ELECTRONICS DEPARTMENT

D-C SHUNT MOTOR

OBJECTIVES:

1. To study the speed characteristics of a d-c shunt motor.
2. To observe the effect on motor rotation by reversing armature or field current.
3. To observe the effect of dynamic braking.

MATERIAL REQUIRED

DC VARIABLE POWER SUPPLIES CAPABLE OF SUPPLYING

a) 140 volts at 1.62 amperes
b) 90 volts at 307 ma
ammeters 0-3 ampere
0-1 ampere

VTVM
MOTOR: DC 90 volt shunt field at 307 ma; 140 volt armature at 1.62 ampere; ¼ HP rated at 1725 RPM; equipped with generator and loading system.

Stroboscope...
Switch, one DPDT
two SPST

INTRODUCTORY INFORMATION

Characteristics of a D-C Shunt Motor:

Because d-c motors lend themselves readily to electronic control, and because of their desirable speed and torque characteristics their use in industry has increased appreciably. The d-c shunt motor can be operated as a variable-speed motor with good regulation and good torque characteristics within its range. Moreover, electronic control units available for use with these motors make possible automatic speed regulation over a wide range of speeds.

The D-C shunt-wound motor consists of a rotating armature, slotted to accommodate the armature winding. This winding is connected to a cylindrical commutator which is part of the armature assembly. Armature current is supplied from an external d-c source, through carbon brushes which make contact with the copper commutator bars as they move beneath the brushes. The stationary shunt field winding on the motor frame is also supplied from a d-c source.

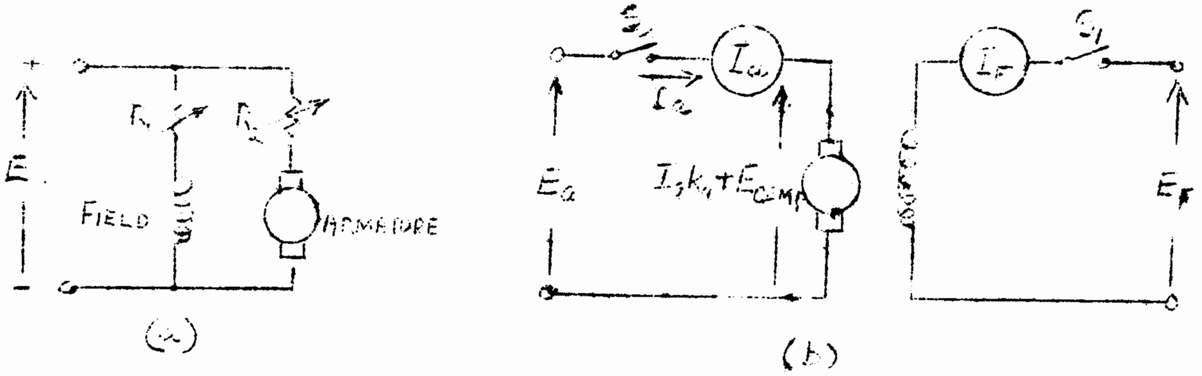


FIGURE 1

Figure 1(a) shows a circuit which uses a common power supply for armature and field. Note that the circuit branch containing the field winding is in parallel with the branch containing the armature winding.

Figure 1(b) shows a circuit which uses two seperate power supplies and makes it practical to independently vary the armature and field voltages without use of large rheostats.

The torque of a dc motor is directly proportional to the armature current if the field current is held constant.

Torque = $K_T ia$ (1)

where K_T is a constant including physical and field characteristics and ia is the armature current.

Let us now consider the characteristics of the field and armature windings and let us note how these characteristics affect the operation of the motor. The field coil has a relatively high resistance, R_F, which limits the current through the field winding to E_F/R_F. If E_F is seperate and constant, i_f will be constant and the motor torque is then considered proportional to i_a.

