8

PLC sequence controller

The following notes describe how a system, which consists of two pneumatic pistons, can be controlled using a Mitsubishi FX PLC.

The PLC is required to operate two single-acting electrically actuated pneumatic pilot valves, which in turn control the two pneumatic pistons.

Basic system

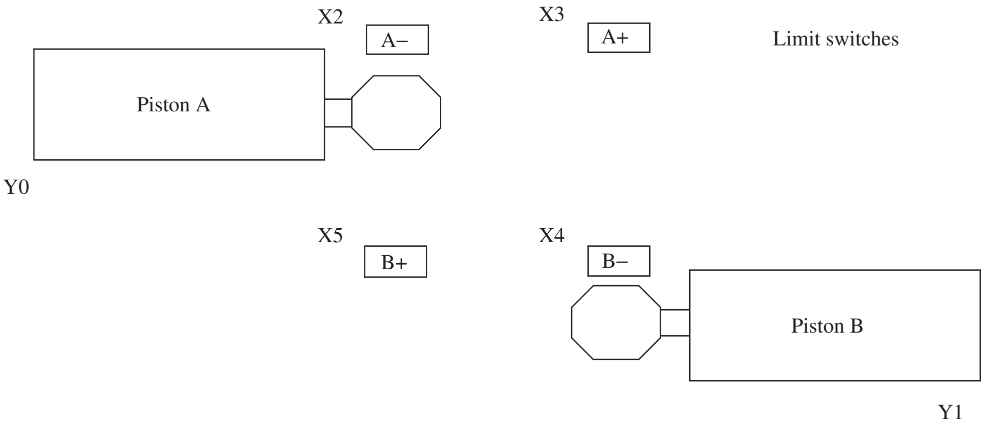


Figure 8.1

Sequence of operation

The sequence of operations for the two pistons is as follows:

1. Start of sequence.
2. A+ Piston A OUT.
3. B+ Piston B OUT.
4. A– Piston A IN.
5. 5-sec time delay
6. B– Piston B IN.
7. End of sequence

8.1 Sequence function chart – SFC

A sequence function chart is a pictorial representation of the system's individual operations, which when combined show the complete sequence of events.

Once this diagram has been produced, then from it, the corresponding ladder diagram can be more easily designed.

The Gx-Developer software, which has as the facility for programming directly in SFC, is not described in this book.

Sequence function chart – PNEU1

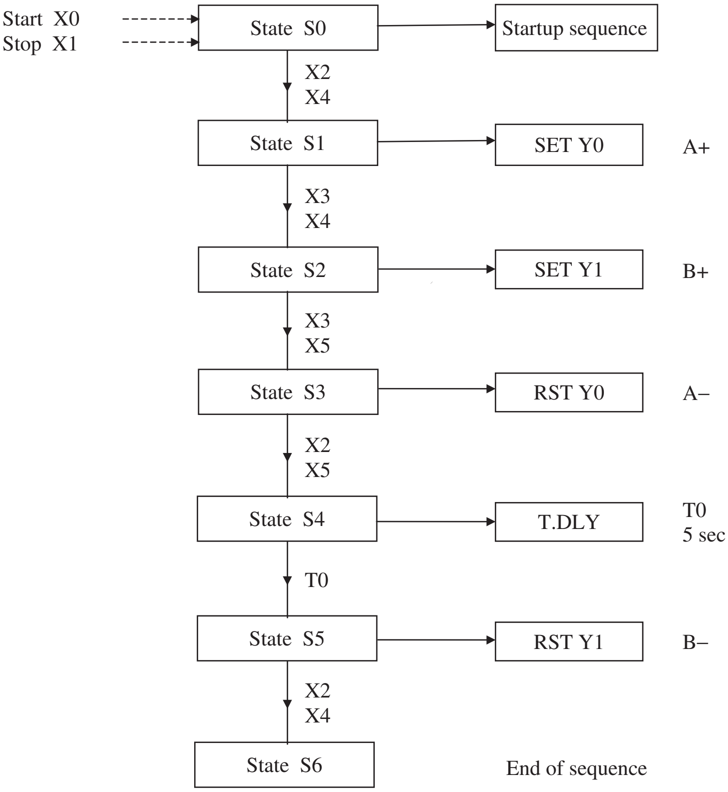


Figure 8.2

Description – sequence function chart

1. The sequence function chart consists, basically, of a number of separate sequentially connected states, which are the individual constituents of the complete machine cycle, that controls the system. An analogy is that each state is like a piece of a jigsaw puzzle; on its own it does not show very much, but when all the

pieces are correctly assembled, then the complete picture is revealed. Each state has the following:

(a) An input condition.
(b) An output condition.
(c) A transfer condition.

