# Chapter 4
# Ladder Diagrams

This chapter describes the ladder diagram functionality that Multisim contains.

Some of the features described in this chapter may not be available in your edition of Multisim. Refer to the release notes for a description of the features available in your edition.

The following are described in this chapter.



## 4.1 Overview

The Education edition of Multisim lets you capture and simulate **Ladder Diagrams**. These diagrams are electrically based, as opposed to the binary/digital representations employed by ladder *logic*. Diagrams of this type are used extensively for industrial motor control circuits.

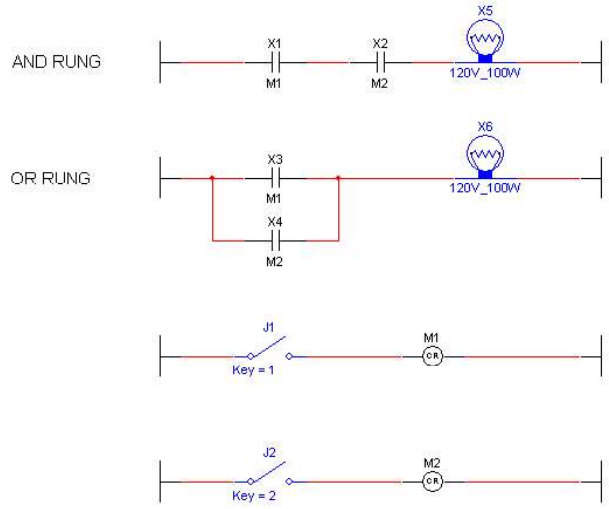
**Ladder Diagrams** are able to drive output devices or take input data from regular schematics and embed the instructions on how input states affect output states in either the same schematic or separate hierarchical blocks or subcircuits that contain the **Ladder Diagram**.

***Note*** Refer to the *Multisim User Guide* for a complete description of hierarchical blocks and subcircuits.

# 4.2 Creating a Ladder Diagram

This section describes the steps required to make a simple **Ladder Diagram**. The concepts described here should be understood before reviewing the more complex circuits found in this chapter.

This section describes how to build the **Ladder Diagram** that is reviewed in "4.3 AND Rungs and OR Rungs" on page 4-5.




***Note*** For details on all ladder diagram components, refer to "A.2 Ladder Diagram Parts" on page A-8.

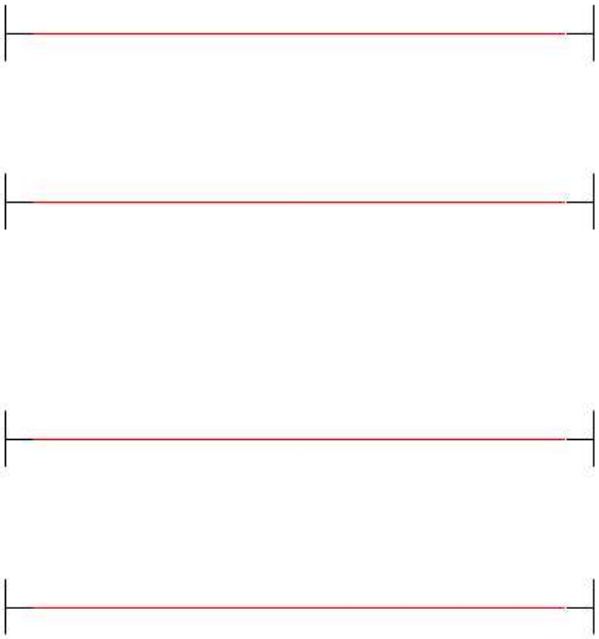
Circuit Notes:

- The relays (X1-X4) are normally open relays. When their controlling coils (M1or M2) are energized they close. (The controlling coils are set in the **Value** tab of each relay's properties dialog box. For details, see "A.2.4.4 Relay Contact NO" on page A-13).
- Both X1 AND X2 must be closed for the lamp in the AND rung (X5) to light up.
- Either X3 OR X4 must be closed for the lamp in the OR rung (X6) to light up.
- Coil M1 controls the relays with M1 as their reference. (X1 and X3).
- Coil M2 controls the relays with M2 as their reference. (X2 and X4).
- Use keys 1 and 2 on your keyboard to open and close switches J1 and J2, or hover your cursor over the desired switch and click on the button that pops up.

➢ To add the diagram's rungs:

1. Select **Place/Ladder Rungs**. The cursor appears with the rung's left and right terminators attached.

2. Click to place the first rung and continue clicking and placing until you have placed four rungs as shown below. Right-click to stop placing rungs.



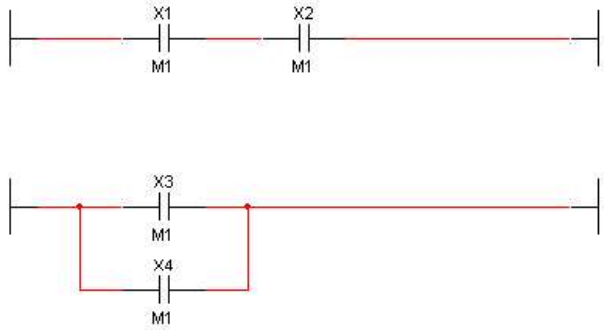
➢ To add components to the rungs:

1. Select **Place/Component**, navigate to the Normally Open Relay Contact (RELAY_CONTACT_NO) click **OK**.

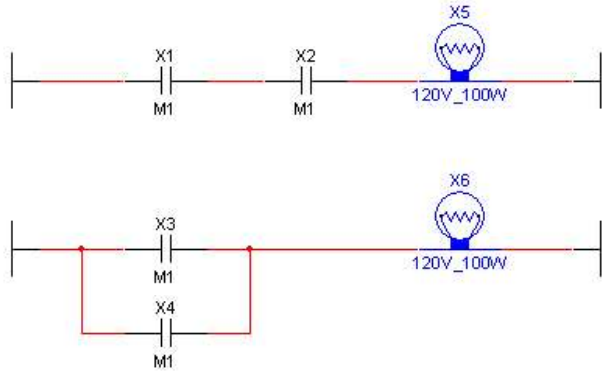
***Note*** This device is found in the Ladder Diagrams Group - Ladder Contacts Family.

2. Drop the relay contact directly onto the first rung.

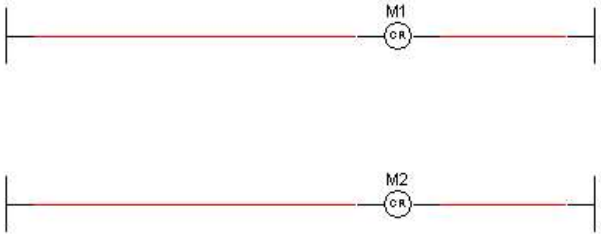
3. Continue in this manner until all relay contacts have been placed. (X4 must be placed and then wired separately).




4. Place the lamps (**Group -** Indicators; **Family -** Lamp).

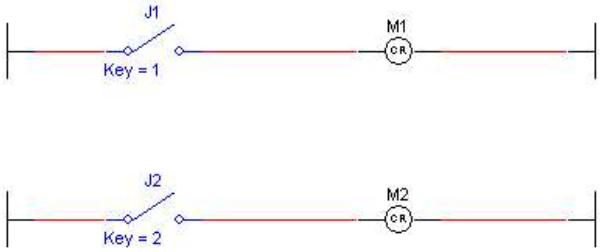



5. Place relay coils M1 and M2 on the third and fourth rungs (**Group -** Ladder Diagrams; **Family -** Ladder Relay Coils).




