BASIC PLC

Laboratory Exercises

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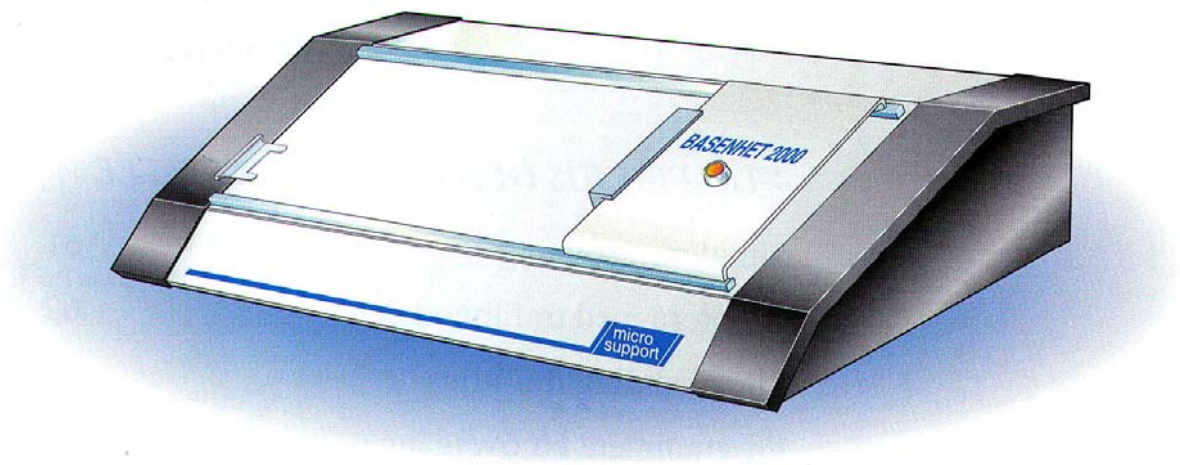
EQUIPMENT

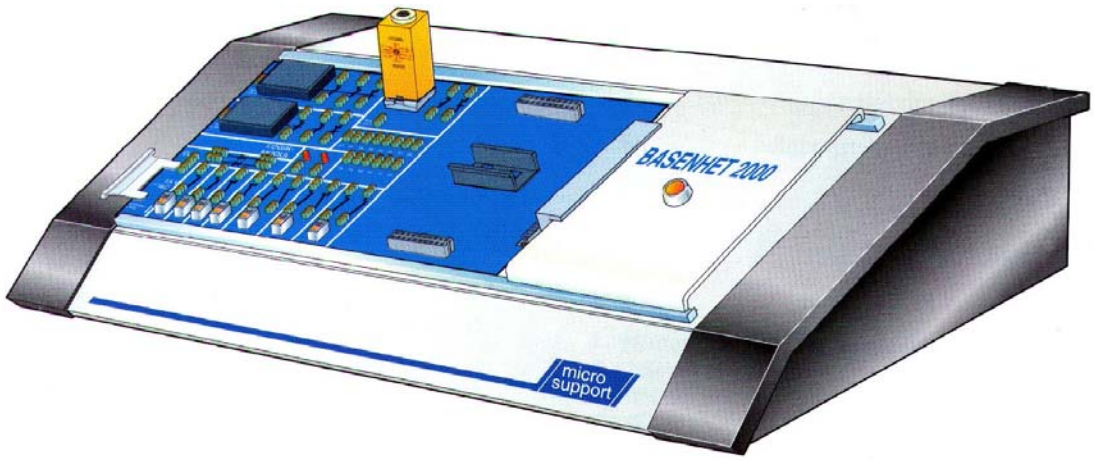
The laboratory experiments shall be carried out using the base-unit 2000. Different kinds of equipment, specially constructed for the 2000 series, can be connected to the base-unit.



The base-unit is connected to a 230V (AC) mains supply. A cable connection outlet is mounted at the back. Also a fuse and an ON/OFF switch.

The equipment for the different exercises is mounted on circuit cards that are called module cards. You will work with the following modules: Logic – cylinder – PLC and a traffic module.

The module cards are mounted in two tracks and pushed into a 64 -pin connector on the base-unit.

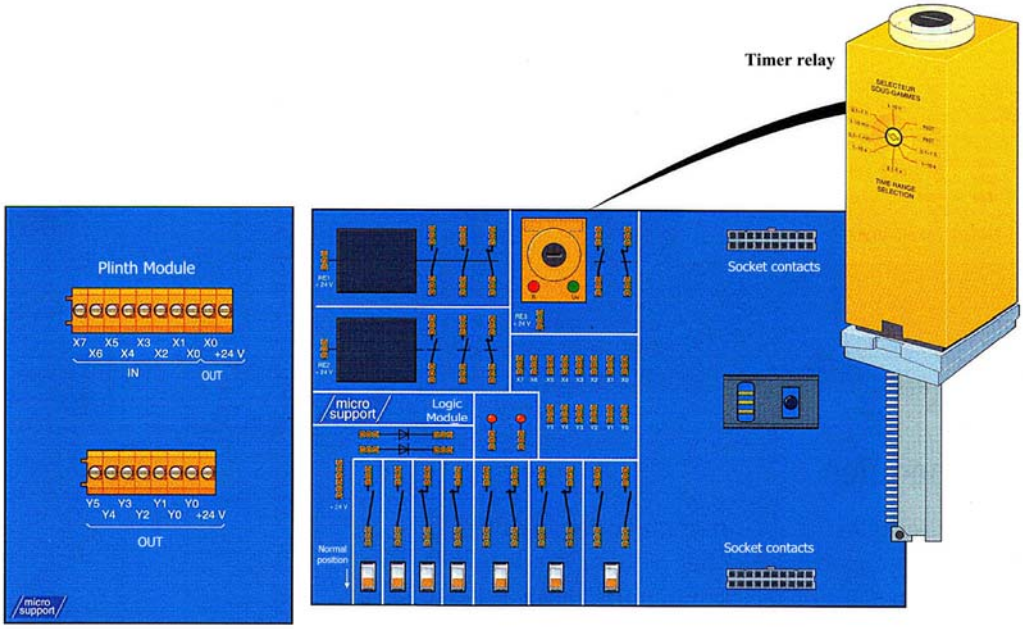


The base-unit with a module card installed.
Note that this card has secondary terminals for additional module cards.

The Logic Module

On the **logic module** there are single switches having 1 or 2 poles. These can be normally open or normally closed or with both. There are also relays with open and closed contacts, and a timer relay. The signal levels are displayed with LED´s (Light Emitting Diodes)

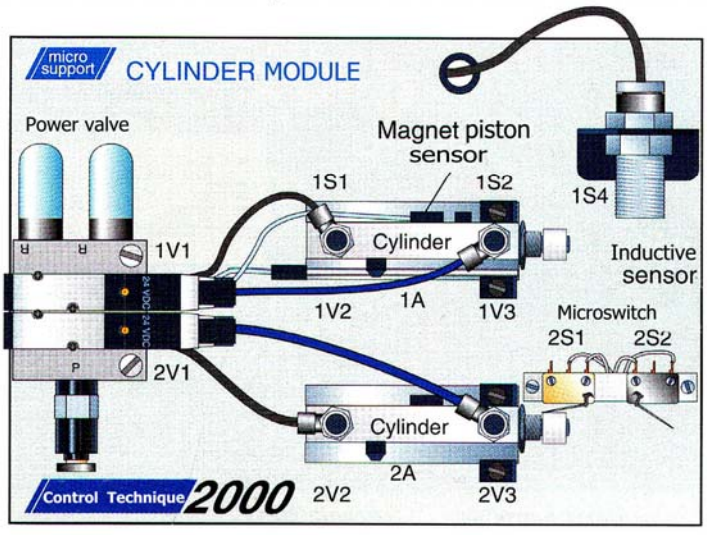
The logic module has also two 20-pin connectors for connecting external modules, and one of these is the connection block module as can be seen in the figure below.



The logic module. This particular logic module can be connected to a 20-pin connector.

The Cylinder Module

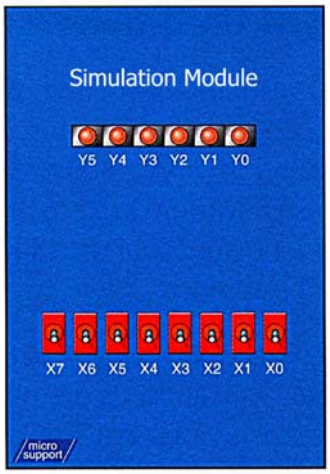
The **cylinder module** consists of some of the most common components. e.g. There are two **double action cylinders** with adjustable piston speed, controlled by **power valves**.
The minus and plus positions of the pistons are controlled by different types sensors, such as **micro-switches**, **magnetic rod and inductive** sensors.



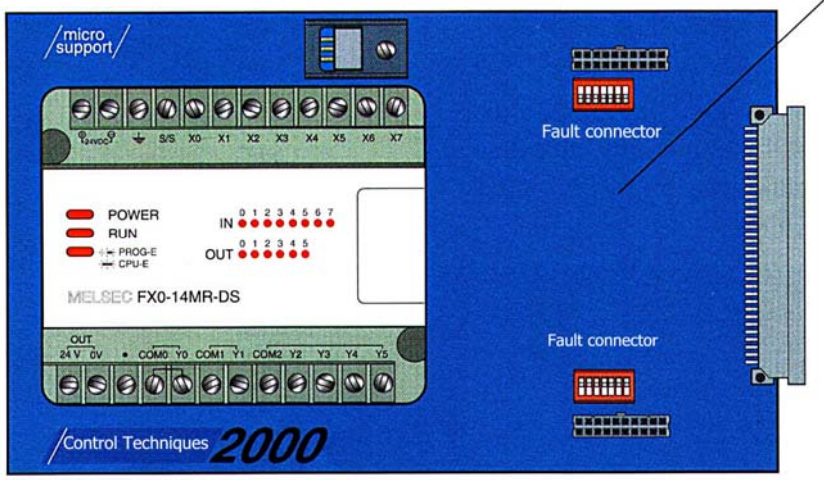
The cylinder module

The PLC Module

The **PLC module** consists of a programmable logic controller unit with **eight** inputs and **six** outputs. There are also two 20-pin connectors for connecting optional external module cards. Each 20-pin connector has a DIP- switch for fault simulation during the use of the external modules. A simulation module consisting of 6 LED´s and 8 switches can be seen in the figure below.



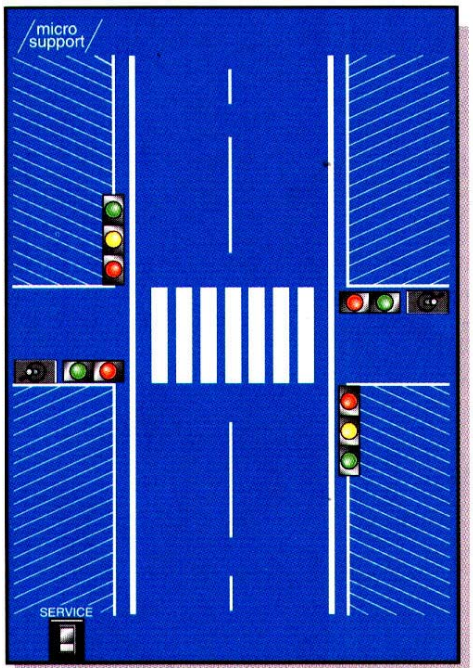
The Simulation Module



The PLC Module

The Traffic Module

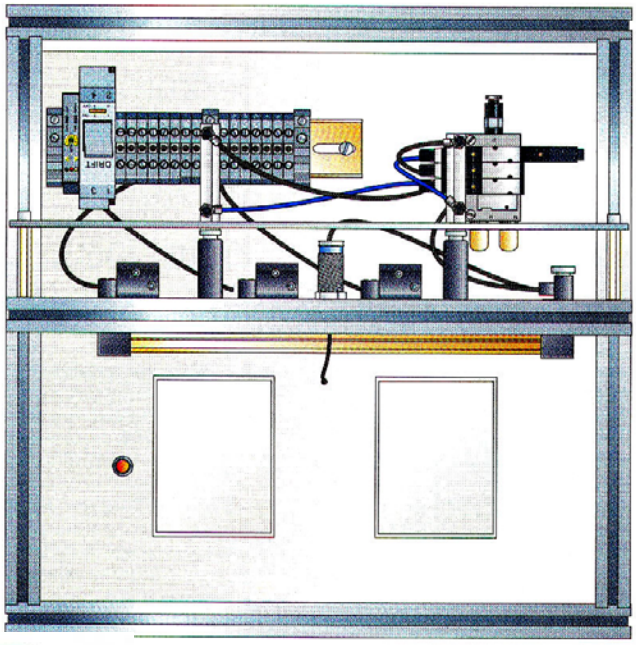
For further training on how to programme a PLC, directed to a limited object, the concentration is on a traffic light system at a pedestrian crossing.
The pedestrian crossing has red and green lights and the vehicle traffic lights have-red, yellow and green lights.