When the input condition into a state is correct, then that state will produce an output condition.

That is, an output device or devices will be:

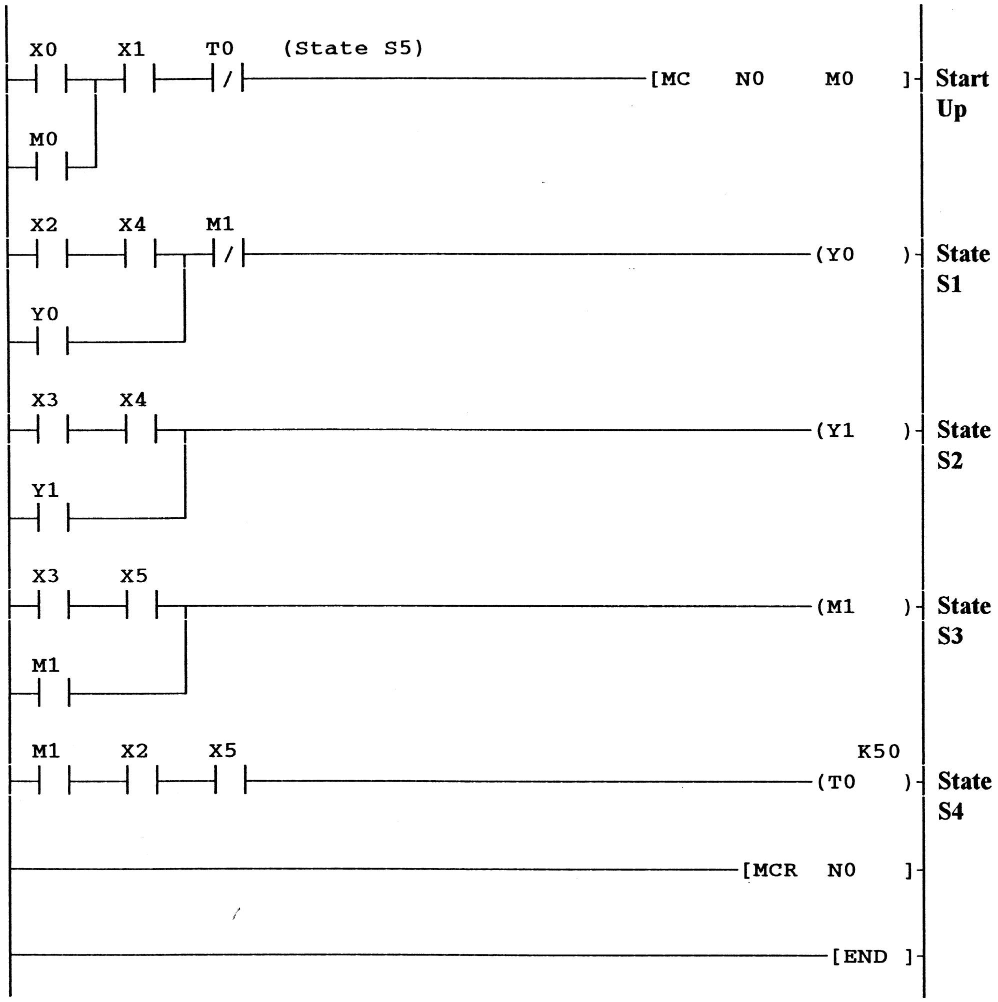
(a) Turned ON and remain ON.
(b) Turned OFF and remain OFF.

2. When the output or outputs are turned ON/OFF, then the system's input conditions will change to produce a transfer condition.
3. The transfer condition is now connected to the input condition of the next sequential state.
4. If the new input condition is correct, then the sequence moves to the next state.
5. From the sequence function chart for PNEU1, it can be seen that when the start push button is operated, this is the input condition for state 0.
6. The output condition from State 0 is the startup sequence, which will reset both Solenoid A and Solenoid B. With Inputs X2 and X4 now made, the transfer from State 0 can take place.
7. The transfer conditions from State 0 are the correct input conditions for State 1, and hence the process now moves from State 0 to State 1.
8. The process will now continue from one state to the next, until the complete machine cycle is complete.
9. From the sequence function chart, the ladder diagram can now be produced.

