

## IND220 Lab 2.3: AS Troubleshooting Basic Electrical Circuits

Upon completion of this lab, the student should be able to:

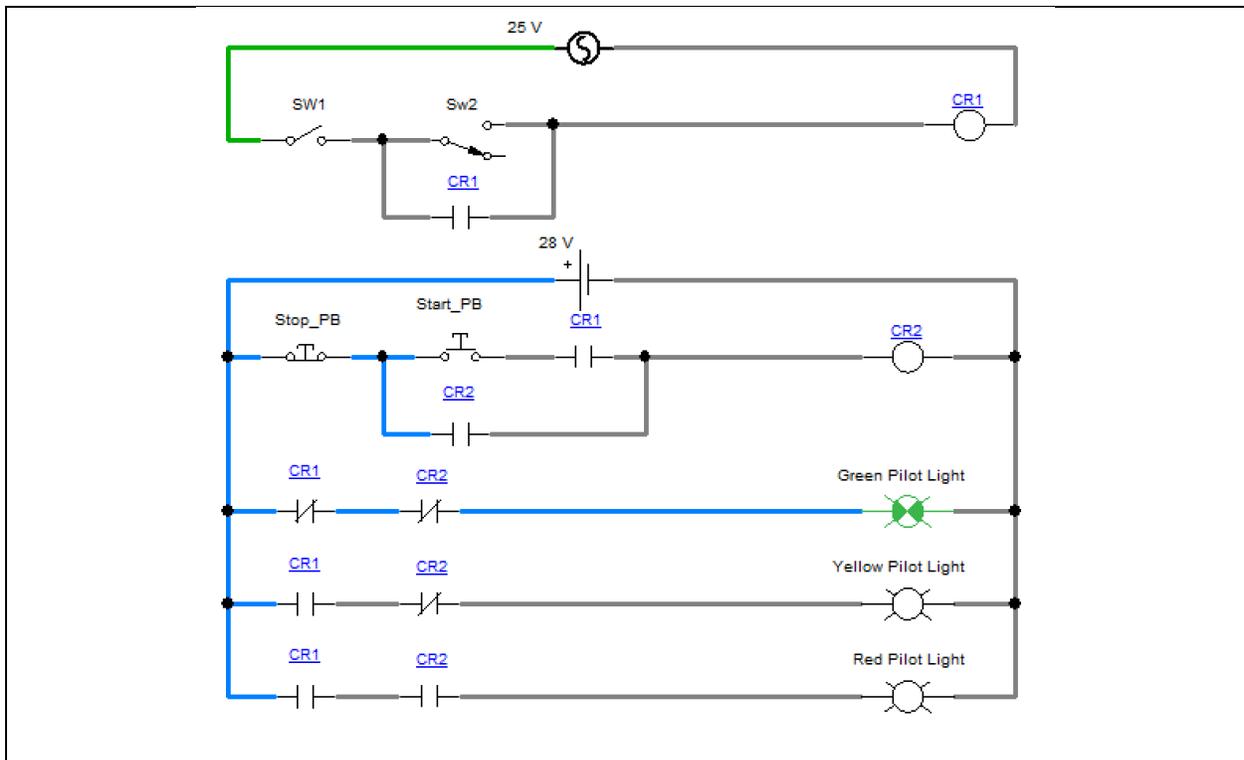
1. Explain how contacts from multiple relays can be configured for control
2. Predict the voltage that should be at various points in a circuit
3. Explain the operation of a multiple relay type of electrical circuit
4. Predict which components could be faulty if a circuit does not work
5. Explain the operation of a DC motor with selector switch and series resistors
6. Explain how a DPDT relay configuration can control the direction of rotation of a DC motor

### Part 1: Two relay circuit operation and voltage checks

\*Log into the Virtual Machine, then open Sakai, then navigate to the IND220 course (sites).

\*Go to Module 2 within Course Content.

\*Click on the .PRX file named IND220 Lab 2.3 Circuit 1



**Figure 1. IND220 Lab 2.3 Circuit 1**

Figure 1 shows the first circuit of this lab that consists of an AC relay and a DC relay, with the contacts of each relay being used together to turn on 3 pilot lights, based on the relay contact configuration. Since this circuit was created in Automation Studio, you can actually open the file and run the circuit through an online simulation.