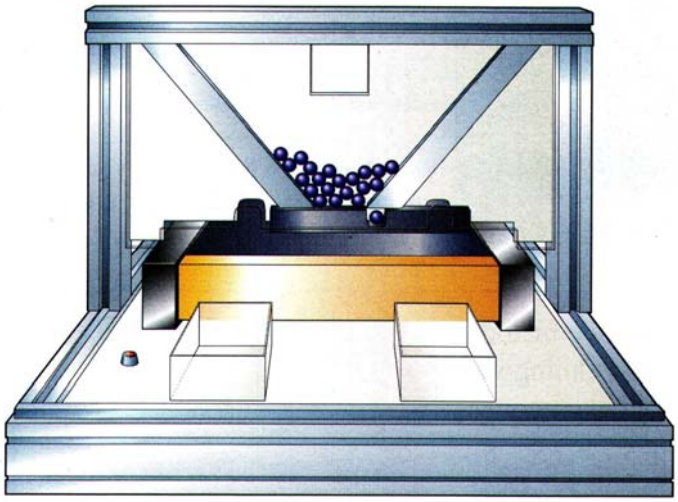
The Traffic Module

The Ball Selection Machine

In the **Ball Selection Machine**, balls are divided into different qualities and to different stores. The selection unit is an application of machine control. It includes a store, a collect position having a measuring fixture, two output positions and two stores.
The control system consists of one shuttle cylinder and two double action cylinders having electrically controlled direction valves as steering elements.
The ball detection is carried out in a measuring fixture having two sensors.



Top view of the Ball Selection Machine



Front view of the Ball Selection Machine

BINARY TECHNIQUE COMPONENTS

Signal Levels

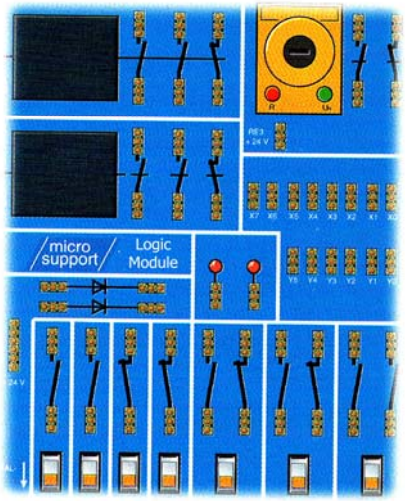
EXPERIMENT 1

In the binary system we use 0 “zero” and 1 “one” to explain different states. A voltage level of 0 (zero) volts and a pressure of 0 bar can be a signal level of 0 (zero).

EQUIPMENT
Logic Module
Cylinder Module
PLC Module
Simulation Module

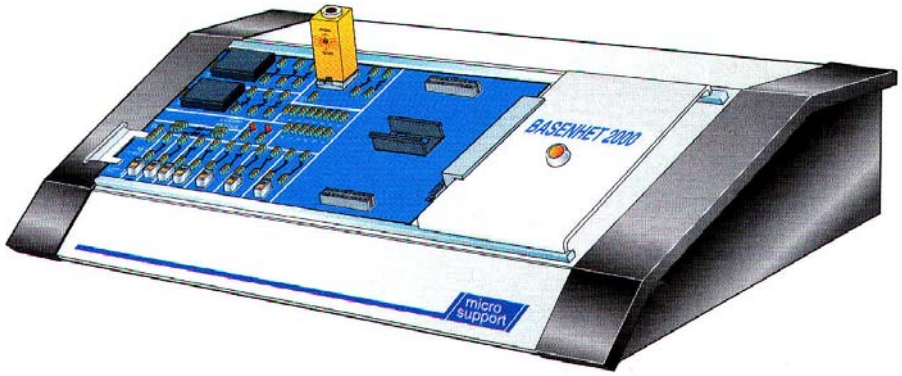
1. Using the logic module, look for the components listed in the table below and fill in the quantity.

Components	**Quantity**
Closed contact electric switch	
Open contact electric switch	
Two closed contacts electric switch	
Relays	
-Closed contacts	
-Open contacts	
Timer relays	
-Closed contacts	
-Open contacts	
Inputs connected to…..	
Outputs connected to …..	



EXAMPLE 1

- Mount the logic module in the tracks on the base-unit.



- Connection between the different components is by connection wire, which has been stripped 5-8 mm and then pressed into the connection blocks.

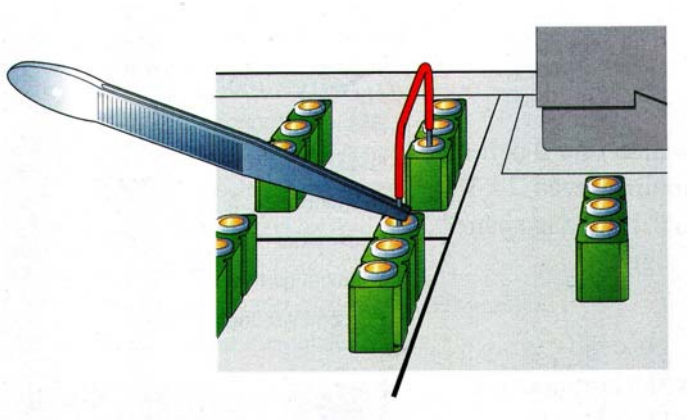


Fig. 1.2 Connection with the help of tweezers. Flat nosed pliers are recommended.

- Connect one of the LED´s to 24V via one of the switches, with a special wire, as shown in Fig. 1.3c.

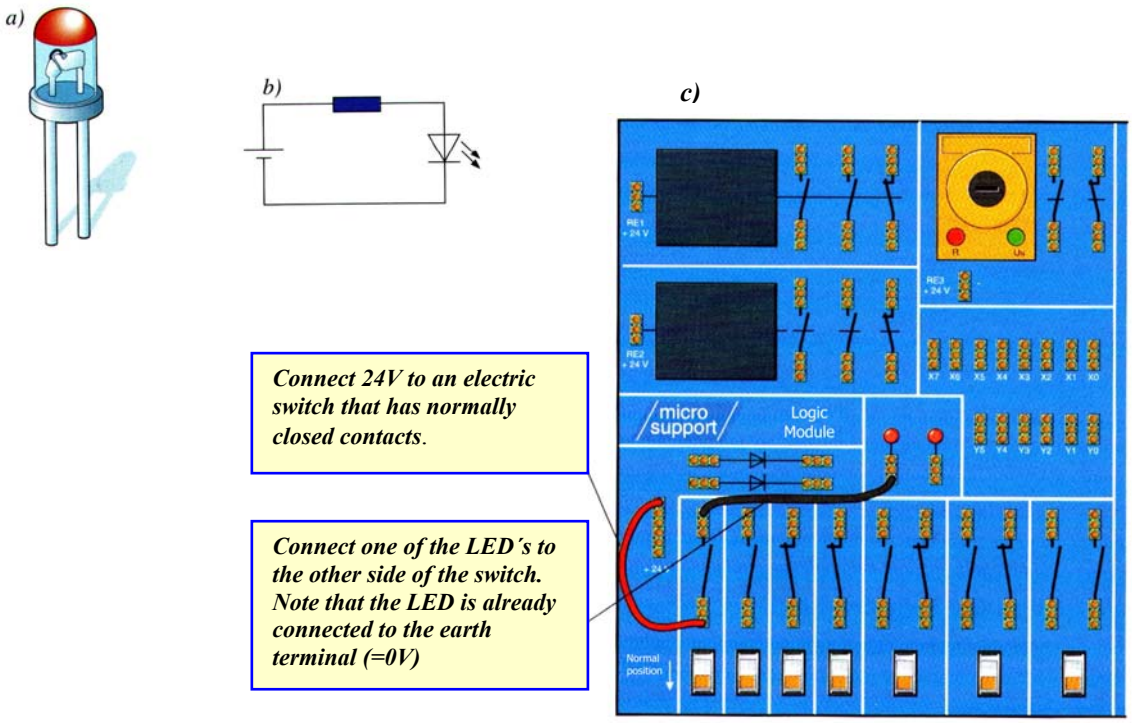


Fig. 1.3 a) LED
b) This resistor acts as a current limiting device.
c) Connection on the circuit card.

- Connect the base-unit to the mains power supply and switch on.

- The LED can now be switched on and off using the selected switch.

- The LED is connected in series with a resistor as a current limiter, the value of the resistor is 1200 ohm. Now measure the current through the LED. Connect the circuit as shown in Fig. 1.4.

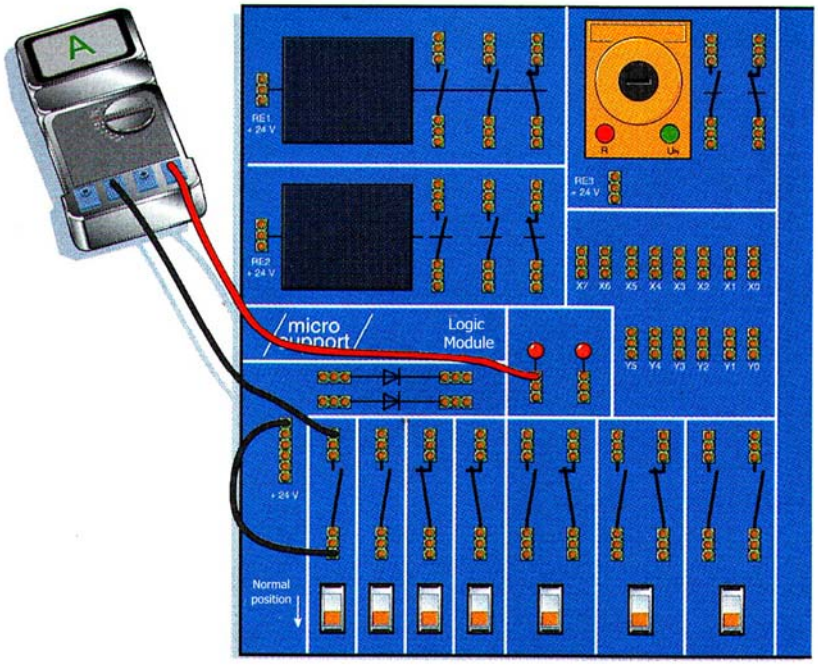


Fig.1.4 Measuring the current flow through the LED.

2. What is the current flowing through the LED?

……..

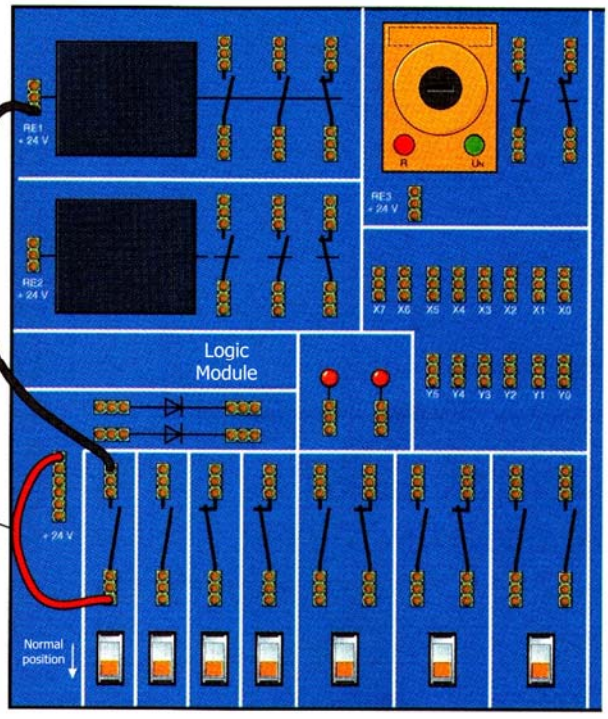
Note:
Before making any reconnections, switch off the mains power supply at the base-unit.

EXAMPLE 2

- One relay will now be controlled with the help of an electric switch.
- Connect one of the relays to 24V via one of the switches. See Fig. 1.5.

Connect from the other side of the switch to the relay coil of one of the relays.

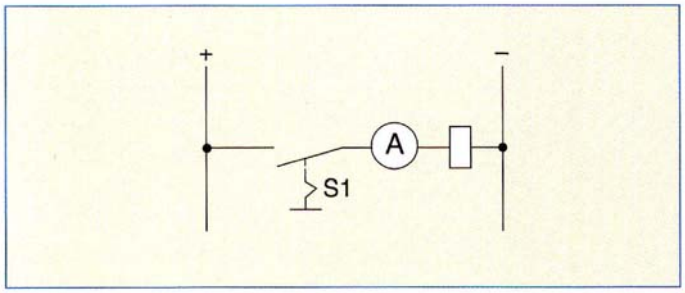
Connect 24V from the plinth to one of the terminals of a normally closed switch.



1.5 Connections for a control circuit having a relay and switch.

- Connect the base-unit to the mains power supply. The relay can now be turned on and off using the switch

- Measure the current flow through the relay. Connect as shown in Fig. 1.6.



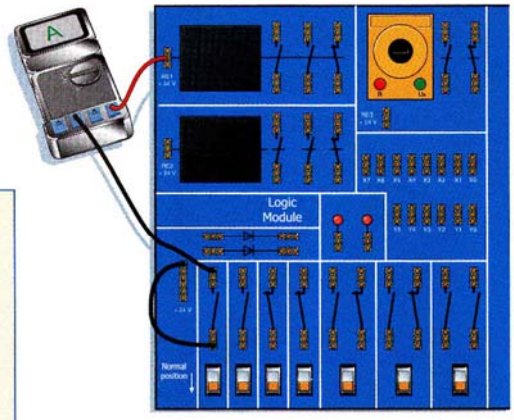


Fig. 1.6 Measuring the current flow through the relay coil.