8.2 Ladder diagram – PNEU1

It will now be found that the production of the PLC ladder diagram, from the sequence function chart, will be a far easier process.

Ladder diagram – PNEU1



Note

The master contacts are entered as follows:

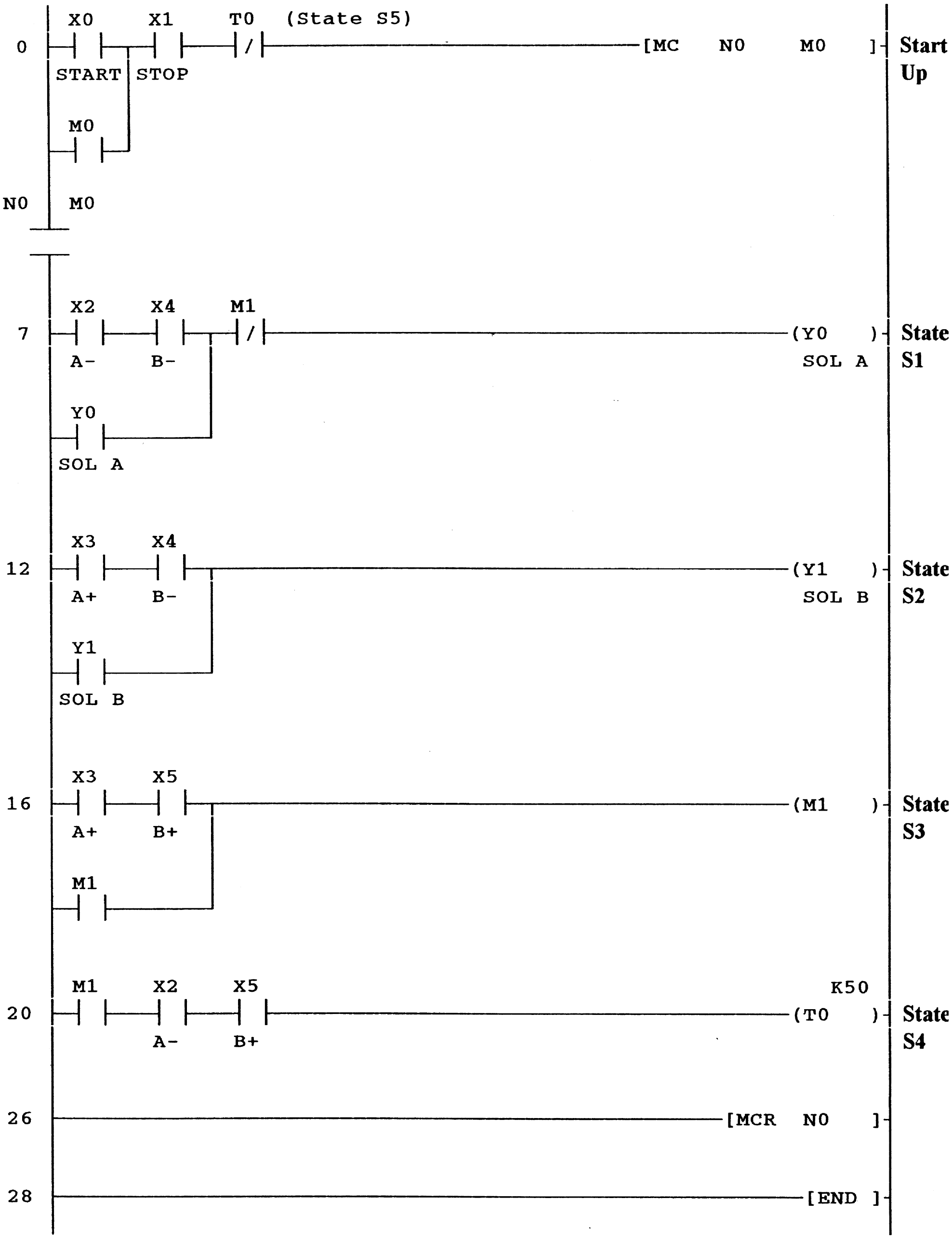
-[MC N0 M0]-

1. mc <space>.
2. n0 <space>.
3. m0 <ent>.

-[MCR NO]-

1. mcr <space>.
2. n0 <ent>.

Converted ladder diagram – PNEU1



Note

The serial master contacts N0 ⊣⊢ MO cannot be programmed in directly. However, they will appear automatically, when the ladder diagram is monitored for the first time.

