SHUNT, SERIES, COMPOUND EXCITED DIRECT CURRENT MACHINE

PREPERATION QUESTIONS

1) Write the coils and their usefullness in DC machines
2) Why are the brushes should be located in neutral position?
3) What is the effect of armature reaction to the neutral region, field under the pole and induced voltage?
4) Where are the DC machines commonly used ?

EQUIPMENTS

One general purpose direct current machine, one salient pole generator, two adjustable dc sources, tachometer, Volt meters, Ammeters, moment meter, single phase Wattmeter, connection cables.

1. GENERAL INFORMATIONS

The name of Direct Current Machines (DC Machines) is determined by the way the machine is excited. Most DC machines have electromagnetic excitation and are classified as Shunt, Series and Compound machines according to the excitation type.

Direct current machine is an energy conversion element and works either as a motor or a generator depending on the input energy.

Figure 1 shows the cross-section of a direct current machine with two poles, auxiliary poles and compensation windings. In small machines, there is only the armature winding (A-B) and the excitation winding (I-K). Larger power machines (several kW) have an auxiliary pole winding (G-H) or an auxiliary pole winding and compensation winding (GW-HW). Additionally, (E-F) series excitation winding is used to correct the commutation characteristics. The ampere-winding of this winding is 5-10% of the free or shunt excitation winding. The series excitation winding ensures the stability of the operating points in speed adjustment over a wide area.

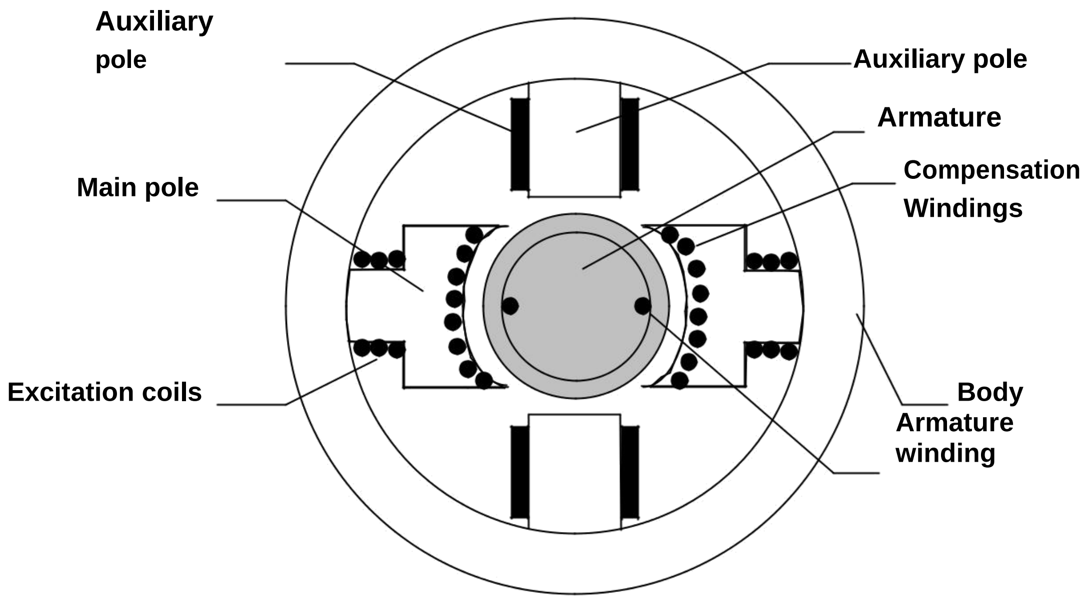

Figure 1. Cross-section of a bipolar DC motor.

