EE-222
Experiment No.: 4
Characteristics of a Separately Excited DC Motor

Adarsh Kumar-160110071
Parthasarathi Khirwadkar - 16D070001
Archiki Prasad-160110085

March 26, 2018

1 Aim

To study the variation of speed with

- Armature Voltage
- Field Current

and to obtain the performance characteristics ($T - \omega$) of a seperately excited D.C motor.

2 Circuit Diagrams

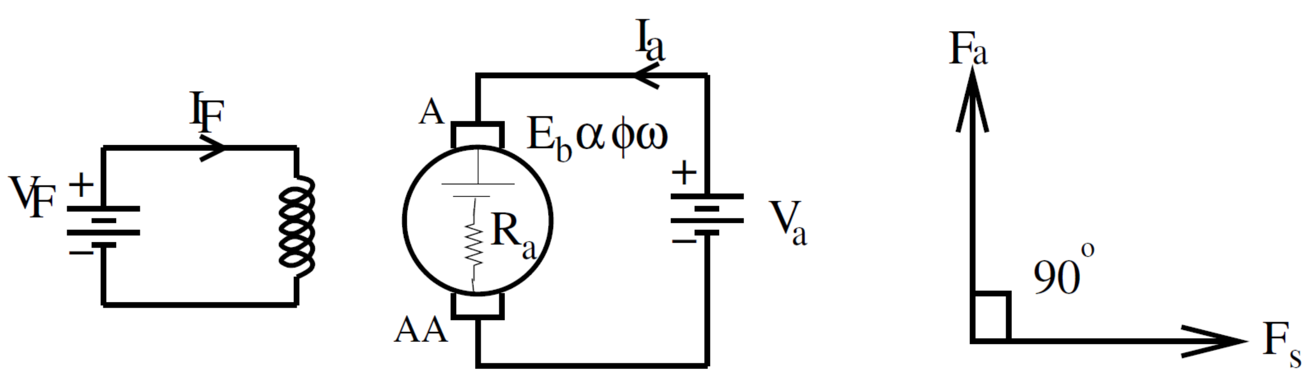

Figure 1: Seperately Excited DC Motor

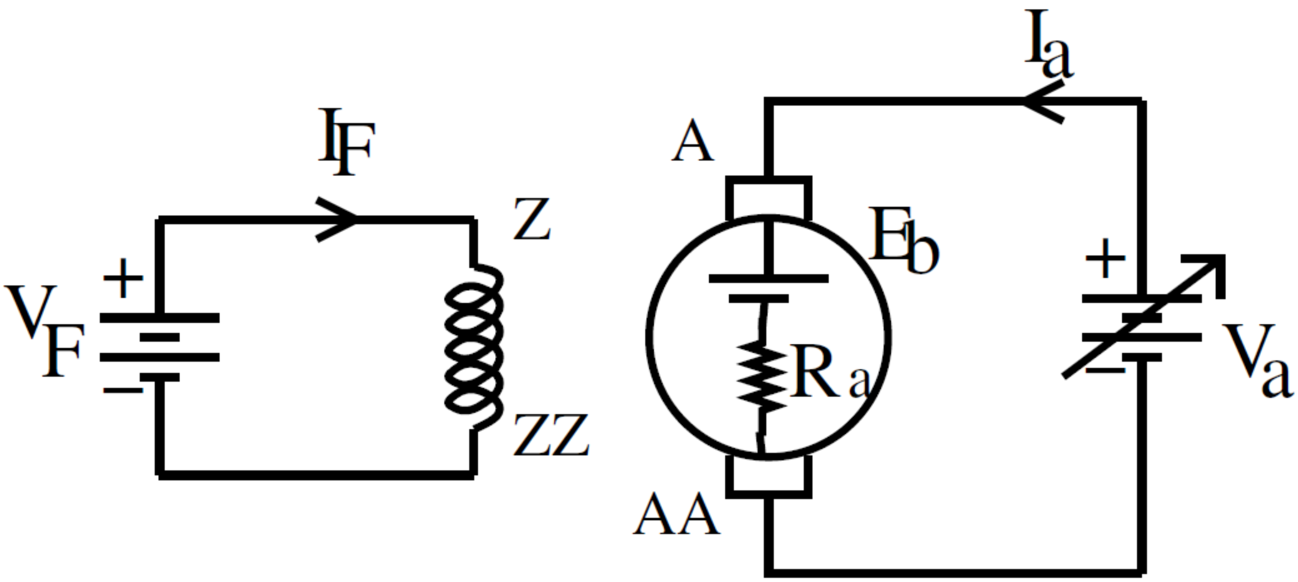

Figure 2: Schematic diagram for armature voltage control

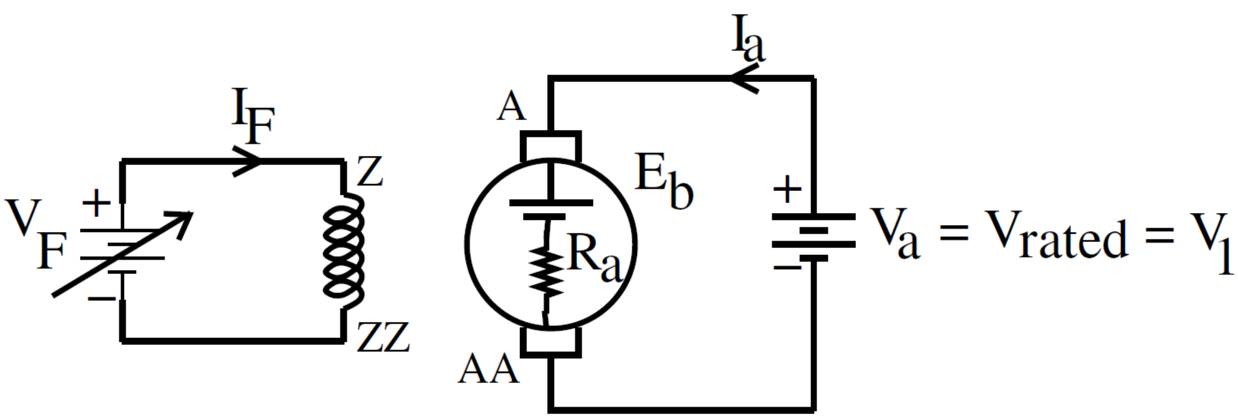

Figure 3: Schematic diagram for field control

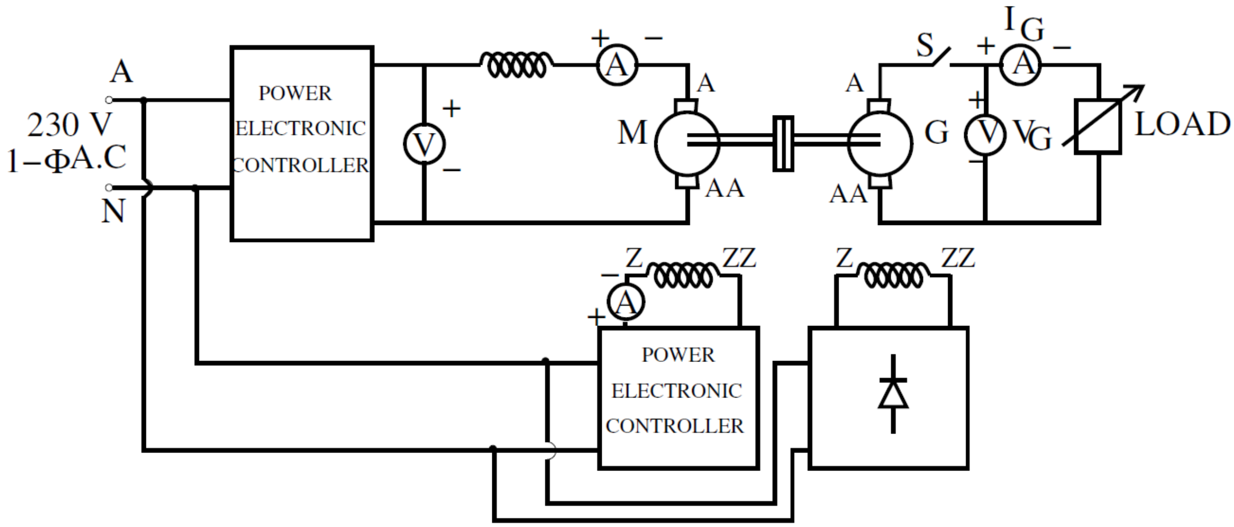

Figure 4: Circuit diagram for speed control of Separately Excited DC Motor