Principle of operation – single cycle

The following describes the single-cycle operation of PNEU1.

The term 'Piston A operates' or 'Piston B operates' refers to the pistons moving from their back positions, i.e. A− or B−, to their forward positions, A+ or B+.

1. Line 0 (Startup)
   When Input X0 is operated, this will cause the Master Control Instruction -[MC N0 M0]- to be executed. Basically, the master control instruction enables a particular part of the ladder diagram to become operative. This is shown on the ladder diagram as a pair of normally open horizontal contacts, which enable the operation of the instructions from Line 7 to Line 26. If the Instruction -[MC N0 M0]- is not executed, then the instructions from Line 7 to Line 26 will be ignored.
2. Line 7 (State S1)
   With Pistons A and B in the back position, i.e. A− and B−, inputs X2 and X4 will operate, causing Output Y0 to energise and latch over its own normally open contact. This will cause Piston A to move to the A+ position. The Memory Coil M1 will operate later in the cycle, when it is necessary for Piston A to become de-energised. Hence, at this point in the cycle, the normally closed contacts of M1 will remain closed. Even though Input X2 now opens, when Piston A moves forward, the latch circuit ensures that Output Y0 will not become de-energised.
3. Line 12 (State S2)
   With Piston A fully forward, then Input X3 (A+) will operate. This plus Input X4 (B−) will cause Output Y1 to be energised and latch over its own contact. Piston B will now move to the B+ position.
4. Line 16 (State S3)
   At this moment in time, both Pistons will be fully forward and hence Inputs X3 and X5 will be operated. This will cause the Memory Coil M1 to operate and latch over its own contact. The normally closed contact of M1 at Line 7 will now open and break the Y0 latch circuit. This will de-energise Y0 and hence cause Piston A to retract to the A− position.
5. Line 20 (State S4)
   When Piston A returns to the A position, Input X2 will re-make, and this plus M1 and X5 (B+) will energise the Timer Coil T0.
6. Line 0
   After 5 sec, Timer T0 will time out (State S5). The normally closed timer contacts of T0 will open, breaking the start latch circuit. This will cause the Master Contact M0 to open, causing all of the energised outputs from Lines 9–20 to become de-energised. Hence, M1 will become de-energised, as will Output Y1. The de-energising of Output Y1 will cause Piston B to retract to the B− position.

7. Line 26
   The Instruction -[MCR N0]- is used to terminate the master control section, and hence, any instructions which follow this instruction will not be affected if the master control is OFF.

8.3 Simulation – PNEU1

Using the simulation unit shown in Figure 8.3, test and monitor the operation of PNEU1.