6. Place switches J1 and J2.

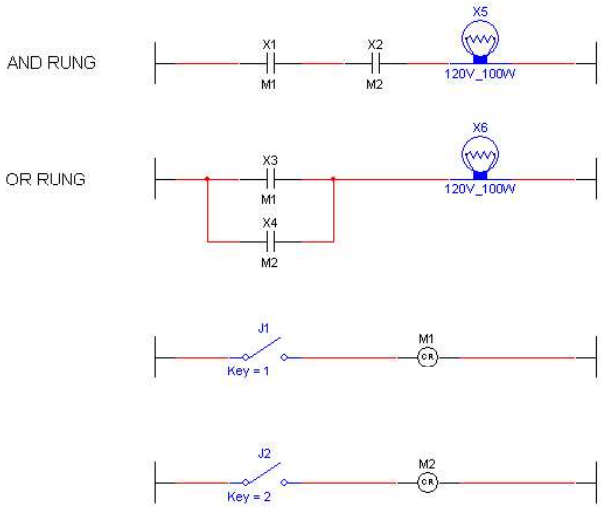
7. Double-click on each switch, select the **Value** tab, and change the key for J1 to 1 and the key for J2 to 2.




➢ To change the controlling device reference for X2 and X4:

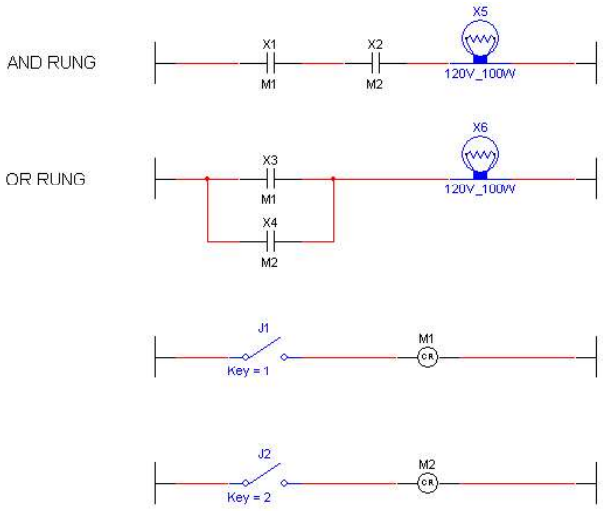
1. Double-click on X2 and click the **Value** tab.
2. Enter M2 in the **Controlling Device Reference** field and click **OK**.

Repeat for X4. The completed **Ladder Diagram** appears as shown below.

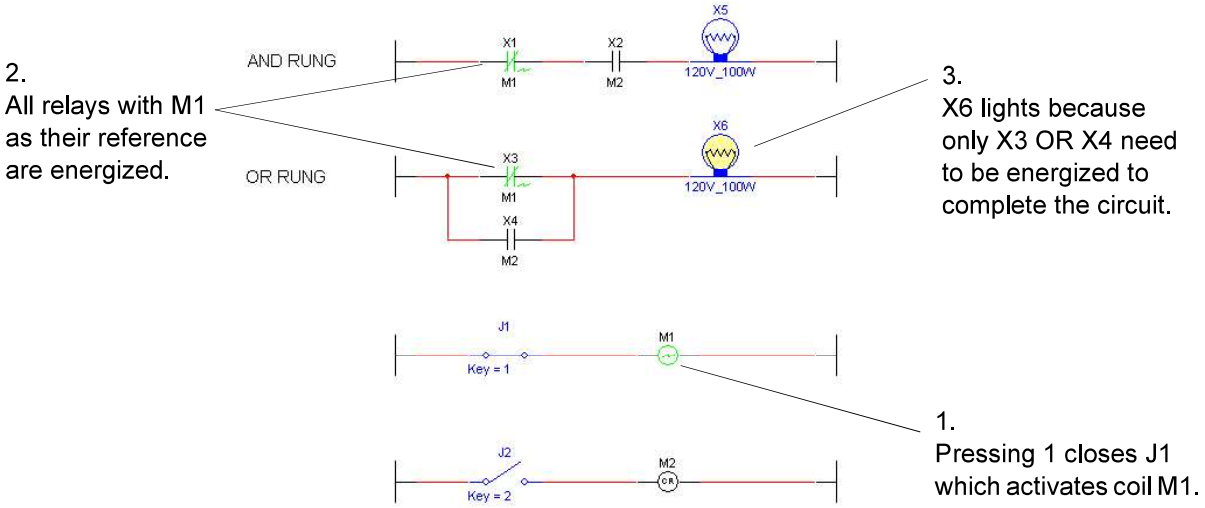



# 4.3 AND Rungs and OR Rungs

This section illustrates the difference between AND rungs and OR rungs that are found in **Ladder Diagrams**. The concepts described here should be understood before reviewing the more complex circuits found in this chapter.



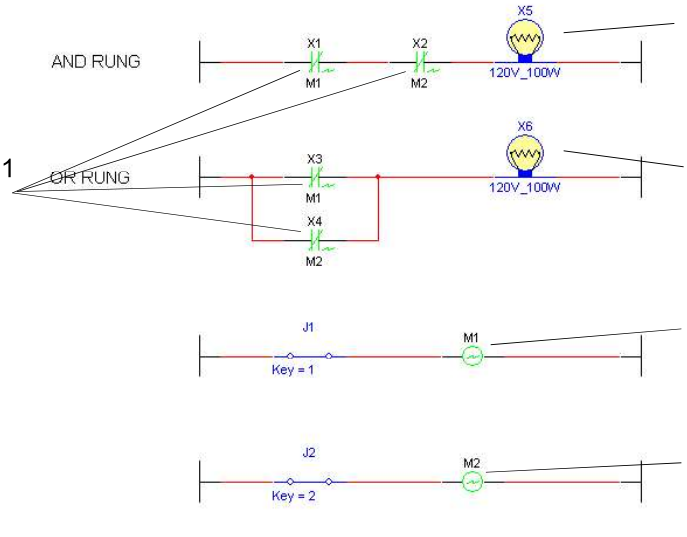

- To activate the lamp in the OR rung:
  1. Select **Simulate/Run** to start simulation of the circuit.
  2. Press 1 on your keyboard to close J1 (or hover your cursor over J1 and click the button that pops up). Lamp X6 lights as described below.




If you press 2 on your keyboard (or hover your cursor over J2 and click the button that pops up), J2 closes which activates coil M2. X6 lights because X4 is energized.

- To active the lamp in the AND rung:
  1. Select **Simulate/Run** to start simulation of the circuit.

2. Press 1 and 2 on your keyboard to close J1 and J2. Lamps X5 and X6 light as described below.




3. All relays with M1 and M2 as their references are energized.

5. X5 lights because X1 AND X2 are energized and the circuit is complete.

4. X6 lights because X3 OR X4 is energized and the circuit is complete.

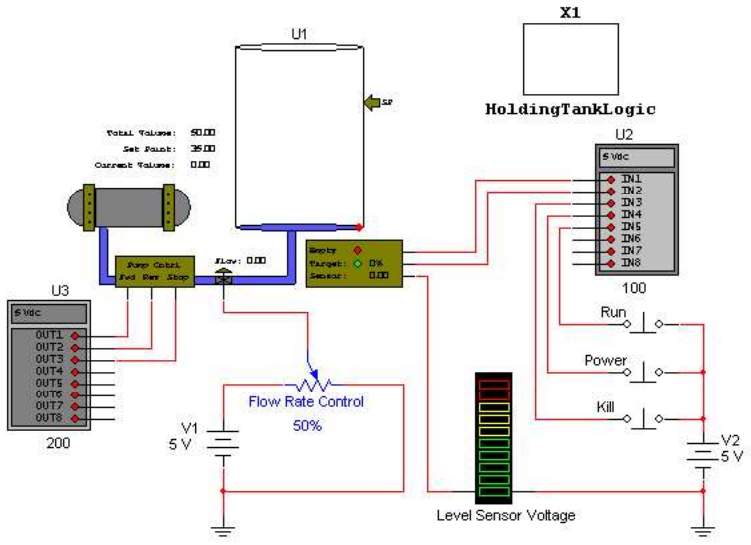
1. Pressing 1 closes J1 which activates coil M1.

