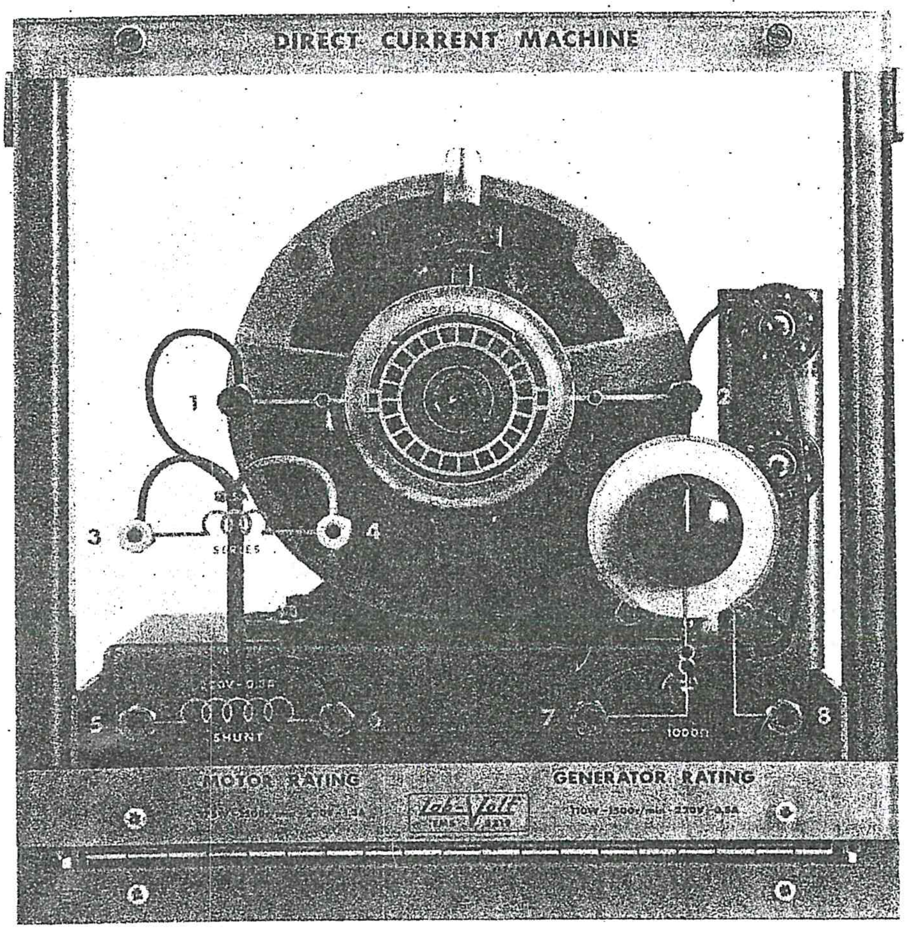
LABORATORY EXPERIMENT NO. 11

THE DIRECT CURRENT MOTOR PART I



OBJECT

1. To examine the construction of a DC motor/generator.
2. To measure the resistance of its windings.
3. To study the nominal current capabilities of the various windings.

DISCUSSION

Direct current motors are unsurpassed for adjustable-speed applications, and for applications with severe torque requirements. Uncounted millions of fractional horsepower DC motors are used by the transportation industries in automobiles, trains and aircraft where they drive fans and blowers for air conditioners, heaters and defrosters; they operate windshield wipers and raise and lower seats and windows. One of their most useful functions is for the starting of gasoline and Diesel engines in autos, trucks, buses, tractors and boats.

The DC motor contains a *stator* and a *rotor*, the latter being more commonly called an *armature*. The *stator* contains one or more windings per pole, all of which are designed to carry direct current, thereby setting up a magnetic field.

The *armature* and its winding are located in the path of this magnetic field, and when the winding also carries a current, a torque is developed, causing the motor to turn.

A *commutator* associated with the armature winding is actually a mechanical device, to assure that the armature current under any given stator pole will always circulate in the same direction irrespective of position. If a commutator were not used, the motor could not make more than a fraction of a turn, before coming to a halt.