3. Complete the table below using the data found in the manufacturers data sheet.

Operating Current:
Number of normally open contacts:
Number of normally closed contacts:
Number of maximum operations:

EXAMPLE 3

- One of the relays has a time function. Change the connections so that it is possible to measure the time relays operating current.

4. What is the level of the operating current through the relay coil? Write down the values in the table below.

Operating Current:
Number of closed contacts:
Number of open contacts:
Number of maximum operations:

- Study the effect of the time delay by adjusting delay time to 5 respectively 20 seconds.

0,1 – 1 s	1 – 10 s
0,1 – 1 min	1 – 10 min
0,1 – 1 h	1 - -10 h

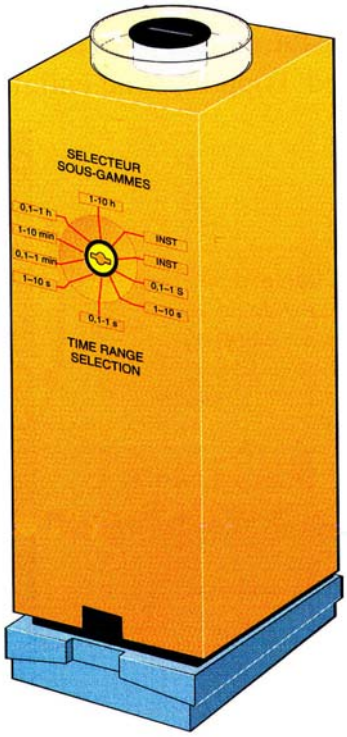


Fig. 1.7 a) Timer relay b) Different settings for time delay.

Experiments with the Cylinder Module

Take up the **Cylinder Module**. Study the module card and try to find more data for the components in the manufacturers catalogue or data sheets.

5. Complete the tables below.

Double action cylinder Type CDJB10-30D			**Variable reducing-clack valve AS 1201F**	
Minimum working pressure			Setting range	
Maximum working pressure			Setting lock	
Cylinder diameter			Working pressure min- max	
Power outward movement at 5 bar				
			Magnetic rod sensor type D-97	
Power inward movement at 5 bar			Function	
Piston rod diameter			Load current	
Cylinder stroke			Indication	
Piston speed				
Power valve SY3140-5LOU			**Micro switch type XC83-11**	
Ports and connections			Function	
Control				
			Inductive sensor	
Does hand operation exist			PNP or NPN	
Indication			Indication	

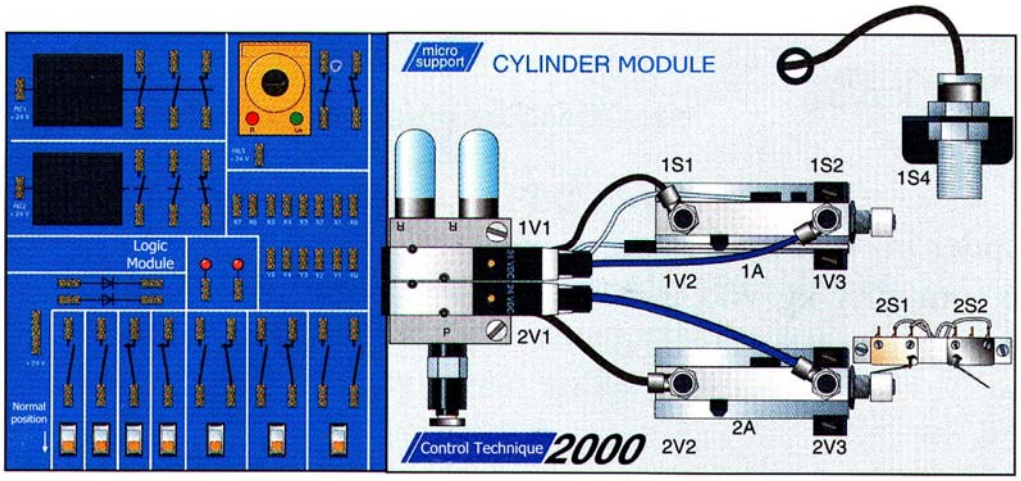


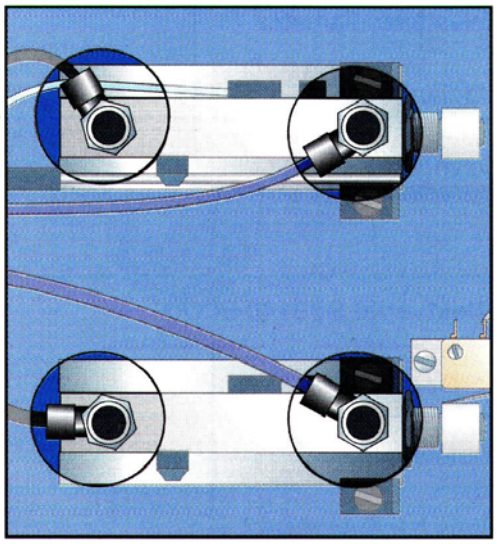
Fig. 1.8 The cylinder module mounted on the logic module.

EXAMPLE 4

- Mount the cylinder module on the logic module, to the base-unit.
- The power valves and sensors are electrically connected to a 20-pin connector on the logic module, as follows:

Valve	1V1	Y0
Valve	2V1	Y1
Sensor	1S4	X0
Sensor	1S1	X1
Sensor	1S2	X2
Sensor	2S1	X3
Sensor	2S2	X4

- Connect the cylinder module to the air supply.
  Note; The working pressure must be between 0,6 and 0,7 bar.
- The cylinders plus and minus movements can be checked manually by pressing the orange knobs.
- The piston movement speed can be adjusted using the valves that are mounted on the cylinder. The speed is adjusted by turning the black axle, which can be locked with the lock nut. Adjust the piston speed to a frequency of 2 seconds for both plus and minus movements.



Fig, 1.9 The speed is regulated using the valves that are placed on the cylinder.

6 Convert the piston speed of 500mm/s to km/h and compare the following:

Leopard 100m:	112.6 km/h
Runner 100m:	36,1 km/h
Marathon runner 42 km:	19,7 km/h
Piston speed:	……

7 Convert the piston force during the plus and minus movements into kp (kilo pound = Force that a 1 kg weight gives) and compare with other forces registered on a force meter.

Chimpanzee weighing 74,8 kg:	384 kp
Human weighing 74,8 kg:	95 kp

Piston rce CDJPD 10-30 D outward movement: ...…… kp
Piston force CDJPD 10-30 D inward movement: …… kp

- Check also the movements. Connect a 24V DC to Y0 respectively Y1 on the logic module, via an electric switch.

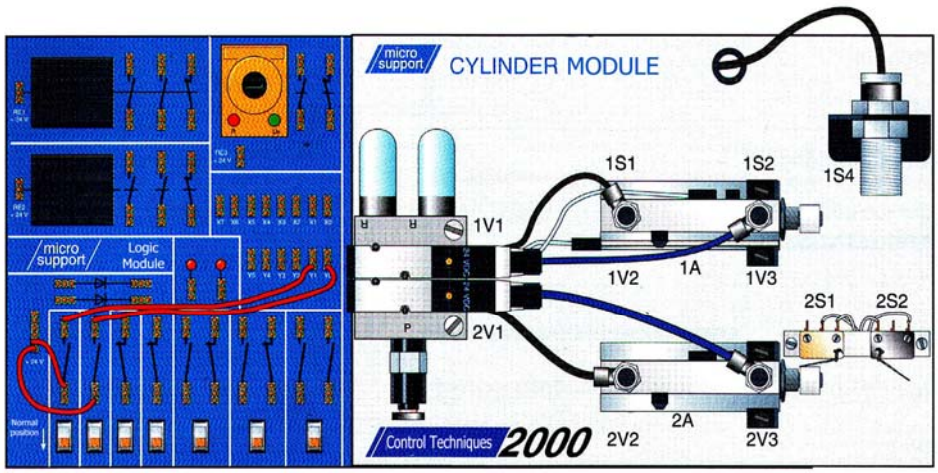


Fig. 1.10 Control of a cylinder from the logic module.

- Check the function of a sensor by using it to control a cylinder. Connect to the connection plinth for the logic modules in and outputs.

Start to Y1

Connect 24 V via an electric switch to 2V1 via Y1. The start button now controls cylinder 2A for one movement. With the cylinder in its outer position, (plus position), sensor 2S2 is activated.

X4 to Y0

Connect 2S2 via X4 and Y0 to 1V1. With this connection the sensor 2S2 makes the cylinder 1A to make a plus movement.

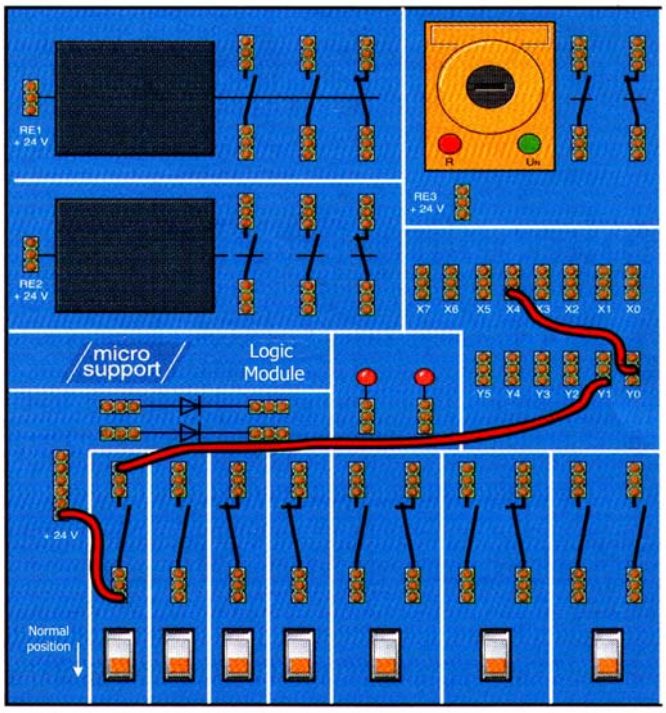


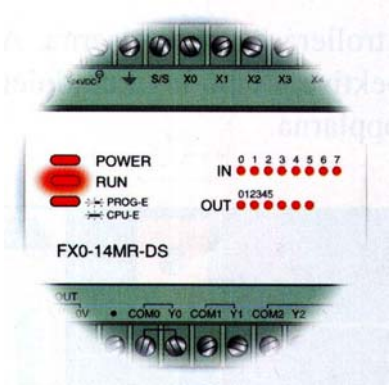
Fig. 1.11 The sensor controls the cylinders movements

Start the process with the start button. First the cylinder 2A will make a plus movement. When it reaches its plus position it will activate sensor 2S2 that, in turn makes cylinder 1A to make an outward movement. Note that as long as the start button is depressed the cylinders will stop in the plus position.

Experiments with the PLC Module and Simulator Module

8 Take up the **PLC module**. Look for data to complete the table below.

Specifications on the PLC	
Number of in- out channels	
Number of input indicators	
Number of output indicators	
Power supply	
Relay and transistor outputs	
What is under the cover?	



9 Take up the **simulation module**. Answer the questions in the table below.

The inputs are simulated by	
Number of inputs	
The outputs are simulated by	
Number of outputs	

Connection of the PLC System

- Mount the PLC module on the base-unit.
- Connect the simulation model via the 20-pin contacts on the PLC module by pressing it carefully into the 2 20-pin contacts. See Fig. 1.13.
- Connect the programming unit to the PLC via a suitable Cable. See Fig. 1.14.
- Check that the change-over switch, RUN-STOP, is in the STOP position.
- Connect the base-unit to the mains power supply.

Fig.1.12 Note that every time a card is put in or taken out from the base-unit, the mains voltage must be switched off. When changing fuses the flex with plug must also be pulled out.

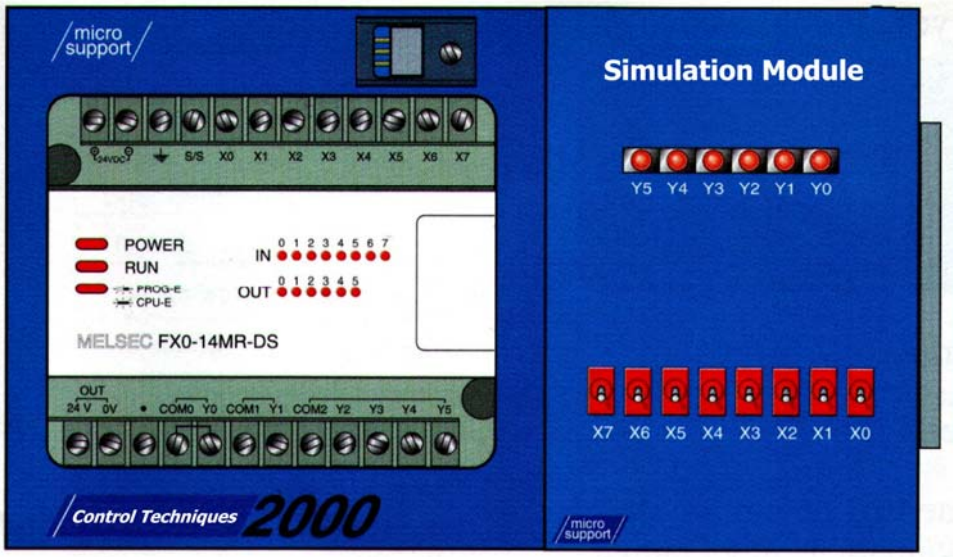


Fig. 1.13 Note that the inputs on the simulation module are at the bottom and the outputs are at the top. The switches are normally closed and will open when the toggles are moved down.

