

Introduction to Programmable Logic Control

In this session you will practise some command techniques which will be of use to you in the field of Programmable Logic Control (PLC).

The objectives of this work session are:

- To gain an understanding of PLC Ladder Logic design.
- Become familiar with the PLC simulator LADSIM.
- Implement and test simple circuits in simulation using LADSIM.

LADSIM

LADSIM (Ladder Logic Editor and Programmable Logic Controller Simulator) is a simulation program that allows potential PLC logic designs to be tested on a PC. Once ready, the design can be transferred from the PC onto an actual PLC device. There are several manufacturers of PLCs; for example Allen Bradley, Mitsubishi and Siemens. Before choosing a PLC, two points should be considered; firstly the physical size of the PLC and secondly its functionality (the type and number of input and output modules).

LADSIM has the following three main features:

- It enables the PC to simulate a PLC such that Ladder Logic PLC programs can be built up on the screen in a simple 'Drag and Drop' manner.
- The PLC programs can be used to control one of several different 'on screen' simulations of control problems.
- It allows the user to control the simulation and become familiar with PLC programming techniques. The user can then move on to control real external items of equipment via a Bytronic Interface if required.

Bytronic manufacture a range of products designed for this purpose; including conveyor systems, traffic control units, rotary transfer units and more. In LADSIM the following items are available for your programs:

- 16 inputs start from IP0 to IP15
- 16 output start from OP0 to OP15
- 16 flags start from F0 to F15 (Auxiliary Relays)
- 8 timers start from T1 to T8
- 8 counters :C1 to C8 (these can be used counter up or counter down)
- 80 reset functions for the timers, counter and shift registers
- 4 16 Shift Bit Registers

Section 1 Basic Logic

Open LADSIM from the **Start > Programs > Bytronic > LADSIM3 > LADSIM3** menu.

A window entitled LADSIM will appear as in Figure 1

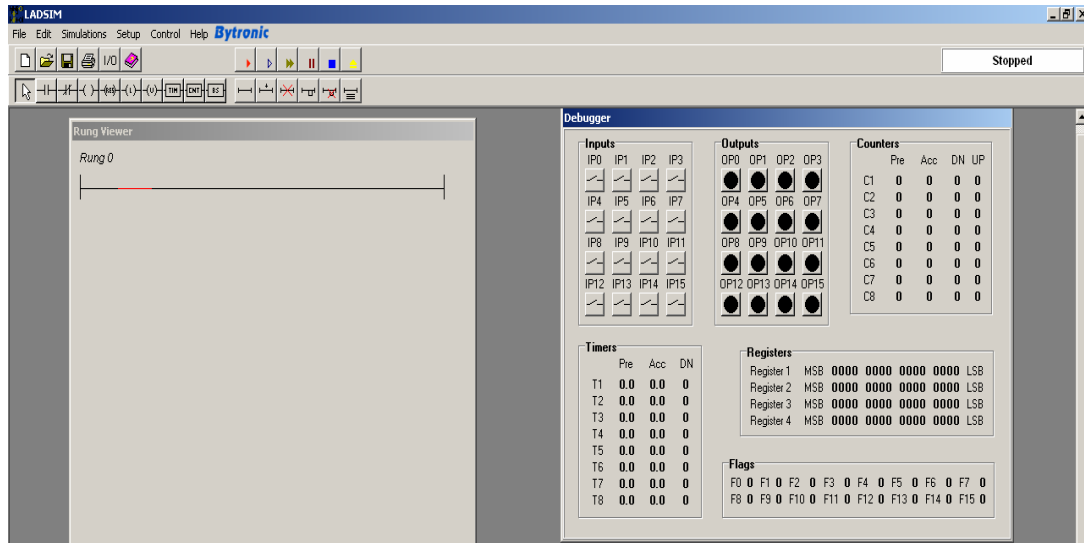


Figure 1 LADSIM window

1.1 Example: Basic Logic

Consider the electrical circuit in Figure 2 below. It consists of a switch, light bulb and a power supply. Closing the switch will allow the current to flow around the circuit and the bulb will light.

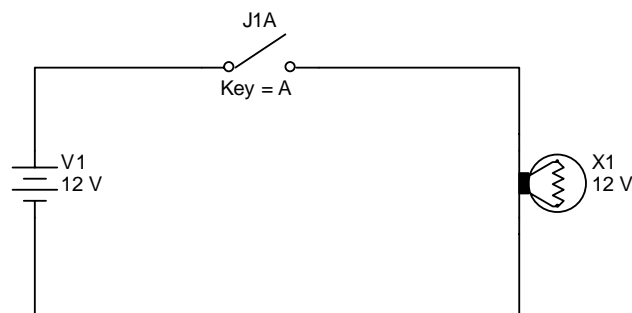


Figure 2

Task: Use LADSIM to create a simulation of the circuit.

Remember: Save your work regularly. Use the Help menu if you need assistance, or ask a demonstrator.

Step 1

Click on the appropriate normally open contact icon, move it to the rung line and place it where the red line appears; then click on it as shown in figure 3.

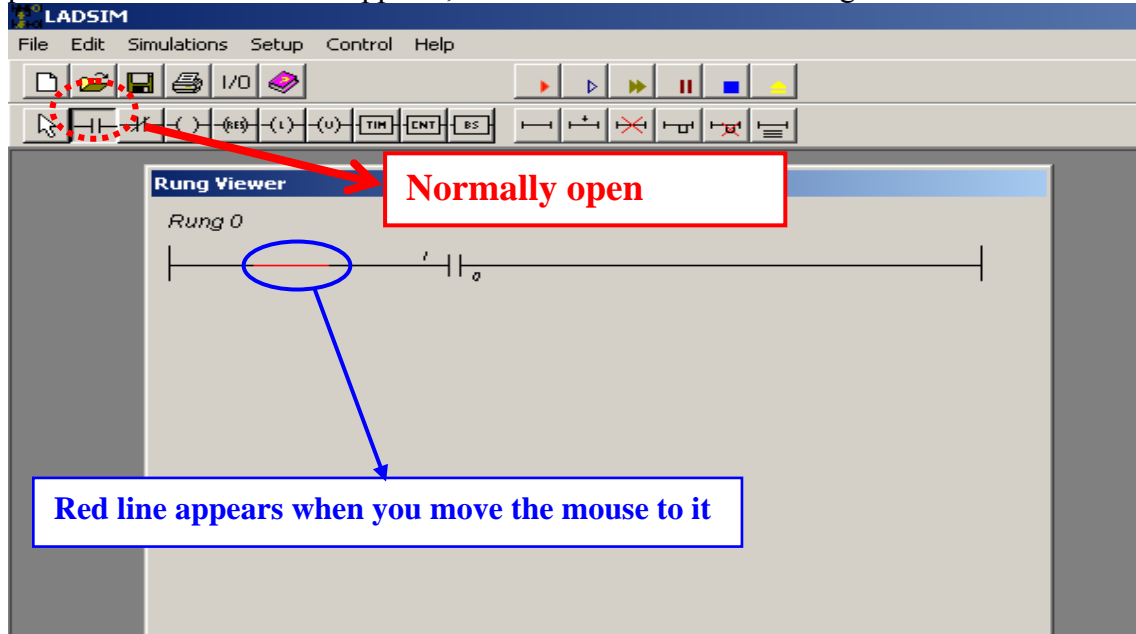


Figure 3

Step 2

When you place the appropriate normally open contact icon on the red line and click, the input selection dialogue box will appear. Under 'Inputs' you will find a group of 16 inputs. Choose any input from the 16 inputs available in the box by clicking inside the white circle to its left. Then click Ok, or press Enter (As in Figure 4)