Answer the following few questions based on your review of the circuit in Figure 1:

1. What needs to occur to turn on CR1?
2. What needs to occur to turn off CR1?
3. What needs to occur to turn on CR2?
4. What needs to occur to turn off CR2?

Figure 2 shows Circuit 1 with the line numbers (left hand side of the ladder circuit diagram), as well as the numbers for each electrical node (wire number).

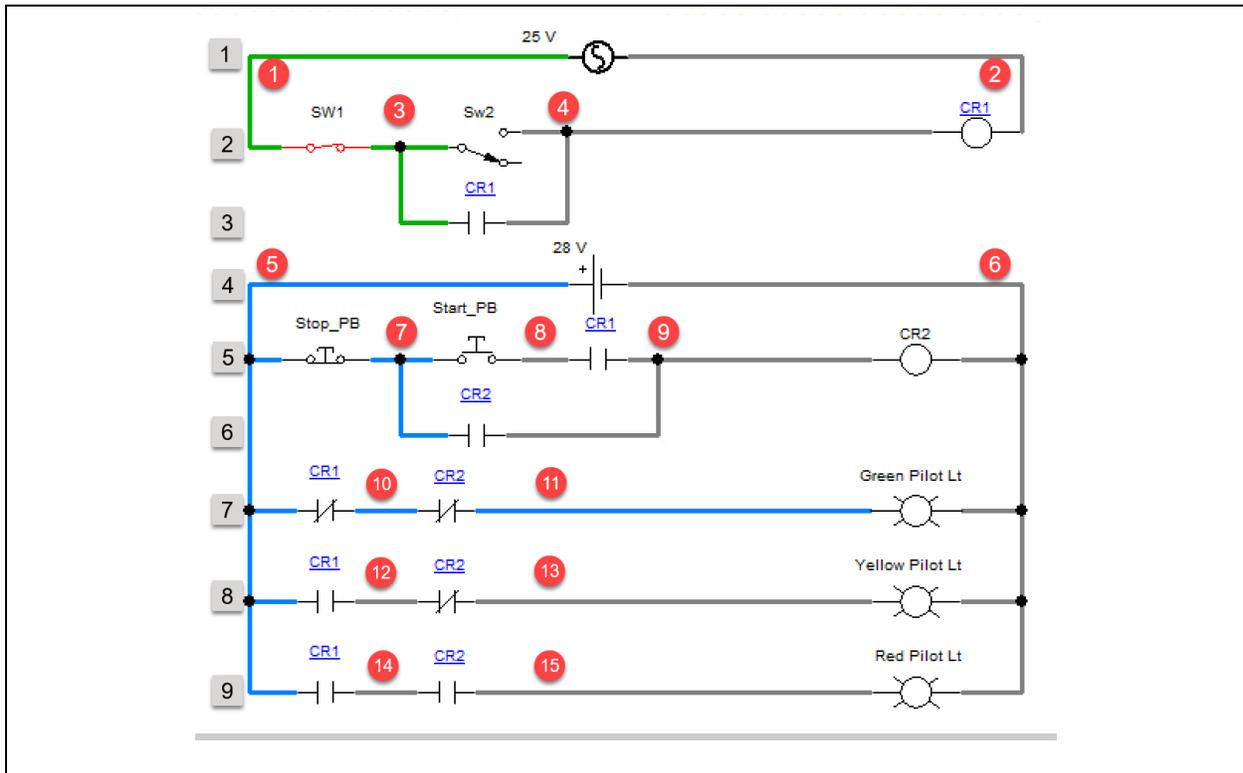
In line 2, a SPST switch (SW1) is used to function as a stop pushbutton, and Sw2 (a SPDT Sw) is used to function as a start pushbutton. The CR1 contact in line 3 is used as a hold-in contact so CR1 remains energized after Sw2 is toggle closed, then back open.

Notice on line 5 in the circuit in Figure 2, CR1 contact must be closed (CR1 coil is energized) and the Start\_PB has to be actuated in order to energize CR2.

Line 7 shows two normally-closed contacts (one from CR1 and the other from CR2). Since a normally-closed contact has continuity when its coil is off, the logic for rung 7 could be said as: when CR1 is not on, and CR2 is not on, the Green Pilot light will turn on.