1.1 DC Motor

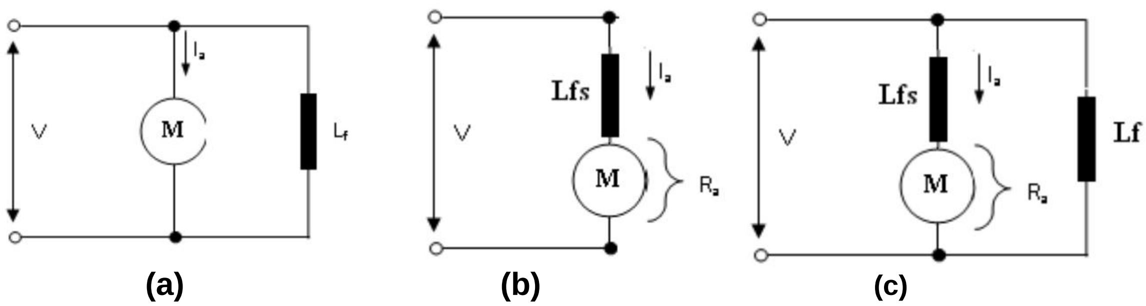

Figure 2. (a) Shunt, (b) Series, (c) Compound Motor Equivalent Circuit

$$V = E + Ia\,R\,a \qquad (1)$$

V: Armature terminal voltage supply
E: Armature induced voltage
Ia: Armature current
Ra: Armature resistance
E = kωΦ (k is a constant)

$$E = V - I_a R_a \quad \text{and } \omega = \frac{V - R_a I_a}{k\varphi}$$

The term IaRa is generally smaller than %5 of V, so ω approximately equal tı V/kΦ. The ω depending on armature current Ia is illustrated below.

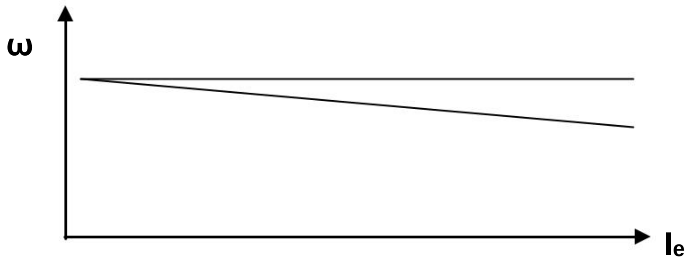

Figure 3. Motor speed vs armature current

The power equation is obtained by multiplying V with Ia:

$V I_a = E I_a + I^2_a R_a$

Here,

V Ia : The electrical power of motor
E Ia : The power transfered to the armatüre (Some portion of this power is consumed as core and friction losses.)

$E I_a = \omega T$ (i.e. $P_o = \omega T$)
$T \propto \Phi I_a = k \Phi I_a$, but $\Phi \propto I_f$

Under shunt and constant armature voltage operation, Φ is constant, torque changes varies with the armature current. This variation can be seen in Figure 4.

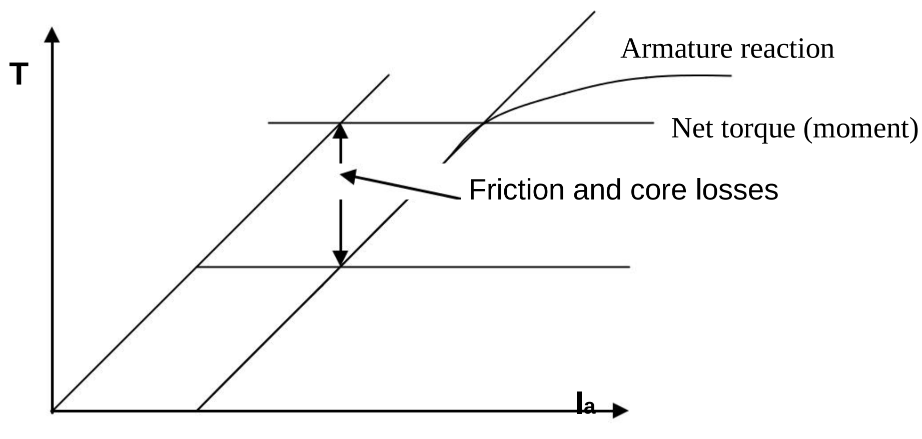

Figure 4. Torque-Armature current graphics

The armature current Ia depends on speed hence there is a relation between speed and moment.

$$I_a = \frac{V - E}{R_a} = \frac{1}{R_a}(V - k\omega\varphi)$$

$$T = \frac{k\varphi}{R_a}(V - k\omega\varphi)$$

If Φ is constant then torque linearly varies quickly and maximum torque is produces when ω = 0.