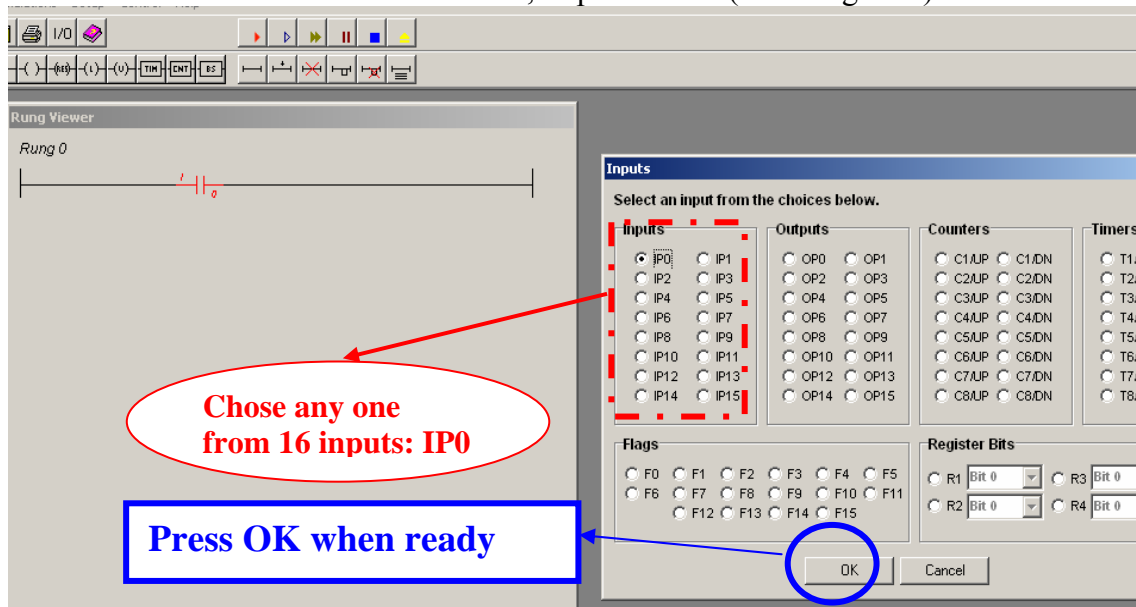


Figure 4

Step 3

Click on the appropriate output coil icon with the mouse, move it to the rung line and place it by the mouse where red line appears at the end of the rung line. Then click on it as shown in Figure 5.

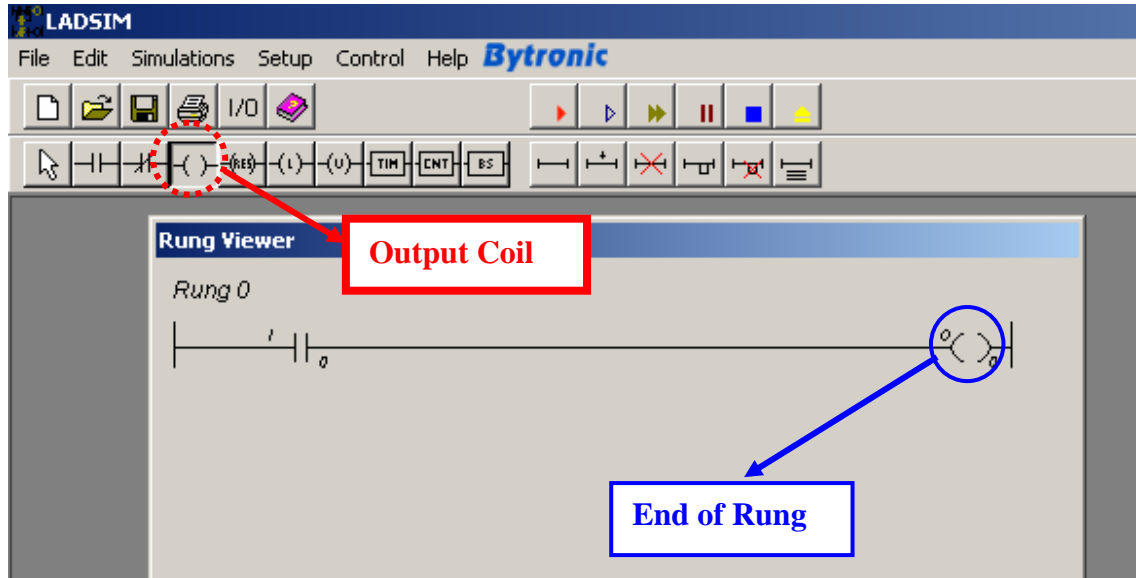


Figure 5

Step 4

When you place the appropriate output coil icon on the red line and click, the input selection dialogue box will appear. Under 'Outputs' you will find a group of 16 Outputs. Choose any output from the 16 Outputs available in the box by clicking inside the white circle to its left. Then click Ok, or press Enter (As in Figure 6)

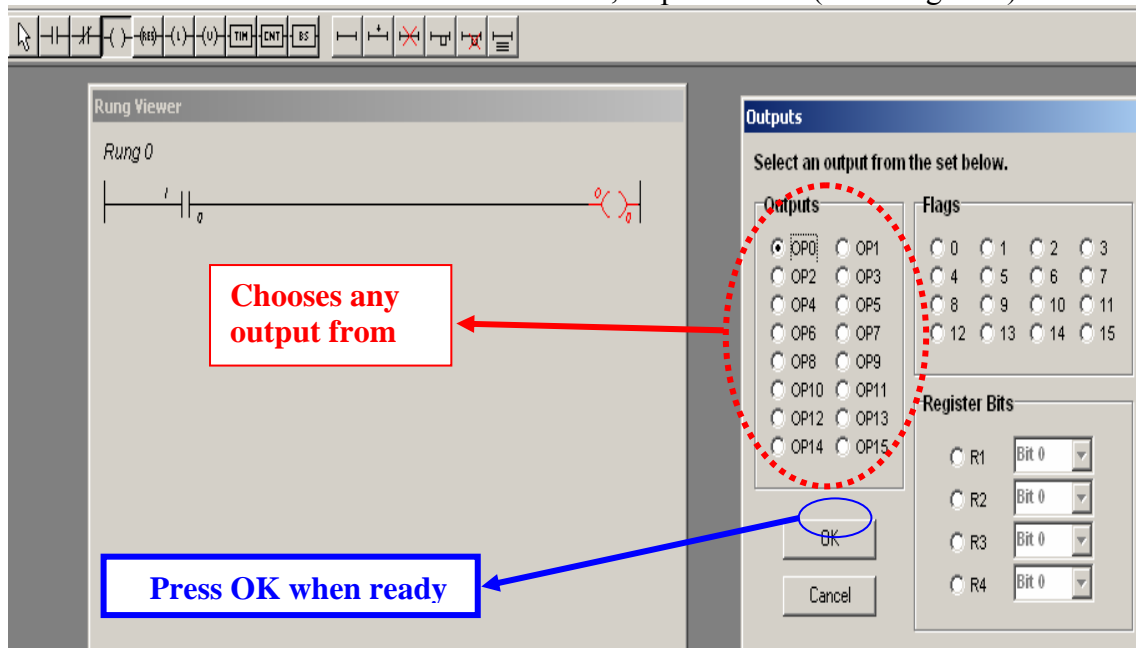


Figure 6

Step 5

Click once on the Run button icon to execute the ladder diagram. Also use this button to resume the ladder diagram when it is paused. Use the pause icon to pause the execution of ladder diagram. When you click once on stop diagram icon, it will stop the execution of the ladder diagram as shown in Figure 7

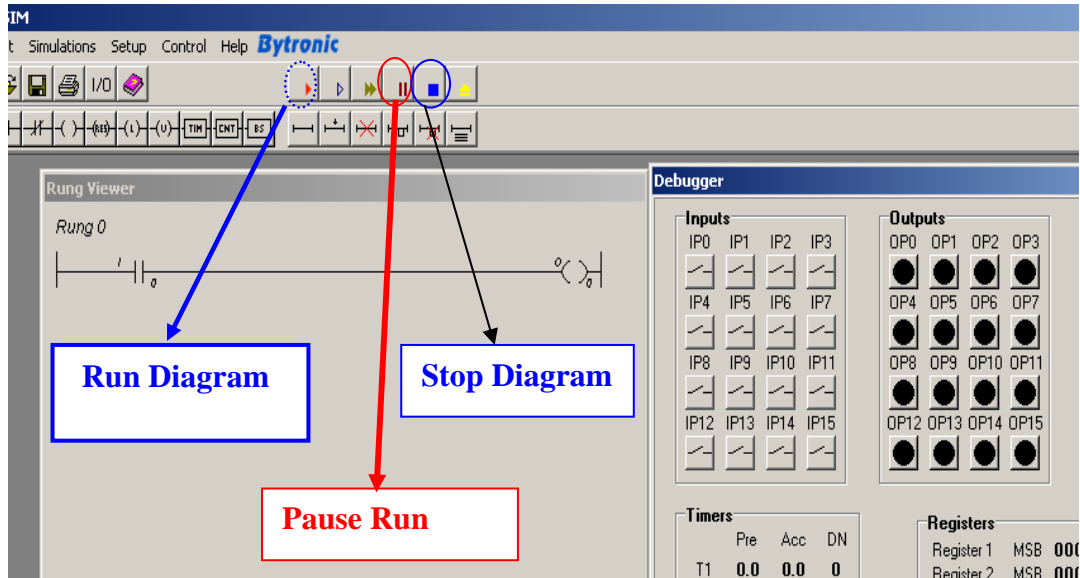


Figure 7

Step 6

When you run the diagram, the light bulb will not be activated until you click IP0. Then, the current will pass to the output coil. A red light will appear under 'Outputs' indicating an active circuit, as in Figure 8.