Since a normally-open contact has continuity when the relay it is on is energized, the logic in line 8 could be said as: when CR1 is on, and CR2 if off, the Yellow Pilot Lt will turn on.

Line 9 logic would be said as: when CR1 is on, and CR2 is on, the Red Pilot Lt will turn on.



**Figure 2. IND220 Lab 2.3 Circuit 1, with line and wire numbers added**

**Start the Simulation in Automation Studio:**

To start the circuit simulation in Automation Studio, click on the Simulation Tab, then either click the small simulation start button, or the larger “Normal Simulation” button.

**Voltage Measurements:**

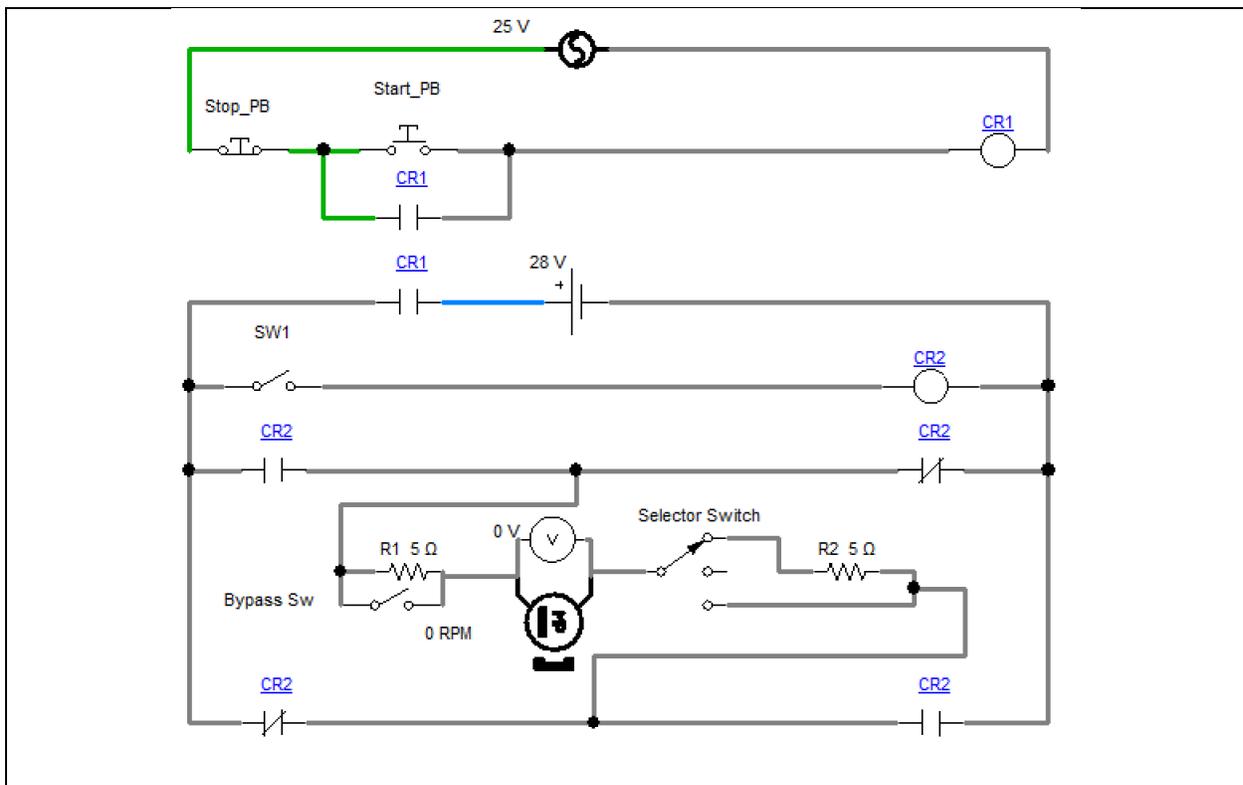
1. If neither relay is on, what will be the following voltage measurements?
  - a. Voltage between 10 and 6? \_\_\_\_\_
  - b. Voltage between 11 and 6? \_\_\_\_\_
  - c. Voltage between 12 and 6? \_\_\_\_\_
  - d. Voltage between 14 and 6? \_\_\_\_\_
  