- The programming unit will give more information. Wait for more information.

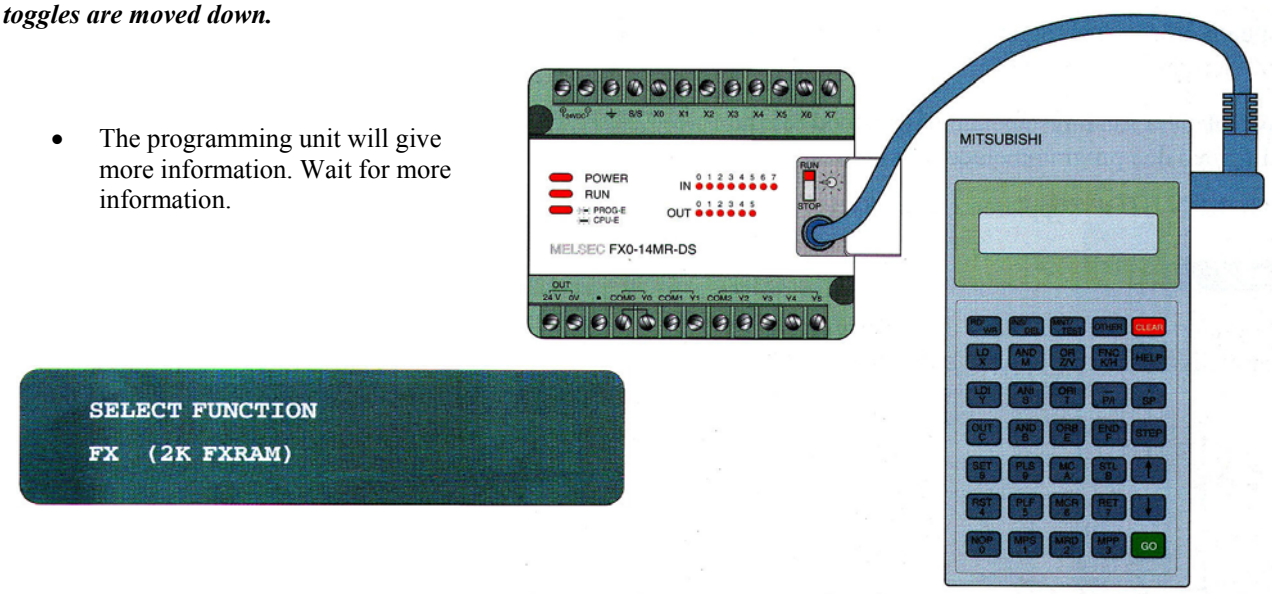


Fig. 1.14 The RUN indication lights up on the PLC when the RUN/STOP switch is in the RUN position.

EXAMPLE 5

- Start to erase the programme memory by pressing RD/WR twice. The letter W can now be seen in the upper left corner.
- The next assignment is to write a PLC programme for a function that includes two switches connected in series.

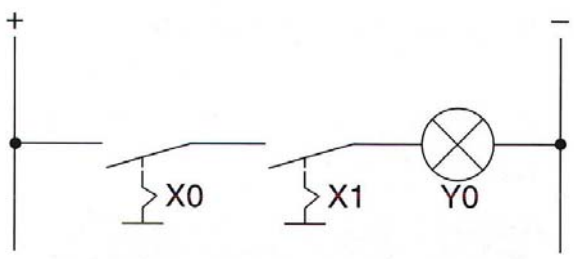
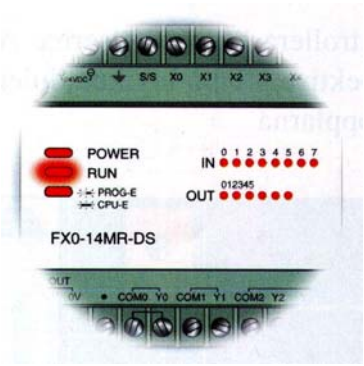


Fig. 1.15 Control circuit with two series connected switches.

- Create a programme by writing the following:

```
LD  X   0   GO
AND X   1   GO
OUT Y   0   GO
END GO
```



The programming is now finished.

- Set the RUN/STOP switch to the RUN position.
- By setting the switches X0 an X1 on the simulation board it is possible to check the programme. Study the different indications for in- and outputs on the PLC and outputs on the simulation module. At which state do you now get an output?

  10 Complete the truth table for the PLC, with its programmed function.

X0	X1	Y0
0	0	
0	1	
1	0	
1	1	

- Set the RUN/STOP switch to the STOP position.

EXAMPLE 6

- Make a new programme for two switches in parallel as shown in Fig. 1.16.

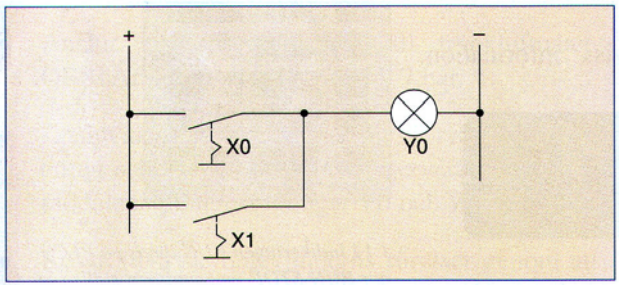


Fig. 1.16 Control circuit with two switches in parallel.

- By pressing the RD/WR button twice the previous programme can be erased.
- Program the new function by writing in the following:

```
LD  X   0   GO
OR  X   1   GO
OUT Y   0   GO
END GO
```

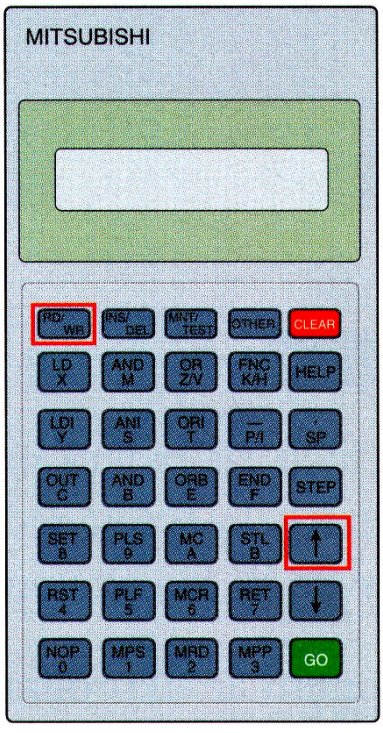


Fig. 1.17 Instead of erasing the previous programme step backwards to the first position. The WR position was earlier on the screen so it is a choice of taking steps back to the start point, using the marker.

- Set the RUN/STOP switch to the RUN position.

Bt setting the switches on the simulation module, it is possible to check the programme. When does it give an output signal 1?

11 Complete the truth table to the right, for the PLC, with its programmed function.

X0	X1	Y0
0	0	
0	1	
1	0	
1	1	

- Set the RUN/STOP switch to the STOP position.

EXAMPLE 7

- Create a programme for the function shown in Fig. 1.18.
- Erase the previous programme or go back in steps and start from the first position.
- Write the new programme as shown below.

```
LD  X   1   GO
OR  X   2   GO
AND X   0   GO
OUT Y   0   GO
END GO
```

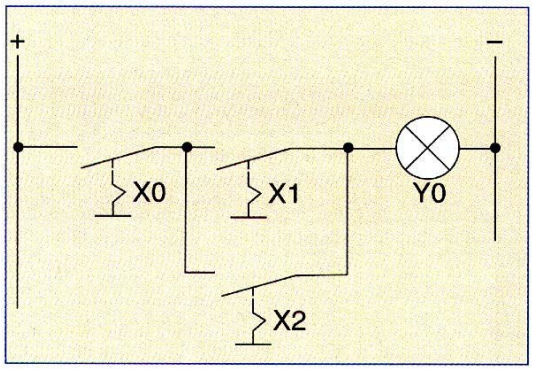


Fig. 1.18 Control circuit with one switch in series and two switches in parallel.

- Set the RUN/STOP switch to the RUN position.
- Check the programme by setting the switches on the simulation module. When does it give a 1output signal?

12 Complete the truth table to the right, with reference to the programme function in example 7.

X0	X1	X2	Y0
0	0	0	
0	0	1	
0	1	0	
0	1	1	
1	0	0	
1	0	1	
1	1	0	
1	1	1	

- Set the RUN/STOP switch to the STOP position.

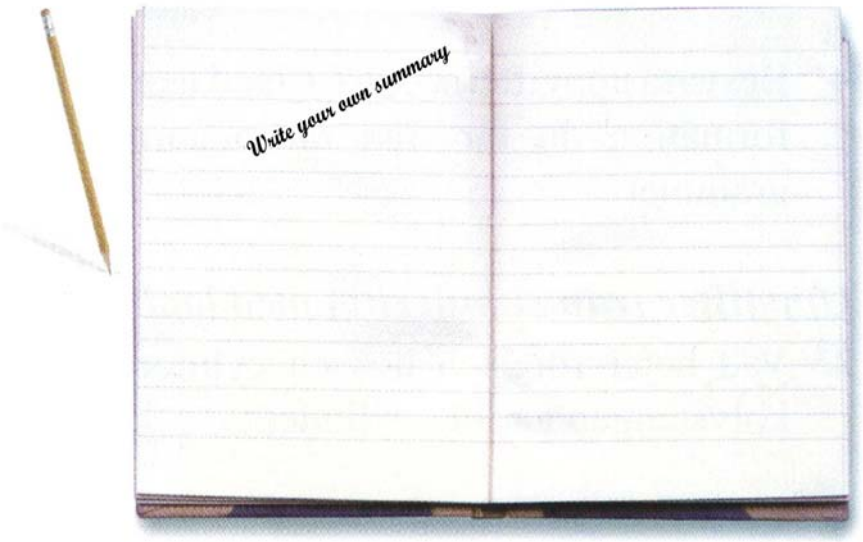
Before finishing this introductory chapter, a simulation of industrial production in a pea factory using the learning programme will be completed.

- Set the RUN/STOP switch to the STOP position.
- Switch off the mains supply.

Summary

With clearly defined 1 and 0 states from various components it is possible to feed in, machine, transfer and take out control technique information.

The binary techniques is based on the use of components where two clear states are defined: 1 respective 0



BUILDING WITH LOGICAL ELEMENTS

Logical Elements

EXPERIMENT 2

Logic elements operate with signal levels that correspond to the two binary levels 1 (one) and 0 (zero). They can be combined to different systems to get integration between in- and output signal from the control equipment.

With the help of the logic module it is possible to simulate and connect a number of fundamental logical functions.

EQUIPMENT
Base-unit 2000
Logic Module
Cylinder Module
PC

The following assignments will be completed, after the simulation exercises with logical elements.

13 What is the movement called, when a piston rod moves in the cylinder?

…….

14 In which assignments are the sensors mounted on the cylinders?

……..

……..

15 Draw the symbol for the NOT-function.

16 Draw the symbol for the AND-function.

17 Draw the symbol for the OR- function.

18 What is the logic function when two switches are connected in series?

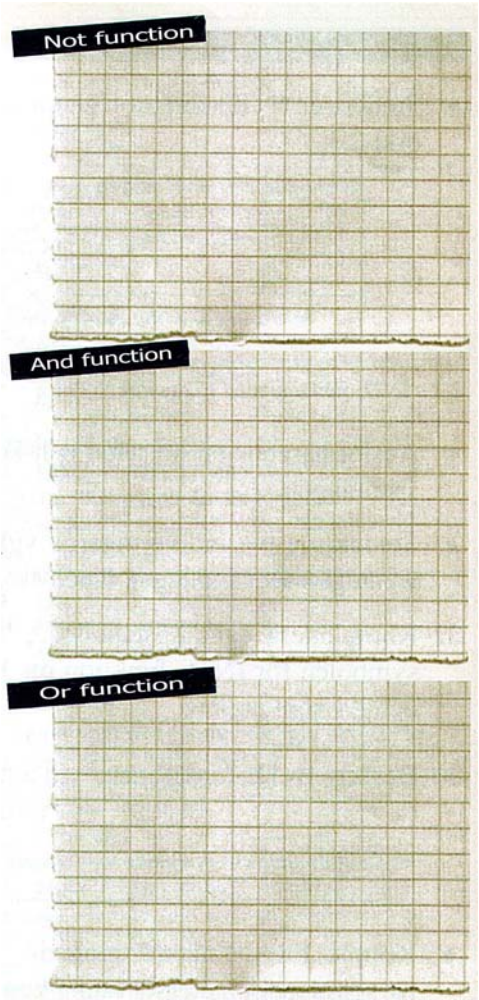
…….