3 Observations

	Generator					Motor				
	Va	Ia	Vf	If	No of Loads	Va	Ia	Vf	If	Speed of motor(Nr)
At Rated	158.8	0	195.5	0.34	0	169.2	1.49	220	0.4	1495
	153.5	1.5	195.4	0.34	2	169.3	2.16	220	0.38	1482
	150	2.6	194.3	0.34	4	169.3	2.83	220	0.38	1471
	147.1	3.2	194.5	0.34	6	169.3	3.45	220	0.38	1460
	144	3.8	194.8	0.34	8	169.4	4.07	220	0.38	1448
Below Rated	132.8	0	196.6	0.52	0	141.9	1.25	220	0.52	1252
	127.8	0.7	194.8	0.48	2	141.9	1.84	220	0.52	1240
	124.6	2.1	195.3	0.46	4	141.9	2.44	220	0.52	1227
	121.7	2.8	195.6	0.46	6	141.9	2.99	220	0.52	1215
	119	3.9	195.6	0.46	8	141.9	3.54	220	0.52	1204
Above Rated	169.1	0	195.6	0.46	0	168.6	1.36	171.5	0.39	1599
	163.2	0.6	194.9	0.48	2	168.6	2.25	171.4	0.4	1580
	159.5	1.7	194.8	0.46	4	168.6	2.81	171.4	0.39	1567
	156.2	2.5	194.5	0.46	6	168.6	3.5	171.4	0.39	1552
	152.9	3.6	194.5	0.46	8	168.6	4.19	171.4	0.39	1539

Figure 5: Observation table

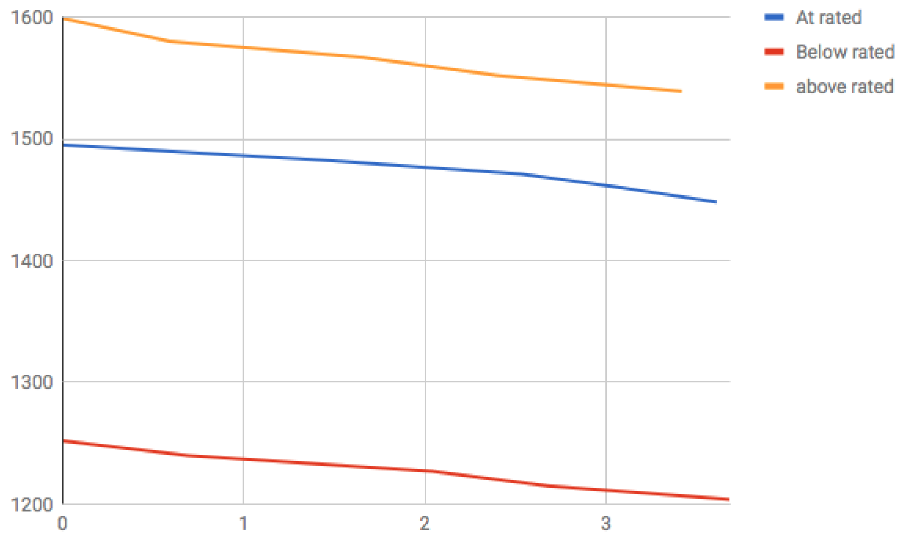

Figure 6: Plot of T-ω Characteristics

4 Inferences

The inferences we gathered from the experiment on separately excited DC motor operation is that that constant Va (armature voltage) speed of rotor decreases linearly with torque. We also noted from the graph that efficiency reaches a maxima with respect to output power. For speed variation, we have two cases. For varying speed below rated we vary the armature voltage and for speed above rated speed we lessen the field voltage thus, decreasing the field intensity.