2. Turn on the CR1 relay.
  - a. Voltage between 10 and 6? \_\_\_\_\_
  - b. Voltage between 11 and 6? \_\_\_\_\_
  - c. Voltage between 12 and 6? \_\_\_\_\_
  - d. Voltage between 14 and 6? \_\_\_\_\_
  
3. Turn on the CR1 relay, and CR2 relay.
  - a. Voltage between 10 and 6? \_\_\_\_\_
  - b. Voltage between 11 and 6? \_\_\_\_\_

- c. Voltage between 12 and 6? \_\_\_\_\_
- d. Voltage between 14 and 6? \_\_\_\_\_

4. Stop the Simulation

**Part 2: Circuit to control the speed and direction of a DC PM motor**

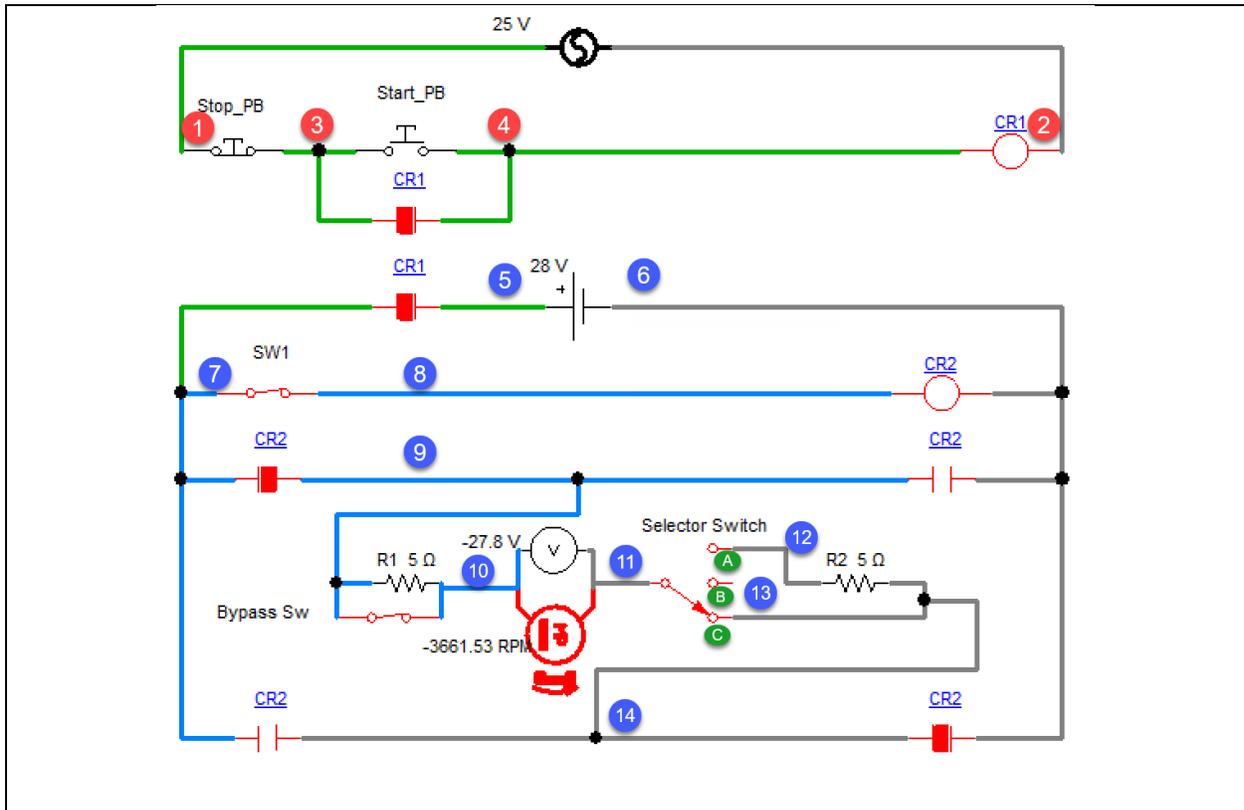
- \*Log into the Virtual Machine, then open Sakai, then navigate to the IND220 course (sites).
- \*Go to Module 2 within Course Content.
- \*Click on the .PRX file named IND220 Lab 2.3 Circuit 2



**Figure 3. IND220 Lab 2.3 Circuit 2**

The circuit in Figure 3 is using a start/stop/hold-in circuit to control an AC relay (CR1). When CR1 is energized, it enables the DC circuit, which uses a 28 Vdc power source. The DC circuit will be used to control the direction of rotation of the DC permanent magnet motor using SW1. When SW1 is open and CR2 is off, the N.C. contacts of CR2 deliver DC voltage to the motor. When CR2 is energized, the polarity of the DC supply is reversed going to the motor.