…….

19 What are the two types of memory functions called?

…….

…….



20 Describe the function of a delay timer.

…….

…….

21 Describe what a control system is.

…….

…….

Experiments with the Logic Module

- Place the logic module in the socket on the base-unit.

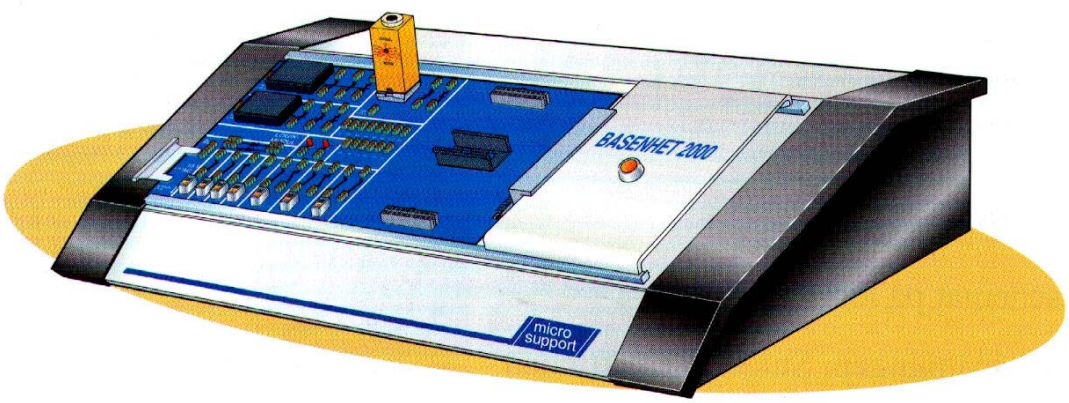


Fig. 2.2 Base-unit 2000 with the logic module

EXAMPLE 1 NOT- FUNCTION

- Connect up a circuit as shown in Fig. 2.3a and study a NOT function.

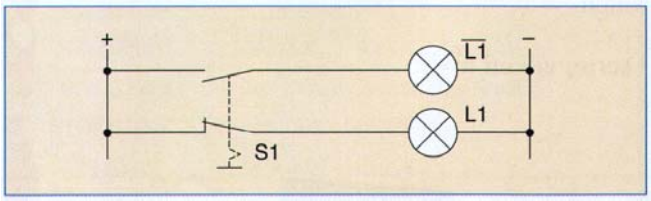


Fig. 2.3a A NOT function with two switches

- Connect the base-unit to the mains power supply and switch on the power.
- Study the two indications in the positions for 0 and 1 for the signal sensor.

22 Complete the truth table. Draw the symbol for the NOT function and mark the input as S1 and the output as L1.

23 Describe the conditions for the NOT function.

……

……

- Switch off the mains power supply at the back of the base-unit and restore your connections.

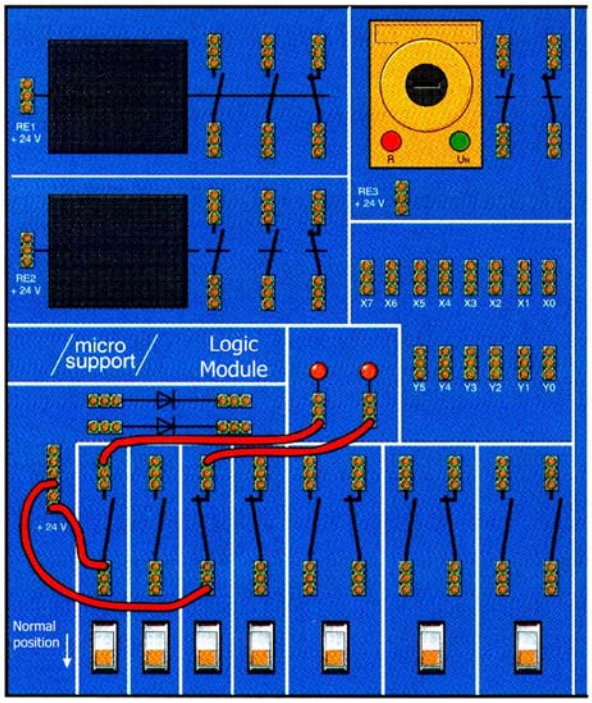


Fig. 2.3b Connections for the logic module

EXAMPLE 2 AND- FUNCTION

- Study the AND function as shown in Fig. 2.4.

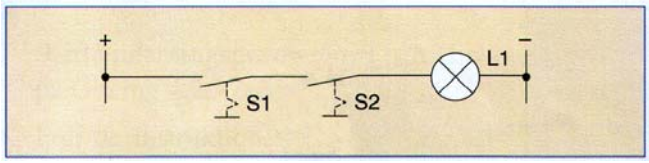


Fig. 2.4a AND Function with electric switches

- Connect the logic module as shown in Fig. 2.4a
- Switch on the power supply at the back of the base-unit. Study the functions in different positions for the two signal sensors.

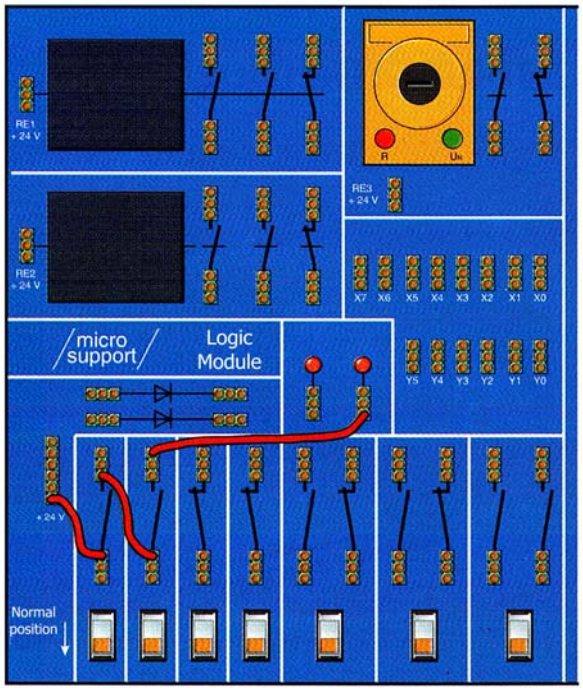


Fig.2.4b Connections for the logic module.

24 Complete the truth table below. Draw the logic symbol for the AND-function with S1 and S2 as inputs, and L1 as an output.

S1	S2	L1
0	0	
1	0	
0	1	
1	1	

25 Describe the conditions for the AND function.

……..

……..

EXAMPLE 3 OR-FUNCTION

- Switch off the mains power supply and connect the circuit as shown in Fig. 2.5a and b.

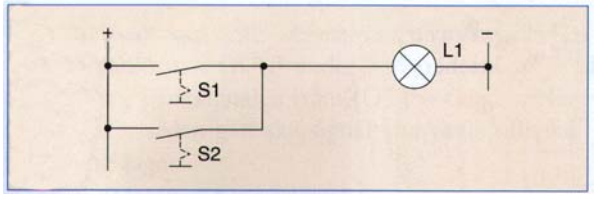


Fig. 2.5a An OR function with two electric switches.

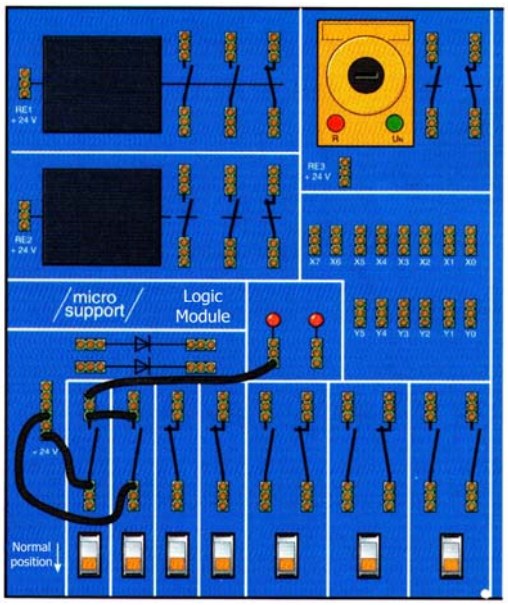


Fig. 2.5b Connections on the logic module

- Switch on the mains power supply and study the function.

26 Complete the truth table below. Draw the logic symbol for the OR function.

S1	S2	L1
0	0	
1	0	
0	1	
1	1	

27 Describe the conditions for the OR function.

…….

……..

EXAMPLE 4 RELAY CONNECTIONS

- Switch off the mains power supply. Connect the NOT function as shown in Fig. 2.6.

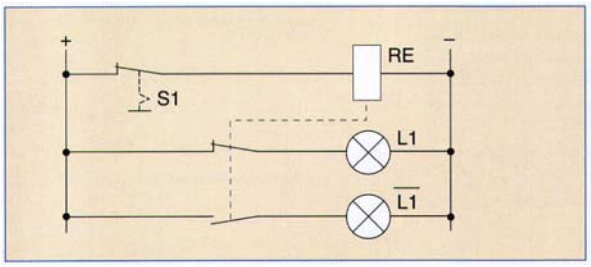


Fig. 2.6a A NOT function with switches and relay.

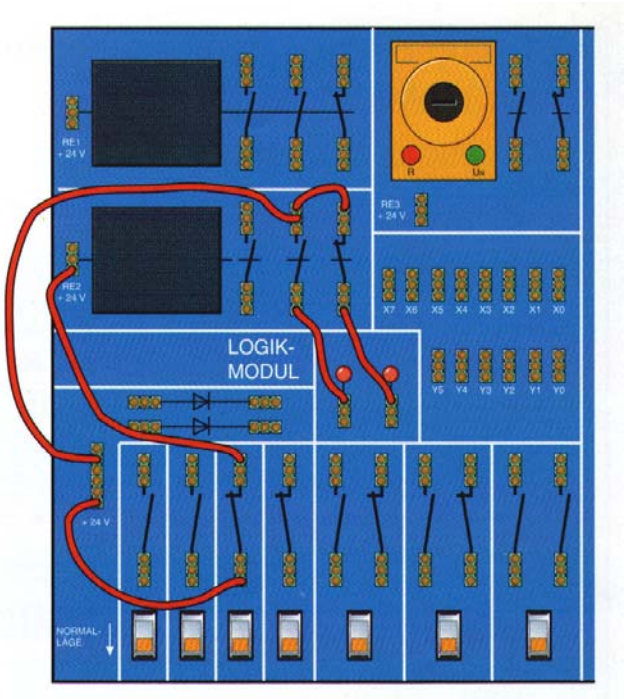


Fig. 2.6b Connections on the logic module.

- Switch ON the mains power supply at the back of the base-unit and check the function.
- Compare the truth table with the NOT function.
- Switch OFF the mains power supply.
- Study the circuit diagram of a relay controlled by a combination of AND- and OR- functions.

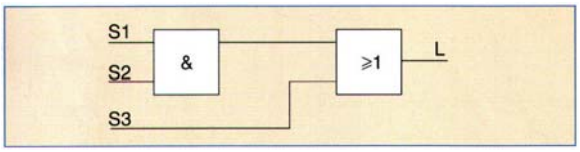


Fig. 2.7 A Combination circuit with AND- and OR- functions.

28 Complete the control circuit diagram in Fig. 2.8.

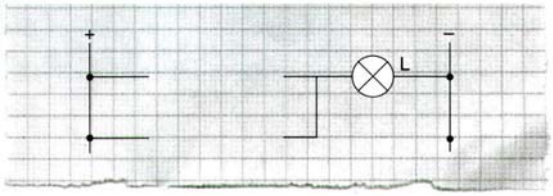


Fig. 2.8 Control circuit for a combination circuit.

- Connect the circuit according to your control circuit above.
- Switch ON the mains power supply and check the function.

29 Complete the truth table below.

S1	S2	S3	L
0	0	0	
1	0	0	
0	1	0	
1	1	0	
0	0	1	
1	0	1	
0	1	1	
1	1	1	

From this point there will be no information about when to switch ON and OFF the mains power supply.
Remember to do this every time changes to circuit connections, or changes to module unit, are made.

EXAMPLE 5 NOR-FUNCTION

- Study the two control circuit diagrams that have a NOR function. See Fig. 2.10.

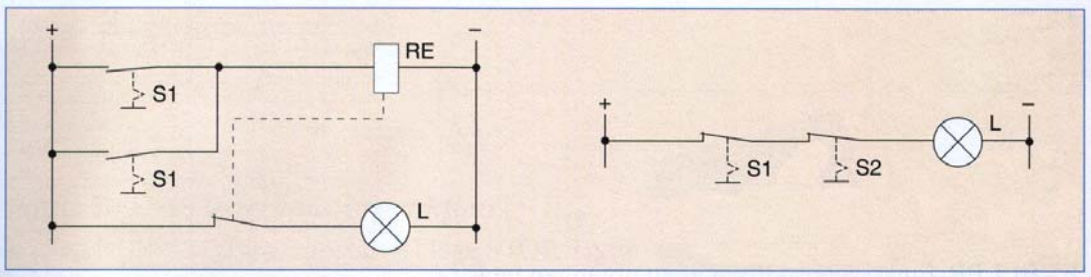


Fig 2.9 NOR-function with two different alternatives

- Connect the two different circuits and compare their functions.