2. Pressing 2 closes J2 which activates coil M2.

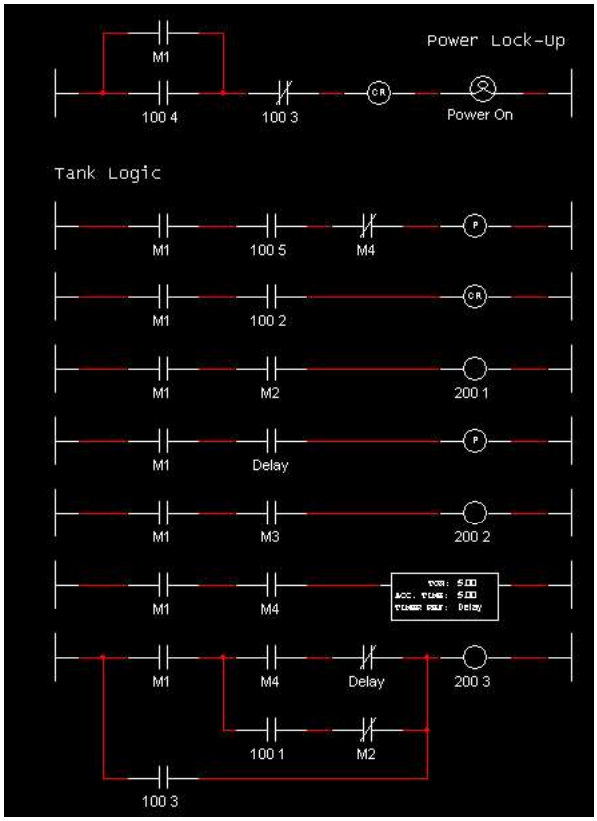
# 4.4 Sample Circuits

## 4.4.1 Holding Tank

This section contains an example of a logic diagram that drives a circuit that fills and then empties a fluid holding tank.




For details on the user-settable parameters for the Holding Tank, Input Module and Output Module see “A.2 Ladder Diagram Parts” on page A-8

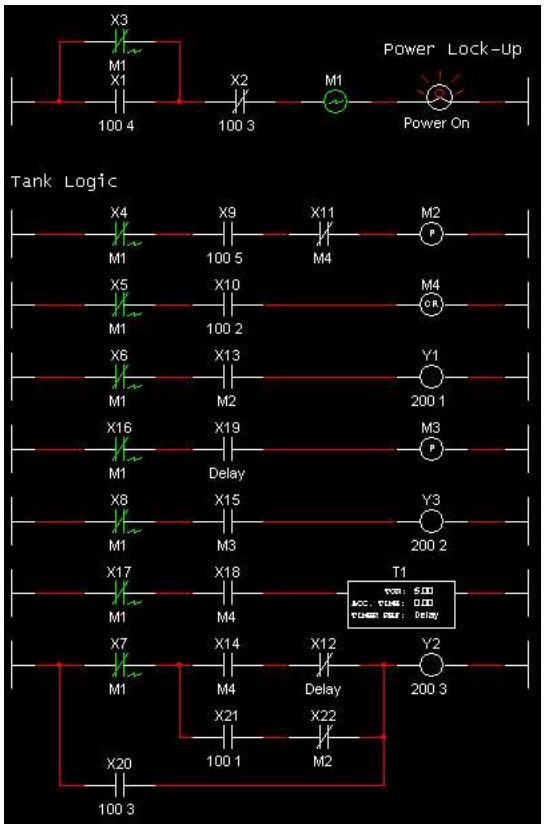



The Ladder Diagram is contained in a separate Hierarchical Block called HoldingTankLogic. For details on hierarchical blocks, refer to the Multisim User Guide.

➢ To activate this circuit:

1. Select **Simulate/Run** to begin simulation.
2. Press P on your keyboard to activate the Power temporary switch (or hover your cursor over the Power switch and click the button that pops up). This sends 5 V to pin IN4 of Input Module U2 (**Input Module Base Address** = 100) which in turn energizes Input

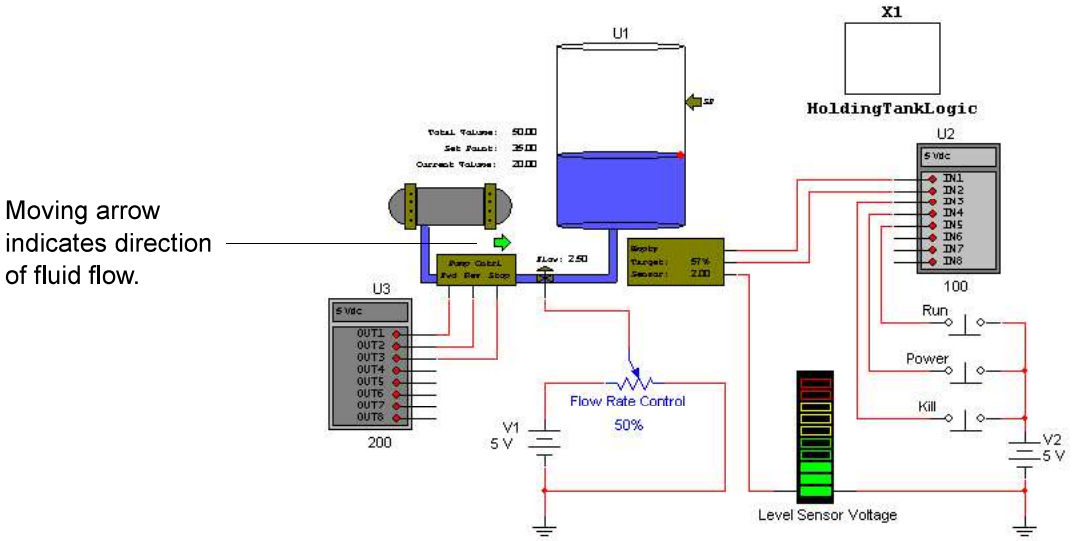
Contact X1 in the Power Lock-up Rung of the ladder diagram. Relay Coil M1 is energized, causing all Relay Contacts with **Relay Device Reference** = M1 to energize.



