

ET 350 Lab No. 8 Capacitor Run AC Induction Motor

Name: _____

Date: _____

Lab Partners: _____

The motor diagram in Figure 1 shows an AC induction motor with two separate windings -- a main winding and a secondary winding.

These two windings have a different physical orientation, and each makes a magnetic field which is oriented differently in space. For simplicity let us say that the secondary winding creates a field which is oriented 90 degrees from the field created by the main winding.

The rotor consists of the standard squirrel cage structure used by an AC induction motor.

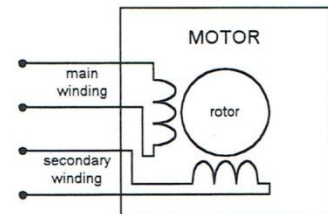


Figure 1.

In order to get the rotor turning, we need to get the overall field to rotate, or have a rotational component, or for the overall field to twist in time.

Even if the two windings were connected together in parallel as shown in Figure 2, the overall total field would just be the vector sum of the field produced by each winding. Still, the total resulting field would not have a rotational component! The total field would just be oriented somewhere between the field produced by each winding.

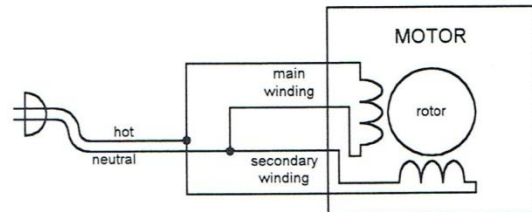


Figure 2.

In order to get the field to have a rotational motion, we need to have the field from one winding to be delayed in its buildup with respect to the other.

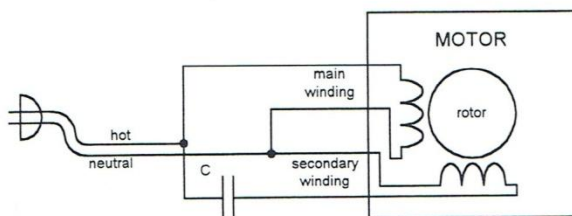


Figure 3.

We can do this by putting a capacitor in series with one of the windings. This is shown in Figure 3. This will cause a phase shift in the buildup of the current in one of the windings compared with the other -- over the period of a 60 Hz cycle. The peak of the current buildup in one winding will occur at a different time compared with the peak of current buildup in the other winding. The net field seen by the rotor will rotate in time.

Lab No. 8 Capacitor Run AC Induction Motor.

Name: _____

Date: _____

Lab Partners: _____

Actually, we know that for a capacitor the voltage lags the current. Think of it this way, in a DC sense: If we want to charge a capacitor to a DC voltage, we have to apply a current first. The voltage on a capacitor builds up later in response to a current applied first. The voltage lags the current, for a capacitor. OR, we could say that for a capacitor the current actually leads the voltage. When you have an AC voltage or current the charging and discharging of the capacitor is happening all the time throughout each cycle. Through the whole AC cycle the capacitor voltage is lagging behind the capacitor current, ... OR ... the capacitor current is leading or ahead of the capacitor voltage!

When we put a capacitor in series with a winding, and we put the AC power line voltage across this series combination, it will cause the net current in both components to lead -- at least more than it would if the capacitor were not there.

Say you have two windings powered by the same AC power line voltage. One winding has a capacitor in series with it. The current in the winding which has a series capacitor will always lead the current in the other winding!

Also remember that the field caused by any winding in a motor is strictly a function of the current in the winding only.

The part of the total field caused by the winding with the series capacitor will always lead, or be ahead of the part of the total field caused by the winding with no series capacitor.

Whether you follow all this lead and lag stuff, all you have to accept is that, referring to Figure 3, if a capacitor is in series with the start winding, then the current in the main winding will peak out at a later point in time than the current in the start winding. AND there will be a rotational motion of the overall field seen by the rotor.

Experimental Part 1. Seeing the whole thing work like it is supposed to. Observation: See motor start and turn in one direction.

1. With the AC power cord unplugged, make the connections from the AC power line to the motor as shown in Figure 4. Note that the capacitor is in series with the start winding.

After checking all your connections, plug in the AC power cord, and observe the motor operation.

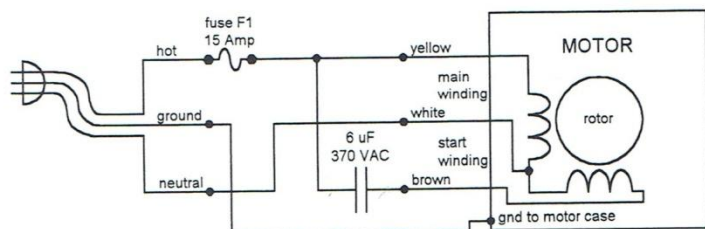


Figure 4.

Recorded Observation: Which direction does the motor start and rotate in (CW or CCW)?

Lab No. 8 Capacitor Run AC Induction Motor.

Name: _____

Date: _____

Lab Partners: _____

Experimental Part 2. Seeing what happens when the AC power is applied to the main winding only.