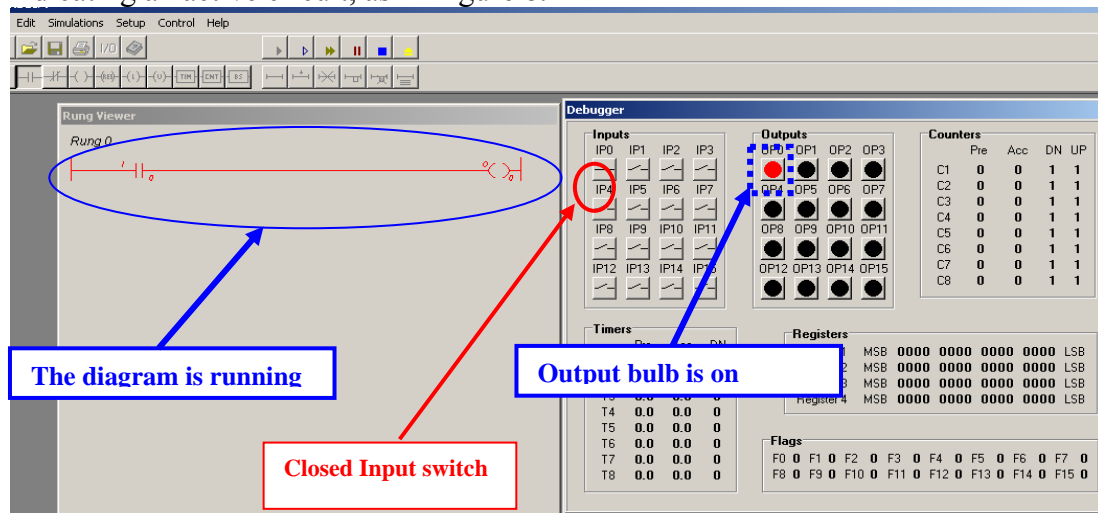


Figure 8

Result

Time sequence is displayed in two signals 1 and 0. When the current passes through IP0 to OP0, the light bulb will be on (signal 1). When IP0 is switched off, no current passes in the circuit (signal 0). When you press on IP0 to turn switch on, the circuit will be activated and OP0 will be activated. Otherwise, if you press on IP0 to turn the switch off, the circuit will be deactivated and OP0 will be deactivated. Figure 9 shows the two stages (on = 1/off=0)

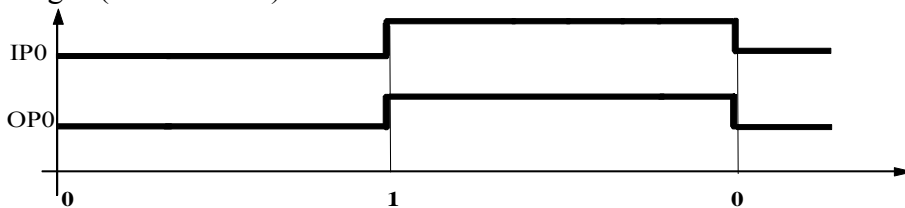


Figure 9

Section 2 Student Exercises I

2.1 Exercise 1: Basic Logic

Consider the electrical circuit in figure 10 below. It consists of two switches series, a light bulb and a power supply. When switch A is closed on its own the lamp will not light. Also when switch B is closed on its own the lamp will not light. Only when both switch A **AND** switch B are closed at the same time the bulb will be activated. Create a simulation of the circuit.

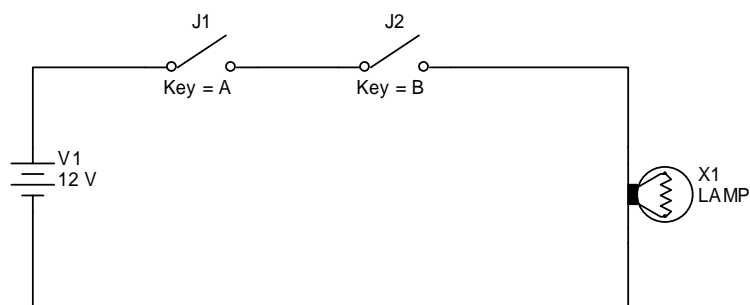


Figure 10

2.2 Exercise 2: Basic Logic

Consider the electrical circuit in figure 11 below. It consists of two parallel switches, light bulb and a power supply. When we close switch A **OR** switch B, this will allow the current to flow around the circuit and the bulb will be on. Create a simulation of the circuit.

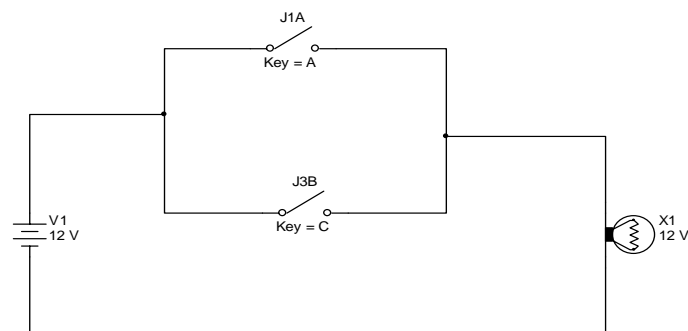


Figure 11

Hint: To implement an OR statement, you will need to use a branch.

