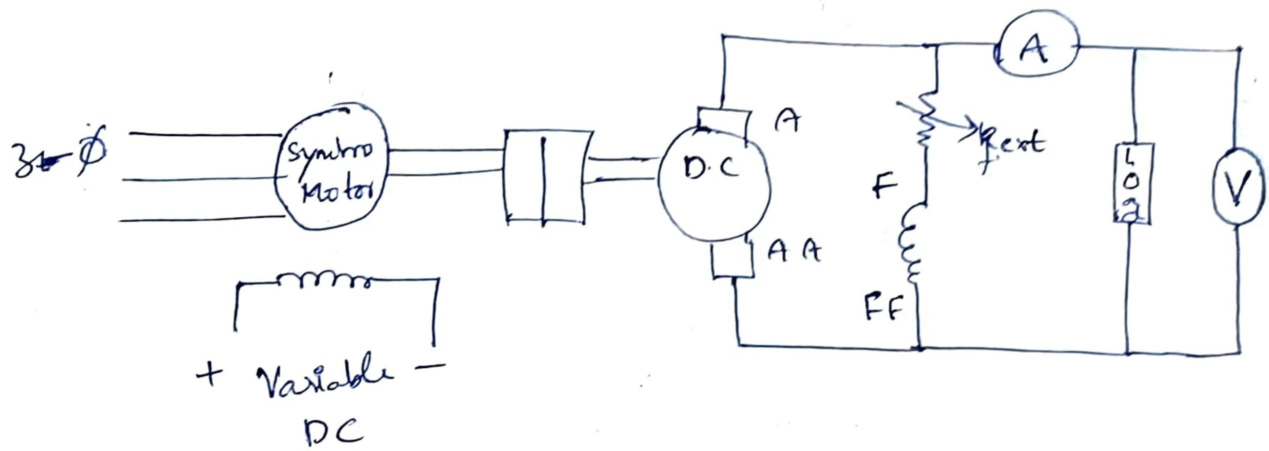
Calculation of Critical resistance and Speed.

Circuit Arrangement:

The circuit arrangements are shown in the following figures. 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 resistance 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.



Circuit to obtain no-load characteristics



Circuit arrangement to Obtain load characteristics

Procedure:

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 speed by adjusting 3-ph variable AC supply and variable D.C supply. The speed of 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 readings across the terminals of D.C. generator. It can be observed that the output voltage is initially very small, but will suddenly start building as resistance of the rheostat is gradually reduced.

4. Tabulate the readings of E_0 and I_f for different rheostat positions (atleast 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 should ~~be~~ first be set at the maximum position.

2. Bring the Synchronous motor speed to the nominal value by adjusting 3-ph variable A C spply and Variable D.C Supply. The speed of the Motor can be measured by using a tachometer

3. Now, the resistance of rheostat is gradually reduced while continously monitoring the voltage reading across the terminals of the DC generator. It can be observed that the output voltage of the DC generator is intially very small, but will suddenly start building as resistance is gradually reduced.

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

Results:

O.C.C

S.No.	No-Load Voltage (E_o)	Field current (I_f)
1	55V	0.12 A
2	75 V	0.16 A
3	80 V	0.17 A
4	84V	0.18 A
5	96V	0.21A
6	109V	0.23A
7	125 V	0.27A
8	141 V	0.32A
9	154V	0.36A
10	164V	0.39 A
11	177V	0.45A
12	182V	0.47A
13	190V	0.52A
14	203 V	0.59A
15	206V	0.61A
16	213V	0.66A
17	215V	0.67A
18	218V	0.70A
19	221V	0.72A

External characteristics :

S.No	Load Current (I_L)	Terminal Voltage (V)
1	2.02 A	220V
2	2.89A	218V
3	3.77A	216 V
4	4.63A	215 V
5	5.47A	213 V
6	6.3 A	212 V
7	7.12A	211 V
8	7.92A	209 V
9	8.71A	208 V
10	9.47A	206 V
11	10.23A	205 V
12	10.98 A	203 V
13	11.72A	201 V
14	-	-
15	—	—

