

EELE 250 Circuits, Devices, and Motors

Lab #9: Power, Power Factor Correction, and DC Motors

Scope:

- Phasor diagrams
- Real, reactive, and apparent power
- Power factor
- DC machine characteristics

Home preparation:

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| <ul style="list-style-type: none">• Review Hambley 5.4-5.5, and chapter 16.• Read through the experiment and plan out each step.• Prepare the results required for the prelab sheets. |
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Laboratory experiment:

In this experiment you will measure the real, reactive, and apparent power of a small AC cooling fan and improve its power factor.

Power and Power Factor

1. Draw the schematic diagram of a fan motor circuit with the power analyzer connected to measure the current to the fan and the voltage across the fan. Assemble the circuit on the lab bench, and have your lab instructor verify the diagram and the circuit before energizing the system.

- With the circuit energized, set the fan to high speed and read the voltage, current, real power, reactive power, and power factor. Record your measurements in Table 2.

Turn off the fan and de-energize the circuit. Wait for the fan to stop completely before changing circuit connections.

- With the power off, place a 6 μF capacitor in parallel with the fan motor. With the fan on high speed, energize the circuit and repeat the current, voltage, and power measurements. Record your measurements in Table 2.

Turn off the fan and de-energize the circuit. Wait for the fan to stop completely, then remove the 6 μF capacitor and set it aside.

- Now set the fan for low speed and energize the circuit. Measure the current, voltage, and power for the fan set on low speed. Record your measurements in Table 2.

Turn off the fan, de-energize the circuit, and wait for the fan to stop completely.

- With the power off, place the 6 μF capacitor in parallel with the fan motor. With the fan on low speed, energize the circuit and repeat the current, voltage, and power measurements once more. Record your results in Table 2.

Turn off the fan, de-energize the circuit, and wait for the fan to stop completely.

Table 2: AC Fan Power Measurements

	<i>Fan Only</i>					<i>Fan with Capacitor</i>				
	Voltage [V _{RMS}]	Current [A _{RMS}]	Real Power (P) [W]	Reactive Power (Q) [VAR]	Power Factor	Voltage [V _{RMS}]	Current [A _{RMS}]	Real Power (P) [W]	Reactive Power (Q) [VAR]	Power Factor
High Speed										
Low Speed										

- Sketch the four *power triangles* for the fan: high speed and low speed, both with and without the parallel capacitor. Recall that a power triangle depicts the relationship between the real power (x-axis), reactive power (y-axis), and apparent power (hypotenuse).

Observing a DC Machine

A DC machine has two windings, the *armature winding* on the rotor (rotating part) and the *field winding* on the stator (stationary part). When DC current flows through the two windings, a torque is exerted on the rotor conductors as a result of the interaction of the magnetic fields associated with the two windings, and the motor starts turning. In order to keep the motor rotating, the magnetic field relationships need to change as the rotor progresses, and a *commutator* is included on the rotor shaft so that the current in the armature winding can reverse direction so that the magnetic torque direction is maintained. A modern DC motor has several separate armature windings and a corresponding set of commutator segments.

The DC motor voltage controller (available at your workbench) has been connected for you, through a power analyzer, to the *armature winding* of the motor. The DC motor controller converts three-phase AC voltage to DC, which can be varied from zero up to the motor rated voltage. Meanwhile, the *field winding* of the DC motor will be connected for you to a fixed 120 VDC supply.

7. Note and record the nameplate ratings of the DC motor mounted beneath the lab bench.

Voltage: _____

Current: _____

RPM: _____

Power: _____

8. While the motor is at rest and completely de-energized, use an ohmmeter to measure the armature resistance.

R_A : _____

9. Once the DC motor is configured and energized by your lab instructor, increase the output voltage from the motor controller in small steps from a low value all the way to the motor rated voltage so that the motor speed increases by about 100 RPM at each step. Record the corresponding speed and armature voltage in Table 3.

Also note the rotation direction of the output shaft when observing the rotation with respect to the stator.

Rotation Direction: _____

Table 3: DC Motor Measurements					
Armature Voltage [V _{RMS}]					
Motor Speed [RPM]					

10. Stop and de-energize the motor, then plot a graph showing rotation rate (RPM) versus motor armature voltage.

11. With the motor de-energized, interchange the connections (switch the polarity) of the *field winding*.

Start the motor and use the motor controller to slowly increase its armature voltage from zero, and note the rotation of the shaft with respect to the stator:

With field voltage reversed, Rotation Direction: _____

PRELAB SHEETS

Perform the calculations before coming to lab, and include your calculations.

Reminder: If you have not already done so, make sure you have firmly attached the experiment and results sheets from the previous lab, Lab #8 Transformers, into your lab notebook.

Power and Power factor

A small AC motor, draws 100 VA (volt-amps) from its 120 V_{rms}, 60 Hz AC source, and consumes 50 W real power.

1. Find the RMS current the motor draws from the supply.
2. Calculate the *power factor*.
3. Draw a phasor diagram depicting the voltage and current for the motor operating as described.
4. Draw a *power triangle* showing the real power, reactive power, and apparent power for this motor.
5. What capacitance would be needed to connect in parallel with the motor to correct its power factor to be unity (100%) ?

Complete Table 1 below, which compares the voltage, current, and power characteristics of the motor operating alone, and operating with the power factor correction capacitance included in parallel.

Table 1: Prelab Power Comparisons						
	Voltage [V_{RMS}]	Current [A_{RMS}]	Real Power (P) [W]	Reactive Power (Q) [VAR]	Apparent Power (S) [VA]	Power Factor
<i>Motor Only</i>						
<i>Motor and Capacitor</i>						

Explain in words the advantage of using power factor correction in this case.