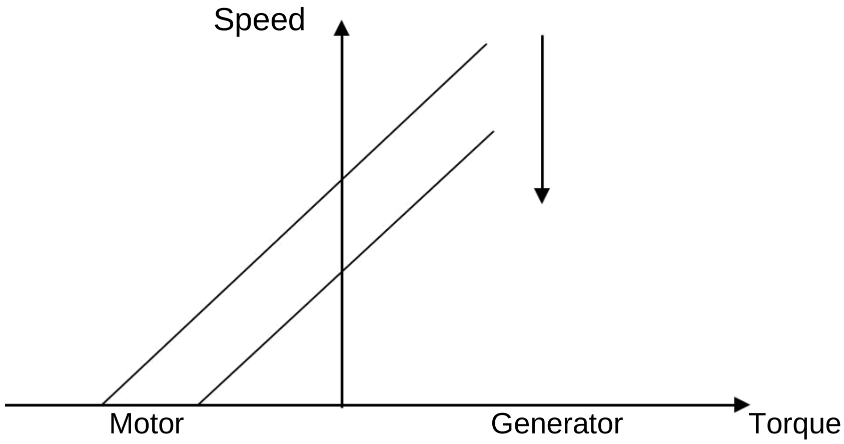

Figure 5. Speed - torque graph

2. DC Motor Experiments

2.1. Relationship Between Field (Excitation) Current of a DC Motor and Speed

Aim :The aim of this experiment is to observe a relationship between the excitation current and speed of a DC motor operating with constant armature voltage.