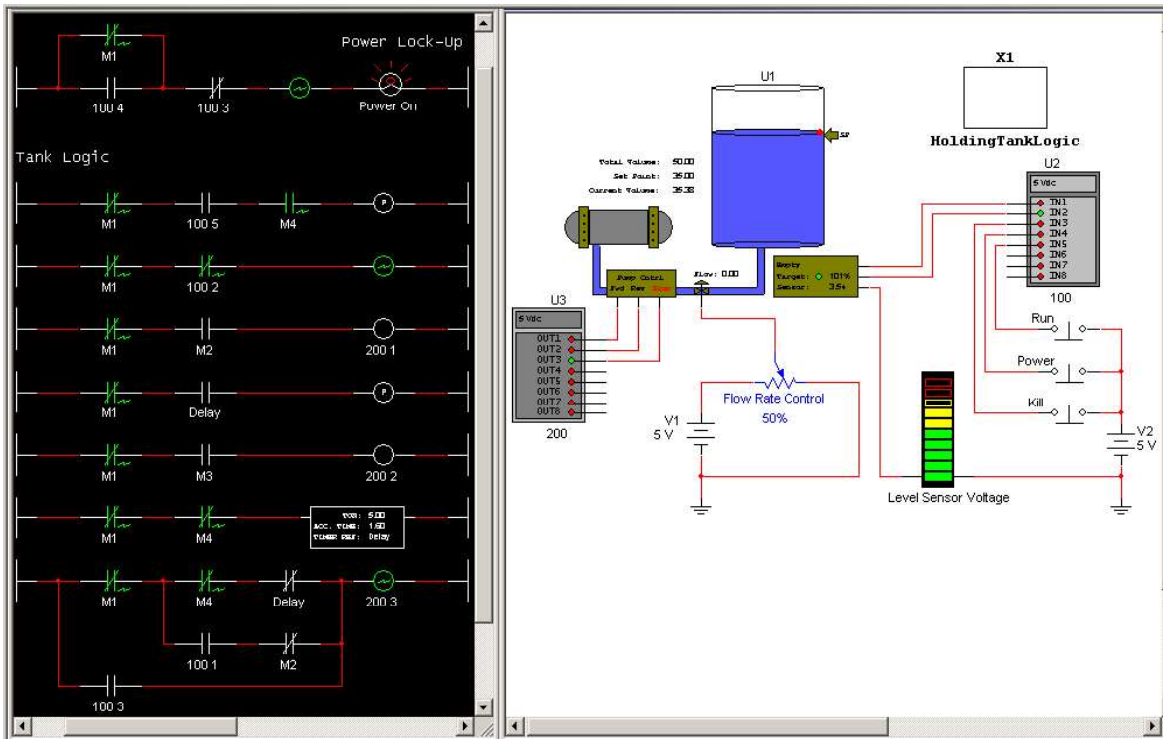

- To run the holding tank circuit:
  1. Activate the circuit as described above.
  2. Press R on your keyboard (or hover your cursor over the Run switch and click the button that pops up) to activate the Run temporary switch.

***Tip*** Select **Window/Tile Vertical** to view the ladder diagram and the circuit at the same time. Observe the interaction between the ladder diagram and the circuit as the simulation proceeds.

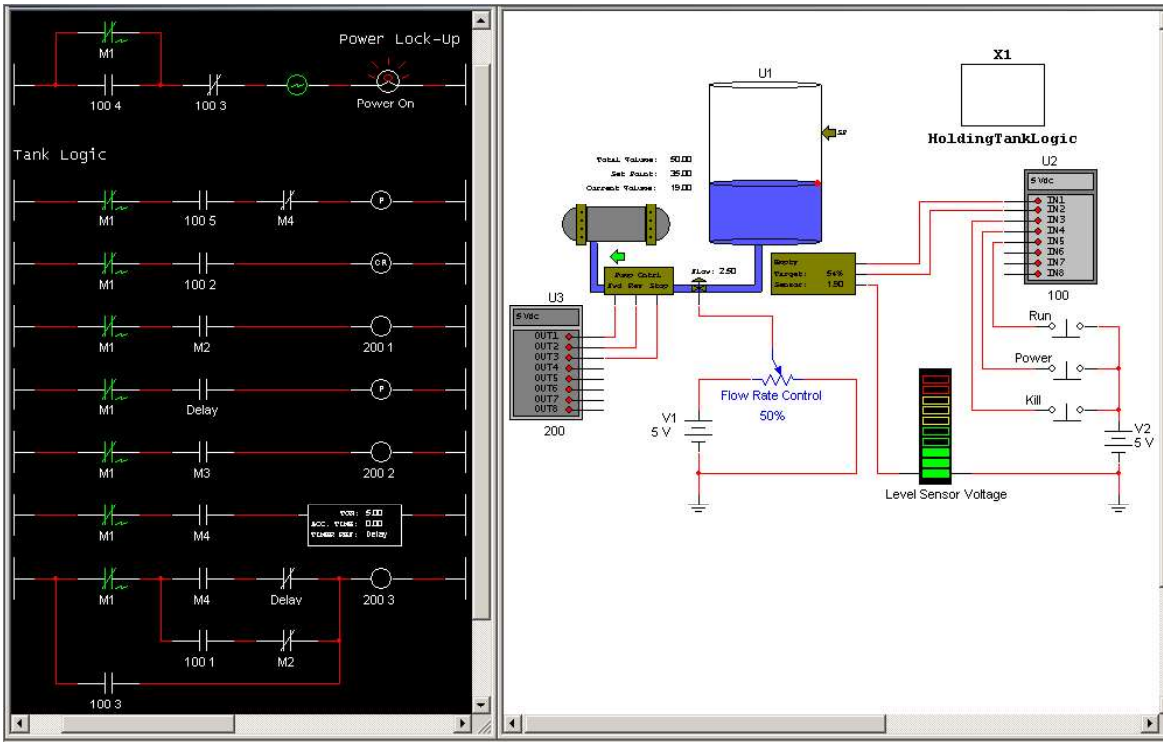
3. As the simulation proceeds, the tank begins to fill.