30 Complete the truth table and draw the logic symbols.

S1	S2	$\overline{S1 + S2}$	$\overline{S1} \cdot \overline{S2}$
0	0		
1	0		
0	1		
1	1		

31 Describe the conditions for the NOR-function.

……..

……..

EXAMPLE 6 NAND-FUNCTION

Study the two control circuits with NAND- function.

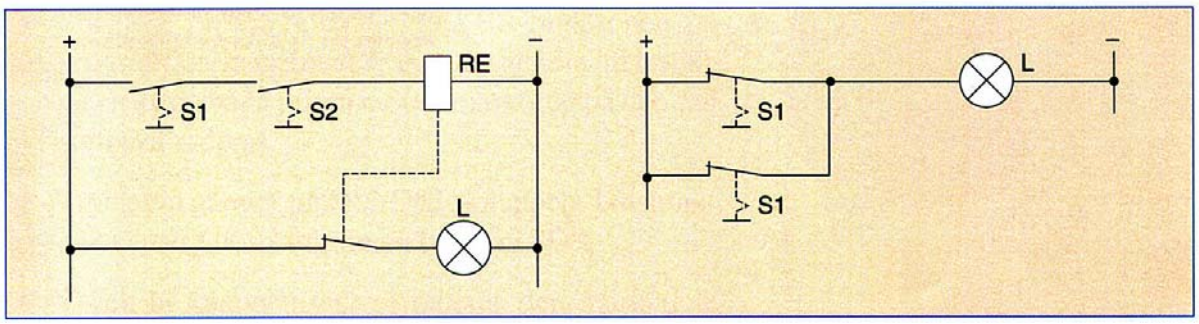


Fig. 2.10 NAND-function with two alternatives

- Connect the two alternatives and compare the functions.

32 Complete the truth table and draw the logic symbols.

33 Describe the conditions for the NAND-function.

…….

…… …….

S1	S2	$\overline{S1 \cdot S2}$	$\overline{S1} + \overline{S2}$
0	0		
1	0		
0	1		
1	1		

EXAMPLE 7 XOR FUNCTION

The condition for the XOR-function is that the output takes a 1 state if, and only one, if one the inputs has a 1 state.

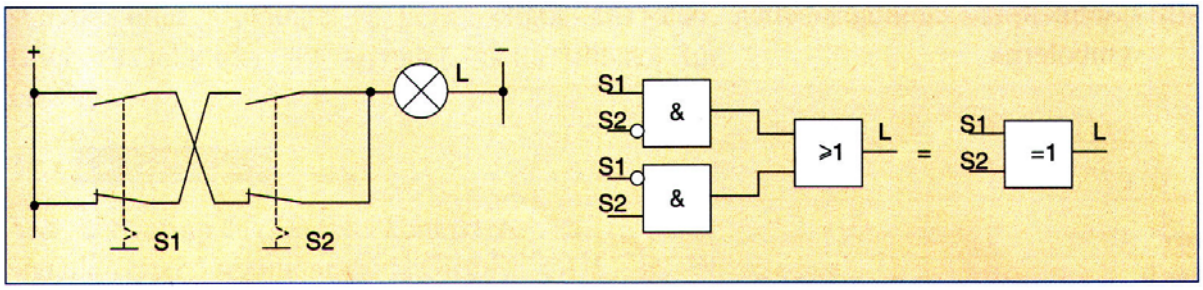


Fig. 2.11 The XOR-function

- Study the control circuit diagram and logic diagram for an XOR-function. See Fig. 2.11.

- Connect the circuit and check its function.

34 Complete the truth table.

S1	S2	$(S1 \cdot \overline{S2}) + (\overline{S1} \cdot S2)$
0	0	
1	0	
0	1	
1	1	

EXAMPLE 8 MEMORY FUNCTION

- Study the memory function in Fig.2.12. Connect the two alternatives and study their differences.

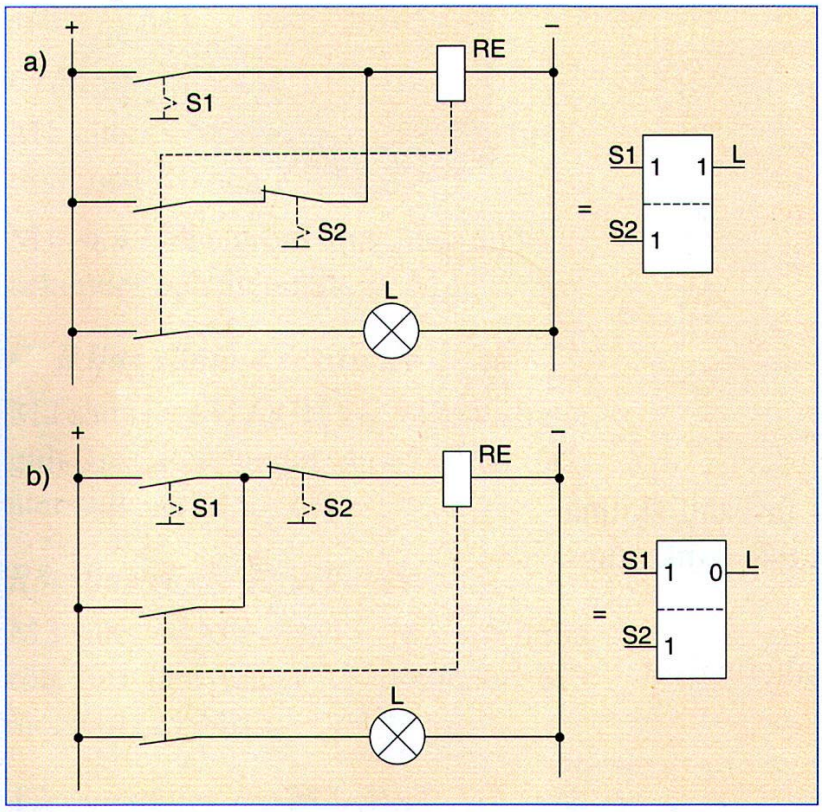
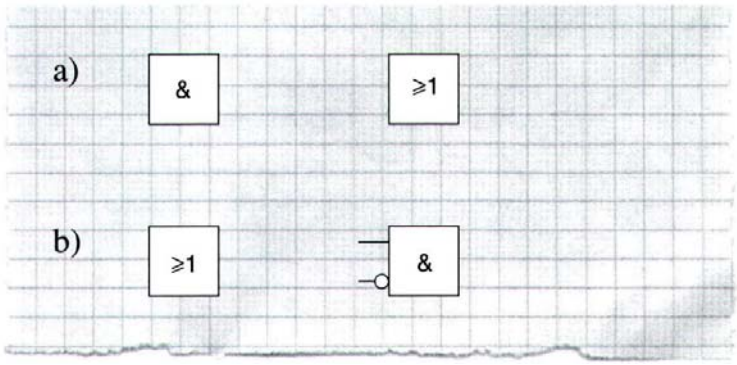


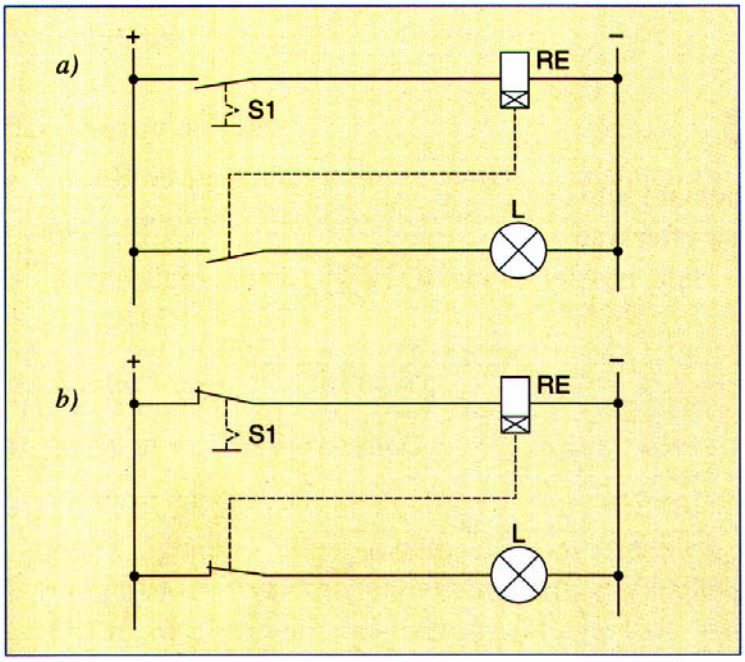
Fig.2.12 The memory function with two alternatives. Note that the signal state is only given for some of the outputs.

35 Complete the logic diagram for the circuits.



EXAMPLE 9 DELAY FUNCTION

- The logic module has one relay with delay action. The delay time can be adjusted in different steps and variable between steps. Setting steps 0.1 – 1 min.



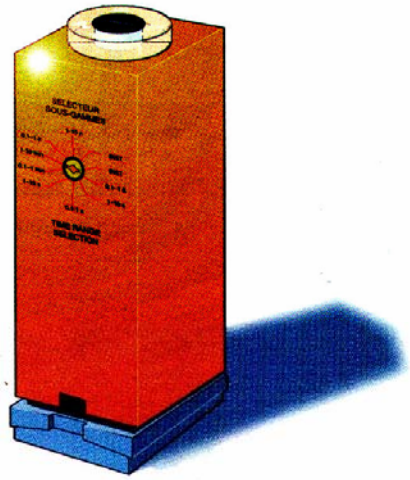


Fig. 2.13 Different alternatives for setting delay time function.

- Connect the two alternatives and study their differences. Observe the two indicating lamps and set them at different delay times.

36 Draw the logic symbol for the a- and b- alternatives.

a) b)

Experiments with the Cylinder Module

Mount the cylinder module on the logic module.

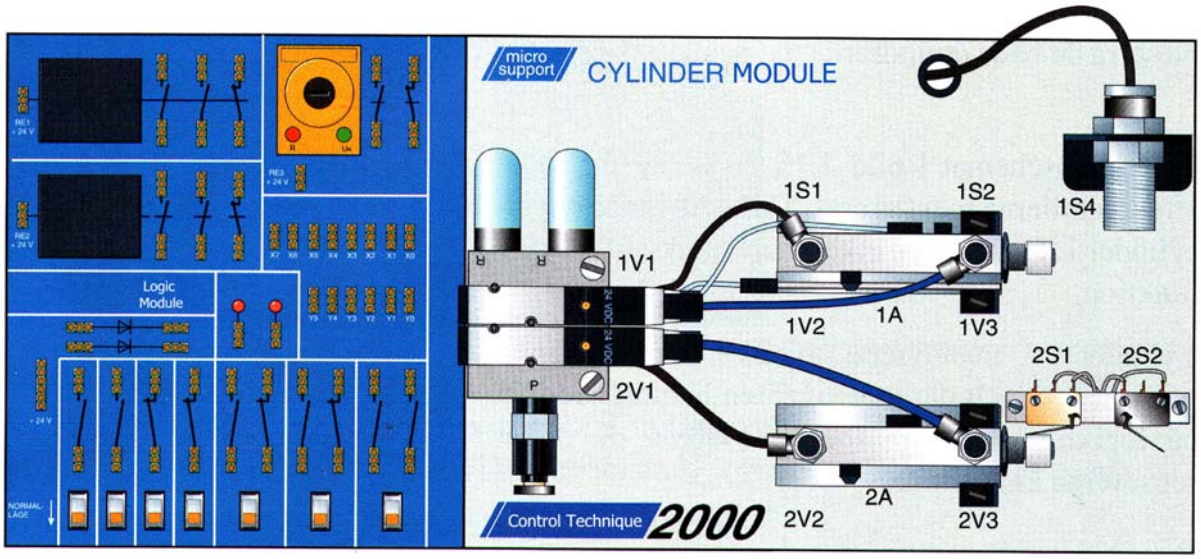


Fig. 2.1 The components mounted on the logic module.

- The two power valves and the five sensors are electrically connected to the logic module's plinth, according to the table below.

Valve	1V1	Y0
Valve	2V1	Y1
Sensor	1S4	X0
Sensor	1S1	X1
Sensor	1S2	X2
Sensor	2S1	X3
Sensor	2S2	X4

- Connect the cylinder module to the compressed air supply. Note that the recommended working pressure is between 0,6 – 7 bar.

- Check the plus- and minus- movements of the two cylinders by operating the valves manually. Press the orange buttons.

  Check the electrical functioning of the valves by connecting 24V to Y0 respective Y1, on the logic module.

- Adjust the two cylinders so that the pistons have a speed of two seconds for the outward movement and 1,5 seconds for the inward movement.

EXAMPLE 10 ELECTRIC – PNEUMATIC CONTROL

The logic module and cylinder module will now be connected so that two cylinders can be controlled by electric signals.