Simulation unit

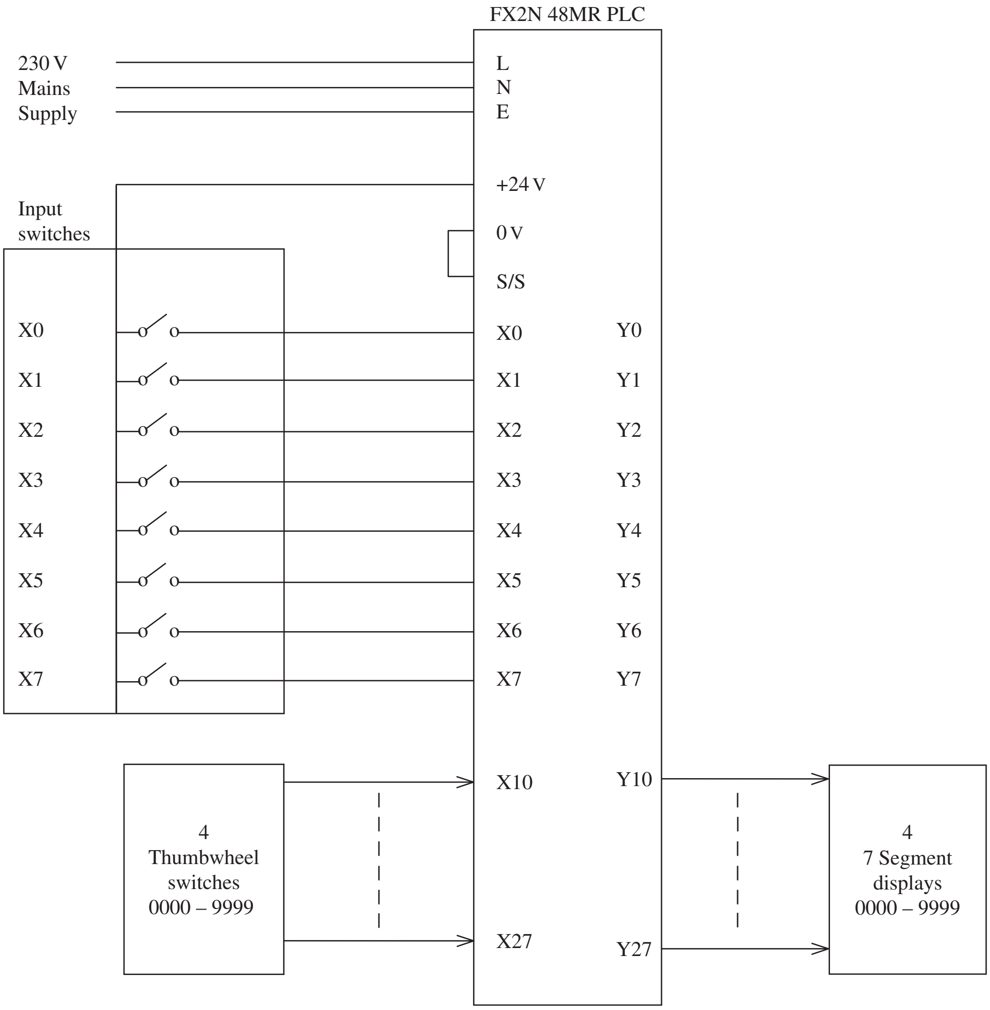


Figure 8.3

Simulation and monitoring procedure

1. **Display and monitor the Ladder Diagram PNEU1.**
2. **Operate the Input Switches X1, X2 and X4.**
   This will simulate the operation of the stop push button and the A− and B−limit switches.
3. **Momentarily operate the Start Switch X0.**
   Output Y0 will now be energised and this will cause Piston A to operate to the A+ position.
   In a real situation with Piston A moving forward, its limit switches X2 would open and X3 would close.
4. **Open X2 and Close X3.**
   This will cause Output Y1 to energise and hence enable Piston B to move forward to its B+ position.
5. **Open X4 and Close X5.**
   Auxiliary Output M1 will energise and cause Output Y0 to de-energise. Hence, Piston A will return to its A− position.
6. **Open X3 and Close X2.**
   With X2 closing, this will start the operation of the Timer T0.
   After 5 seconds, Timer T0 will time out and its normally closed contact (Line 0) will open, breaking the Master Control Circuit of M0.
   Output Y1 will now be de-energised.
7. **Open X5 and Close X4.**
   The process can now be repeated, by pressing the Start push button.

8.4 Pneumatic panel operation

The PLC can now be connected to a pneumatic panel to enable the complete system to be tested.

This enables the PLC and the program PNEU1 to control more of an industrial type process, than just being simulated with Switches and LEDs.

The panel, which has been used successfully for this purpose, is produced by SMC Ltd.