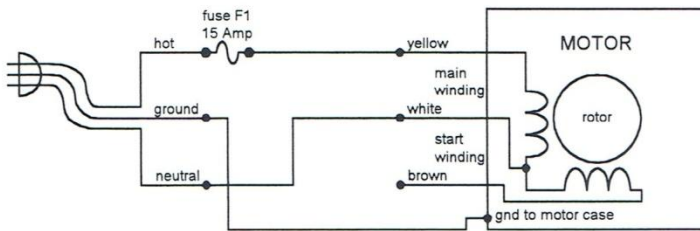


Figure 5.

1. With the AC power cord unplugged, make the connections from the AC power line to the motor as shown in Figure 5. Note that the AC power line is connected to the main winding only.

After checking all your connections, plug in the AC power cord, and observe the motor response for two or three seconds, then unplug the AC power cord.

Recorded Observation: State what the motor shaft did when the AC power was applied:

2. Keep the connections to the motor the same as shown in Figure 5. Plug in the AC power cord and twist the shaft in the clockwise direction. Unplug the power cord if nothing happens.

Recorded Observation: State what the motor shaft did when the AC power was applied, and the shaft was twisted in the clockwise direction:

Report this part as many times as needed to verify what the motor shaft does. Be sure to unplug the AC power cord after each trial.

3. Keep the connections to the motor the same as shown in Figure 5. Plug in the AC power cord and twist the shaft in the counterclockwise direction. Unplug the power cord if nothing happens.

Recorded Observation: State what the motor shaft did when the AC power was applied, and the shaft was twisted in the counterclockwise direction:

Report this part as many times as needed to verify what the motor shaft does. Be sure to unplug the AC power cord after each trial.

Lab No. 8 Capacitor Run AC Induction Motor.

Name: _____

Date: _____

Lab Partners: _____

Experimental Part 3. Seeing what happens when the AC power is applied to the start winding only.

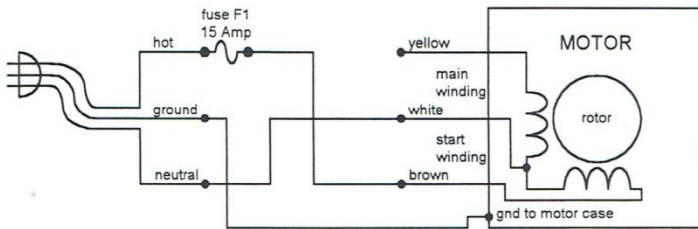


Figure 6.

1. With the AC power cord unplugged, make the connections from the AC power line to the motor as shown in Figure 6. Note that the AC power line is connected to the start winding only.

After checking all your connections, plug in the AC power cord, and observe the motor response for two or three seconds, then unplug the AC power cord.

Recorded Observation: State what the motor shaft did when the AC power was applied:

2. Keep the connections to the motor the same as shown in Figure 6. Plug in the AC power cord and twist the shaft in the clockwise direction. Unplug the power cord if nothing happens.

Recorded Observation: State what the motor shaft did when the AC power was applied, and the shaft was twisted in the clockwise direction:

Report this part as many times as needed to verify what the motor shaft does. Be sure to unplug the AC power cord after each trial.

3. Keep the connections to the motor the same as shown in Figure 6. Plug in the AC power cord and twist the shaft in the counterclockwise direction. Unplug the power cord if nothing happens.

Recorded Observation: State what the motor shaft did when the AC power was applied, and the shaft was twisted in the counterclockwise direction:

Report this part as many times as needed to verify what the motor shaft does. Be sure to unplug the AC power cord after each trial.

Lab No. 8 Capacitor Run AC Induction Motor.

Name: _____

Date: _____

Lab Partners: _____

Experimental Part 4. Seeing what happens when the AC power is applied to the series combination of a capacitor and the start winding.

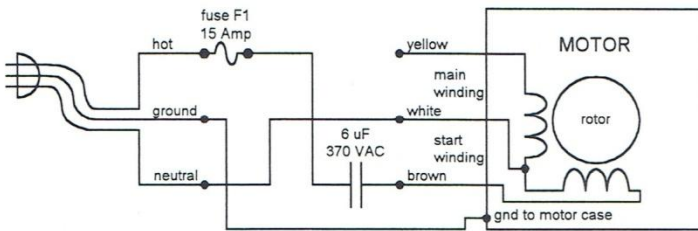


Figure 7.

1. With the AC power cord unplugged, make the connections from the AC power line to the motor as shown in Figure 7. Note that the AC power line is connected to the start winding only.

After checking all your connections, plug in the AC power cord, and observe the motor response for two or three seconds, then unplug the AC power cord.

Recorded Observation: State what the motor shaft did when the AC power was applied:

2. Keep the connections to the motor the same as shown in Figure 7. Plug in the AC power cord and twist the shaft in the clockwise direction. Unplug the power cord if nothing happens.

Recorded Observation: State what the motor shaft did when the AC power was applied, and the shaft was twisted in the clockwise direction:

Report this part as many times as needed to verify what the motor shaft does. Be sure to unplug the AC power cord after each trial.