2.1.1 Conducting the Experiment

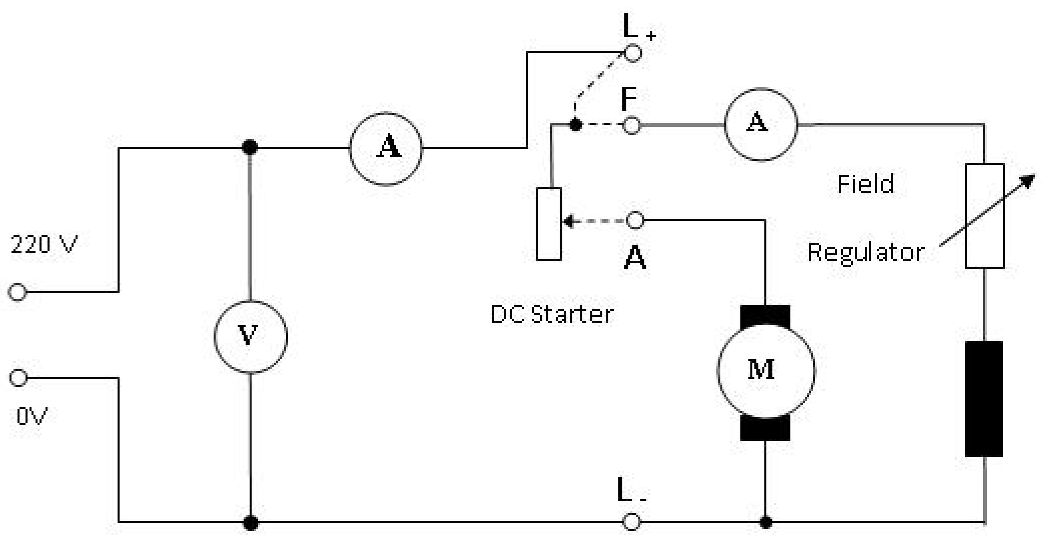

Figure 6.Simple experimental connection diagram of shunt excited DC motor

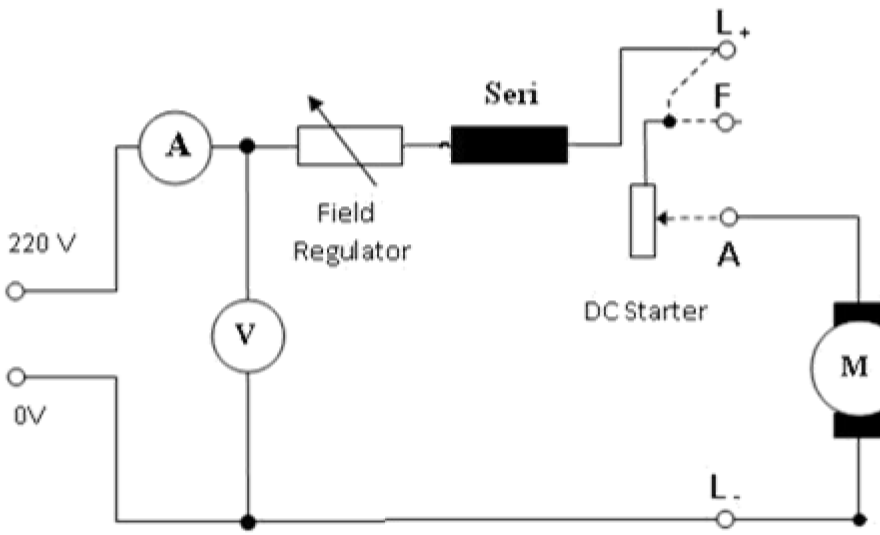

Figure 7. Simple experimental connection diagram of series excited DC motor

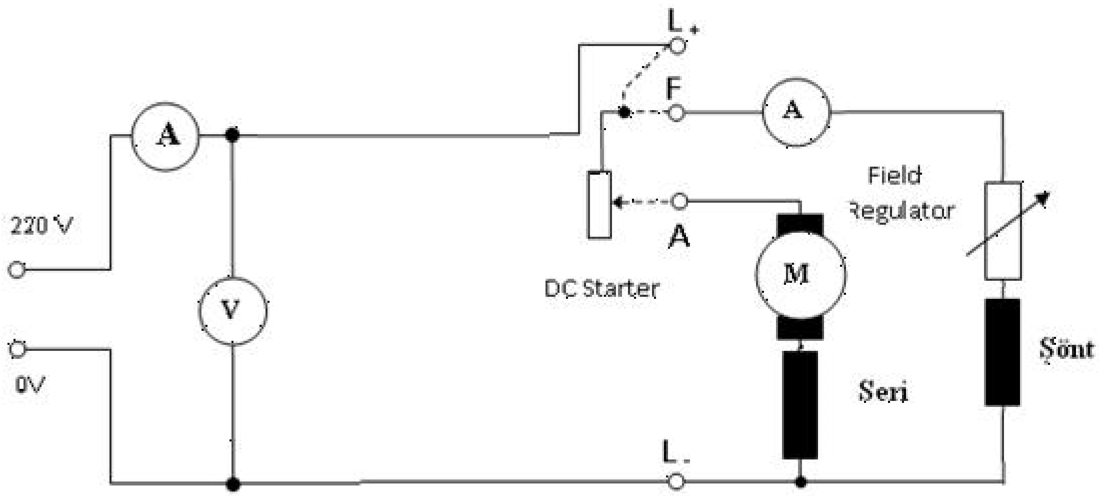

Figure 8.Simple experimental connection diagram of compound excited DC motor

Make the test connection as shown in Figure 7. Press the 'Supplies Reset' button. By turning the DC starter fully clockwise, start the machine at maximum excitation current (Field Regulator 'R' at 0%) and increase the speed to the nominal speed. (Note that by increasing the 'R' resistance, the engine speed may increase above 1900 rpm). Set the motor speed to 1800 rpm by increasing 'R' and note the excitation current corresponding to this speed, ensuring that the supply voltage is constant throughout the experiment.

Table 1. DC Machine with Shunt Excitation

As 'R' Increases

If(A)	ω(rad/s)	n (r/d)

As 'R' Decreases

If(A)	ω(rad/s)	n (r/d)

Note: Shunt connection diagram is shown in figure 9.

Table 3. Compound Excited DC Machine

As 'R' Increases

I_f (A)	ω (rad/s)	n (d/d)

As 'R' Decreases

I_f (A)	ω (rad/s)	n (d/d)

