
EXPERIMENT NO. 5

LOAD CHARACTERISTICS OF AN ALTERNATOR

PURPOSE:

To discover the effect of differing power factor loads on the terminal voltage of an alternator.

BRIEFING:

If there is no load on an alternator, its terminal voltage depends solely on speed and field current. However, load current flows through the armature coils making terminal voltage depend on the nature of the load. In this experiment we will maintain a constant speed and a constant field current while loading the alternator with a unity, leading, and lagging loads.

There are three reasons why terminal voltage is different from that generated. First is armature resistance. Second is armature reaction. Third is armature reactance.

With a resistive (unity power factor) load, there is the voltage drop due to the armature coil's resistance. This IR drop increases as the load increases. Also there is the inductance of the armature coil. This IX_L increases as the load increases. Armature reaction is the effect that the magnetic field of the armature has on the main rotor field. It weakens the main field reducing the generated voltage. It, too, acts like a voltage drop, increasing as the load increases.

When the load is inductive (lagging power factor) all three elements are still present. However, the load current is already lagging terminal voltage. This doesn't change the IR drop but it does increase the effects of armature reactance and armature reaction.

With a capacitive (leading power factor) load, there is a completely different situation. You still have the IR drop due to resistance, but the IX_L adds to the generated voltage instead of subtracting from it. From Lenz's law we know that inductive reactance tends to oppose whatever causes it. Its cause in the alternator is the load current. The load current, however, leads the generated voltage. If the angle of lead is great enough, the coil's back-voltage (which is where inductive reactance comes from) makes the terminal voltage larger than the generated voltage. Armature reaction helps too. Instead of weakening the main field, it strengthens it. Therefore, with a leading power factor load, terminal voltage increases as the load increases. Voltage regulation (V.R.) is the ratio between the total drop in voltage and the full load voltage. The equation is:

$$\% \text{ V.R.} = \frac{\text{No-load volts} - \text{Full load volts}}{\text{Full load volts}} * 100$$

PERFORMANCE OBJECTIVES:

Upon successful completion of this experiment, the student will be able to:

1. Explain why loading has an effect on terminal voltage.
2. Differentiate between unity, lagging, and leading power factor loads.

MACHINES REQUIRED:

DM-100A DC Machine operating as a motor
SM-100-3A Synchronous Machine operating as a generator

POWER REQUIRED:

O-125 volt variable DC, 5 amps
O-125 volt variable DC, 1 amp

METERS REQUIRED:

O-300 volt AC voltmeter

ADDITIONAL MATERIAL REQUIRED:

MGB-100DG Bedplate
SLA-100D Strobe-Tachometer
RLC-100 Resistance/Reactance Load

PROGRAM PLAN:

- step 1. Place the two machines on the bedplate. Couple and clamp the machines securely. Install guards.
- step 2. Connect the DC machine as a self excited shunt motor as shown in Figure 5-1. Do not turn the power on yet.
- step 3. Connect the DC excitation (O-150 volt) supply to the alternator's field. Be sure the switch is in the SYNC RUN position. Connect the RLC-100 load to the alternator's terminals, as shown in Figure 5-1. Be sure that all of the resistance toggle switches are in the downward (OFF) position and that the three reactance load knobs are in the 0 (12 o'clock) position.