A series of switches and resistors is used to change the speed of the DC permanent magnet motor.



**Figure 4. IND220 Lab 2.3 Circuit 2, with line and wire numbers added**

Currently in the circuit in Figure 4, the Bypass Sw is closed, which bypasses the R1 5 ohm resistor, and the Selector Switch is in position “C” which also bypasses R2 5 ohm resistor. In this scenario, the motor is running at maximum speed. If one or both of the resistors is in series with the motor, part of the voltage from the 28 Vdc will be dropped across the resistor(s) leaving less voltage for the motor, which will slow the motor down.

**Step 1:** Click on the Start\_PB to energize CR1. This should enable the DC circuit that controls the motor.

**Step 2:** Close the bypass switch and put the Selector Switch into position “C”. Also, open SW1, turn off CR2.

What is the speed of the motor? \_\_\_\_\_

What is the voltage on the motor? \_\_\_\_\_

**Step 3:** Close SW1, energizing CR2.

What is the speed of the motor? \_\_\_\_\_

What is the voltage on the motor? \_\_\_\_\_

**Step 3:** Open the Bypass Sw, keeping the Selector Switch in the “C” position.

- a. What is the voltage on the motor? \_\_\_\_\_ What is the RPM? \_\_\_\_\_
- b. What is the voltage across R1? \_\_\_\_\_ What is the voltage across R2? \_\_\_\_\_

**Step 4:** Move the Selector Switch to the “A” position.

- a. What is the voltage on the motor? \_\_\_\_\_ What is the RPM? \_\_\_\_\_
- b. What is the voltage across R1? \_\_\_\_\_ What is the voltage across R2? \_\_\_\_\_

**Stop the simulation.**

**Review Questions for Part 1:**

1. T F In the circuit in Figure 2, CR2 can be energized without having CR1 energized.
2. T F In the circuit in Figure 2, the DC circuit will be disabled if SW1 is opened.
3. In the circuit in Figure 2, which pilot light should be on if CR1 and CR2 are both on?
  - a. Green Pilot Lt
  - b. Yellow Pilot Lt
  - c. Red Pilot Lt
  - d. No pilot lights will be on in this condition
4. In the circuit in Figure 2, if CR2 is on, and no pushbuttons are actuated, what would the voltage be between wires 9 & 6?
  - a. 0 V
  - b. 28 Vdc
  - c. 25 Vac
  - d. 24 Vdc
5. In the circuit in Figure 2, if CR2 is on, and no pushbuttons are actuated, what would the voltage be between wires 8 & 6?
  - a. 0 V

- b. 28 Vdc
- c. 25 Vac
- d. 24 Vdc

**Review Questions for Part 2:**

**Answer these questions based on the Circuit in Figure 4.**

1. What could cause CR1 to shut off after it is energized?
  - a. The Stop\_PB is pressed
  - b. The DC motor overloads
  - c. CR2 drops out
  - d. All of the above
  
2. What is the purpose of CR2 in this circuit?
  - a. Enable the motor circuit
  - b. Reverse the motor
  - c. Change the speed of the motor
  - d. Disable the motor circuit
  
3. If CR2 is energized, what should be the voltage between wires 9 & 6?
  - a. 0 V
  - b. 28 Vdc
  - c. 25 Vac
  - d. 25 Vdc
  
4. If CR1 is off, what should be the voltage between wires 7 & 6?
  - a. 0 V
  - b. 28 Vdc
  - c. 25 Vac
  - d. 25 Vdc
  
5. If CR1 is off, what should be the voltage between wires 5 & 6?
  - a. 0 V
  - b. 28 Vdc
  - c. 25 Vac
  - d. 25 Vdc