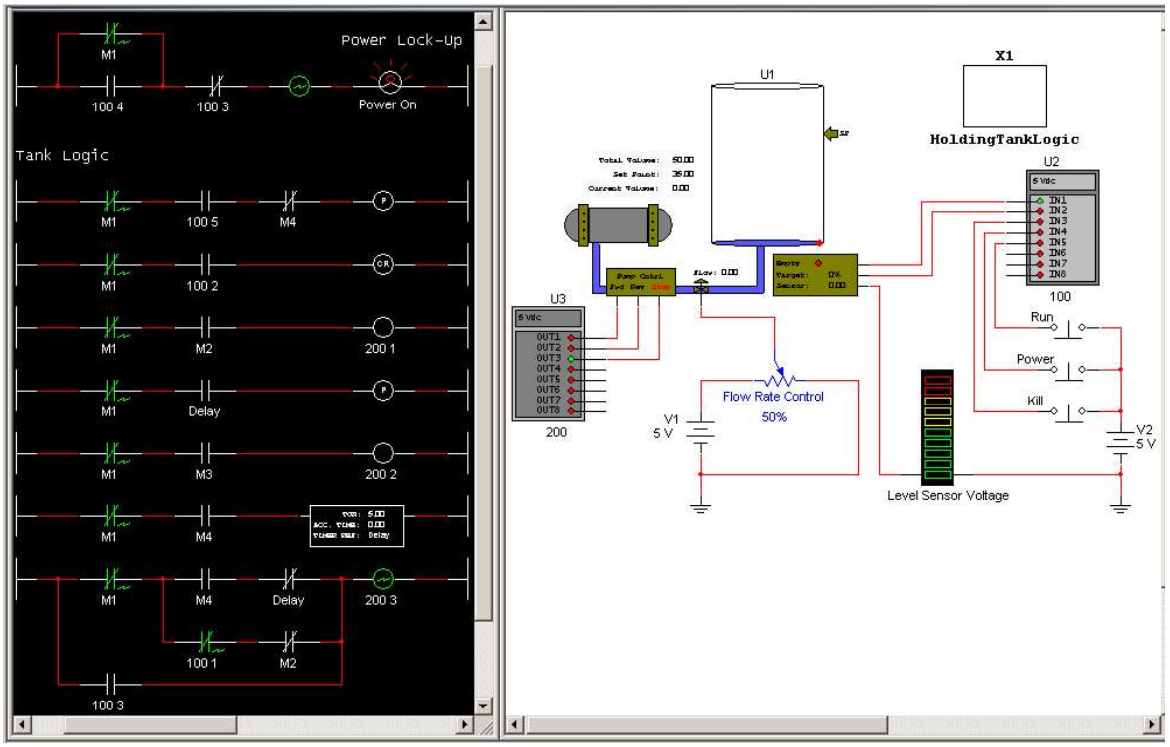

4. When the level of the fluid in the tank gets to the **Set Point**, fluid stops being pumped.



5. After a delay of five seconds, the tank begins to empty.




6. When the tank is empty, the flow stops.



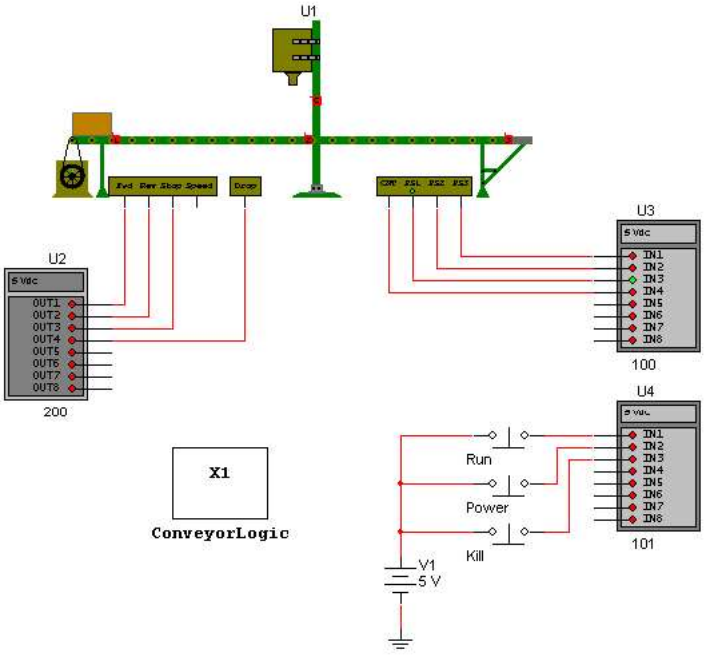
➢ To turn off the power at any point in the simulation:

1. Press K on your keyboard (or hover your cursor over the Kill switch and click the button that pops up) to activate the Kill temporary switch. This sends 5 V to pin IN3 of Input Module U2 (**Input Module Base Address** = 100) which in turn energizes Input Contact X2 (the contact opens). The continuity in the Power Lock-up Rung is broken and Relay Coil M1 is de-energized, which in turn switches off all Relay Contacts with **Relay Device Reference** = M1.

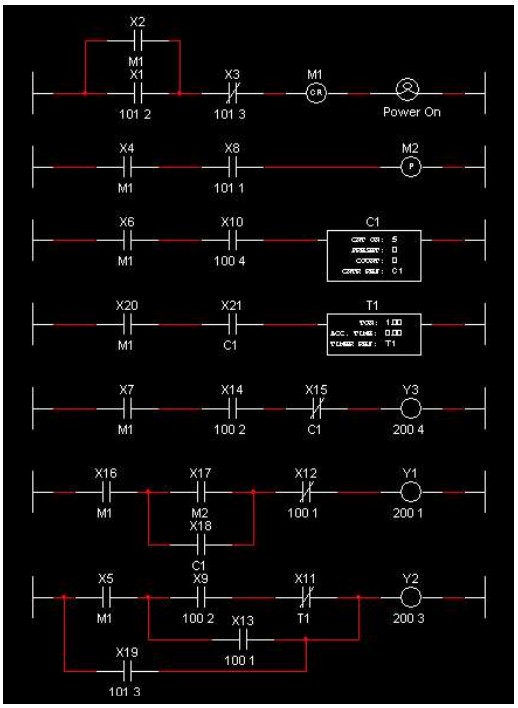
   When you press K, X20 is also temporarily energized, which in turn temporarily energizes Output Coil Y2, which sends a pulse to pin Out3 of Output Module U3. This is wired to the **Stop** pin of the holding tank, so the tank stops filling or emptying (depending on which is currently occuring).

## 4.4.2 Conveyor Belt

This section contains an example of a **Ladder Diagram** that drives a conveyor belt.




For details on the user-settable parameters for the Conveyor Belt, Input Module and Output Module, see “A.2 Ladder Diagram Parts” on page A-8

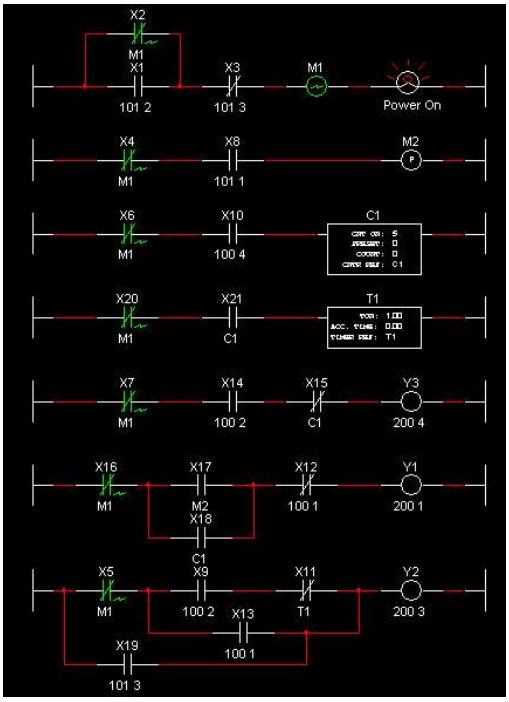



The Ladder Diagram is contained in a separate Hierarchical Block called ConveyorLogic. For details on hierarchical blocks, refer to the Multisim User Guide.

➢ To activate this circuit:

1. Select **Simulate/Run** to begin simulation.
2. Press P on your keyboard (or hover your cursor over the Power switch and click the button that pops up) to activate the Power temporary switch. This sends 5 V to pin IN2 of Input Module U4 (**Input Module Base Address** = 101) which in turn energizes Input Contact X1

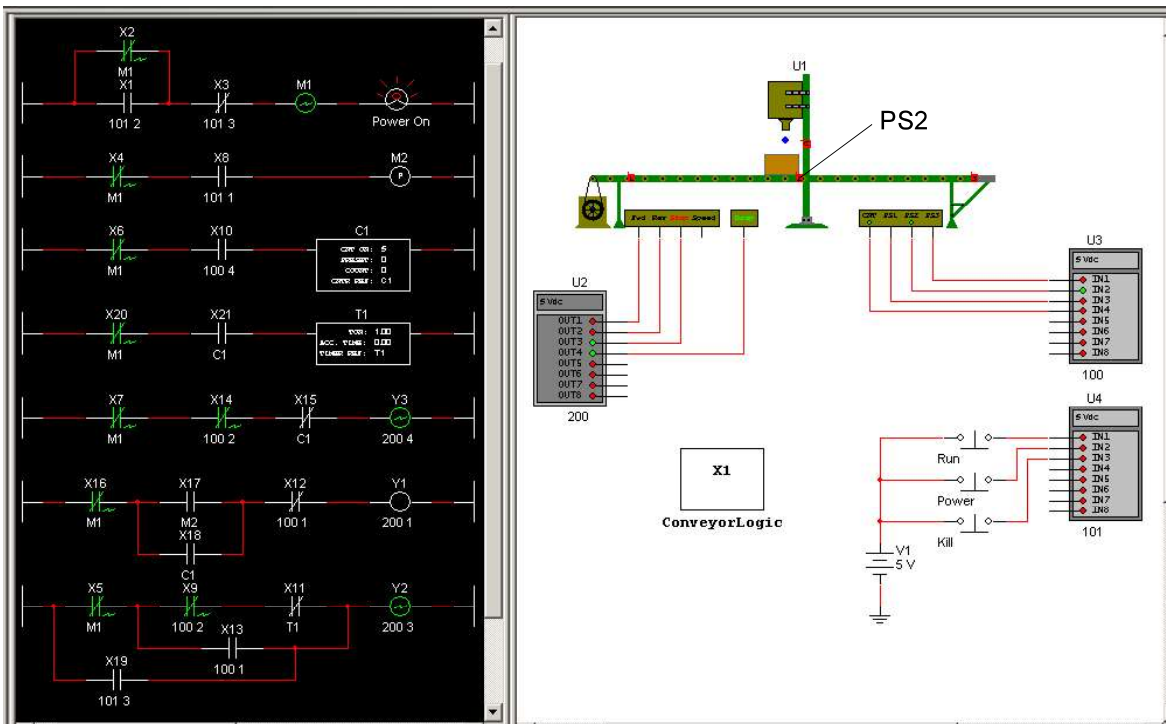
in the Power Lock-up Rung of the ladder diagram. Relay Coil M1 is energized, causing all Relay Contacts with **Relay Device Reference** = M1 to energize.