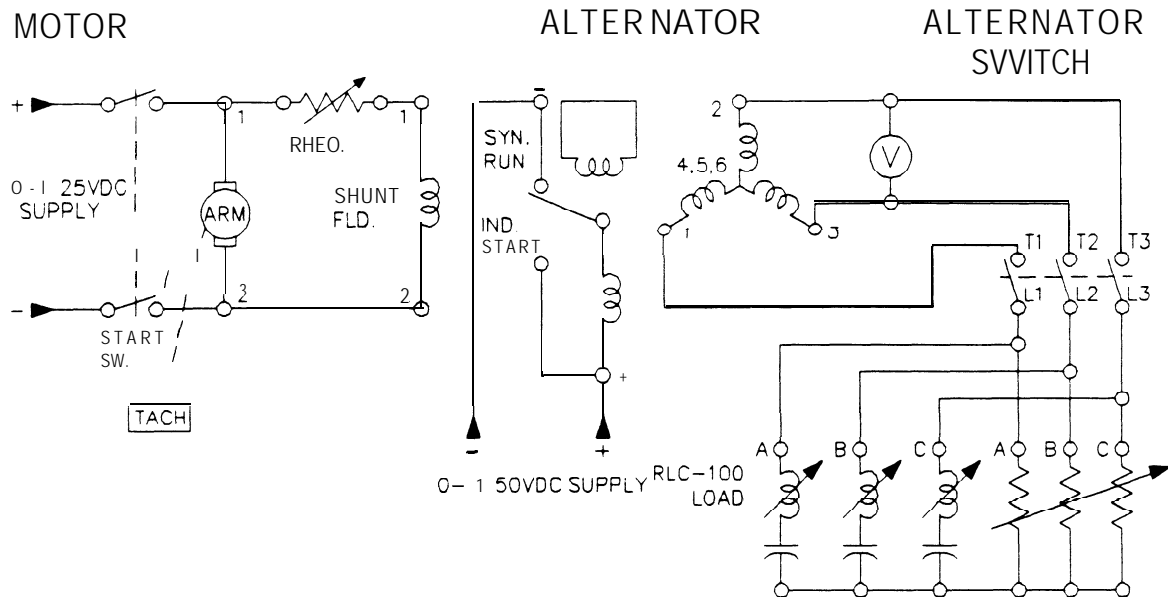


Figure 5-1

- step 4. Have someone check your connections to be sure they are correct.
- Step 5. Turn the motor's field rheostat fully counterclockwise to its minimum resistance position. Turn the voltage control knob of the two DC power supplies fully counterclockwise to their zero output positions.
- Step 6. Turn on the main AC circuit breaker; the 0-125VDC circuit breaker and the motor.
- Step 7. Slowly increase the output of the 0-125VDC supply to 125 volts to start the motor.
- Step 8. Turn on the excitation (150V.DC) supply and the alternator switch and increase its output until the alternator terminal voltage is 208 volts (T2 to T3).
- step 9. Turn on 4 resistance load steps.
- Step 10. Set the Strobe-Tachometer to 1800 RPM and use the motor's field rheostat to achieve that speed.
- step 11. Re-adjust the excitation supply until the alternator's terminal voltage is exactly 208 volts.

- step 12. Repeat Steps 10 and 11 as necessary until the full load terminal volts of the alternator is exactly 208 volts at 1800 RPM.
- Step 13. Turn OFF the alternator switch. Then repeat Step 10.
- step 14. Read the no-load terminal volts and record the reading in TABLE 5-1.
- step 15. Set the reactance load knobs at their 9 o'clock positions to produce a lagging power factor load. Then turn on three steps of resistance load.
- Step 16. Turn on the alternator switch and repeat steps 10, 11, 12, 13, and 14.
- step 17. Set the reactance load knobs at their 3 o'clock positions to produce a leading power factor load. Then turn on three steps of resistance load.
- step 18. Turn on the alternator switch and repeat steps 10, 11, 12, 13, and 14.
- step 19. Turn off all circuit breaker switches. Disconnect all leads.

TEST RESULTS:

	TYPE OF LOAD		
	UNITY	LAGGING	LEADING
FULL LOAD VOLTS	208	208	208
NO LOAD VOLTS			
VOLTAGE REGULATION			

TABLE 5-1

DE-BRIEFING:

1. From the data recorded in TABLE 5-1 compute the voltage regulation of this **alterna-**tor when connected to a unity power factor load.
2. From the data recorded in TABLE 5-1 compute the voltage regulation of this alterna-
tor when connected to a lagging power factor load.
3. From the data recorded in TABLE 5-1 compute the voltage regulation of this alterna-
tor when connected to a leading power factor load. Note: when full load voltage is

greater than no-load voltage, the alternator has a negative regulation, indicated by a minus sign.

4. From your observations, was the percentage voltage regulation better or poorer when a reactive load was connected?

What led you to this conclusion?

5. The terminal voltage of an alternator increases as additional capacitive load is applied. Where does the additional voltage come from?

QUICK QUIZ:

1. As resistive load is added, terminal voltage:
 - (a) Increases
 - (b) Decreases
 - (c) Remains the same

2. The power factor of the connected load:
 - (a) Affects armature resistance and inductive reactance
 - (b) Affects armature reactance and reaction.
 - (c) Affects armature resistance and reactance.

3. As inductive load increases, terminal voltage:
 - (a) Increases
 - (b) Decreases
 - (c) Remains the same

4. A zero percent voltage regulation means:
 - (a) No-load voltage is greater than full-load voltage
 - (b) No-load voltage is less than full-load voltage
 - (c) No-load voltage is the same as full-load voltage

5. As capacitive load increases, terminal voltage:
 - (a) Increases
 - (b) Decreases
 - (c) Remains the same