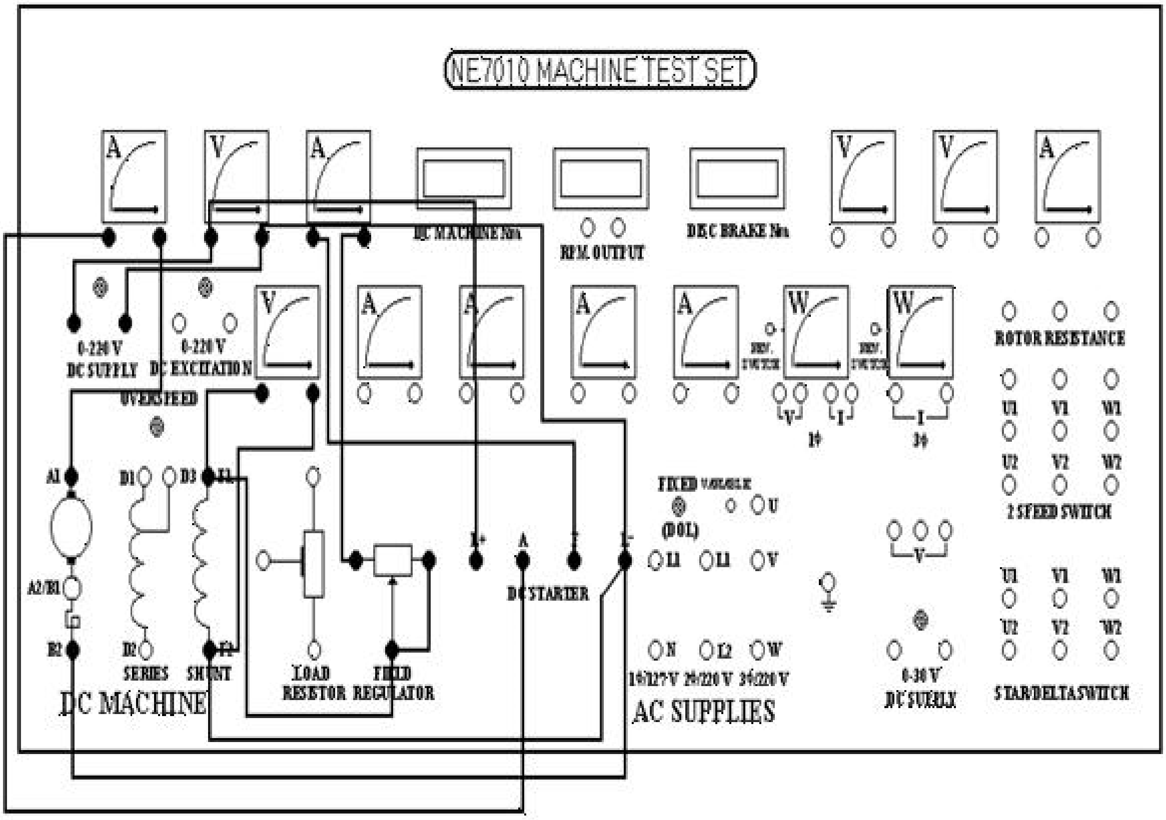

Figure 9. NE7010 DA Shunt Motor Connection Diagram

2.2 Obtaining the Load Characteristics of a DC Motor

Aim: To determine the relationship between speed and torque of DC shunt motor under variable load. To find the relationship between the efficiency and current of the motor under variable load. To obtain the mechanical characteristics of a shunt motor.

2.2.1 Conducting the Experiment

Make the connections shown with the thick line in Figure 10. Place the required terminal connection plate on the experiment set. Set the excitation circuit voltage of the salient pole generator to zero (0V) volts

A) Start the shunt excited machine and ensure the speed is 1500 rpm. Record the input current while the motor is running with 220 V supply voltage. Increase the load of the generator until the motor current reaches 9A. Repeat the experiment for different loads, noting the current and speed. Make sure that the supply voltage is constant at 220 V throughout the experiment.

B) Operate the machine with serial excitation. Repeat the steps in option A with serial excitation.

C) Operate the machine with compound excitation. Repeat the steps in option A for compound excitation.

Repeat the experiment for different loads by setting the motor voltage to half the nominal value and keeping it constant.

$$P_0 = T \cdot \omega$$

$$\omega = \frac{N \cdot P \cdot 2\pi}{60}$$

T: Moment (Nm) ω: Angular velocity (rad/s) N: Speed (rpm)

P: Number of dipoles P_o: Output power

Table 4. Determination of Load Characteristic of Shunt Motor

Torque (Nm)		Efficiency (%)		Current (A)		Speed (rpm)		Output power (Watt)	
V	V/2	V	V/2	V	V/2	V	V/2	V	V/2

Table 5. Determination of Load Characteristic of Series Motor

Torque (Nm)		Efficiency (%)		Current (A)		Speed (rpm)		Output power (Watt)	
V	V/2	V	V/2	V	V/2	V	V/2	V	V/2