The armature winding has a relatively low resistance, Ra. When power is first applied to the armature, only the ohmic resistance of the winding limits the current through it. This large i_a produces a large torque which starts rotating the armature. As the armature rotates, its conductors cut the lines of magnetic force about the field windings. This action induces a counter-emf, in the armature winding which acts in opposition to the d-c voltage applied to the armature. The counter-emf is directly proportional to the speed of rotation of the motor.

Counter-EMF = $K_s N$ (2)

where K_s is a constant and
N is the speed in RPM.

As the motor speed increases, the counter-emf rises and i_a decreases. The torque decreases and eventually the motor speed stabilizes. The armature current, i_a, is then just sufficient to produce the torque necessary to overcome the friction and drive the load.

$$Ea = \text{counter-emf} + IaRa \qquad (3)$$

Varying Speed of a DC Shunt Motor

It is possible to change the speed of a dc shunt motor by changing the armature voltage or field current.

The manufacturer's specifications sheet lists the characteristic of a motor, including its "base speed". This is the speed at wich the motor operates under load, when the "rated" voltages are applied. For example, Figure 2 shows that the base speed of a particular motor is 2000 RPM when 200 volts are applied to both the armature and firld windings.

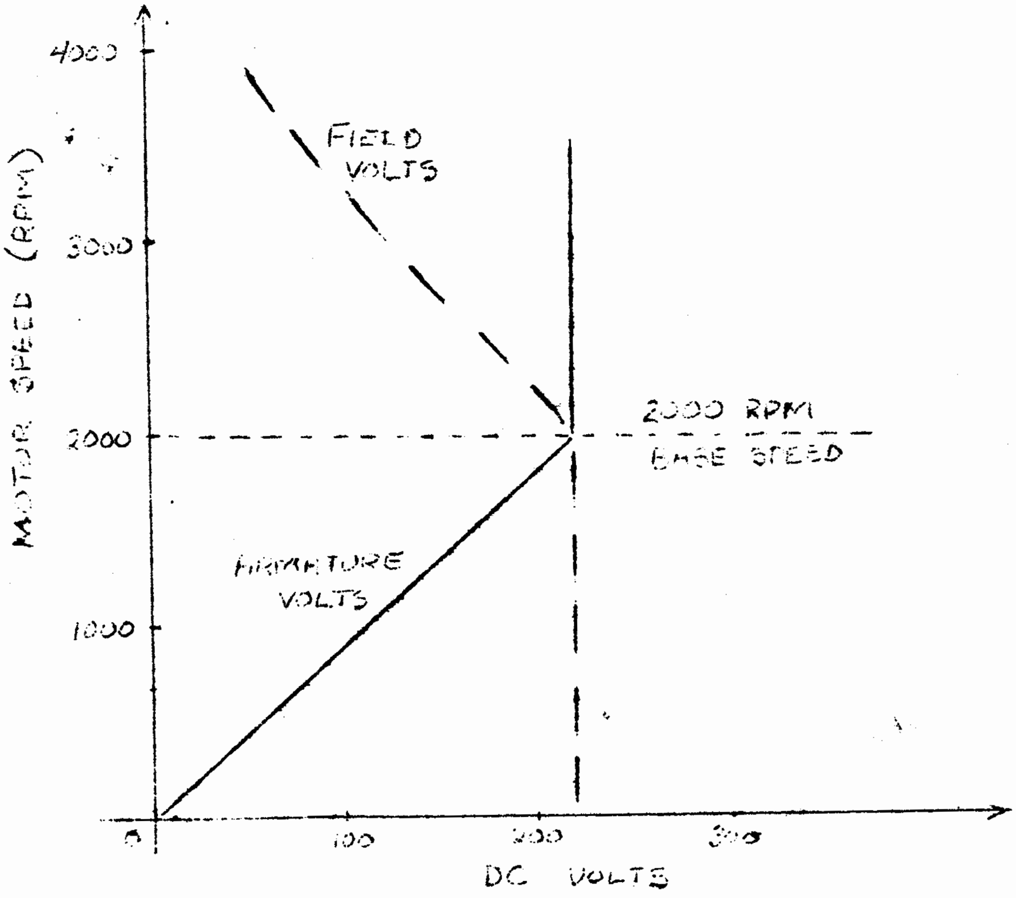


Fig. 2. DC motor speed control by varying the armature or field voltage

The graph indicates that we may increase the motor speed beyond the base speed by reducing the field voltage while keeping the armature voltage constant, or that we can decrease the motor speed below the base speed by reducing the armature voltage while keeping the field voltage constant.