INSTRUMENTS AND COMPONENTS

DC Motor/Generator Module	*EMS 8219*
Power Supply Module *(0-220Vdc)*	*EMS 8829*
DC Metering Module *(40/400V, 300mA, 1.5A)*	*EMS 8419*
Connection Leads	*EMS 8941*

PROCEDURE

Caution: High voltages are present in this Laboratory Experiment! Do not make any connections with the power on! The power should be turned off after completing each individual measurement!

☐ 1. Examine the construction of the **DC Motor/Generator Module, EMS 8219** paying particular attention to the motor, rheostat, connection terminals and wiring. Note that the motor housing has been designed to allow you to view the internal construction. Most commercial motors do not have this open construction.

☐ 2. Viewing the motor from the rear of the module:

☐ a) Identify the armature winding.

☐ b) Identify the stator poles.

☐ c) How many stator poles are there?________

☐ d) The shunt field winding on each stator pole is composed of many turns of small diameter wire. Identify the shunt field winding.

☐ e) The series field winding, wound inside the shunt field winding on each stator pole, is composed of fewer turns of larger diameter wire. Identify the series field winding.

☐ 3. Viewing the motor from the front of the module:

☐ a) Identify the commutator.

☐ b) Approximately how many commutator bars (segments) are there?________________

☐ c) How many brushes are there?________________

☐ d) The neutral position of the brushes is indicated by a red line marked on the motor housing. Identify it.

☐ e) The brushes can be positioned on the commutator by moving the brush adjustment lever to the right or to the left of the red indicator line. Move the lever both ways and then return it to the neutral position.

☐ 4. Viewing the front face of the module:

☐ a) The shunt field winding (many turns of fine wire) is connected to terminals________and________.

☐ b) The series field winding (fewer turns of heavier wire) is connected to terminals____________ and____________.

☐ c) The current rating for each winding is marked on the face of the module. Can you answer (a) and (b) having only this information?

__________Explain.______________________________

____

☐ d) The brushes (commutator segments and armature winding) are connected to terminals ____________and____________.

☐ 5. The rheostat, mounted on the module face, is designed to control (and safely carry) the shunt field current.

☐ a) It is connected to terminals ________ and ________.

☐ b) What is its rated resistance value?________Ω

☐ 6. You will now measure the resistance of each of the motor windings using the voltmeter-ammeter method. With this information you will calculate the power losses for each of the windings. Using your **EMS Power Supply, DC Metering and DC Motor/Generator Modules**, connect the circuit shown in *Fig. 11-1*.

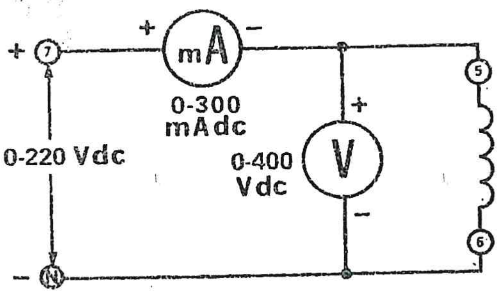


Fig. 11-1

☐ 7. Turn on the power supply.

☐ a) Slowly increase the dc voltage until the shunt field winding is carrying *0.2A* of current as indicated by the *0-300mAdc* meter (this is the nominal current value for the shunt field winding).

☐ b) Measure and record the voltage across the shunt field winding.

$E_{(shunt\ field)}$ = ________ *Vdc*

☐ c) Return the voltage to zero and turn off the power supply.

☐ d) Calculate the resistance of the shunt field winding.

$R_{(shunt\ field)} = E/I$ = ____/____ = ________Ω

☐ e) Calculate the I^2R *(power)* losses of the shunt field winding.

$P_{(shunt\ field)} = I^2R$ = ____X____ = ____*W*

☐ 8. Connect the circuit shown in *Fig. 11-2.*

☐ a) This is the same circuit as shown in *Fig. 11-1* except that the series field winding has replaced the shunt field winding, the *1.5Adc* meter has replaced the *300mAdc* meter and the *40Vdc* range has replaced the *400Vdc* range of the voltmeter.