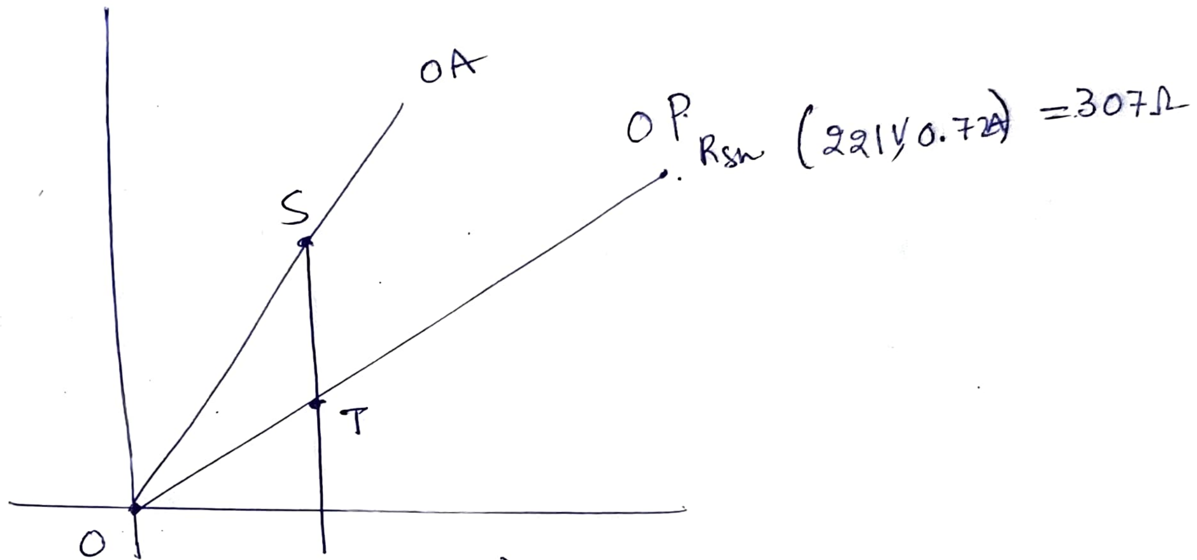
6 Conclusions:

Here

1. Nominal Speed = 1500 rpm.

Critical resistance = Slope of O.C.C at initial

$$R_C = \frac{20V}{0.04} = 500\,\Omega$$



$RT = R_{sh}(I_o)$

$RS = R_c(I_o)$

$$N_c = N_{nominal} \times \frac{RT}{RS} = 1500 \times \frac{R_{sh}}{R_c}$$

$$\boxed{N_c = 920.83 \text{ rpm}}$$

Critical Speed = 920.83 rpm

Conclusions :

(2) Residual Magnetism :

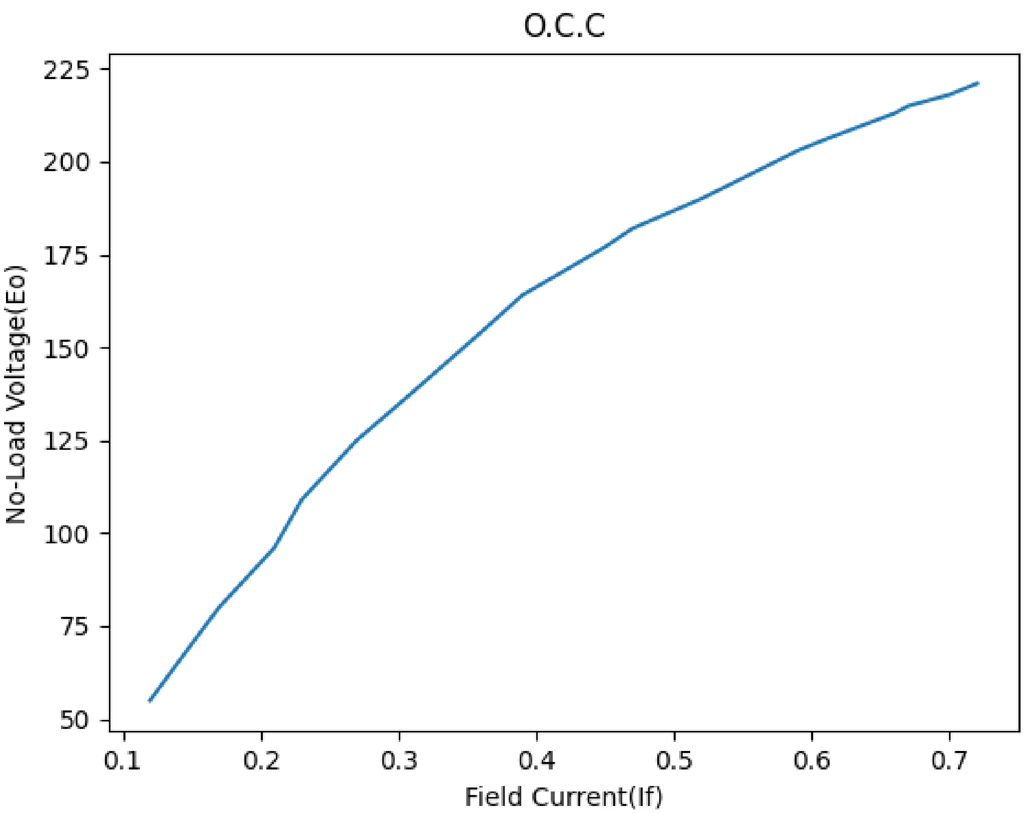
Magnetization left in the core(or) ferromagnetic material when the external excitation or magnetic field is removed is called residual magnetism.

Residual voltage :

The EMF generated in D.C. genator at which field current is zero and ~~word~~ rotors are rotated under the influence of Residual flux is called residual voltage.

$\boxed{V_{residual} = 0.1\,V}$ Here we haven't observed residual voltage value when experiment was conducted.

O.C.C :



External Characteristics: