

Selective Branching

Parallel Branching

Appendix: Using the TriLogi software

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1.4 Network Protocols

The wiring diagram in *Fig 1.5* shows the inputs and outputs connected directly (*hard wired*) to the PLC. The devices shown are on/off or digital in nature but the signal to the PLC is analog. Many commonly used devices conform to a 4-20 mA standard whereby signals of 4mA and 20mA form respectively the minimum and maximum values of an analog signal.

With analog devices, a separate cable needs to be run between the end device and the control system because only a single analog signal can be represented on the circuit. The 4-20 mA standard is slowly being replaced by network or *fieldbus* communications. *Fieldbus* is a multi-drop digital two-way communication link between intelligent devices. *Fieldbus* allows the connection of a number of sensors all located in the same area to the same cable. *Fieldbus* comes in many varieties depending on the manufacturer and application. Examples include *ASibus*, *Profibus*, *Devicenet* and *Modbus*.

A more recent trend is the development of *Industrial Ethernet* which has the capacity to transport large quantities of data not only for process control but also to integrate the process with management information systems.

This book concentrates on PLC programming and while the sample wiring diagrams are of the type shown in *Fig 1.5* the programs are designed to receive data from inputs and to send data to outputs regardless of the network system being used.

Questions

1. Switches, proximity devices and sensors are generally used in what way in a plc application?

- Answer: a. Relays
 b. Software elements
 c. Inputs
 d. Outputs

Chapter 2 Ladder Programming

2.1 Conditional Logic

The PLC scans its inputs and, depending on the program, switches on or off various combinations of outputs. The logic state of the output depends on the input conditions and so the term *conditional logic* is used.

A simple example of conditional logic could be stated as follows:

“A machine switches on if either of two *start* switches are closed and all of three *stop* switches are closed.”

The conditions could be realised by a hard wire solution as shown in Fig 2.1.

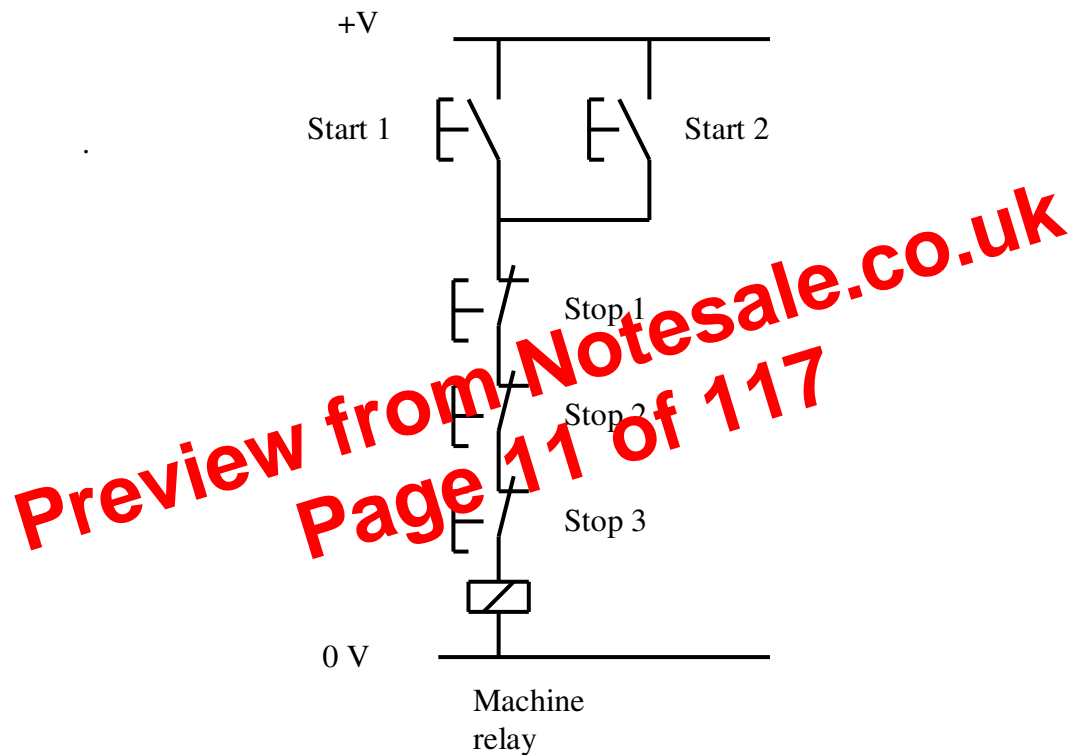


Fig 2.1 Hard-Wire Conditional Logic Example

The two *start* switches are connected in parallel. Current will flow if one *or* the other *or* both are closed. The start switches are normally open. This means that the contacts are apart and no current flows when the switches are in their normal (or *unoperated* or *rest*) state.

The three *stop* switches are connected in series. Current can only flow if the first *and* the second *and* the third are closed. The *stop* switches are normally closed. This means that the contacts are connected and current can flow when the switches are in their normal state.

To avoid later confusion regarding the concept of normally open (n/o) and normally closed (n/c) it is worth looking again at Fig 2.3 and remembering that the plc scans each input and asks “Is it on or is it off?” The five switches shown are external devices and the PLC knows nothing about them. As far as the PLC is concerned, at the moment, inputs X1 and X2 are off and X3, X4 and X5 are on.

I have written the ladder logic using the TriLogi software. (For details of entering program elements see the Appendix)

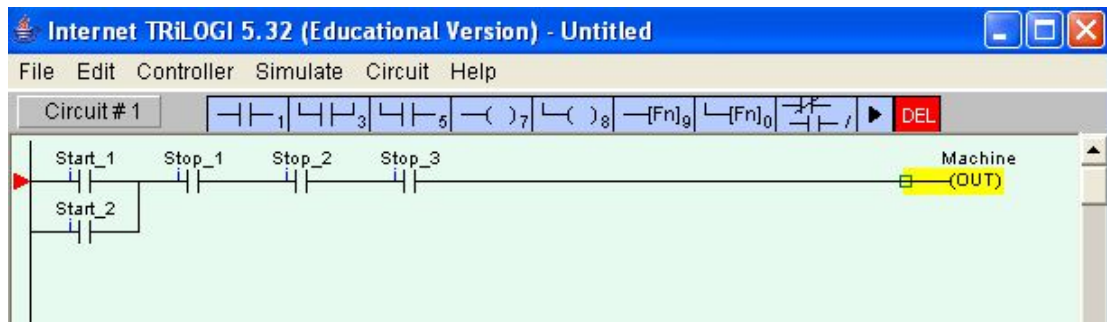


Fig 2.4 PLC Ladder Diagram

It can be seen from the Fig 2.3 and Fig 2.4 that the output *machine* will not be energised until one of the inputs *Start 1* or *Start 2* is switched on. Pushing any of the three *Stop* switches will turn off the input and so de-energise the output. It is normal practice to use normally closed push-button switches for *stop* buttons so that a failure of control voltage supply has the same effect as the pressing of the *stop* button.

2.3 Normally closed contacts

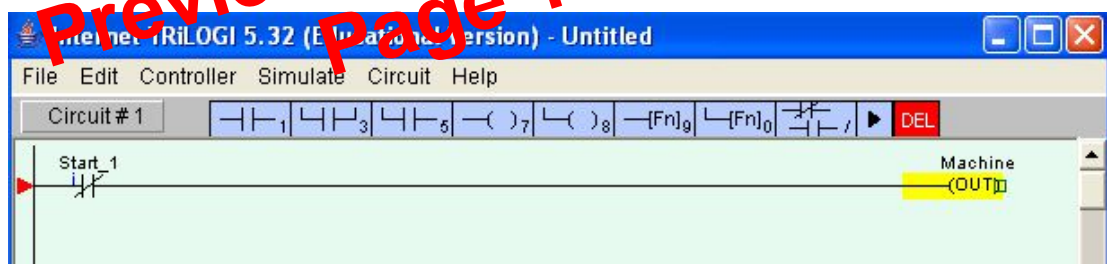


Fig 2.5 Normally closed contact.

The contact *Start 1* in Fig 2.5 will be closed when the input is switched off and so the output *Machine* will be switched on. Switching on the input opens the contact and switches the output off. Remember that the nature (n/o or n/c) of the external switch that turns the input on, has no effect on the ladder logic.

The push button and limit switches most commonly used in industrial automation are the *momentary contact* type. A spring action reverts the switch to the normal state as soon as the button or roller is released. These are obviously not the same as the *self-latching* switches used, for example, in domestic circuits.

The fact that the majority of control switches are not self-latching is not as inconvenient as it sounds. We can easily program in a latch in the ladder diagram.

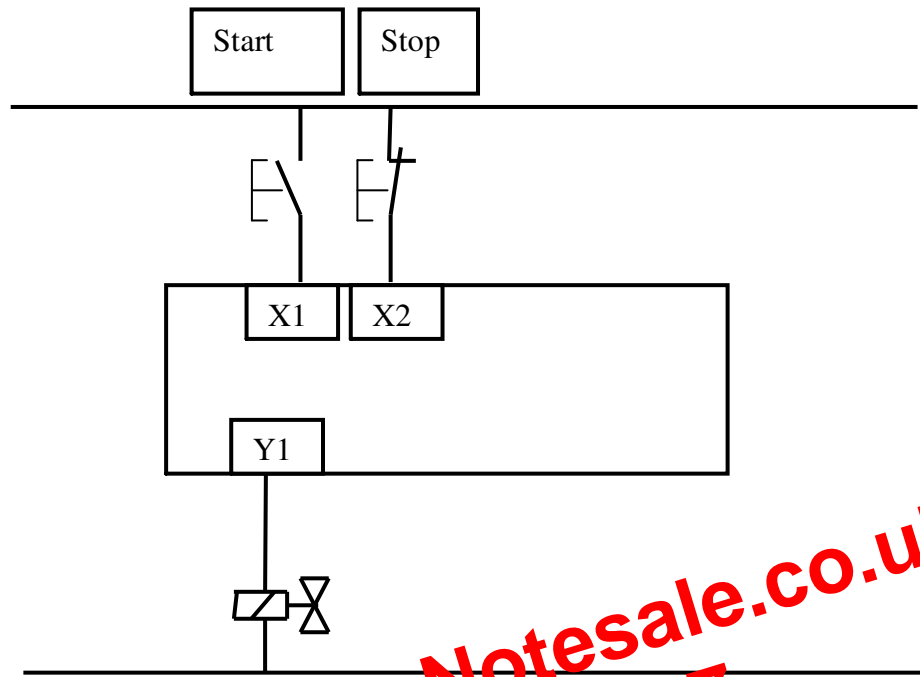


Fig 2.11

When the *start* push button switch in Fig 2.11 is pressed, the output Y1 is to switch on and stay on until the *stop* button is pressed.

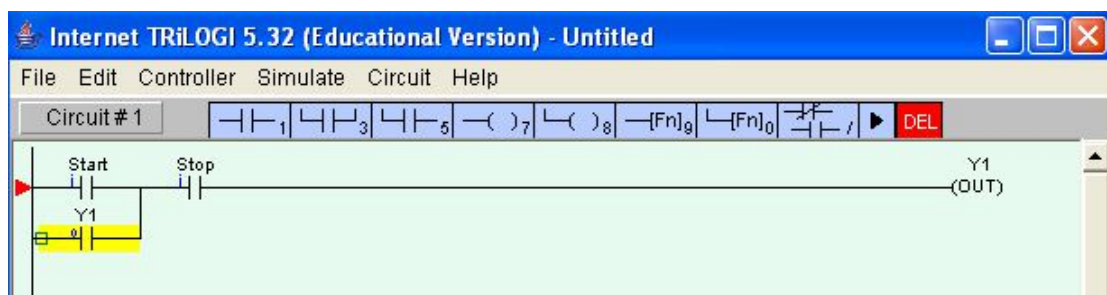


Fig 2.12

When the output Y1 is energised we use a normally open contact of it in parallel with the *start* button to hold (or latch) it on. The output can only be de-energised by the pressing of the *stop* button. Note that we have used a normally closed switch as a stop button as explained in section 2.2.

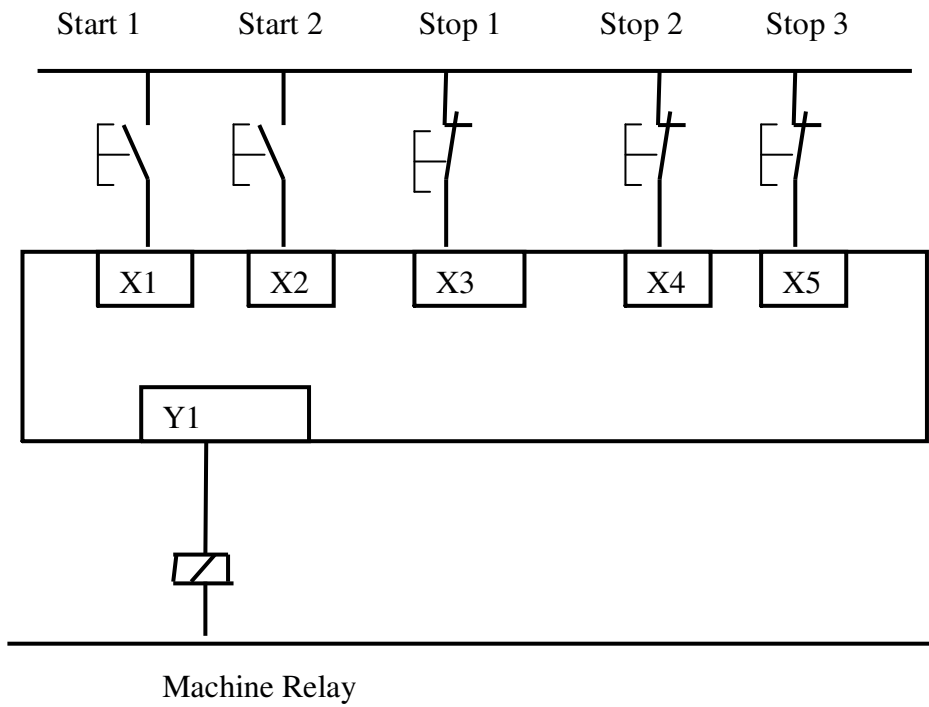


Fig 2.13

The latch concept can be extended to any number of start and stop switches. The output Y1 in *Fig 2.13* is to be switched on by X1 or X2 and is to stay on until any of the inputs X3, X4 or X5 is switched off. The required ladder diagram is shown in *Fig 2.14* below.

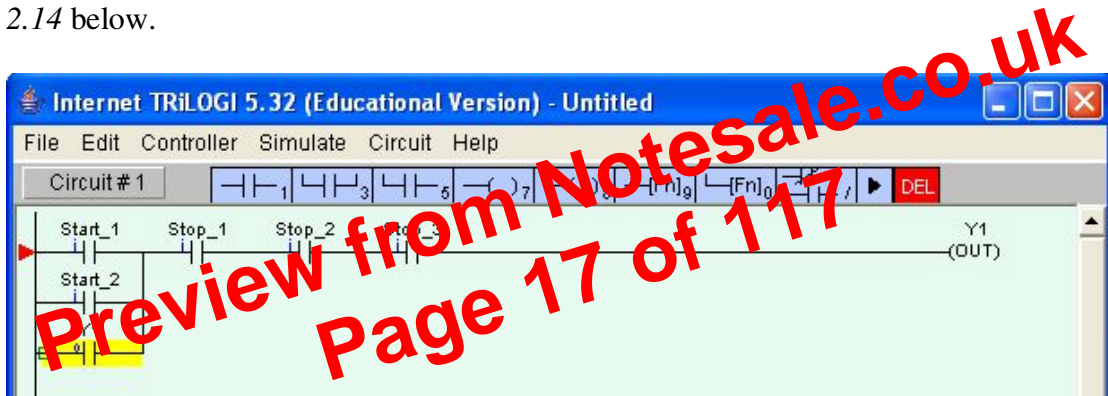


Fig 2.14

2.7 The Pulse Generator

Two counters can be combined to make a pulse generator. This is best illustrated by an example.

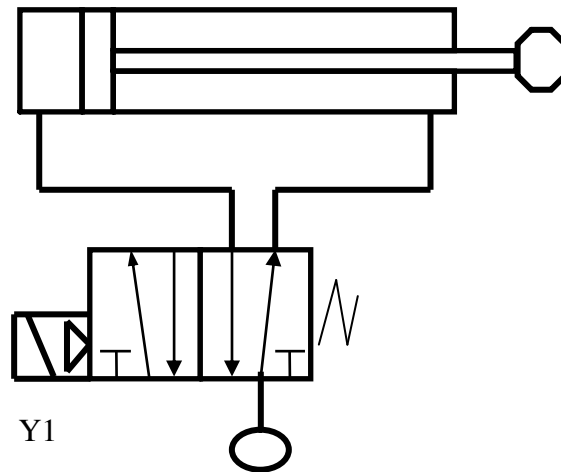


Fig 2.23

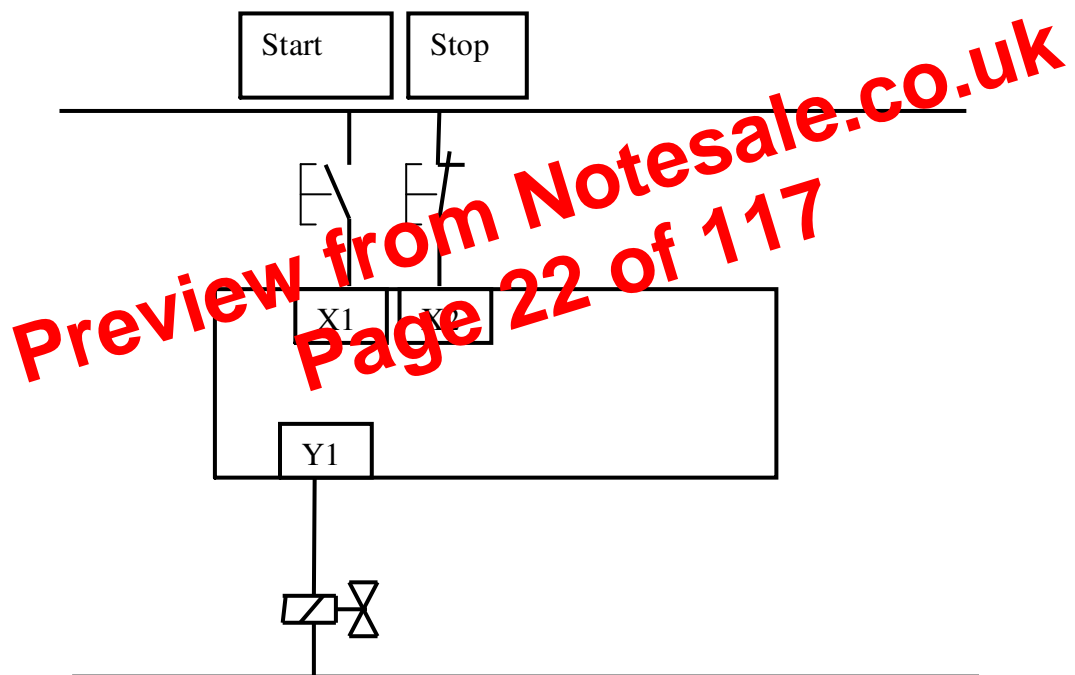


Fig 2.24

When the *Start* button in Fig 2.24 is pressed the cylinder in Fig 2.23 oscillates, extending for 2 s and returning for 1 s until the *Stop* button is pressed.

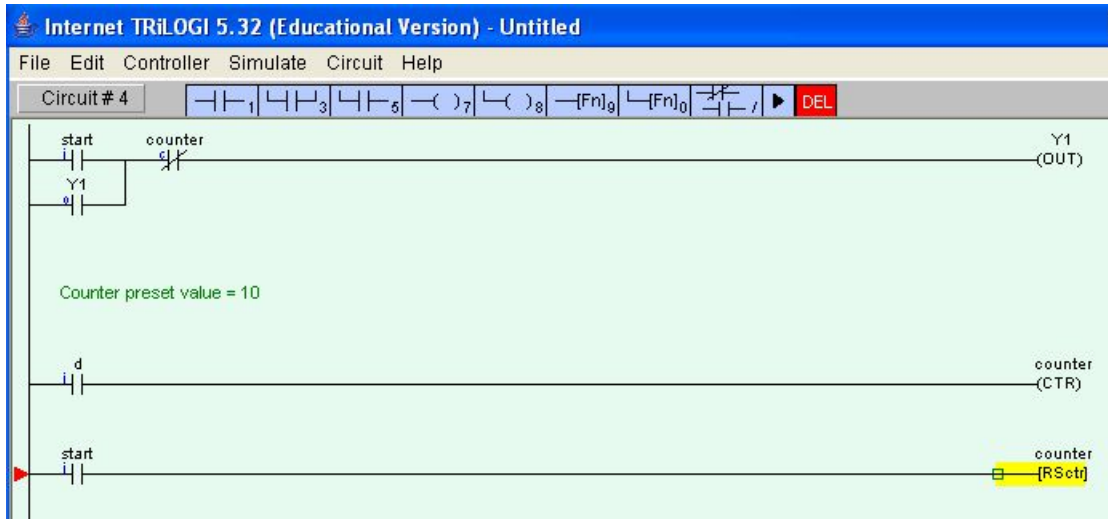


Fig 2.29

The pulse generator and counter can be combined as shown in this final example.

When a *start* push button is pressed and held down, an alarm sounds six times before a conveyor starts. Pressing the conveyor *stop* button also resets the counter. Fig 2.30 and Fig 2.31 show a solution to the problem.

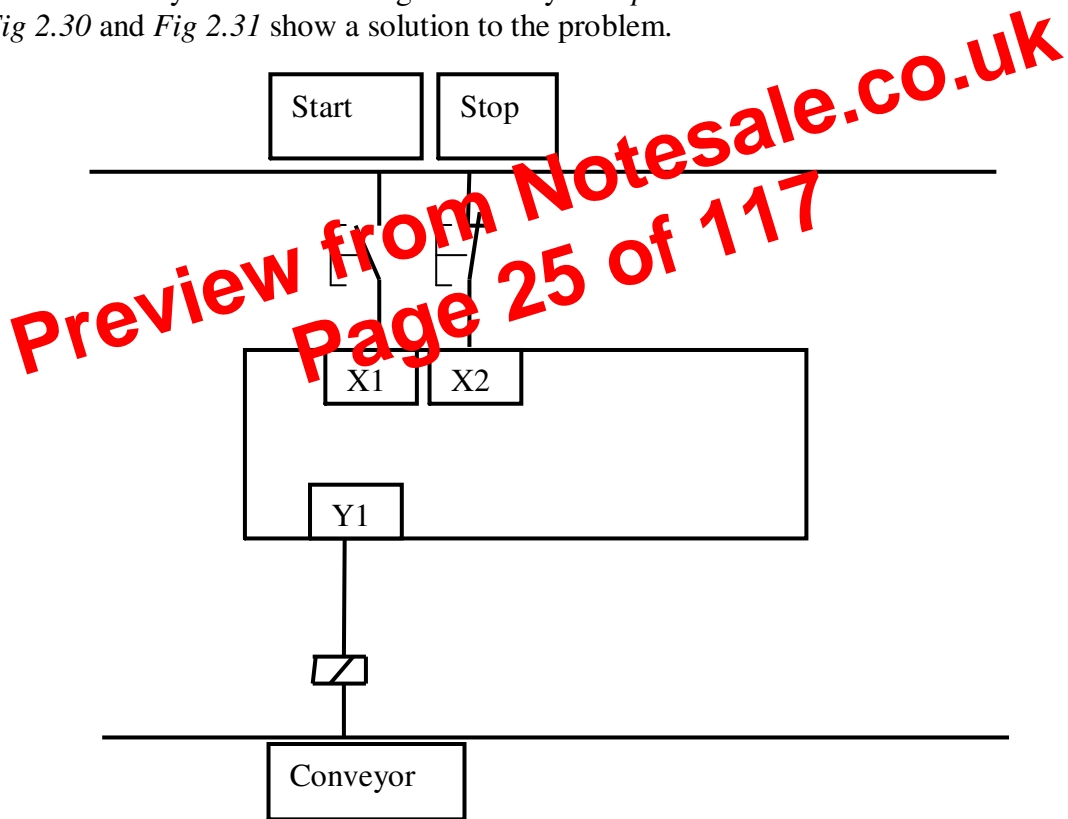


Fig 2.30

Questions and Exercises

1. Pick the correct statement below about the plc ladder

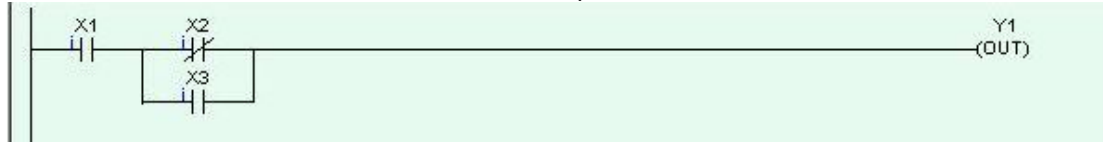


Fig 2.32

- Answer: a. Y1 switches on if X1 is off OR either X2 is on AND X3 is off
 b. Y1 switches on if X1 is on AND either X2 is off OR X3 is on
 c. Y1 switches on if X1 is on OR either X2 is off AND X3 is on
 d. Y1 switches on if X1 is off AND either X2 is on OR X3 is off

2. Pick the incorrect statement below about the ladder diagram shown

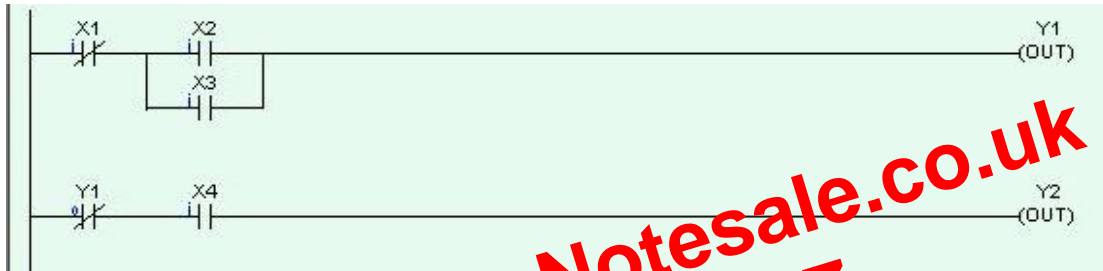


Fig 2.33

- Answer: a. Y2 switches on if X1 is on AND X2 AND X4 are on.
 b. Y2 switches on if X1 is on AND X3 AND X4 are on
 c. Y2 switches on if X1 is off AND X2 AND X3 are off AND X4 is on.
 d. Y2 switches on if Y1 AND X4 are both on

3. Which form of logic gate system is given by a ladder diagram with a rung having two normally open sets in parallel as shown?



Fig 2.34

- Answer: a. OR
 b. NOR
 c. AND
 d. NAND

States:

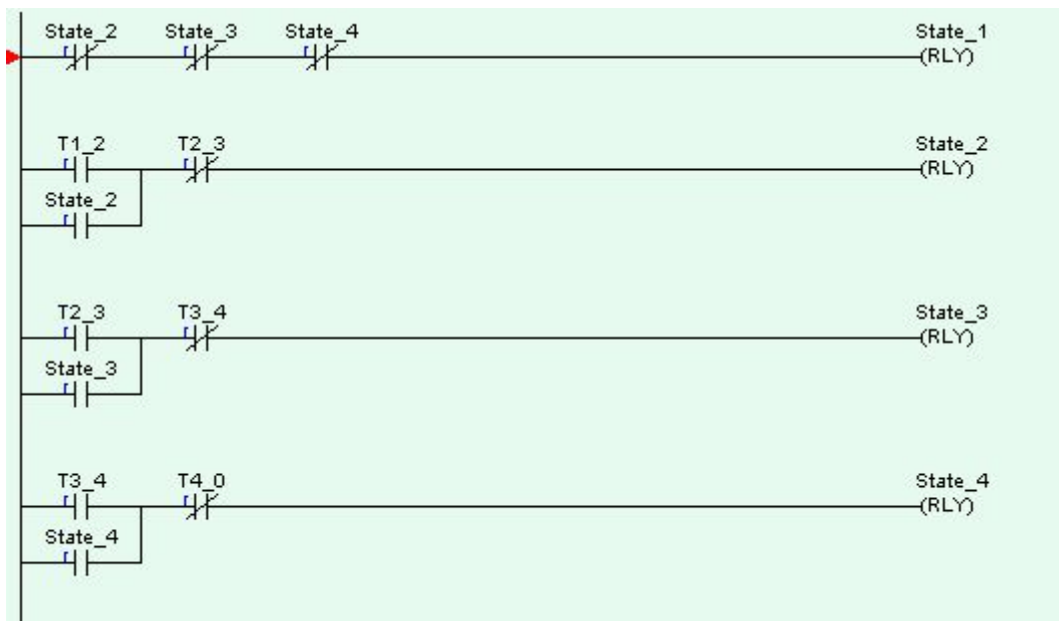


Fig 3.30

Outputs:

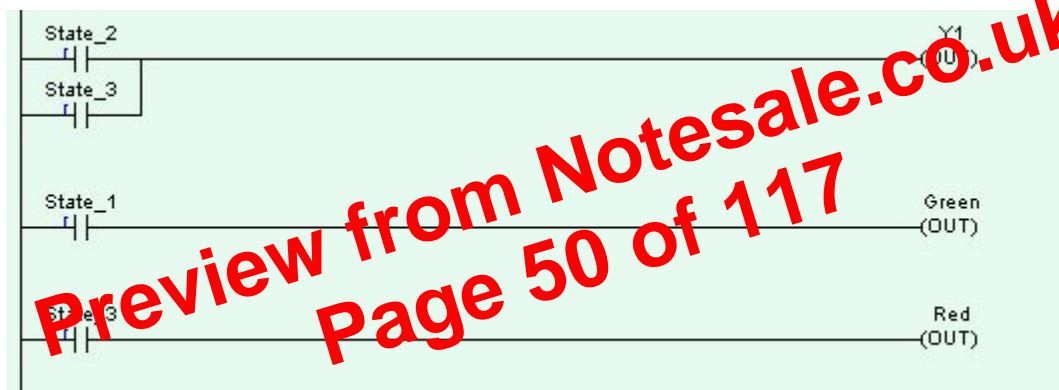


Fig 3.31

Timer:



Fig 3.32

So when State 3 becomes active the timer starts (Fig 3.32). When the delay has finished a normally open contact of the timer is used to activate Transition 3-4 (Fig 3.29).

2.



Fig 3.43

Select the only correct statement regarding the diagram Fig 3.43.

- Answer: a. A latch for state 0 is missing in the diagram.
- b. State 0 is energised by transitions
- c. State 0 will be energised when the plc is first powered up
- d. State 0 is switched on when all the other states are on

3.

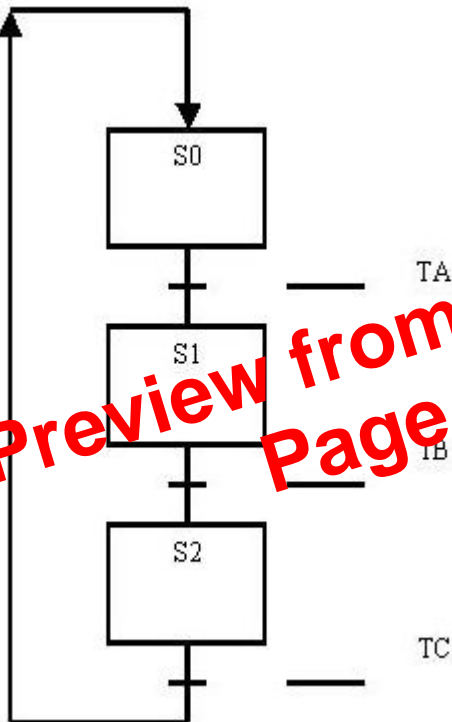


Fig 3.44

Select the only incorrect statement below regarding the diagram Fig 3.44.

- Answer: a. The states and transitions are represented in ladder logic by internal relays.
- b. States are latched on with the exception of state 0
- c. A transition is enabled by an input or timer contact.
- d. TA, TB and TC are plc inputs

The SF chart is shown in *Fig 4.10*

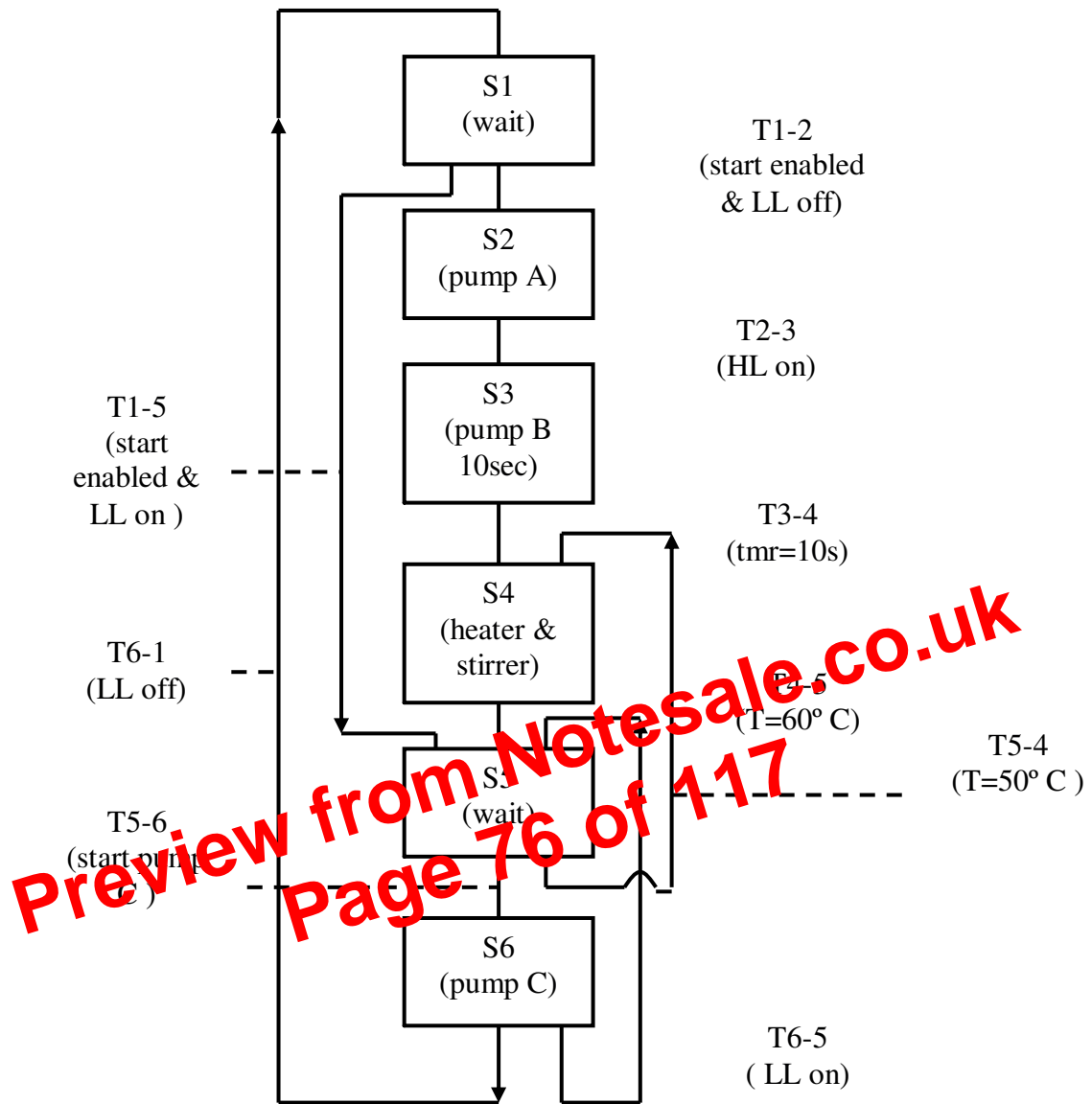


Fig 4.18

We will look at the various branches of the program.

We will first consider the case that the start button has been pressed and the tank is completely empty. The low-level (LL) switch being open, T1-2 is enabled and State 2 becomes active. During this state Pump A pumps liquid into the tank.

When the liquid level reaches the high-level (HL) switch, State 3 becomes active and Pump B runs for 10 seconds.

Outputs:

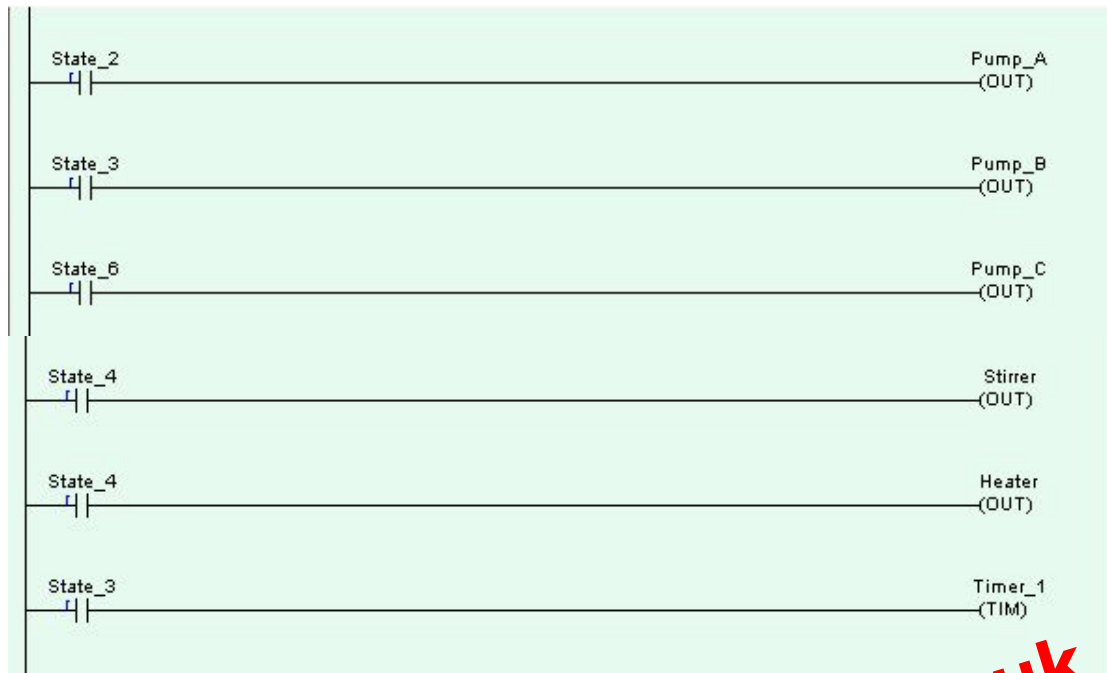


Fig 4.23

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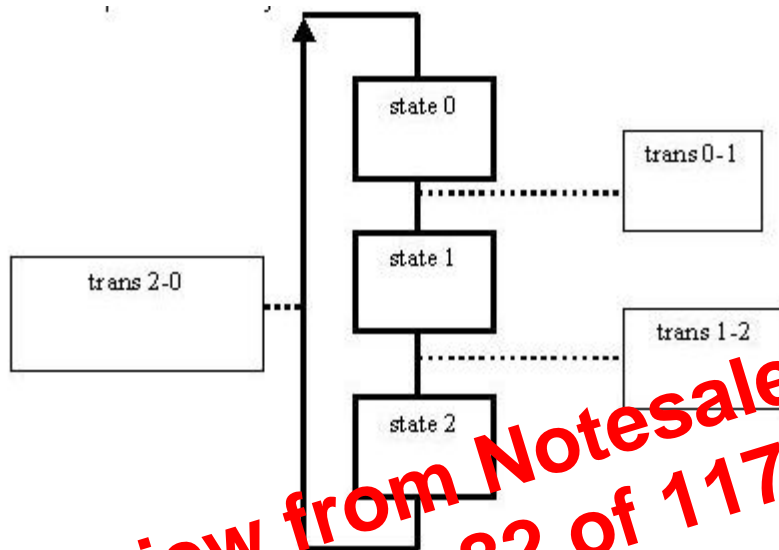
Questions and Exercises 4

1.



Fig 4.25

Which option correctly identifies the fault with the ladder conditions shown in Fig 4.25 for state 2 of the state/transition diagram shown in Fig 4.26?



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Fig 4.26

- Answer: a. The required output should be included.
- b. State 2 is the default state.
- c. The state should be latched on.
- d. An input or timer contact should be included in the conditions.

11.

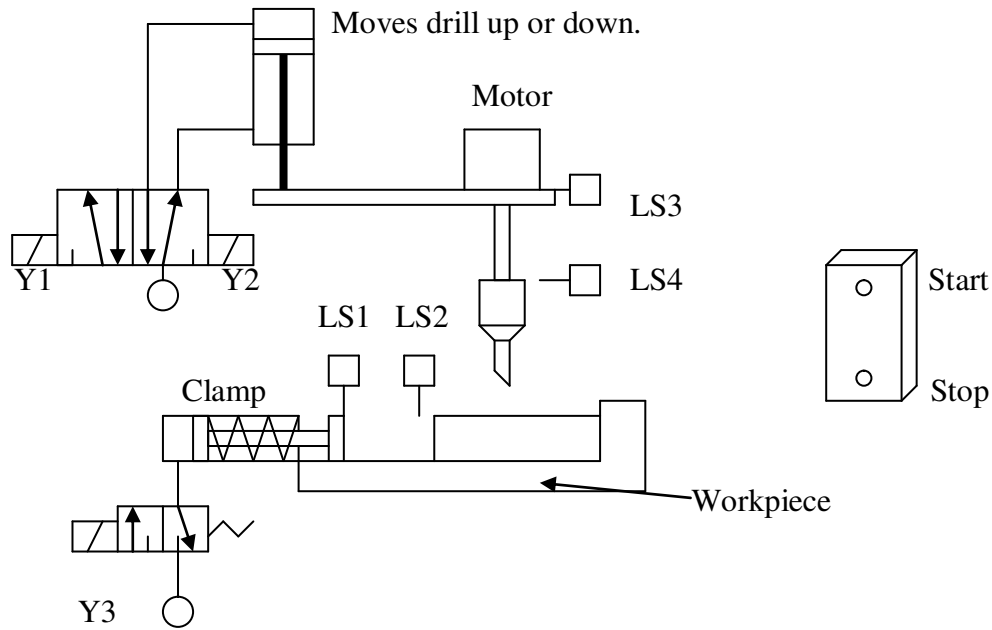


Fig 4.37

The diagram shows a workstation for the clamping and drilling of parts. When the start button is pressed the piece is clamped, drilled and then released.

If the stop button is pressed then both cylinders return to their retracted positions and the drill motor stops.

(a) Draw a PLC wiring diagram for the system.

(b) Draw a state/transition diagram for the sequence.

(c) Draw the necessary lines of ladder logic to operate the system as designed.

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In the next example, we will design a circuit that uses parallel branching and then, as a modification, we will add some selective branches to it.

Example 5.2

A drilling and countersinking operation is carried out on components on a conveyor using tools mounted on two pneumatic cylinders. The conveyor is indexed by a third cylinder extending and retracting. Each cylinder is operated by a 5/2 double solenoid directional control valve. The installation is shown in *Fig 5.10*.

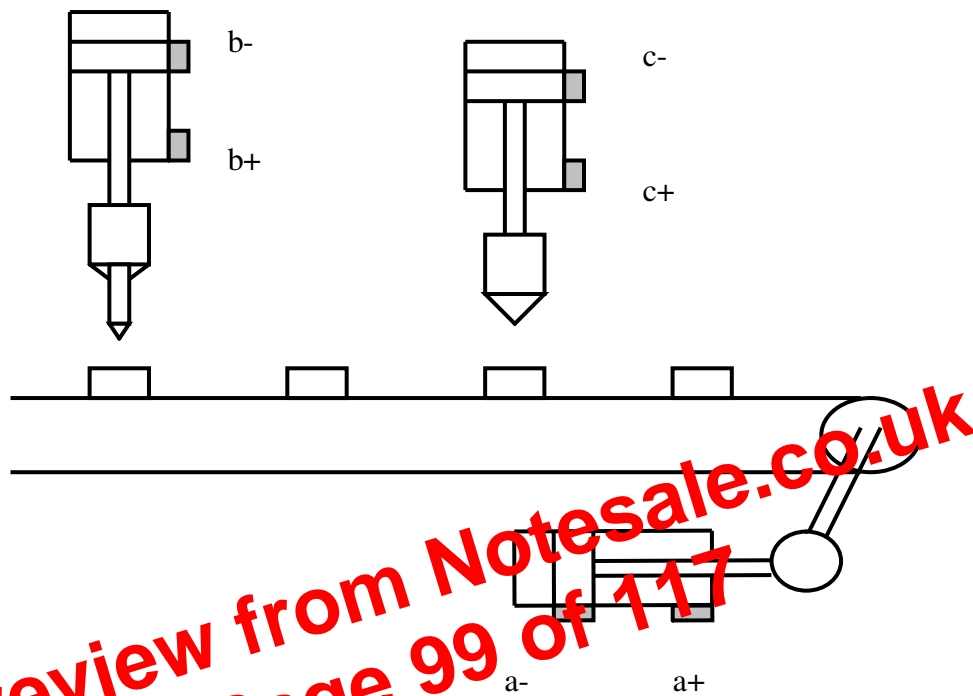


Fig 5.10

For the sake of simplicity no provision has been made for the clamping of the components. The task of inclusion of clamping has been added as an exercise at the end of the chapter.

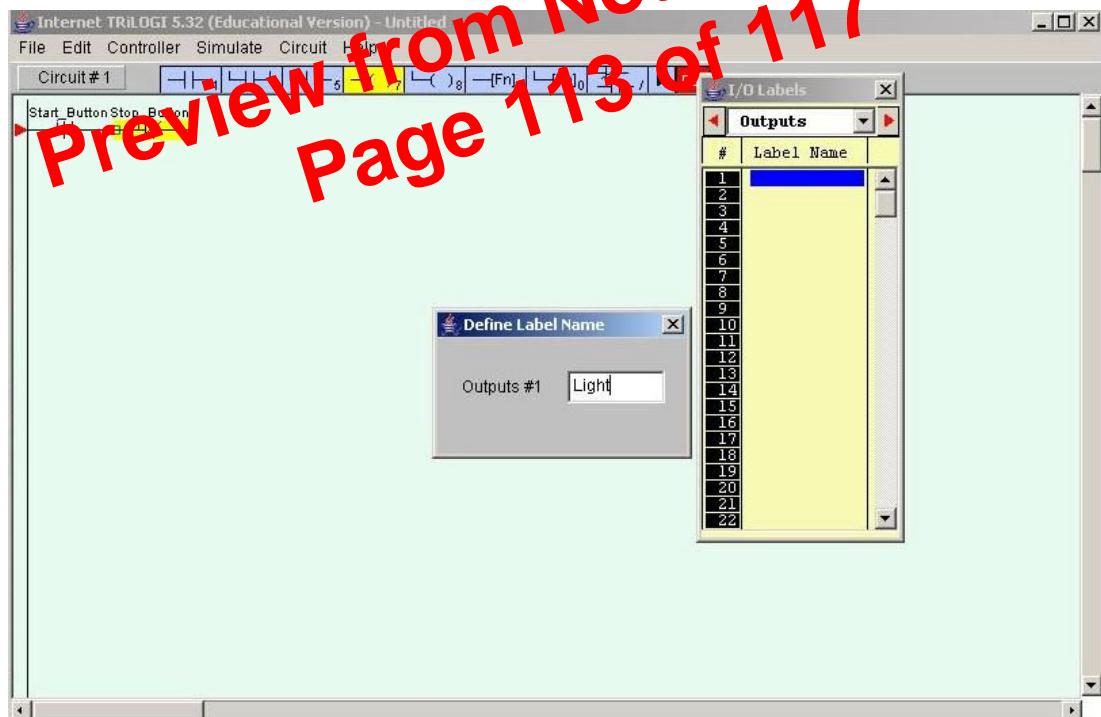
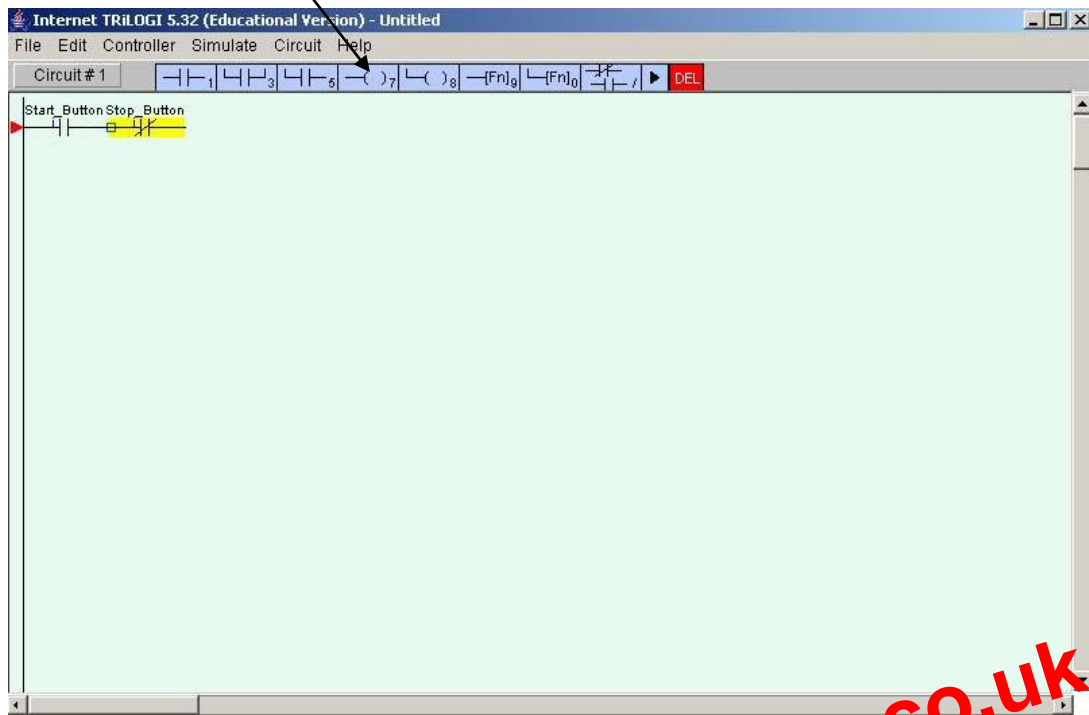
The PLC wiring diagram and the SF chart are shown in *Fig 5.11* and *Fig 5.12*. The assignment list is shown in *Table 5.2* and the ladder logic follows.

S1	R1
S2	R2
S3	R3
S4	R4
S5	R5
S6	R6
S7	R7
S8	R8
S9	R9
S10	R18
S11	R19
T1-2	R10
T2-3	R11
T3-(10,11)	R12
T4-5	R13
T5-6	R14
T7-8	R15
T8-9	R16
T(9)-1	R17
T10-4	R20
T10-6	R21
T11-7	R22
T11-9	R23
Start Enbl	R50

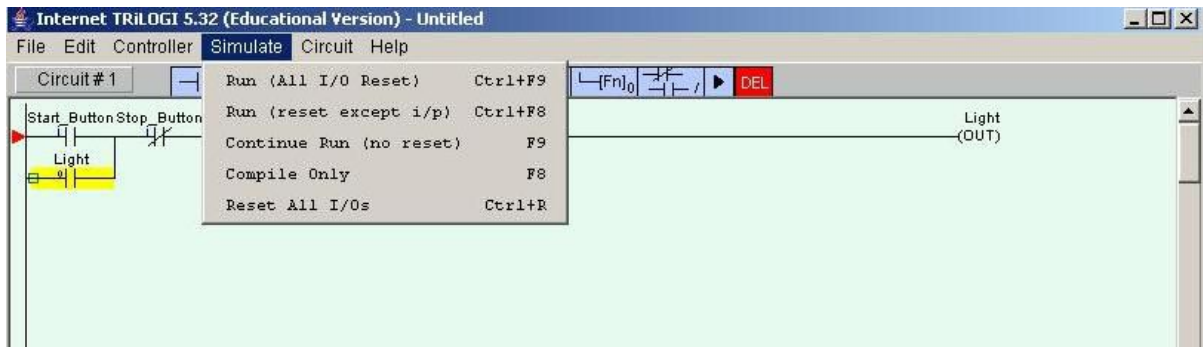
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Table 5.3

Now select an output and call it *light*



Click on the *Simulate* menu and select *Run (All I/O Reset)*



The two inputs and one output can be seen on the simulator.
Click on the *Start_Button* input to switch it on.