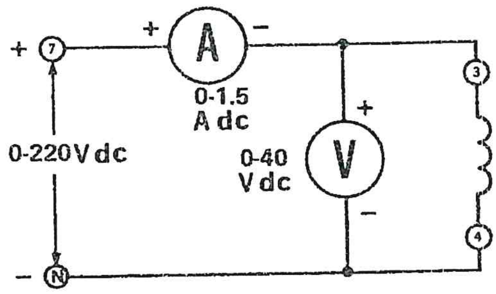


Fig. 11-2

☐ b) Turn on the power supply. Slowly increase the dc voltage until the series field winding is carrying *1.5A* of current as indicated by the *1.5Adc* meter, (this is the nominal current value for the series field winding). **Warning! This only requires a few volts so advance the voltage control slowly.**

☐ c) Measure and record the voltage across the series field winding.

$E_{(series\ field)}$ = ________ *Vdc*

☐ d) Return the voltage to zero and turn off the power supply.

☐ e) Calculate the resistance of the series field winding.

$R_{(series\ field)} = E/I$ = ____/____ = ________Ω

☐ f) Calculate the I^2R losses of the series field winding.

$P_{(series\ field)} = I^2R$ = ____X____ = ____*W*

☐ 9. Connect the circuit shown in *Fig. 11-3.*

☐ a) This is the same circuit shown in *Fig. 11-2* except that the armature winding (plus the brushes) has replaced the series field winding.

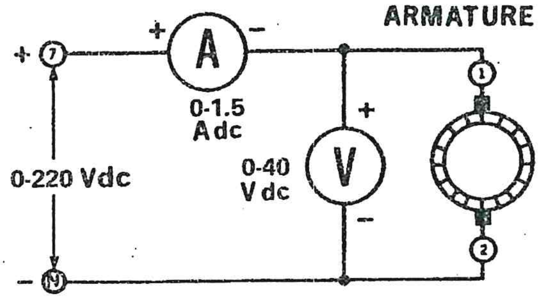


Fig. 11-3

☐ b) Turn on the power supply. Slowly increase the dc voltage until the armature winding is carrying *1A* of current as indicated by the *1.5Adc* meter (this is the nominal current value for the armature winding).

☐ c) Measure and record the voltage across the armature winding (plus brushes).

$E_{(armature)}$ = ____________ *Vdc*

☐ d) Return the voltage to zero and turn off the power supply.

☐ e) Calculate the resistance of the armature winding (plus brushes).

$R_{(armature)} = E/I$ = ________/________ = ________ Ω

☐ f) Calculate the I^2R losses of the armature (plus brushes).

$P_{(armature)} = I^2 R$ = ______ X ______ = ________ *W*

☐ 10. Rotate the armature winding approximately 90^0 to the left.

☐ a) The brushes are now making contact with different commutator segments.

☐ b) Repeat *Procedure 9.*

☐ c) *E* = ______ *Vdc*, *R* = ______ Ω, *P* = ______ *W*

☐ 11. Rotate the armature 15^0 further to the left.

☐ a) Repeat *Procedure 9.*

☐ b) *E* = ______ *Vdc*, *R* = ______ Ω, *P* = ______ *W*

TEST YOUR KNOWLEDGE

1. What would be the shunt field current of your motor if the shunt field winding is excited by *220Vdc?*

____

2. If a current of *1.5Adc* flows in the series field winding of your motor, what would the resultant voltage drop be? ________________

3. If the rheostat were connected in series with the shunt field winding and the combination placed across a *220Vdc* line, what shunt field current variations could be obtained from your motor?

____

____

$I_{minimum}$ = ________ *Adc* $I_{maximum}$ = ________ *Adc*

4. All of the windings and even the commutator of your motor are made of copper. Why?

____

5. Why are the brushes of your motor made of carbon rather than copper?

____

____

6. If the series field winding of your motor was connected directly across the *220Vdc* supply:

a) What current would flow?

____

b) What would the power loss be (in watts)?

____

c) Is this power loss entirely given up as heat?

____

d) What do you think would happen to the winding if the current were sustained for a few minutes?

____

7. What is meant by a "nominal current" o "nominal voltage"?

____

8. If the armature winding and the series fiel winding of your motor were connected in serie across a *220Vdc* source, what would the current b

____

9. In your motor, is the armature (plu brushes) resistance substantially the same for ever rotational position of the armature? ________

Explain. ________________________