N.B. Safe operation requires that the field voltage be operated with-in specified limits. It should not be reduced below a predetermined value to prevent excessive motor speed. Nor should the field voltage be increased beyond its maximum value.

Certain precautions must be observed in starting and stopping a d-c shunt motor. The motor should be started with full field voltage, but with low armature voltage. Armature voltage is increased slowly to increase motor speed. In stopping a d-c shunt motor with seperate field and armature sources, power should be removed from the armature circuit first.

Speed Regulation of a DC Shunt Motor

If the rated Ea is applied to the unloaded motor armature, ia will be small and the counter-emf and motor speed will be high in accordance with formula 3. Now, if the motor is loaded, ia increases, iaRa increases and since Ea is constant; the counter-emf and motor speed must decrease. This decrease in speed is usually undesirable. The smaller the change in speed, the better is the motor speed regulation.

It should be obvious that a large Ra in the motor armature or a large output impedance of the armature supply contribute to poor regulation.

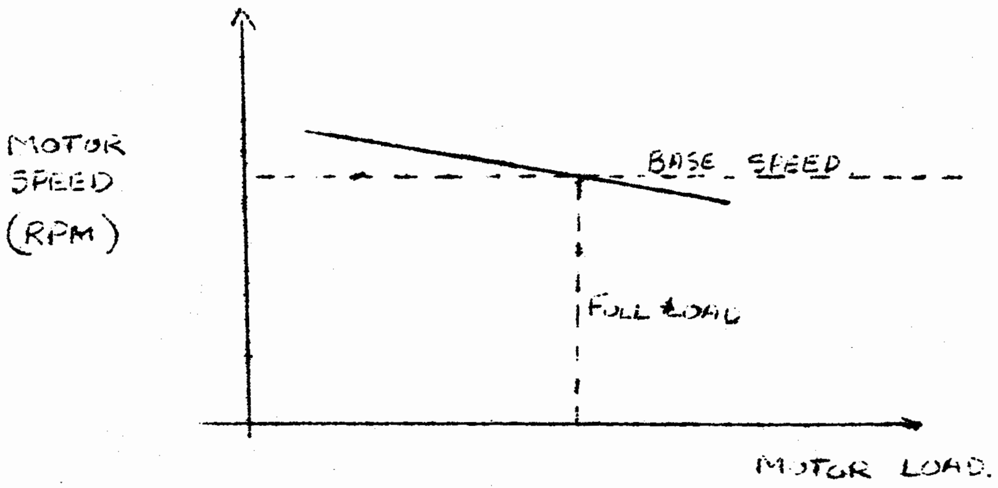


Fig. 3

Measuring Counter-EMF of a Motor

The circuit of fig. 4 shows how the counter-emf may be measured experimentally. A DPDT switch, S_3 , is used either to apply power to the armature winding or to apply a voltmeter across the armature winding. In position (1), DC is applied to the armature circuit and the motor starts building up a counter-emf. After the motor is running, the counter-emf generated n the armature winding may be measured by moving S_3 to position (2). The counter-emf decreases as the motor slows down.

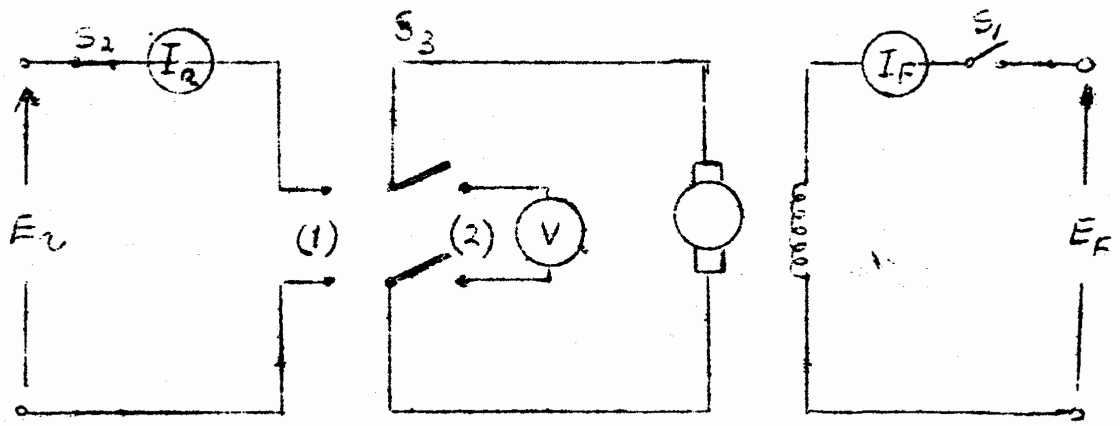


Fig. 4

Reversing Direction of Rotation

The direction of rotation of the motor is determined by the polarity of the voltage applied to the armature and field windings. We can reverse the direction of rotation of the motor by reversing the armature connections or the field connections.

The circuit of fig. 5 shows a method of reversing the armature connections.

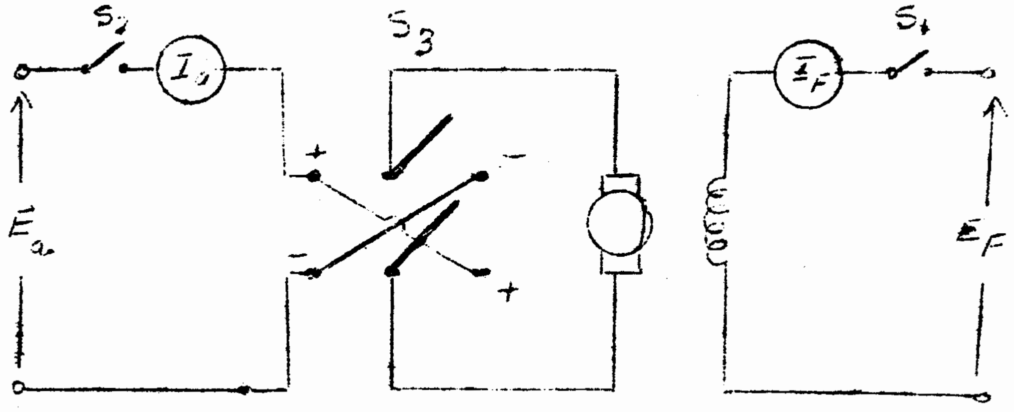
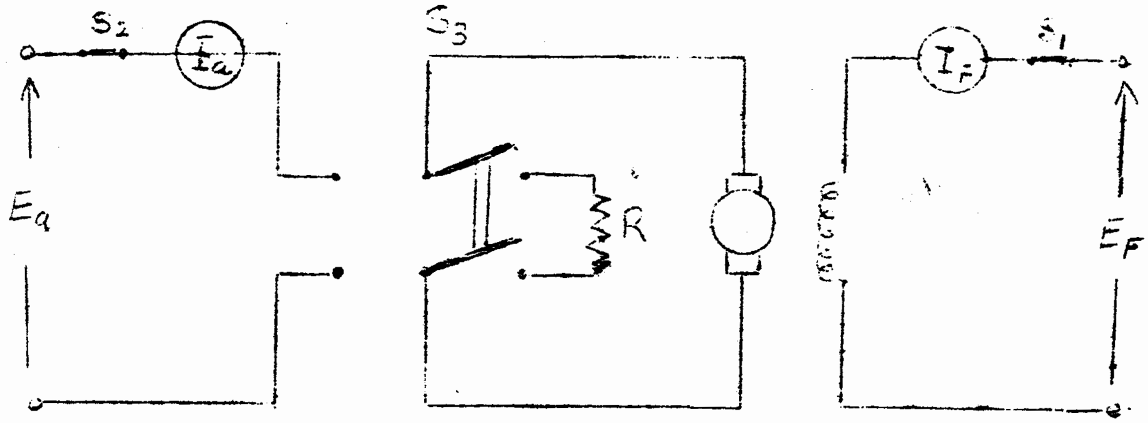