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Pneumatic drawing – PNEU1

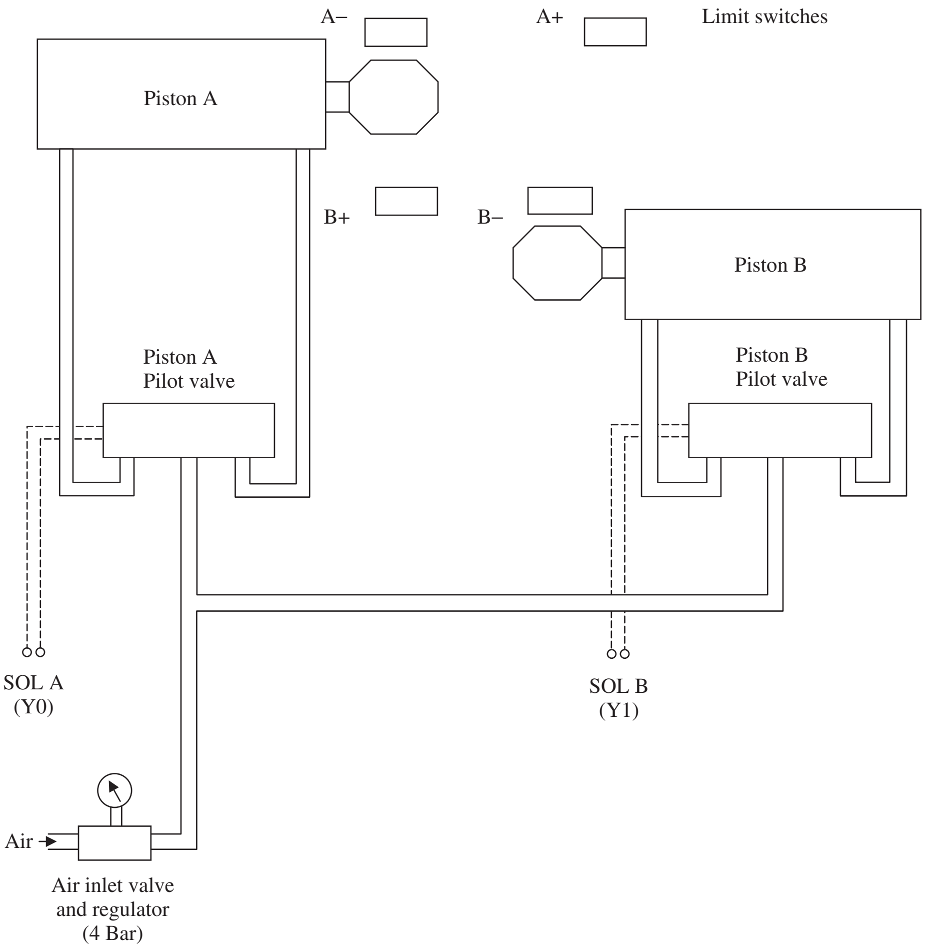

Figure 8.4

PNEU1 wiring diagram (relay output)

The electrical diagram in Figure 8.5, shows how an FX2N PLC system is wired to the SMC pneumatic panel.

This enables the PLC and the program PNEU1 to control an industrial type application, instead of being simulated with input switches and output LEDs.

PNEU1 wiring diagram

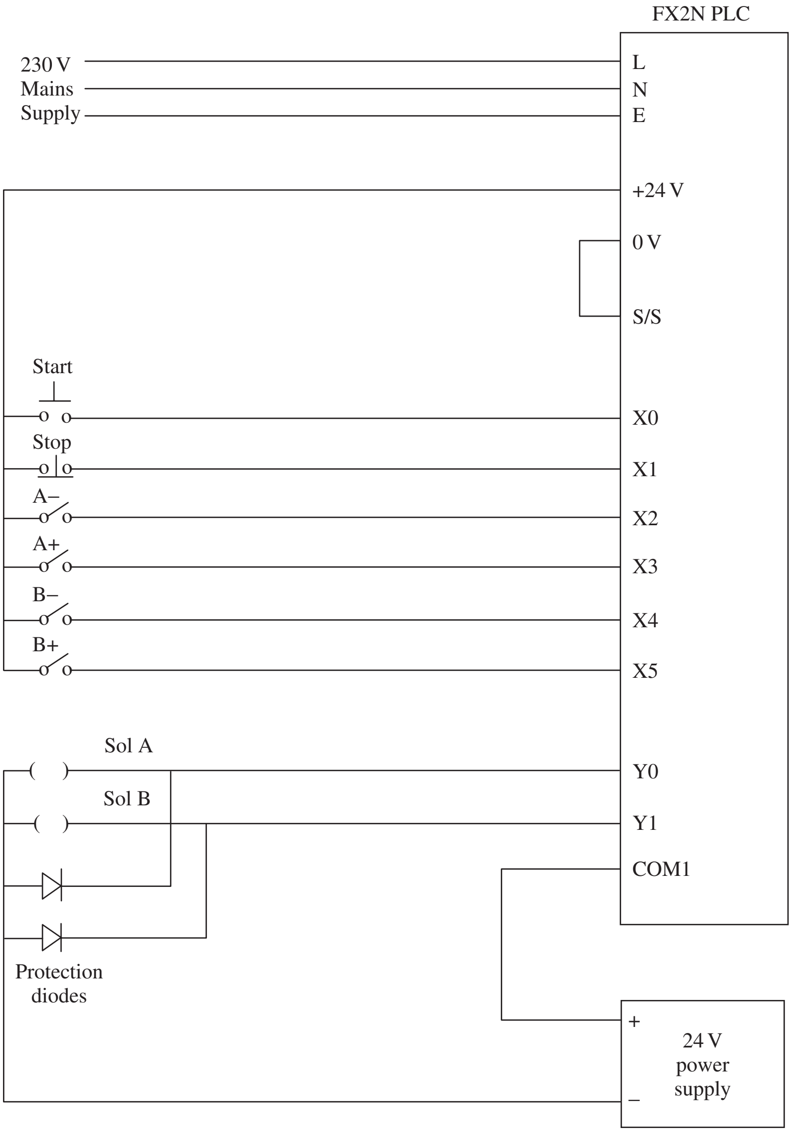

Figure 8.5

8.5 Forced input/output

The Mitsubishi FX2N PLC has the facility to enable inputs and outputs to be turned ON and OFF directly from the computer, without the PLC program running.
This is extremely useful when commissioning a system or when fault finding.
It enables a check to be carried out on the wiring from the inputs and the outputs to the PLC and also, whether or not the input and output devices are operating correctly.