Industrial Automation: LADSIM Exercises

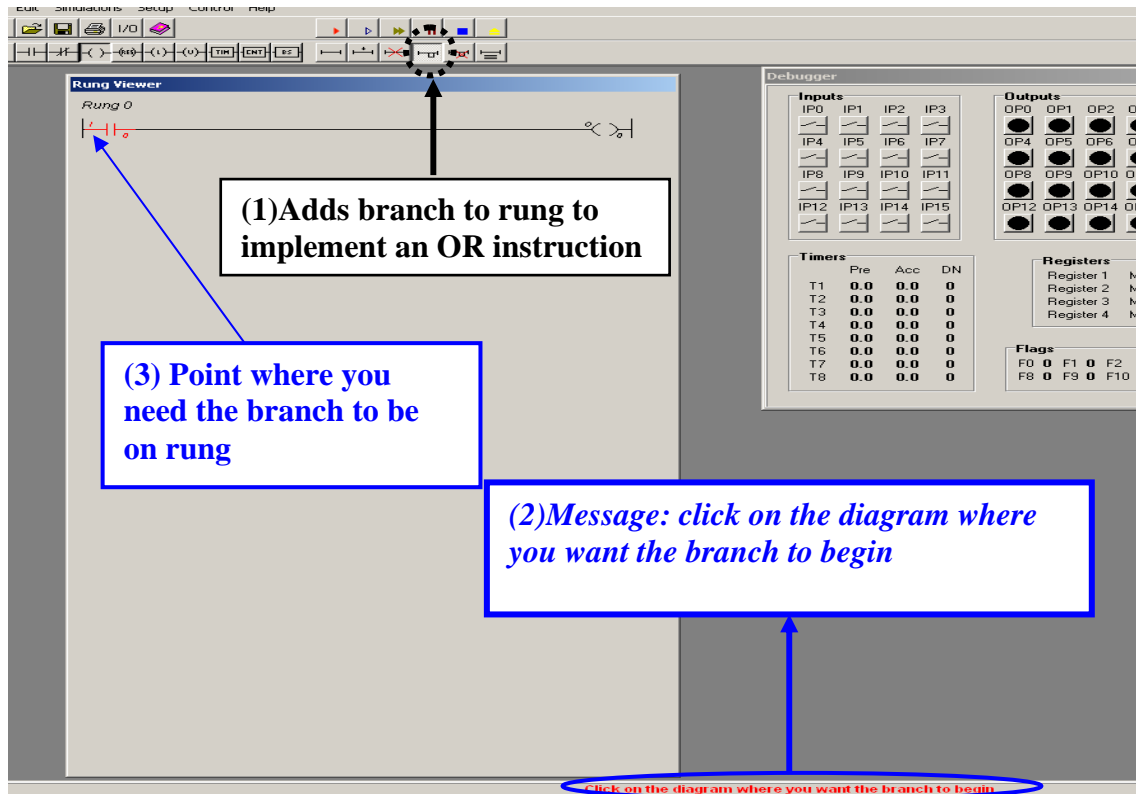


Figure 12

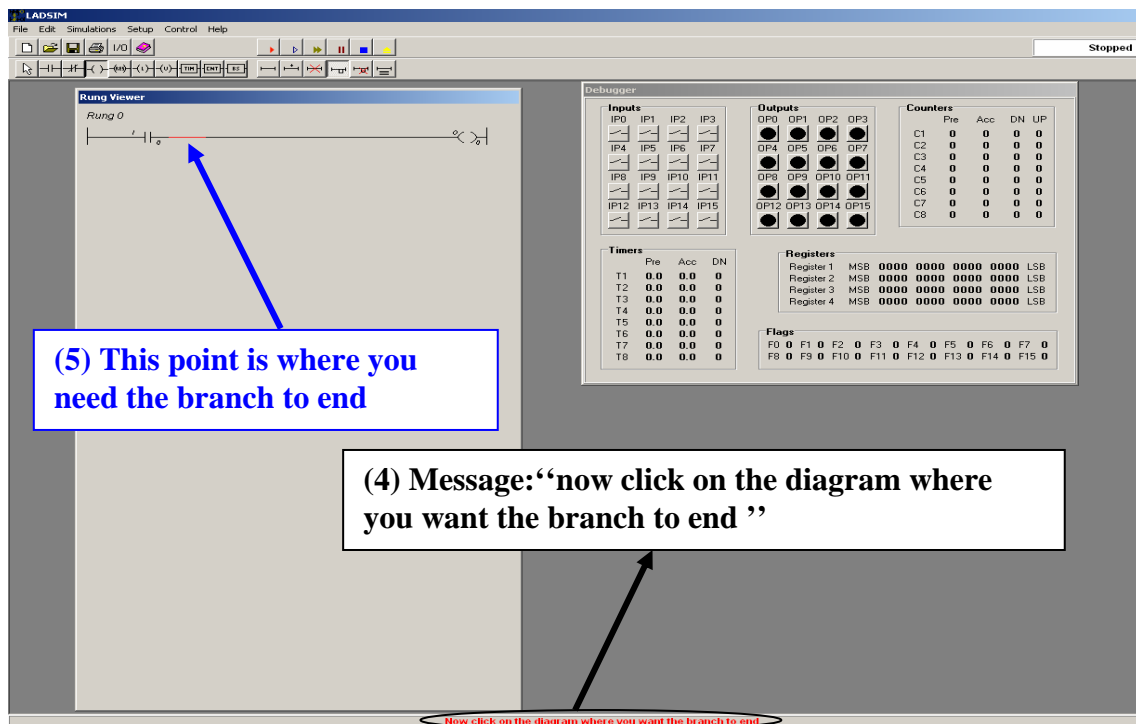


Figure 13

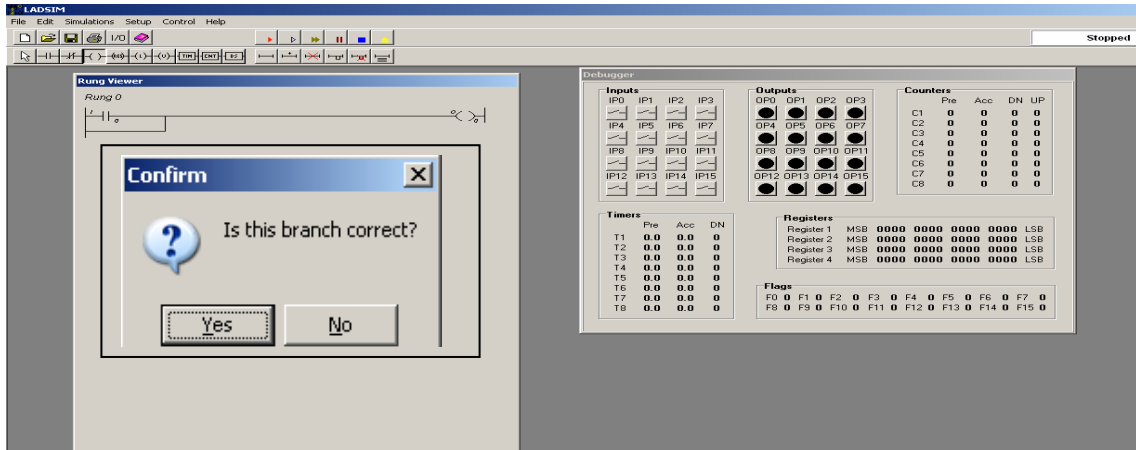


Figure 14

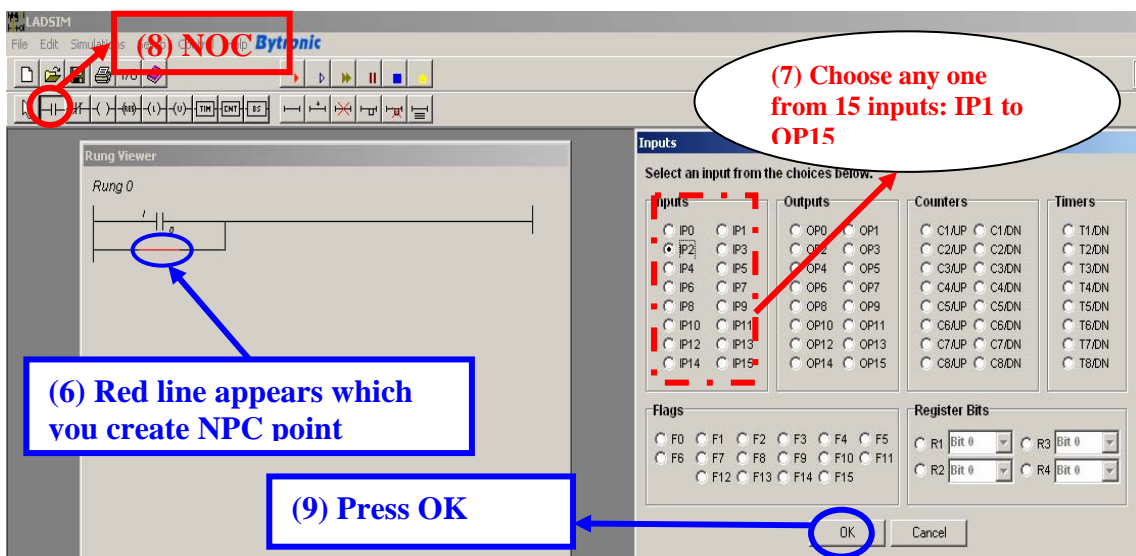


Figure 15

2.3 Exercise 3: Basic Logic

Consider the **XOR** gate electrical circuit in figure 16 below. The XOR gate circuit consists of two switches (switch A ON/OFF switch B ON/OFF), light bulb and a power supply. The output will be activated if switch A is closed on OR switch B is closed on, but not both. When the two switches A & B are closed on the light bulb will be deactivated also if both switches are off the lamp will be not be ON

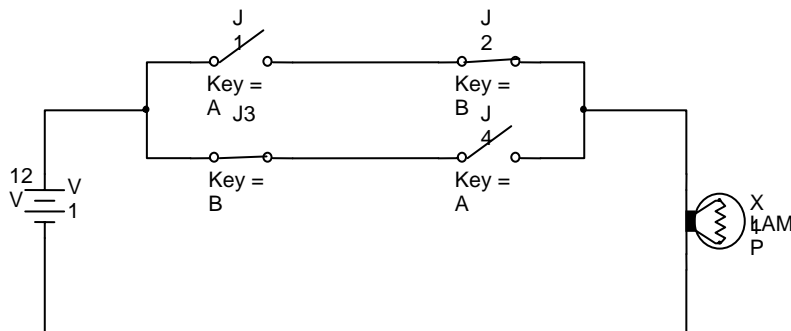


Figure 16

Section 3 The Timer Function

There are two types of timer available in LADSIM, both have similar properties associated with them but perform their functions in slightly different ways. The on-delay timer (shown in figure 17) has a delay it will count up to only while energised, if it is de-energised whilst counting up to its delay it will reset its counting. On the other hand, a Latched On-Delay timer (shown in figure 18) will continue counting up to its delay once initially energised, regardless of whether or not it is de-energised before it reaches its delay. LADSIM limits the total number of timers (on-delay or latched on-delay) to eight.

The following points can be noted about all LADSIM timers:

- The incrementing can be observed in simulation mode in the timer's Accumulator, with increments in tenths of a second.
- If the timer is de-energized then it will continue to increment until the preset value (in seconds) is reached only in a Latched On-Delay timer.
- The Done Bit (DN) is energised when the Accumulator reaches the Preset Value.
- Once DN has been set it can only be switched 'OFF' by using the reset (RES) function.
- The reset is an output function that can be energized by an input contact and has priority over the timer's accumulator incrementing.
- When the timer has completed its incrementing an x will appear in the DN box of the Simulator box.

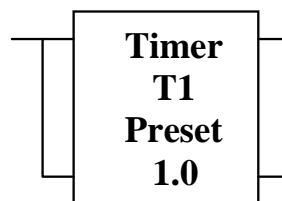


Figure 17

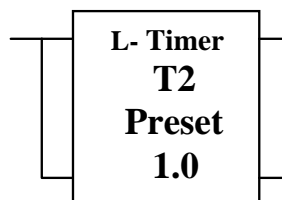


Figure 18

3.1 Example: Timer Function

Consider the electrical circuit in figure 19 below. The timer function consists of one switch, two lamps, one timer (a Latched On-Delay timer) and a power supply. The first lamp will be activated if switch A is closed then after 10 sec the second lamp will be activated, alternatively if switch B is closed (on) then lamp X2 will be deactivated. When the switch A is open (off) the lamps will be deactivated. Create a simulation of the circuit.

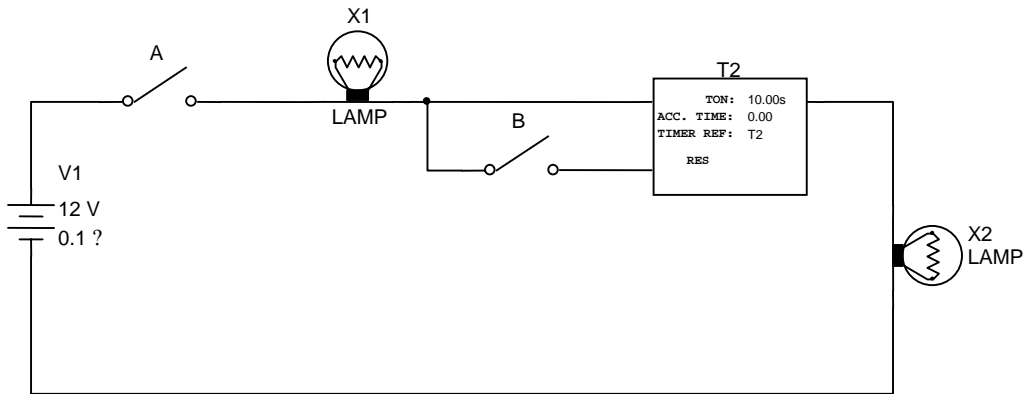


Figure 19

Step 1

Start a new project and create a normally open contact, NOC (IP0) and create the output (OP0).

Step 2

Click on add rung icon to add a rung to the current diagram. The new rung will be position at the end of the current diagram you can also use the delete rung icon to delete a rung from your diagram then the message (click on the rung you wish to delete) will appear at the bottom of screen when you use this. Click anywhere on the rung you wish to delete, in this case Rung 2 the rung will be highlighted red, and a dialogue box asking you to confirm deletion will be displayed as shown in figure 20.

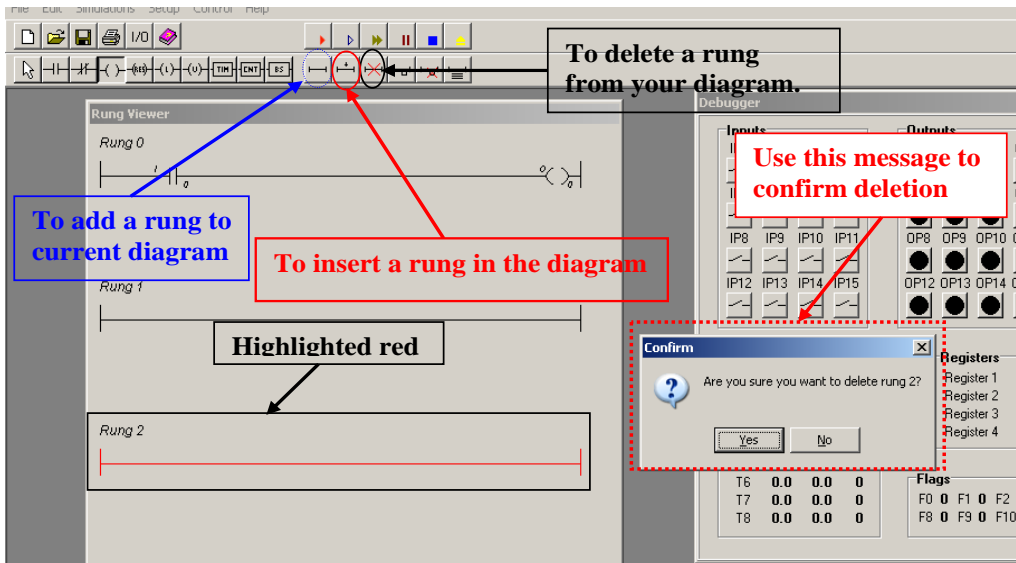


Figure 20

Step 3

Create another normally open contact in the rung (rung 1) then choose OP0 from the Outputs group, which will be the input this time, by clicking inside the white circle to its left in the box. Then click Ok, or press Enter (As shown in Figure 21)

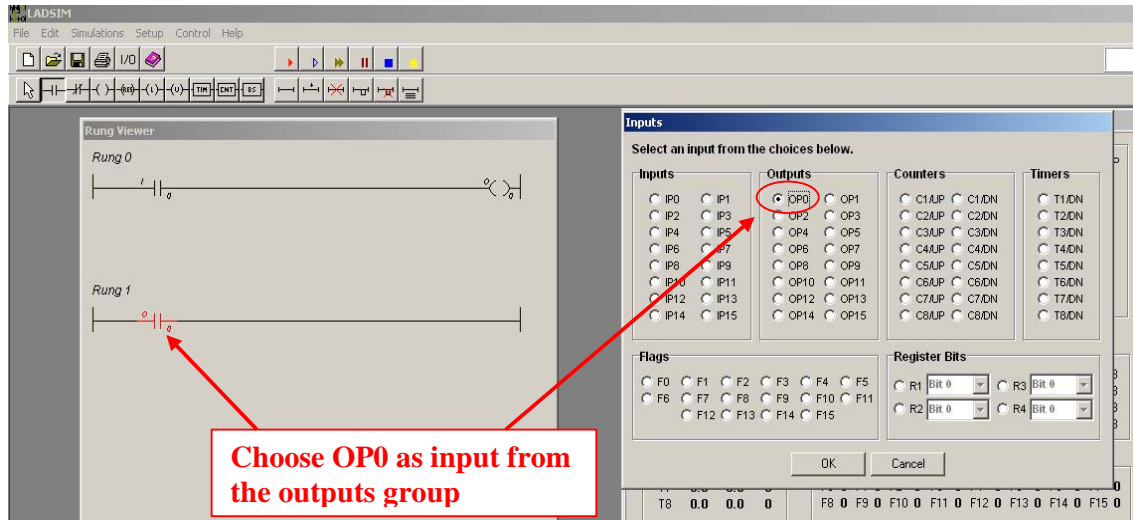


Figure 21

Step 4:

Click on the timer icon and drag a timer onto Rung 1 and release it to the right of the rung. When the timer is placed onto the rung, the timer dialogue box will appear. From this select T1 from the list of timers. Enter a preset value of 10 by clicking the preset field and typing 10, following this select the required Timer Style (which is an On-Delay Timer) and finally click OK to accept the timer settings as shown in figure 22

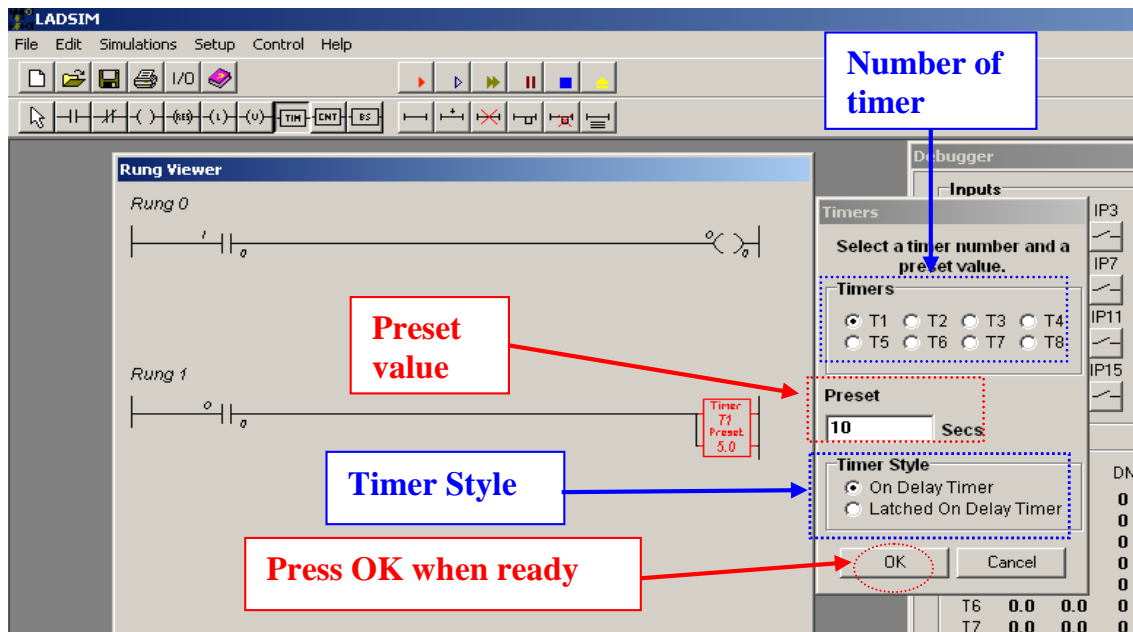


Figure 22

Step 5

Click on add a new rung and place a normally open contact input contact on it. Assign the input contact as the timer 1 done bit (T1/DN) by selecting it from the timer section of the inputs dialogue box as shown in figure 23.

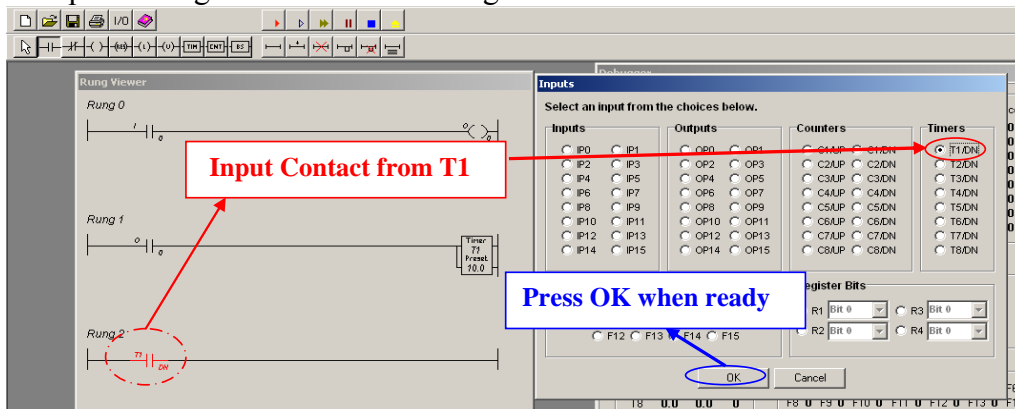


Figure 23

Step 6

As you have done before assign the output (OP1) in rung 2 then run your diagram as shown in figure 24

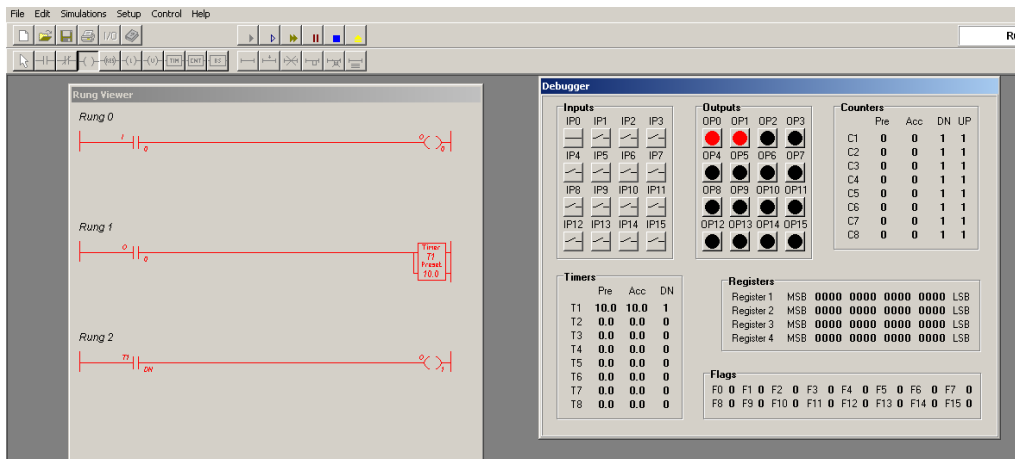


Figure 24

Result

When IP0 is switched off, no current passes in the circuit (low). If you press on IP0 to turn the switch on, the output OP0 will be activated and the timer will be activated after 10sec the timer allows OP1 to be activated as shown in figure 25.

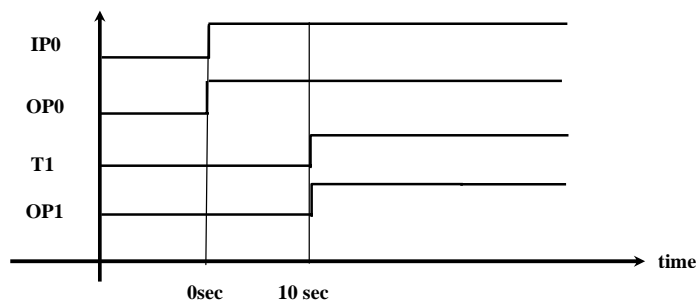


Figure 25

Section 4 The Counter Function

The counter function in LADSIM also comes in two major forms, with both using the positive (OFF to ON) transition as the input change as their trigger to change count. The Up counter increments its count up to a limit whereas the Down counter decrements its count from a limit to zero. The count value is held by the Accumulator for both types of counter but whereas the up counter increments the accumulator up to the pre-defined Preset number, the down counter decrements the accumulator from the preset number to zero. The bit which is set on completion of a counter run also differs between the two types of counter, the up counter only energises the UP (called Cn/UP, where n is the number of the counter) bit when the accumulator's value has reached the preset but on the other hand the down counter only energises the DN (called Cn/DN, where n is again the number of the counter) bit once it has reached zero. The symbol for an Up/Down counter is shown in figure 26.