5 Post-Lab Questions

1. **The condition to develop steady state torque is that the relative speed between the two fields should be zero. In other words, the two fields should be stationary wrt each other. In DC motor ,the speed of Fs is zero, while the armature is rotating .Explain how the condition is satisfied?**
   Answer: In a DC motor, while the armature is rotating, the effective F_a due to the current flowing in the armature windings is stationary. This is due the commutating action of the split ring and carbon brushes. The magneto-motive force F_a is in quadrature with F_s. Thus the torque produced is constant, both in direction and magnitude, and a steady torque is obtained.

2. **Why is the full field and reduced armature voltage applied to the DC motor while starting?**
   Answer: We apply a full field voltage to get maximum starting torque. When we start the machine the speed of the rotor is zero.Due to low armature resistance and the fact that at the start E_b or back emf is zero (since it is proportional to rotating speed of rotor), a reduced armature volatge is applied so that the armature current does not exceed it s rating.

3. **Whether the speed is independent of the direction of rotation? If it isn't what could be the reason?**
Answer. To reverse the motor, you need to change the polarity of the supply voltage to either the field winding or the armature winding, but not both. Generally it is better to reverse the field voltage because the field current is less than the armature current, so your reversing switchgear is more lightweight. The speed of the dc motor is not exactly independent of the direction of motion. This is because the no load speed of a dc motor = $\frac{V_o}{K\phi}$.
Theoretically, reversing the voltage in the field winding should reverse the magnetic field and hence the direction of rotation of the dc motor. However, due to the non-idealities, such as residual flux and the fact that B-H curve for the field coil is not exactly identical in the first and third quadrants. Hence the resultant flux is slightly different for both the cases, resulting in differing speeds of rotation.

4. **Armature reaction improves speed regulation. Is this statement true? Justify your answer.**
Answer: The armature reaction does indeed improve the speed regulation in a dc motor. Generally the drop in speed with increase in torque is small. In an actual machine, the armature reaction helps in maintaining the speed almost constant since a small decrease in the effective flux (due to armature reaction) reduces the drop in the speed as torque increases. (ω is inversely proportional to ϕ) Therefore if V_a and ϕ is almost constant, the speed is almost constant, independent of the torque applied to the shaft. Hence, to vary the speed of rotation, only the no-load speed needs to be varied.

5. **What may happen if the field circuit gets open circuited during motoring?**
Answer: The field circuit has an inductor and thus suddenly opening would generate a voltage spike and sparking in the field winding. Furthermore, the current there will be zero make the field zero and thus torque will become zero eventually thus stopping the motor after some time as there will be losses due to friction.

6. **Which type of motor is most suitable for electric traction?**
Ans. A DC series motor is the most suitable for use in electric traction. This is because it has a capability to produce higher torque at relatively lower speeds than a shunt machine. This provides a larger acceleration at low speed.

7. **What are the limitations of the S.E. dc motor?**
Ans. The S.E. dc motor requires two power supplies instead of one. Having two such separate DC power supplies(while accounting for additional space,additional circuits for- charging, discharging, over- voltage/undervoltage protection, etc.) This makes the process of designing the machine complex and also adds to the cost of the machine making it expensive. So it is rarely used until very precise control of torque is required.

8. **Why is it mentioned in section 2.1.2 that the maximum speed of operation is about 150% of the rated speed?**

Answer: At speed above the rated speed we are in the field weakening zone and thus field is decreased and thus torque is lower. If the torque becomes sufficiently small then it might not be able to overcome friction and thus the maximum speed may be capped to 150 percent of rated speed.

9. **In DC series motor the field winding is connected in series with the armature. Can a separately excited motor be converted to a series motor by connecting the field in series? Justify your answer.**
Ans. In a separately excited Dc motor, the field circuit carries only the magnetizing current which is very less as compared to the armature current. Thus, the field winding is very thin as compared to the armature winding. If the field winging is connected in series with the armature, due to the large current, the field will burn out. Hence a S.E DC motor cannot be converted into a series motor.