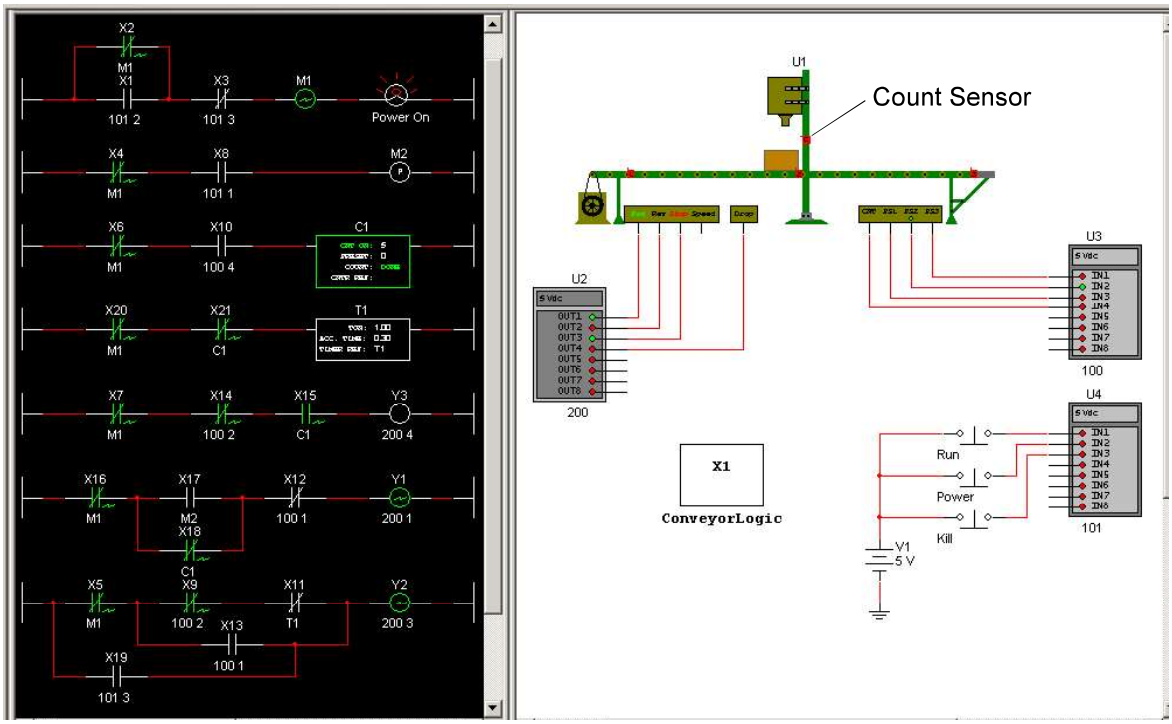

- To run the conveyor belt:
  1. Activate the circuit as described earlier.
  2. Press R on your keyboard (or hover your cursor over the Run switch and click the button that pops up) to activate the Run temporary switch.

***Tip*** Select **Window/Tile Vertical** to view the ladder diagram and the circuit at the same time. Observe the interaction between the ladder diagram and the circuit as the simulation proceeds.

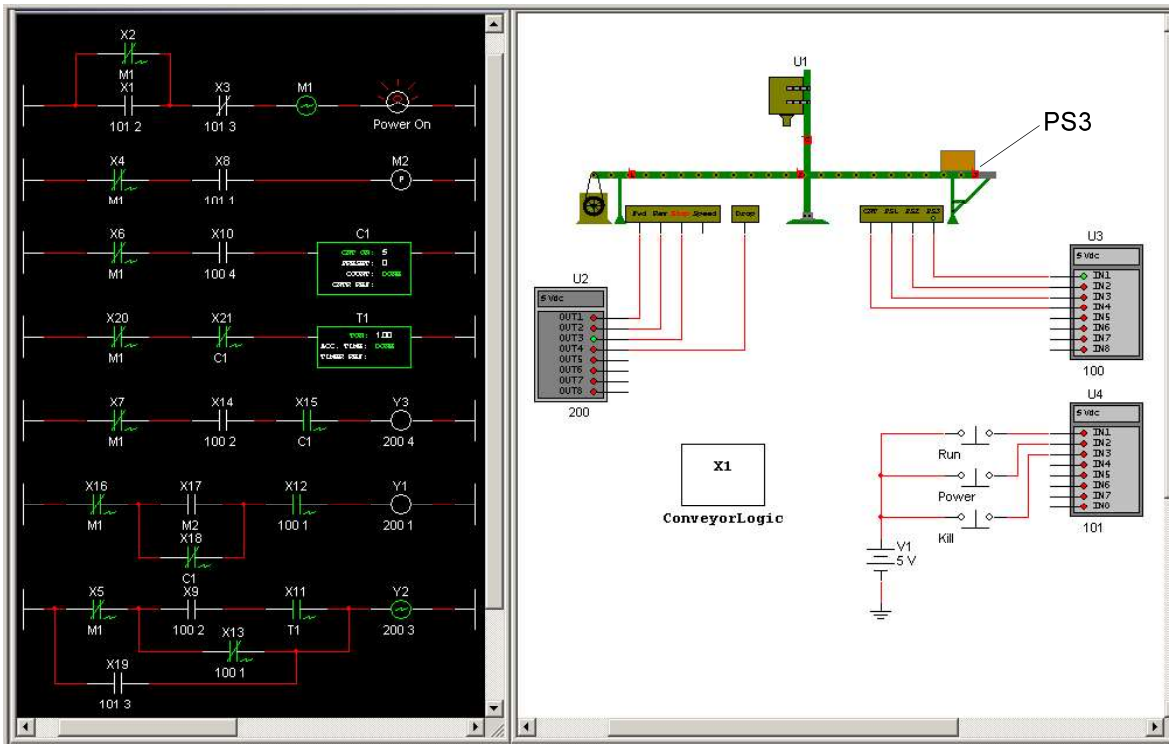
3. As the simulation proceeds, the box moves along the conveyor belt to Position Sensor 2 (PS2). The box stops moving and balls begin dropping from the hopper into the box.




4. When five balls have dropped into the box (counted by Count sensor and C1), the hopper stops dropping balls.



5. The conveyor continues moving and stops when the box gets to Position Sensor 3 (PS3).



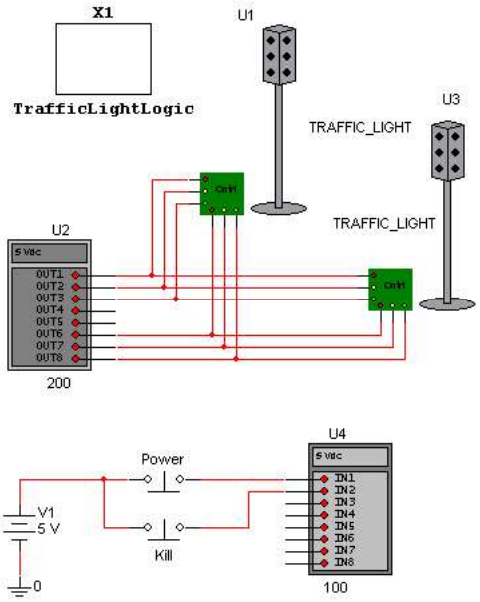

➢ To turn off the power at any point in the simulation:

1. Press K on your keyboard (or hover your cursor over the Kill switch and click the button that pops up) to activate the Kill temporary switch. This sends 5 V to pin IN3 of Input Module U4 (**Input Module Base Address** = 101) which in turn energizes Input Contact X3 (the contact opens). The continuity in the Power Lock-up Rung is broken and Relay Coil M1 is de-energized, which in turn switches off all Relay Contacts with **Relay Device Reference** = M1.

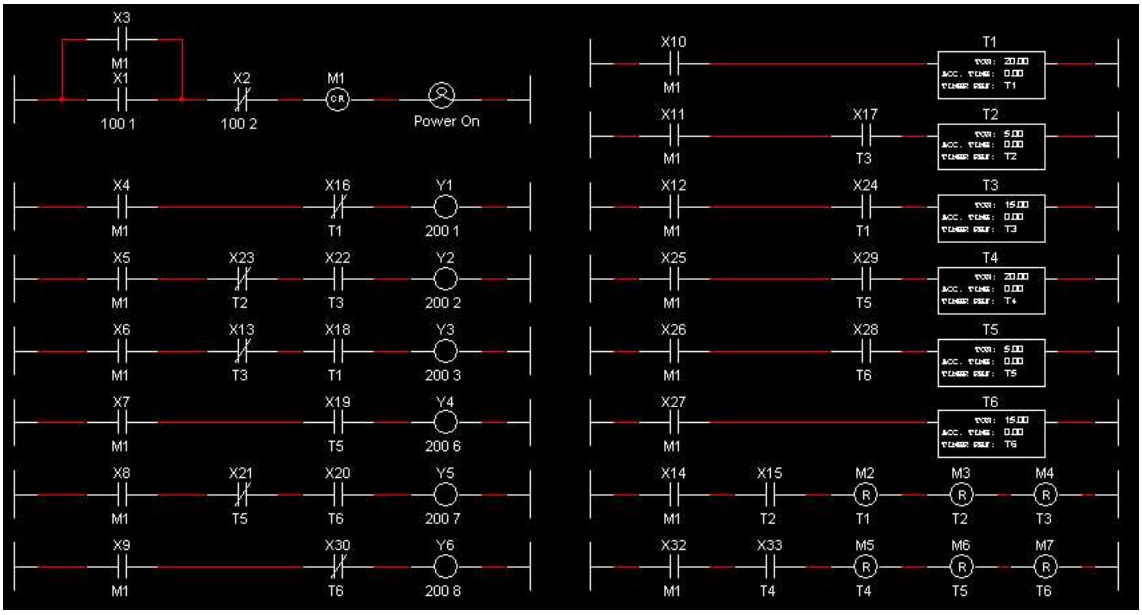
   When you press K, X19 is also temporarily energized, which in turn temporarily energizes Output Coil Y2, which sends a pulse to pin Out3 of Output Module U2. This is wired to the **Stop** pin of the conveyor belt, so the belt stops.

# 4.4.3 Traffic Light

The ladder diagram in this section runs two traffic lights.



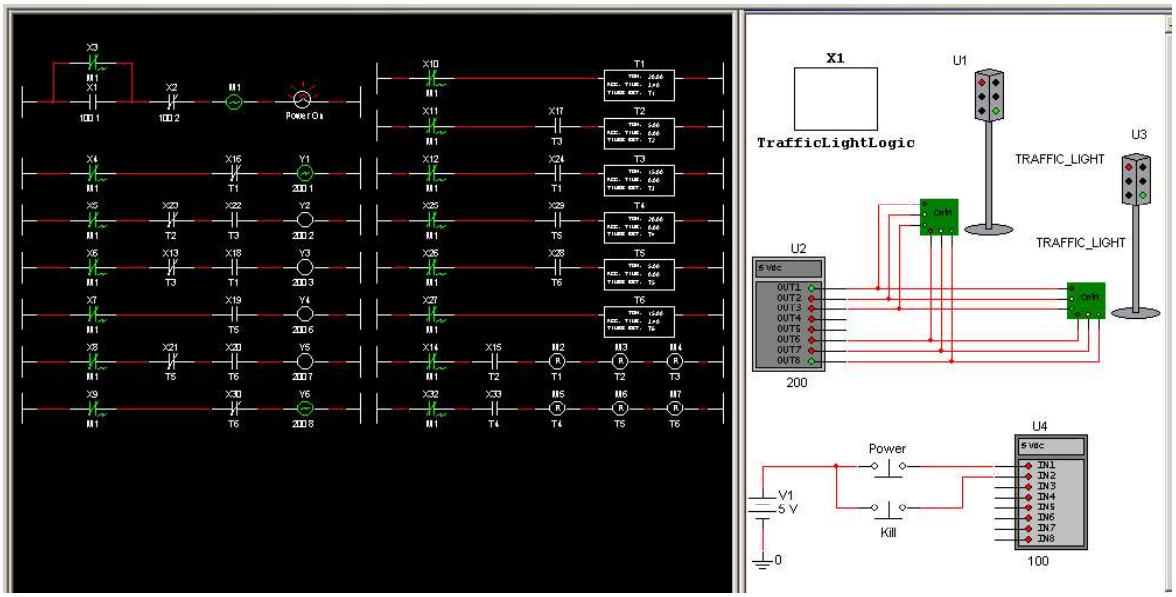

The Ladder Diagram is contained in a separate Hierarchical Block called TrafficLightLogic. For details on hierarchical blocks, refer to the Multisim User Guide.



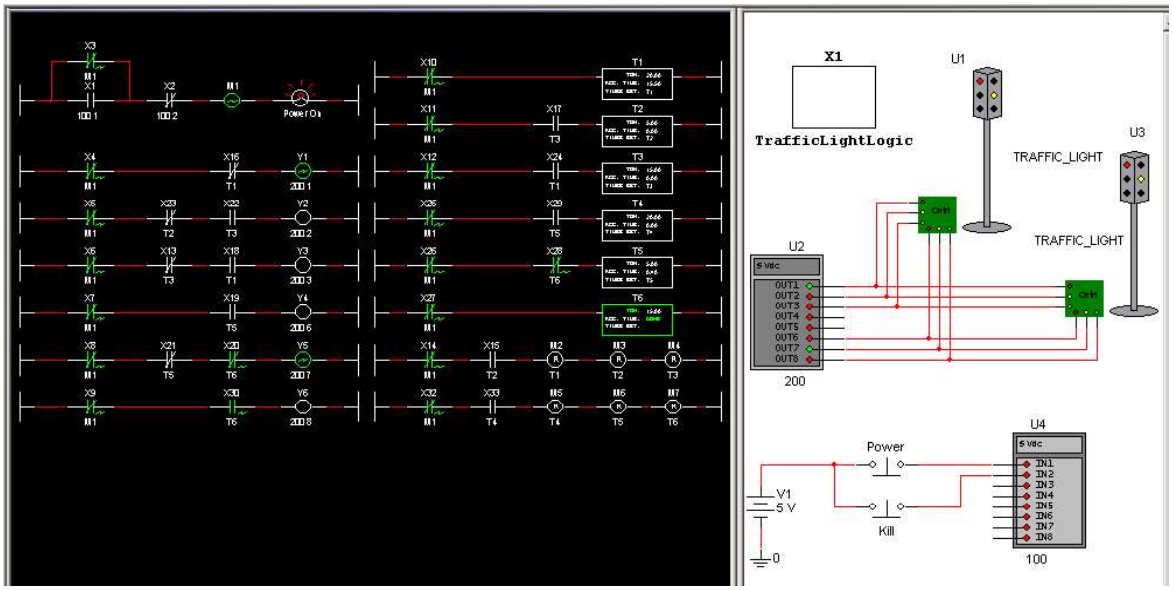

- To run the traffic lights:
  1. Select **Simulate/Run**.
  2. Press P on your keyboard (or hover your cursor over the Power switch and click the button that pops up) to activate the Power momentary switch.

***Tip*** Select **Window/Tile Vertical** to view the ladder diagram and the circuit at the same time. Observe the interaction between the ladder diagram and the circuit as the simulation proceeds.

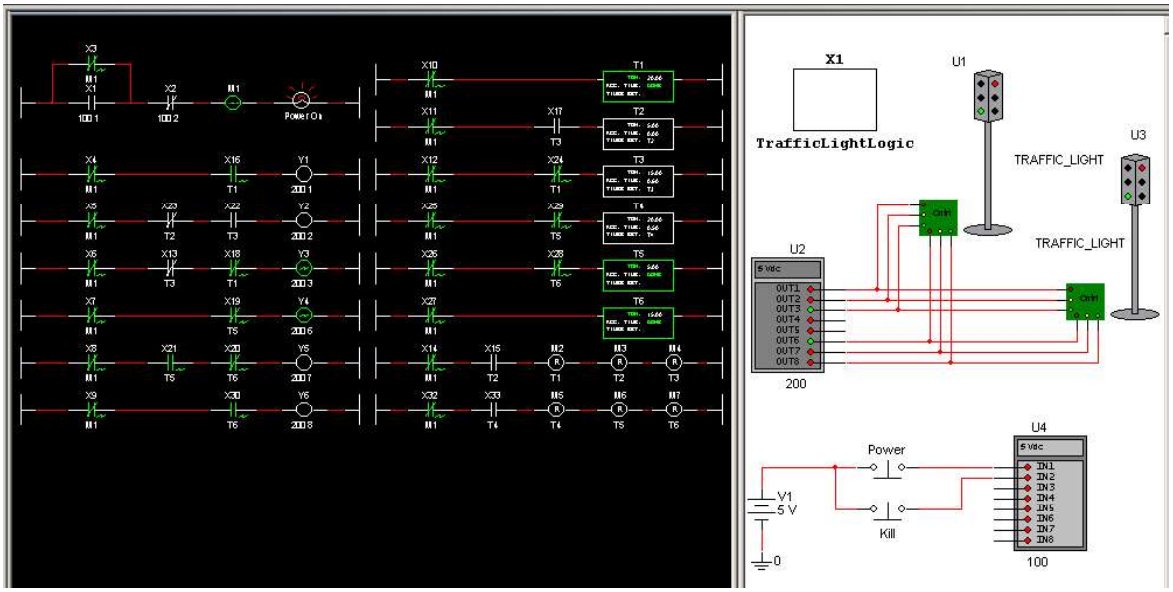
3. The red and green lights in traffic lights U1 and U3 light as shown below.



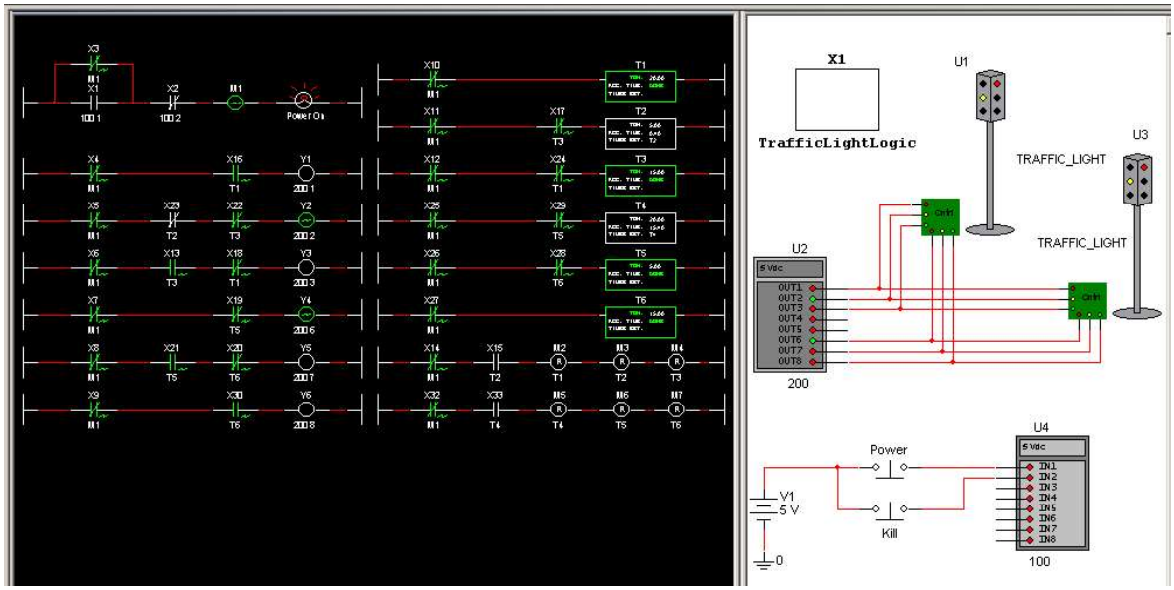

4. After 15 seconds, the green lights turn amber.



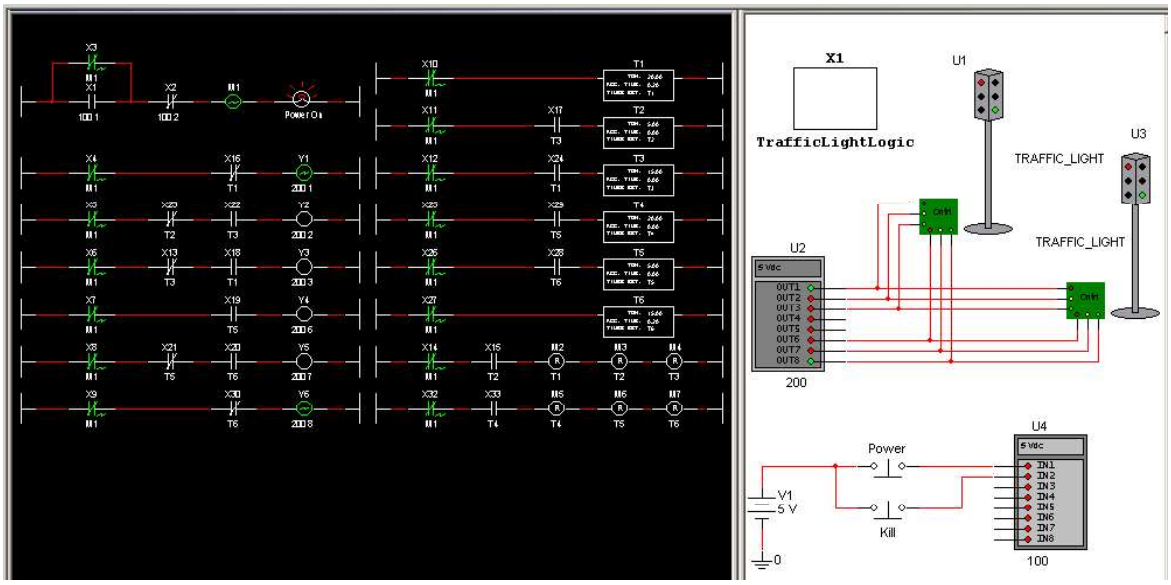
5. After 5 more seconds, the amber lights turn red and the red lights turn green.




6. After 15 seconds, the green lights turn amber.



7. After 5 more seconds, the amber lights turn red and the red lights turn green.




8. The cycle continues in this way until you stop the simulation, or press K (or hover your cursor over the Kill switch and click the button that pops up) to activate the Kill momentary switch.