Note

The forcing of inputs when the PLC is in RUN can cause the PLC to automatically start operating. This can cause problems involving safety and should only be done with great care.
The following describes how forcing can be used with the project PNEU1.

Forcing the Start Input X0

1. Ensure that the Ladder Diagram PNEU1 is being displayed and that it has been downloaded to the PLC.
2. Operate the following input switches to simulate the start conditions for PNEU1.
   (a) X1 Stop.
   (b) X2 A−.
   (c) X4 B−.
3. Ensure the PLC is switched to RUN.
4. From the menus select:
   (a) Online.
   (b) Debug.
   (c) Device test.
5. Enter X0, into the Device test window, as shown in Figure 8.6.
6. On selecting FORCE ON, the following will occur:
   (a) The Input X0 will turn ON.
   (b) The Output Y0 will turn ON.
7. The Output Y0 is turned ON due to the Input X0 being forced ON and starting the operation of PNEU1 (Figure 8.7).
8. By following the simulation and monitoring procedure, on page 98, the operation of PNEU1 can be continued.
9. Ensure all forced inputs are now Forced OFF.

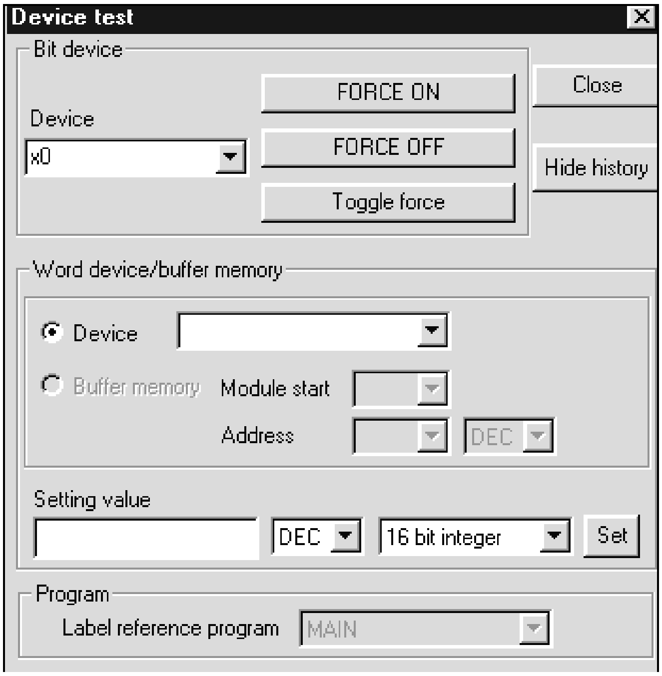

Figure 8.6

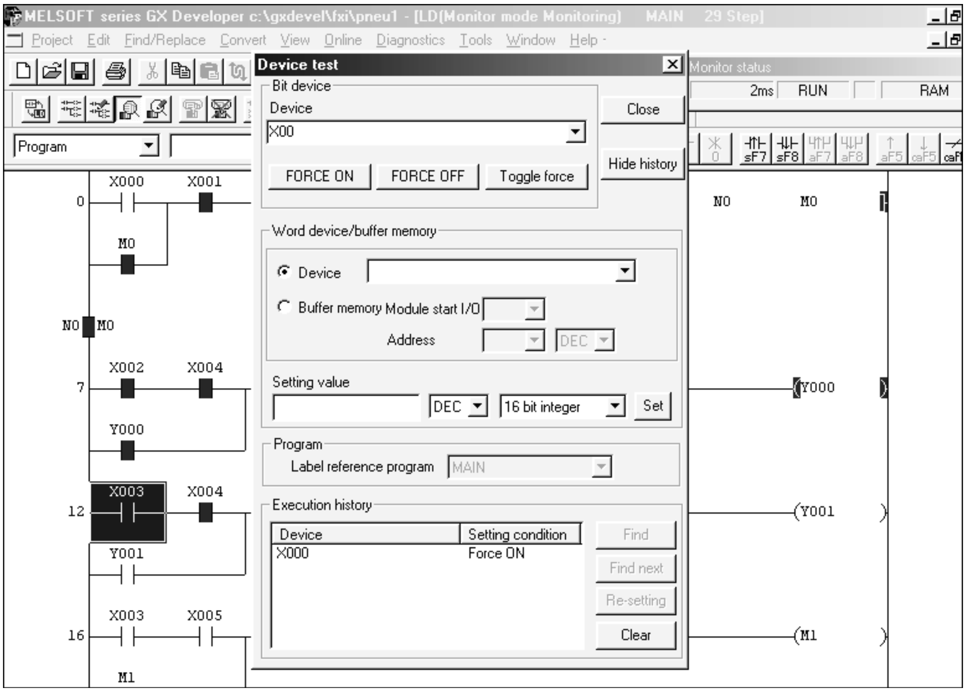

Figure 8.7

Forcing the Y Outputs

The Y Outputs, i.e. Y0 and Y1 can also be forced ON/OFF. However, as the PLC program will override any forced output, it is necessary before forcing outputs to turn the PLC switch from RUN to STOP.