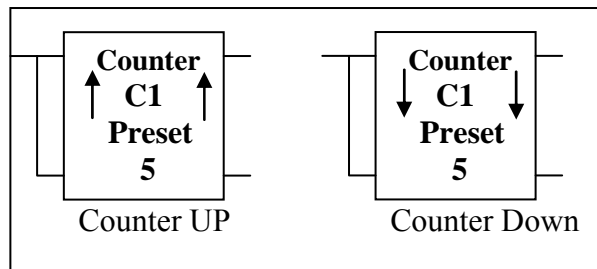


Figure 26

Note:

- The counting can be observed in the simulation mode in the counter's Accumulators.
- The same counter can be used to count both up and down.
- Like timers, once the Bit has been set it can only be reset by the (RES) function and this has priority over the counting, and once reset the accumulator returns to its original state (i.e. zero for an up counter or the preset number for a down counter).

4.1 Example: Counter Function

Create a simulation for two lamps, where after a count of three the lamps will be activated. If switch A is closed three times the lamps will be activated, when the switch B is closed (ON) the lamps will be deactivated and the counter will be reset.

Step 1

As you have done before in “how to start the diagram,” create a normally open contact (IP0).

Step 2

Click on the counter icon and drag a counter onto Rung 0, releasing it to the right of the rung. When the counter is placed onto the rung, the counter dialogue box will

appear, from that select C1 from the list of counters. Select UP from the Up/Down section and set the preset value as 3 and leave the accumulator value as 0 by clicking the preset field, typing 3 clicking OK to accept the counter setting as shown in figure 27.

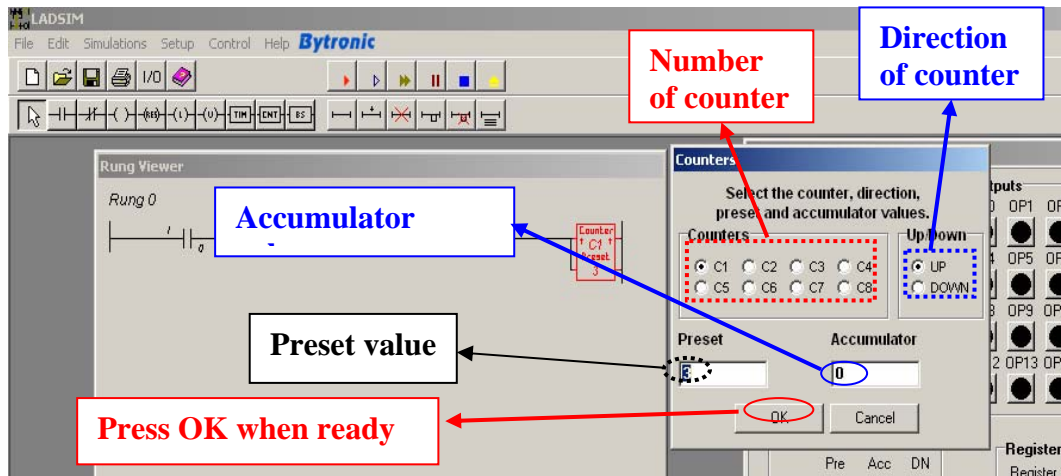


Figure 27

Step 3

Click on add a new rung and place a normally open contact input contact on it. Assign the contact counter 1's done bit (C1/UP) by selecting it from the counter section of the inputs dialogue box then position an output contact to the right of the rung and assign it (OP0) as shown in figure 28.

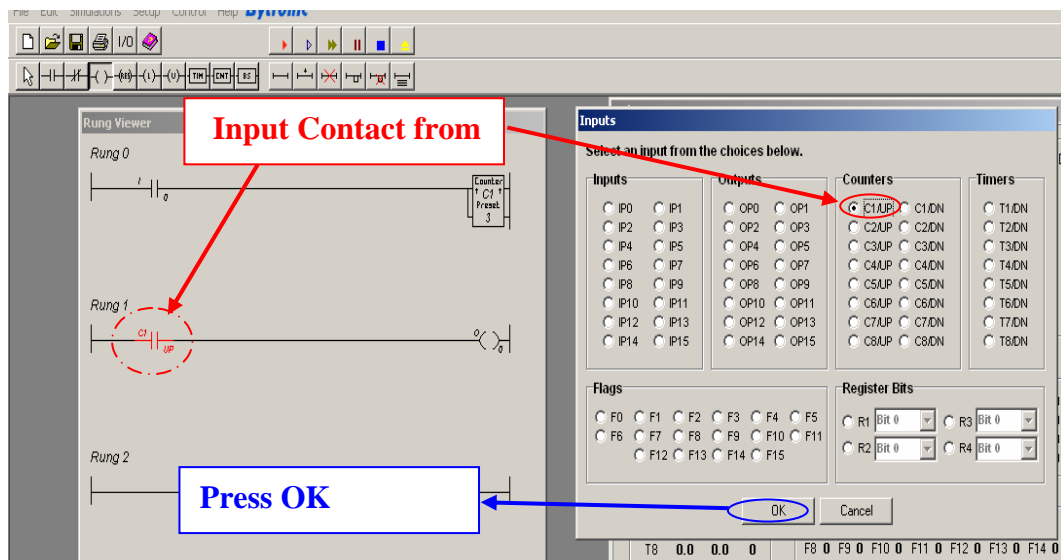


Figure 28

Step 4

Click on add a new rung and place a normally open contact input contact on it and select C1/UP from inputs dialogue box. Following this position an output contact to the right of the rung and assign it an appropriate output (e.g. OP1).

Step 5

Add a final rung and create a normally point contact (IP1). Position a reset icon and assign it to C1.

Step 6

Run your diagram and test the operation of the counter by switching IP0 (on) and IP1 (off) while observing both the preset and accumulator. Experiment with the reset of C1 by clicking IP1 to execute a reset function and observe its effect on the counter preset and accumulator as shown in figure 29

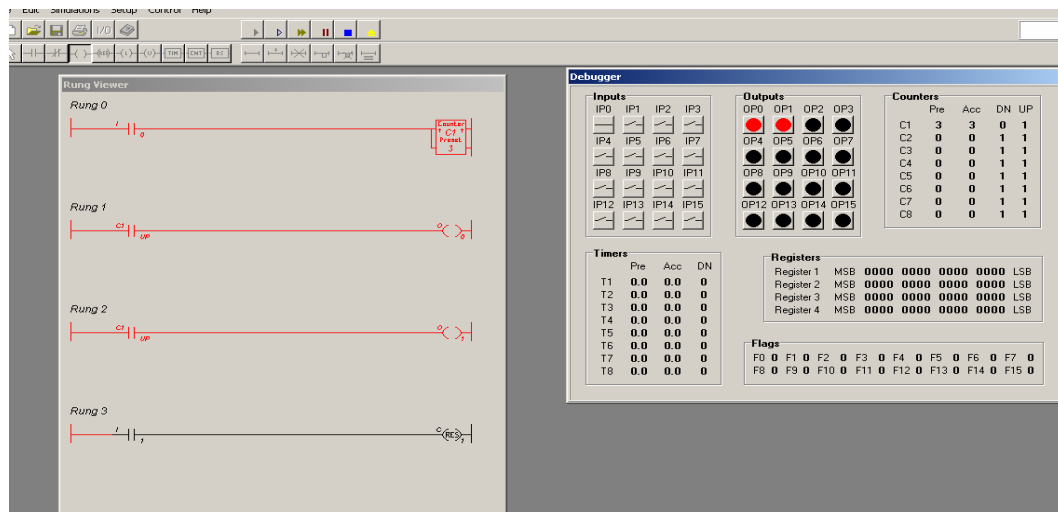


Figure 29

Result

When you run the simulation programme initially IP0 is switched off and no current passes in the diagram. If you press on IP0 to turn the switch on, C1 will start counting up. The counter C1 allows OP1 and OP0 to be activated. When IP1 is operated, the counter will be deactivated (reset) so that OP1 and OP2 will be deactivated as shown in figure 30.

