Self-excitation In DC Generator

Aim

- To observe voltage buildup in a self-excited DC generator

Theory

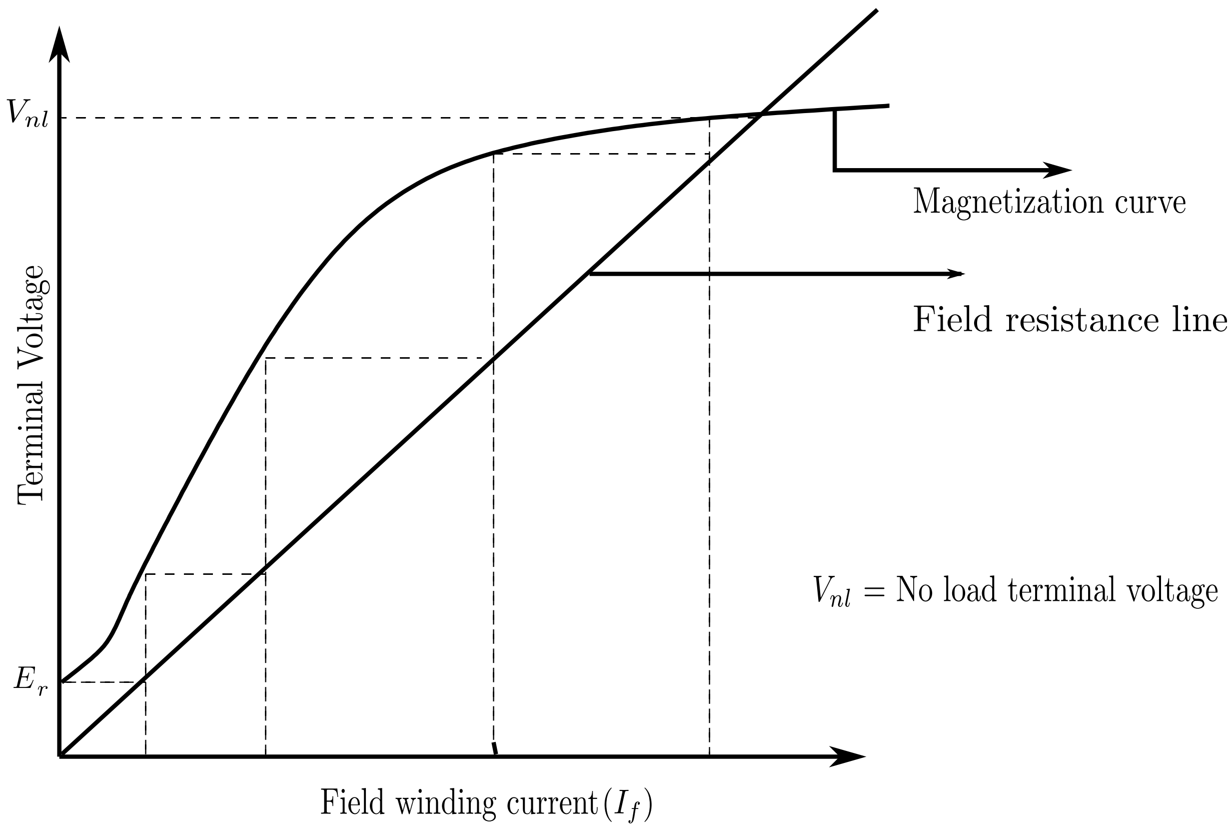

Figure 1: Voltage buildup in self-excited generator

Most of the shunt DC generators work on the principle of self-excitation. Following a positive feedback like action, the flux in a self-excited DC generator, builds up from a small amount of residual magnetism present in the field poles. From the theory of magnetism, this means that not all magnetic dipoles are randomly aligned but some of them are aligned in the same direction giving rise to a residual magnetic field.

In self-excited DC generators, the field winding is connected across the armature. Hence, the terminal voltage is also the field voltage and the armature current is the sum of load and field currents. When the rotor of this machine is rotated, the residual flux in the field winding induces some voltage (E_r) in the armature winding as shown in Fig.1 . Since the field winding is connected across the armature, because of this induced emf a small current starts flowing in the field winding. If the field mmf due to this current aids the residual flux, total airgap flux increases. This increase in flux increases the induced emf, which, in turn, increases the field current. This action is cumulative in nature.

If the field winding is connected in such a way that the flux produced by the field current opposes the residual flux, the generator fails to build up. This problem can be corrected by either reversing the direction of rotation or interchanging the field winding connections across the armature. The value of no-load voltage at the armature terminals depends on the field resistance (point of intersection of field resistance line with magnetization curve is the operating point). A decrease in the field resistance causes the generator to build up faster to a higher voltage.