Forcing the Output Y0

1. Ensure that the Ladder Diagram PNEU1 is being displayed and that it has been downloaded to the PLC.
2. Turn the PLC switch from RUN to STOP.
3. Similarly, as for FORCING Inputs, select:
   (a) Online.
   (b) Debug.
4. Select Device test once more.
5. Enter Y0 into the Device window.
6. The Output Y0 can now be either Forced ON and OFF or Toggled ON and OFF.
7. After Forcing Y0 ON, force some of the other outputs ON.
8. Ensure all forced outputs are now forced OFF.

Execution history

1. Check the Execution history display to confirm that all of the outputs, which were forced ON, have now been forced OFF (Figure 8.8).
2. Select Close to return to the ladder diagram.

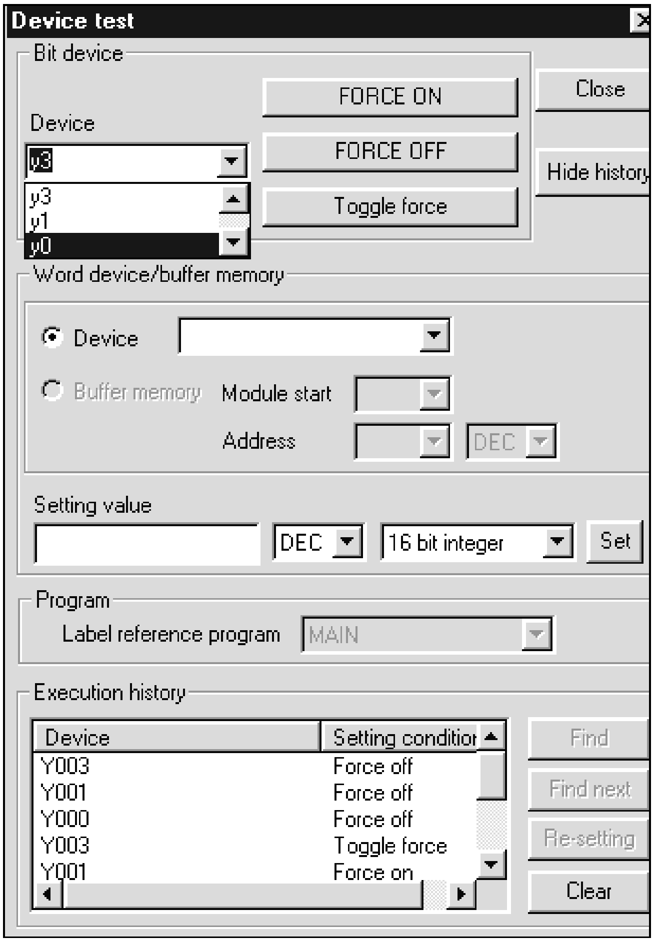

Figure 8.8

8.6 Assignment – PNEU2

Automate PNEU1 so that it will:

1. On operating the start button, carry out three complete cycles before stopping.
2. Repeat the automatic cycle each time the start button is operated.

Note

It is obvious that a counter will be required, hence the following must be considered:

1. What input will be used to enable the counter to count up?
2. What will happen when the counter reaches a count of 3?
3. What input will be used to reset the counter?