- In the control circuit diagram (Fig. 2.15) it can be seen how the two power valves are controlled. Cylinder 1A is controlled by the power valve 1V1. An electric switch for START/STOP functions controls the power valve.

  Cylinder 2A is controlled by 2V1which in turn is controlled by sensor 1S2. The signal is taken from X2 on the logic module's connection plinth. All the sensors are connected to this plinth.

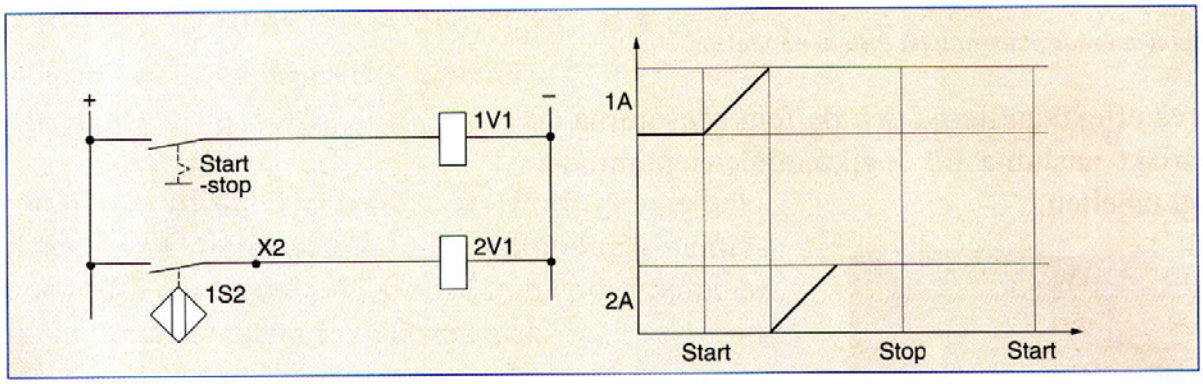


Fig 2.15 Control of the two cylinders.

- Connect the circuit as shown in Fig. 2.15 and check the circuit's manual functions. Note that 1S2 controls the outward movement for 2A. When the START/STOP valve is set to the STOP position, 1A starts its inward movement. This then activates 1S2 so that 2A starts its inward movement.

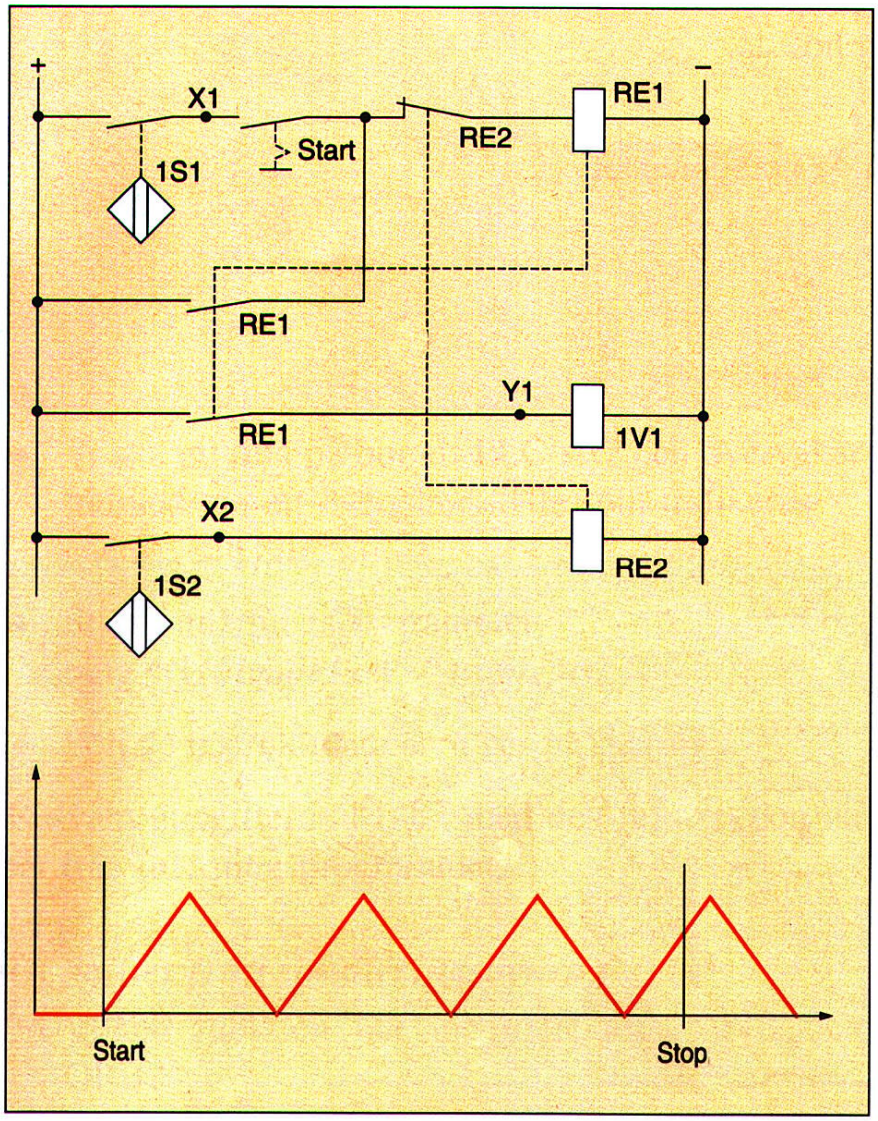
- Adjust the piston speed for the cylinders until a suitable speed is attained.

- Study the functions of all the connected elements.

37 Complete the function diagram in Fig. 2.15 for the two cylinders piston movements.

EXAMPLE 11 ONE CYLINDER IN AN AUTOMATIC CYCLE

The circuit diagram in Fig. 2.16 shows how the cylinder 2A is connected in an automatic cycle.



A process with one or more cylinders, which is always controlled by human supervision, is known as a manual cycle.

A ***semi-automatic*** cycle means a process that, after start carries out the complete cycle and then stops at the start position.

An ***automatic cycle*** is a process that after start will continue until it stops either manually, or if the conditions for the process are not fulfilled.

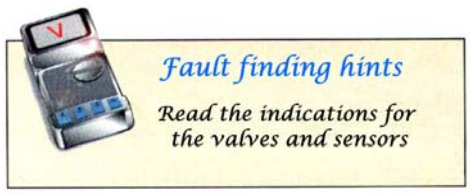
Fig. 2.16 One cylinder in an automatic cycle.

- Study how the control function is built up in the control circuit diagram.

A cylinder movement can be easily operated via a memory function. It is activated by a set signal respectively a reset signal from sensors or other sensor device.

The power valve has a spring return and is electrically controlled in one of the directions. When the activating signal is given (0 zero), the spring return will immediately reset the valve to its start position.

One relay, RE1, at the logic module, is used as a memory function. In addition to the hold-in contact a second contact is used to control the electric valve 1V1.



- Connect as shown in the control circuit diagram and check the function of the circuit.
- Study the functions and the indications of all the connected components.

38 What are the different indications shown?

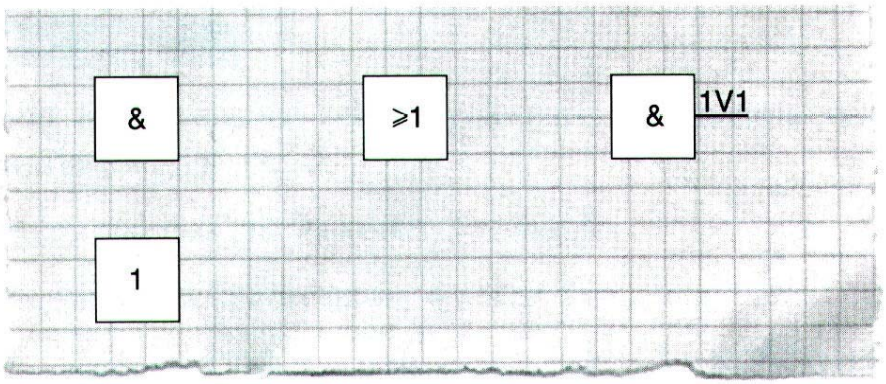
……

……..

……

……

39 Complete the logic diagram for one cylinder in an automatic cycle.



40 How does the cycle stop when a stop signal is given?

……..

……..

……..

……..

……..

EXAMPLE 12 TWO CYLINDERS IN AN AUTOMATIC CYCLE

In this automatic cycle, the following exercises will be completed:

- ***When given a start signal, the cylinder 1A will complete an outward movement to fix the work piece.***
- ***When the piston reaches its plus position the cylinder 2A will start its outward movement, and the work piece is machined.***
- ***When the cylinder 2A has reached its plus position, both cylinders will start their inward movement.***
- ***During the inward movement there is a change to a new work piece. The cycle will be automatic and will be repeated until a stop signal is given.***

Study the control circuit diagram in Fig. 2.17.

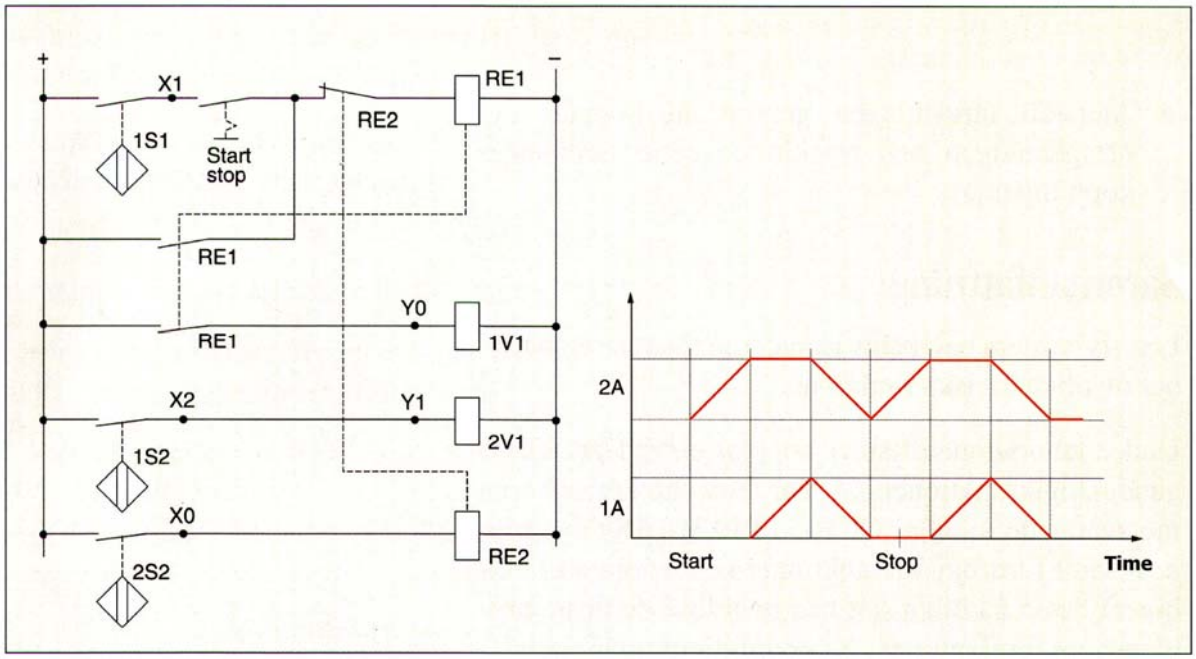


Fig. 2.17 Two cylinders in an automatic cycle.

- Connect the circuit as shown in the circuit diagram.
- Start up the circuit and check the automatic function.
- Study the function of all the connected components.

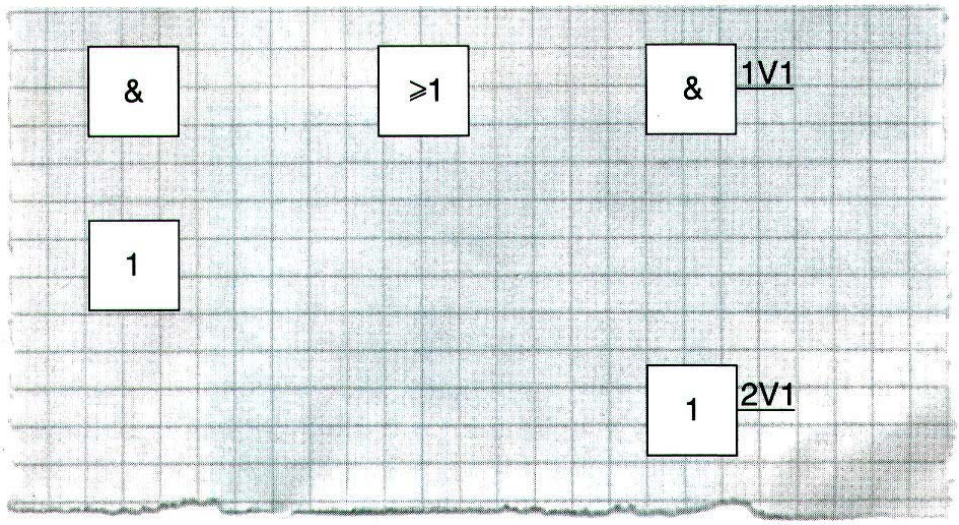
41 How did the cycle stop after the stop signal was given?