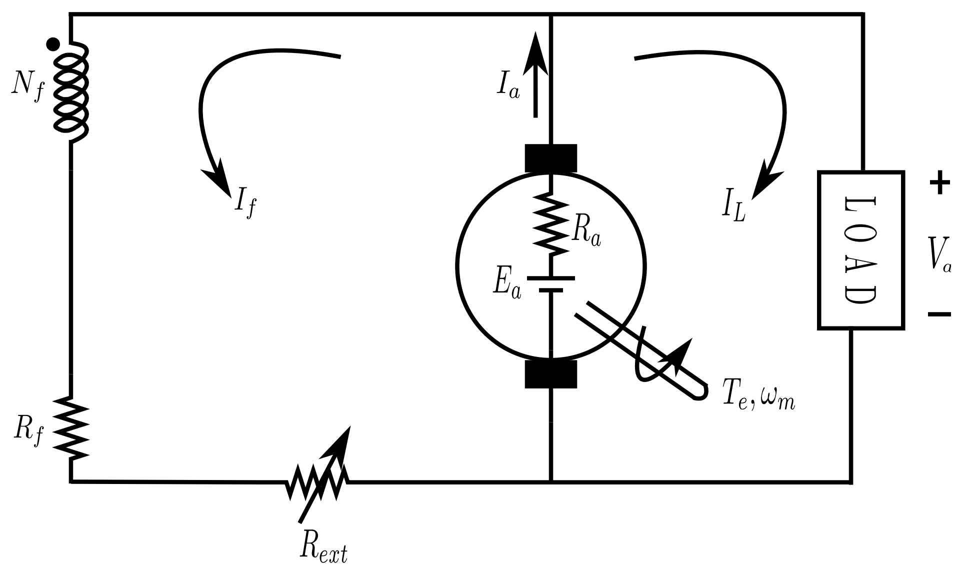

Figure 2: An equivalent circuit of self-excited DC generator

The equivalent circuit representation under steady state condition is shown in Fig.2. Here, $R_f + jX_f$ represents the field impedance. The armature current I_a can be split into two parts, namely, field current I_f and load current I_L. E denotes the armature voltage developed. The equations that govern the operation of a self excited generator under steady state are:

$$\begin{aligned} I_a &= I_L + I_f \\ V_a &= I_f(R_f + R_{ext}) \\ &= I_L R_L \\ &= E - I_a R_a \end{aligned}$$

Under no load condition, the armature current is equal to the field current, which is a small fraction of load current. Therefore the terminal voltage under no-load condition is nearly equal to the induced emf ($I_a R_a$ drop on no-load is very small). As the load current increases, the terminal voltage decreases due to the following reasons:

- I_a R_a drop
- demagnetization effect of the armature reaction
- decrease in the field current due to reduction in the terminal voltage (in self excited generator field current falls with terminal voltage).

Procedure

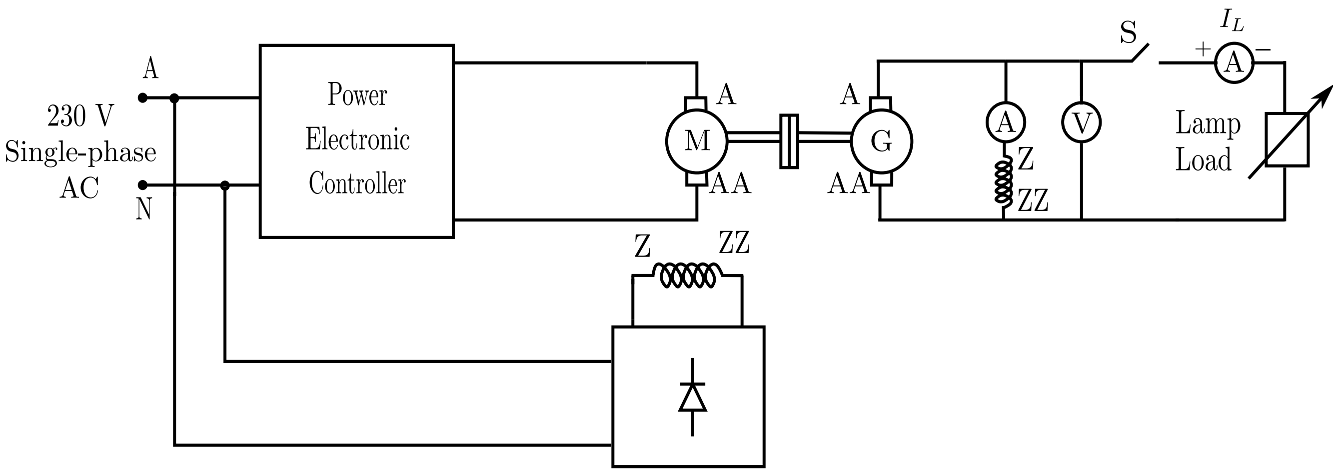

Figure 3: Circuit diagram for self-excited DC generator

* Note down the DC generator ratings from the name-plate.

A. Connect the circuit diagram as shown in Fig.3 (you need to connect the field winding across the armature instead of connecting it to a separate supply).

B. Slowly increase the input to the prime-mover. Speed of the set will increase. Observe the voltmeter connected across the terminals of the dc generator. Above a certain speed the voltmeter reading starts increasing (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). By controlling the input to the prime mover adjust the speed to the rated speed of the machine.

C. Incase in step-B the machine did self excite in the first attempt, interchange the field terminals of the dc generator and repeat the step - B.

D. Reduce the prime mover input and put off the AC supply to the controller.

Follow-up Questions

1. Why do you expect the field winding turns and resistance to be higher compared to the load?

2. What are the different types of self-excited DC generators?

References

(1) P.S.Bimbhra, “Electrical Machinery”, Ch.4

(2) A.E. Fitzgerald, C. Kingsley Jr., S.Umans, “Electric Machinery”, 6th Ed., Ch.7

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