3. Keep the connections to the motor the same as shown in Figure 7. Plug in the AC power cord and twist the shaft in the counterclockwise direction. Unplug the power cord if nothing happens.

Recorded Observation: State what the motor shaft did when the AC power was applied, and the shaft was twisted in the counterclockwise direction:

Report this part as many times as needed to verify what the motor shaft does. Be sure to unplug the AC power cord after each trial.

Lab No. 8 Capacitor Run AC Induction Motor.

Name: _____

Date: _____

Lab Partners: _____

Experimental Part 5. Measuring the starting current and the running current.

1. With the AC power cord unplugged, make the connections as shown in Figure 8.

Note that this is the same configuration as used in Part 1, with the addition of an AC current meter in series with the hot lead of the AC power cord, which allows us to see the current going to the whole motor circuit as it is first starting and then running, for both windings of the motor.

First check all of your connections before plugging in the AC power cord.

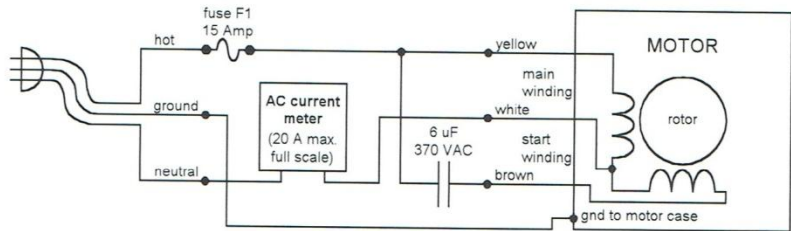


Figure 8.

2. Plug in the AC power cord, and observe the reading on the AC current meter after the motor shaft has built up to full speed. Notice that at first the current spikes up to a higher value than the running current. The peak of this spike is the starting current required by the motor, by both windings, when the rotor is not turning. Always the starting current is greater than the running current due to the "counter emf" effect. Unplug the AC power cord after you observe the running current.

Recorded Observation: What is the measured value of the running current for this motor?

3. Hold the motor shaft to keep it from turning. Then let a lab partner plug in the AC power cord, while observing how high the AC current meter goes.

This reading is the starting current, and it persists as long as the motor shaft is kept from turning. Be sure to release the motor shaft after a couple of seconds, because the motor windings are not designed to take this large amount of current for a long period of time.

Feel the force on the shaft, making it want to turn. This is the starting torque for the motor, and it is always smaller than the running torque for an AC induction motor.

Repeat this part enough times to allow each lab group member to feel this starting torque.

Recorded Observation: What is the highest value measured for the motor starting current?

4. Try this experiment just for fun. Spin the motor shaft in the opposite direction that the motor wants to run. Observe what happens to the motor shaft when AC power is immediately applied.

In previous experiments, when only one winding was active, the motor ended up running in the direction of the original spin put on the motor shaft.

This time, when two windings are involved they work together to create a rotating field, and the rotating field wins, and the motor ends up turning in the direction normally dictated by this rotating field.

Lab No. 8 Capacitor Run AC Induction Motor.

Name: _____

Date: _____

Lab Partners: _____

Experimental Part 6. More advanced observations and specific measurements and questions.

This experimental part uses the same configuration you left off with in Part 5. For convenience the diagram of Figure 8 is repeated here.

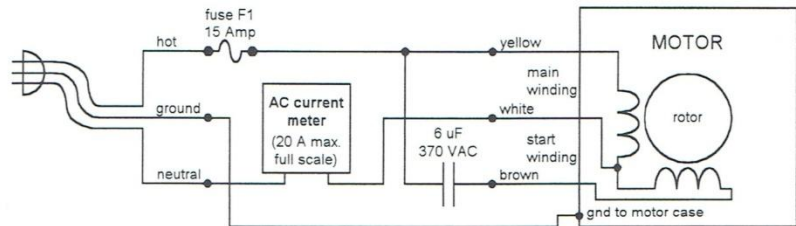


Figure 8.

1. Measure the voltage on the capacitor (V_C) while the motor is running. How does it compare with the AC line voltage? If greater, why could this be?
2. Measure the voltage on the start winding (V_{SW}) while the motor is running. How does it compare with the AC line voltage? If greater, why could this be? Measure the voltage on the main winding (V_{MW}). Is this the same as the AC line voltage? Why is the voltage on the start winding different from the voltage on the main winding?
3. What is the sum of V_C and V_{SW} ? Is this greater than the AC line voltage? If so, why could this be?
4. Put the capacitor in series with the main winding. Does the motor start? Which direction does it rotate in? Explain why this could be. In class try to be ready to participate in a discussion about why this observation occurred, and offer your explanation.
5. Use a glove or a strip of leather or a long piece of wood to slow down the speed of the motor shaft. This represents an increased mechanical load for the running motor. How does the series current measurement for the motor respond?
6. Do the same thing as in #5 above to increase the mechanical load, and slow down the speed of the motor shaft. Does this change the value of V_C or V_{SW} as measured in #1 and #2 above?