Table 6. Determination of Load Characteristic of Compound Motor

Torque (Nm)		Efficiency (%)		Current (A)		Speed (rpm)		Output power (Watt)	
V	V/2	V	V/2	V	V/2	V	V/2	V	V/2

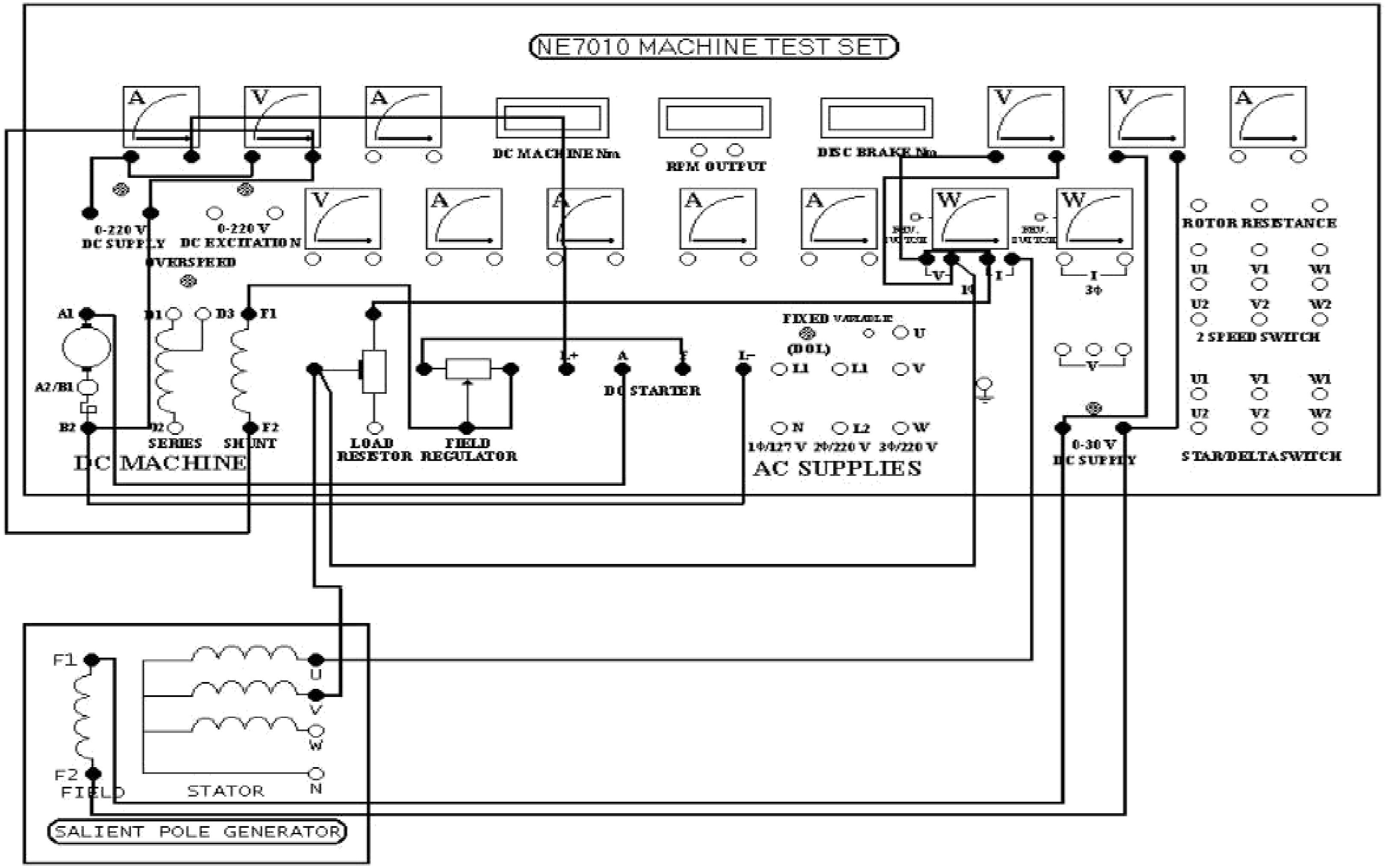

Figure 10. Load Characteristics of NE7010 DC Shunt Motor, Experimental Connection Diagram.