Fig. 5

Dynamic Braking

It is possible to stop a motor rapidly by the method of dynamic braking, illustrated in fig. 6. When S_3 is in position (1), power is applied to the armature winding and the motor is operative. Switching S_3 to position (2) removes the power from the armature and applies the braking resistance, R, across it.

The motor cannot stop instantly with removal of power from the armature, because of its inertia. The turning motor, therefore, acts as a generator and forces current to flow through the braking resistance.



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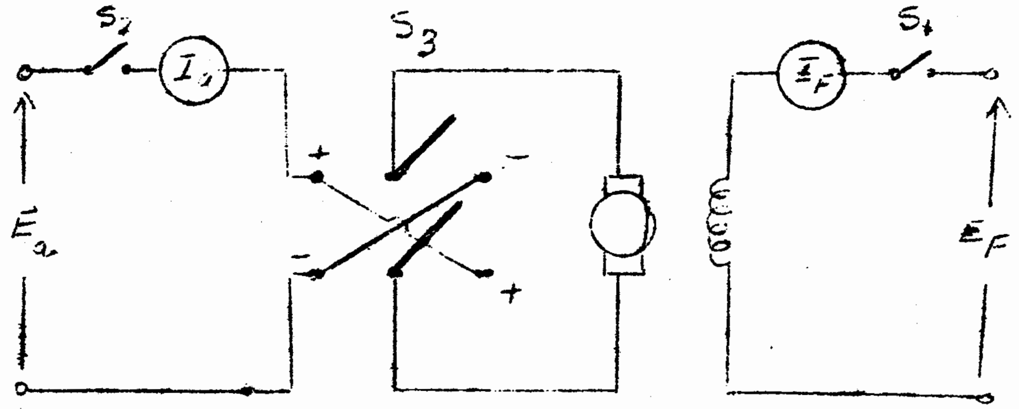

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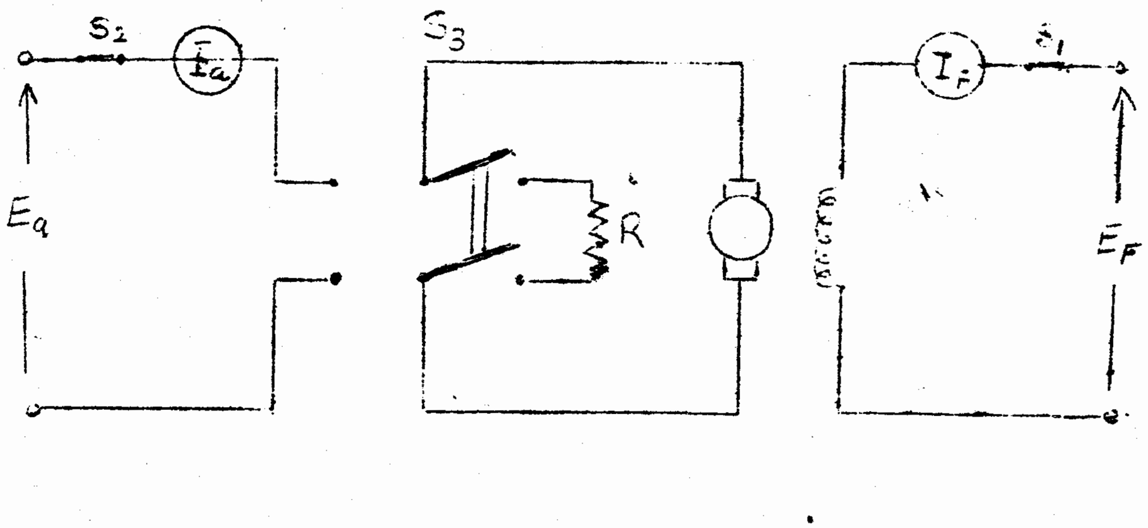

Fig. 6

The value of R determines how quickly the motor will stop. The lower the value of braking resistance, the higher is the braking current which will flow in the circuit, and the more rapidly will the motor stop.

Maximum braking current occurs at the instant the "brake" is applied. As the motor slows down, the generated voltage drops and the braking current and braking effect is reduced.

Procedure

1. You will receive a shunt wound ¼ Hp dc motor with four terminals. Two of the terminals are connected to the armature winding. The other two are the terminals of the field winding. By a continuity check at the terminals, determine and record the connections associated with each of the windings. Measure the resistances of the armature and field windings and record,

2. Connect the circuit of fig. 1 (b) (NO LOAD ON MOTOR). Close S_1 and adjust power supply so that field current is 300 ma.

   NOTE: NEVER APPLY ARMATURE VOLTAGE WITHOUT FIRST APPLYING FIELD VOLTAGE.

3. Set the armature power supply to 125 volts. Now close S_2 applying power to the armature. Observe, measure and record the armature current at the instant S_2 is closed. Note that the armature current is highest at the instant power is applied. However, this current is reduced as the motor speed stabilizes. After the motor speed stabilizes, measure and record the armature current, voltage across the armature winding and speed of motor in rpm.

4. Adjust the armature voltage to various settings from zero volts to the maximum value of 140 volts. Measure and record the armature current and motor speed for each setting, still without load.

5. With the armature voltage set for maximum rated motor speed, observe and record the effect on the motor speed as the field current is reduced from 300 ma to 100 ma. DO NOT REDUCE FIELD CURRENT BELOW 100 MA.

6. Plot the dc motor speed. control curve from the data obtained in steps 4 and 5.

7. Readjust the field current back to 300 ma. Connect the circuit shown in fig. 4, and use it to measure the counter-emf, just after the motor was running at rated speed. Why does the voltage, measured by V_1 decline as the motor slows down?

8. Connect the circuit shown in fig. 5 and use it to demonstrate how reversal of motor rotation is accomplished. Do not set your speed to more than 50 rpm during this demonstration. Never remove your field current while armature voltage is applied.

9. Connect the circuit of fig. 6 and use to to show the effect of dynamic braking. R is a 200 watt light bulb. Measure the length of time it takes the motor to stop from its maximum rated speed with the braking resistance and without it. Compare the two time intervals. Explain.

10. Connect the circuit of fig. 1 (b). Adjust the field current to 300 ma and armature voltage for maximum rated speed. Adjust the load in steps from maximum load to minimum load. (CAUTION: DO NOT EXCEED AN ARMATURE CURRENT OF 1.6 AMPERES.)
Measure and record the armature voltage, armature current and motor speed for each setting of load.

11. Repeat step 10 for an armature voltage of 100 volts.

12. Plot the speed regulation curves from data obtained in steps 10 and 11.

Questions

1. What is the effect on motor speed of increasing armature voltage? What is the effect on armature current of increasing the load on the motor?

2. What is meant by counter-emf in a motor? Where and how is the counter-emf generated?

3. What is the effect on motor speed of decreasing the field current of a dc shunt motor? Why?

4. How may the direction of rotation of a dc shunt motor be changed?

5. What is the purpose of a dynamic brake? Explain the principle of operation of a dynamic brake.

6. Explain why the speed of rotation decreased with increase in motor load.