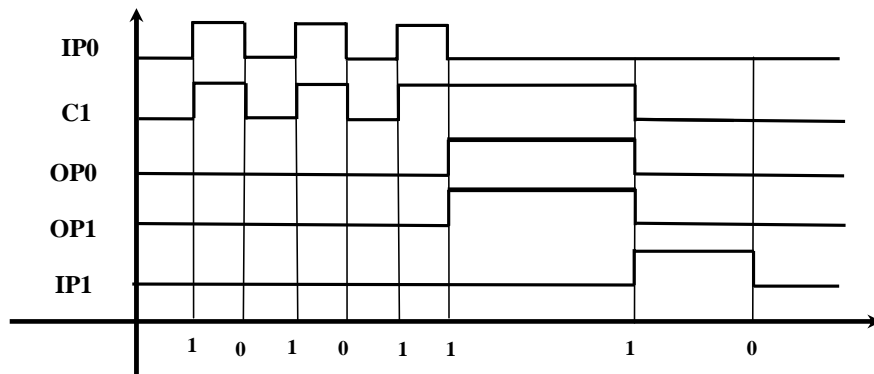


Figure 30

Section 5 Student Exercises II

5.1 Exercise 1: Timers and Counters

Consider the electrical circuit in figure 31 below. When you have star motor will be controlled by five switches. The switch A, B and C will start the motors and the switch D and F will stop it. When the motor is active a lamp X2 will be turned on. Also when the motor is deactivated a lamp X1 will be turned on. Create a simulation for this circuit.

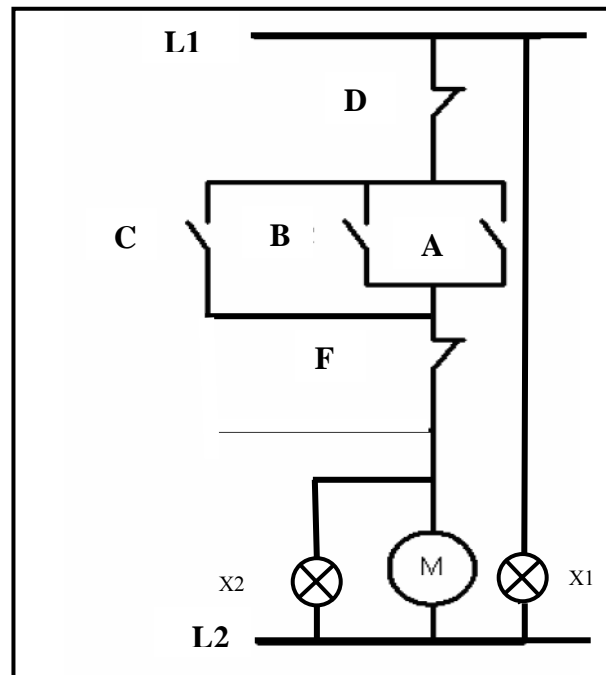


Figure 31

5.2 Exercise 2: Timers and Counters

A motor is to be controlled by two switches. Switch A will start the motor and switch B will stop it. If the Stop switch is used to stop the motor, then switch A must be thrown twice to start the motor. When the motor is active a lamp will be turned on. The Stop switch will be wired as normally closed contact. Create a simulation for this circuit.

Section 6 Advanced Exercises

6.1 Advanced Exercise 1

A car tunnel is equipped with traffic lights at the entrance and sensors at both the entrance and exit. In addition, there are three fans with managed engines (M1, M2&M3). There are two lamps (red and green). The green lamp will light as long as the number of vehicles in the tunnel is less than 3 vehicles and the first fan (M1) will be in operation. If the number of cars is greater than 3 and smaller than 5, the first fan and second fan will work together (M1, M2). If the number of vehicles in the tunnel exceeds 5 all three fans will work together (M1, M2&M3). When the number of vehicles has reached 10, the red lamp will light at the entrance to prevent the entry of further cars. Create the simulation for this programme

6.2 Advanced Exercise 2

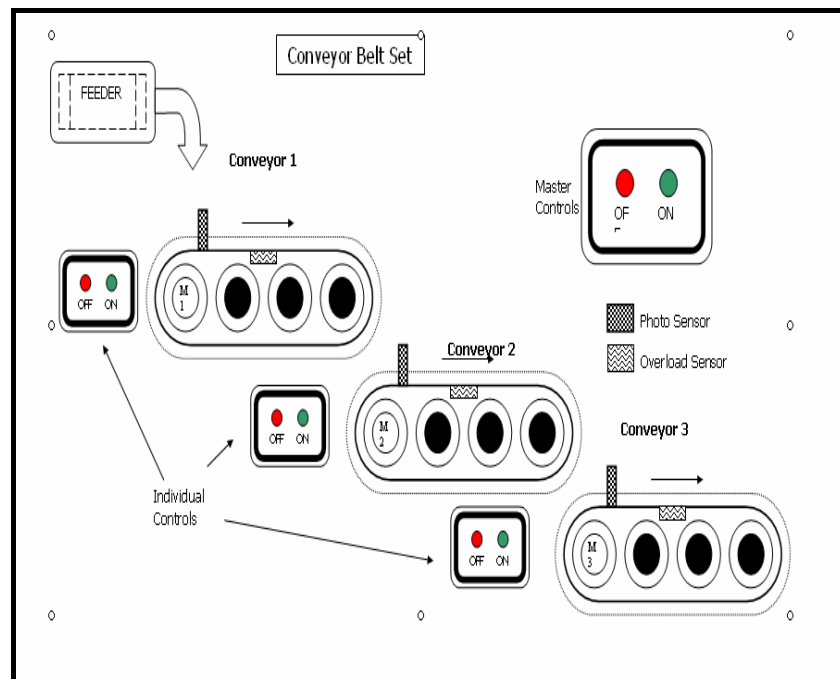


Figure 32

Consider the electrical circuit in figure 32. A customer, who is a newspaper printing workshop owner, wants to send his printed newspaper bundle from the printing room to the distribution point via a conveyor belt set. The conveyor belt set consists of a series of a three long conveyor belts which are run by motors. The conveyor belt runs as follows:

- The system has a single Master Start Button (MSTB) and Master Stop Button (MSPB) which controls the whole set.
- Each conveyor belt motor is fitted with a sensor which detects overload. The overload may cause an overheating which may cause serious damage to the system.

Also, if the system stops abnormally for any other reason, then it is essential that the conveyor feeding the faulty one must be stopped immediately to prevent the load spilling. Therefore:

- If motor 1 trip on overload (OVL1), motor 1 trip immediately while motors 2 and motor 3 remain running.
- If motor 2 trip on overload (OVL2), motor 2 and motor 1 trips immediately while motors 3 remain running.
- If motor 3 trip on overload (OVL3), all motors (M1, M2 & M3) trips immediately. Indicator lamps are needed for the following reasons to show progress, as shown in figure 32.

Input & Output list:

The input and output list is giving a clear understanding of the system so it can help constructing ladder diagram and showing what it indicates and control

Input	Terminal
Master Stop Button	IP0
Master Start Button	IP1
Overload detector 1	IP2
Overload detector 2	IP3
Overload detector 3	IP4
Photo Cell Sensor 1	IP5
Photo Cell Sensor 2	IP6
Photo Cell Sensor3	1P7
INDIVIDUAL START BUTTON 1	IP8
INDIVIDUAL STOP BUTTON 1	1P8
INDIVIDUAL START BUTTON 2	IP9
INDIVIDUAL STOP BUTTON 2	IP9
INDIVIDUAL START BUTTON 3	1P10
INDIVIDUAL STOP BUTTON 3	1P10

Input	Terminal
Feeder	OP0
Motor.1	OP1
Motor.2	OP2
Motor.3	OP3
Motor.1 & Lamp 1	OP4
Motor.2 & Lamp2	OP5
Motor.3 & Lamp 3	OP6
Alarm	OP10