……

……

……

42 Complete the logic diagram using your results.



- Switch off the mains power supply and compressed air supply. Disconnect the equipment and the connections.

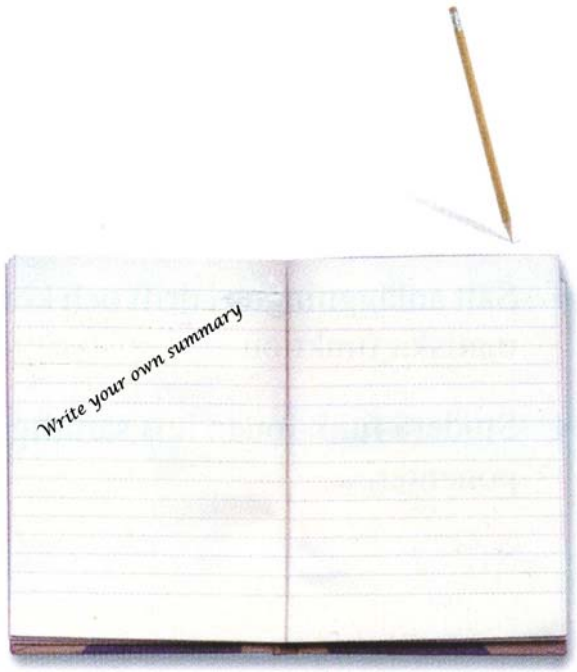
SUMMARY

In a control system, signals are used in combination with different logic functions to complete processes or tasks automatically.

During the exercises a series of fundamental logic functions have been connected. The most common of these, AND, OR, NOT Memory and Time Delay functions. By combining these functions most of the problems found in a production line can be solved.

To make it easier to understand how a combined circuit is built up, function blocks for the binary logical elements, were used.

During the exercises it was established that combinations of different elements can be substituted by other equivalent combinations. One AND-function with a NOT-function in series with the output, can be substituted by one OR-function with a NOT-function connected to the inputs.



BUILDING WITH THE PLC

PLC System Programming

EXPERIMENT 3

The PLC- system has all the necessary functions collected in one capsule.

The input signals come from different sensors. The output signals go out to contactors, valves and other external connections.

The PLC- system cannot complete any function until a programme is loaded to its memory.

When programming a PLC, the method is the same as building with logical elements, only that with the PLC it is easier.

EQUIPMENT
Base-unit 2000
PLC-module
Programming unit for the PLC
Simulation-module
Cylinder-module
PC

Programme Control

With the help of LED's it is easy to see if there are any faults in the programme, or if breakdowns occur. See Fig. 3.1.

The **POWER** indicator lights up when the mains supply is connected.

When the **PLC** is running the indicator RUN, lights up.

The LED, **PROG E** blinks if:
There is an error in the programme
There is an error in the programming language
A timer circuit or counter has been programmed without a constant
There are any electrical disturbances from other units, or other outside influence in the unit.

CPU-E is displayed with a constant light when:
There are electrical disturbances from other units, or other outside influence in the unit.
The programme cycle time of 0,2 s has been over-ridden.

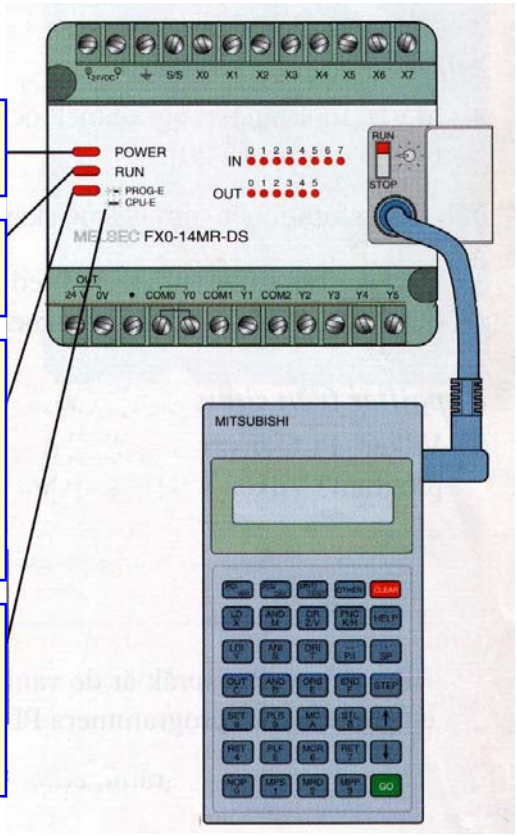


Fig. 3.1 Indicators for POWER, RUN and CPU-E together with in- and outputs.

Simulation Exercise **(See also start manual for GX-Dev)**

The functions NOT, AND, OR, Memory and Time delay, will now be programmed into a PLC. In order to do this the "PLC language" must be practiced. i.e. the language that the PLC understands.

To translate the human language into PLC-language, different language symbols must be used. One such language symbol is the ***Ladder Diagram***. With the help of a ladder diagram it is quite easy to translate to a PLC-programme.

Another language symbol is ***Function Block***.

When programming a PLC the following method shall be used:

- Start with the rules that will apply to this PLC programme. This means that either a Ladder diagram ***OR*** a Function block system will be used.

- Translate this system to the PLC programme.

- Load this into the PLC and do a test run.

Tasks from the simulation exercise

43 Which PLC- instruction always starts the PLC programme? Which will always end the programme?

…….

44 Which are the two most common language symbols used in programming a PLC?

…….

45 Give the instructions for the Mitsubishi PLC for the following functions:

AND function:

……..

OR function:

……..

NOT function:

……

46 Load in the PLC programme completed in the previous simulation exercise. First write the function then the PLC- programme. Use separate paper.

Experiments with the PLC Module

- Mount the PLC-module on the base-unit.

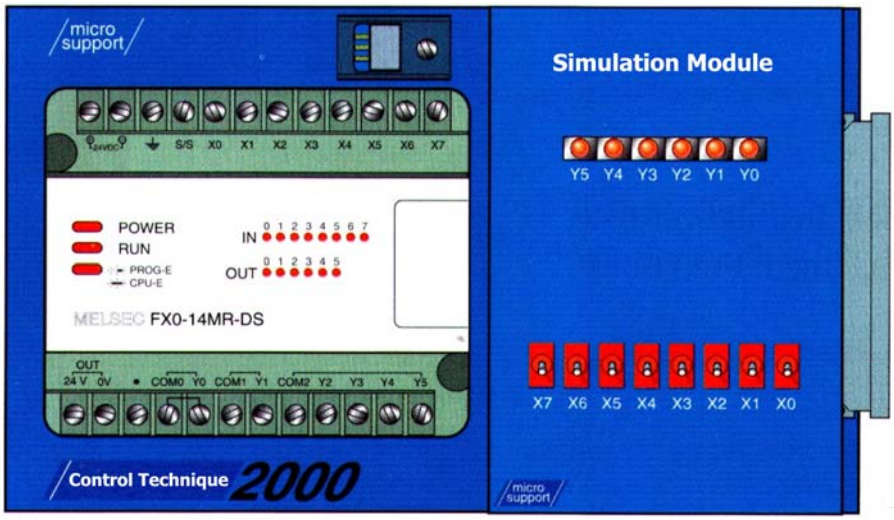


Fig. 3.3 The PLC-module with the simulation- module

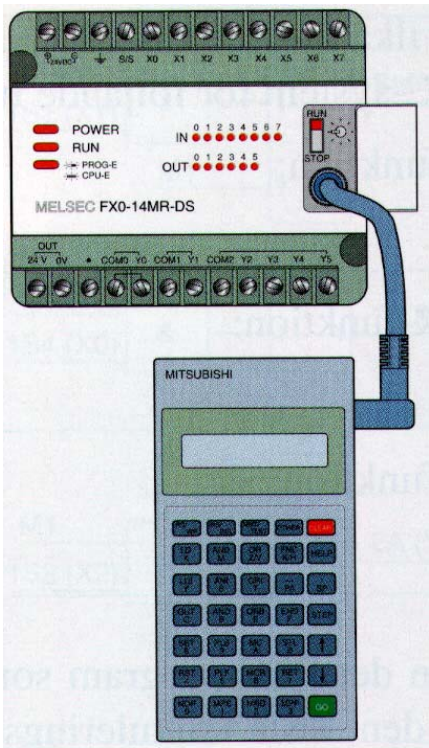
Fault Finding Training

In conjunction with the socket connectors on the PLC-module to which other units or modules can be connected, there are also a number of changeover switches for simulating faults from the different in- and outputs. The most common type of faults found in control equipment are signal faults, i.e. signals from the sensors fail to appear.

On the logic-module it is possible to simulate different faults for in- and outputs, using the DIP switch. In this way training with false indication signals can be completed, without damaging any components. This means that there will be no renewal of components only establishing which component is giving showing a misleading function.

To get more experience, it is always good to train fault- finding using different methods. Ask the teacher to make new faults.

- Mount he simulation-module on the PLC-module.
- Connect the programming unit to the PLC, using a suitable cable.
- Check that the RUN-STOP switch is in the STOP position.
- Connect the base-unit to the mains power supply, 220V.



The programming unit now gives some information. Please wait.

EXAMPLE 1

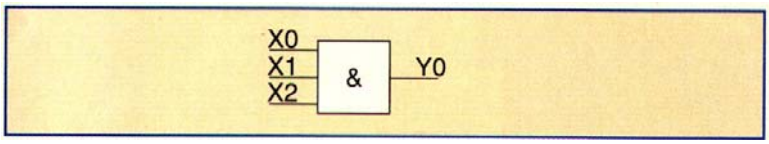
Practice with different PLC instructions. The assignments shall be completed in three stages:

FB Diagram with Function block

LD Ladder Diagram

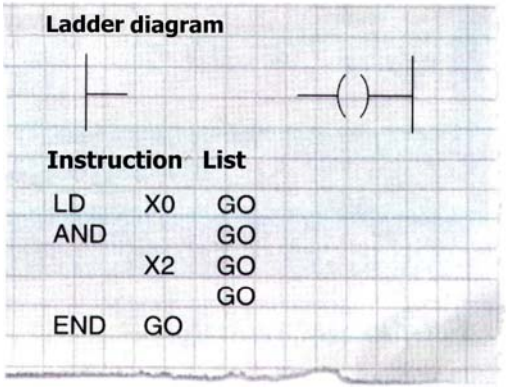
IL Instruction List

47 Complete the Ladder Diagram and Instruction List with the help of the following Function Block:

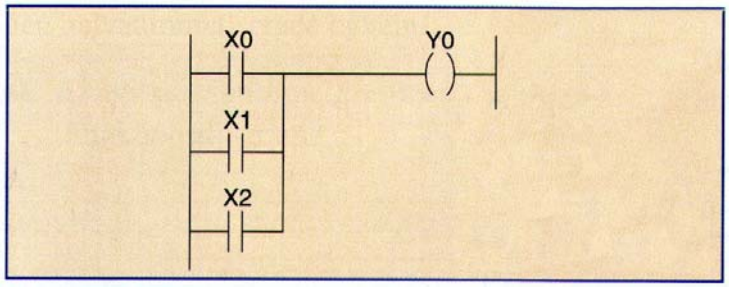


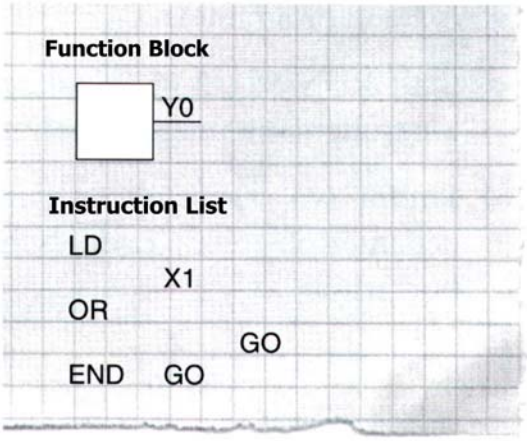
The terms S1, S2 and S3 etc have been used for inputs. These are in line with the terms used for the sensors. In the following programmes X0, X1, X2 etc will be used for the inputs. This is in line with the terms used for the PLC inputs.

- Load the programme.
- Set the RUN/STOP switch to the RUN position. Check the programme by following the indications on the PLC system. Write a truth table.



48 Complete the Function Block diagram and Instruction List using the information from the following Ladder Diagram.



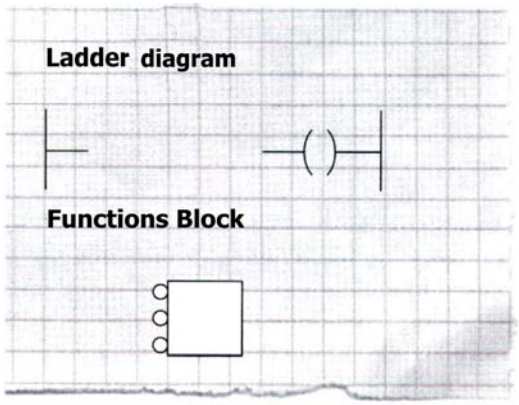


- Load the programme.

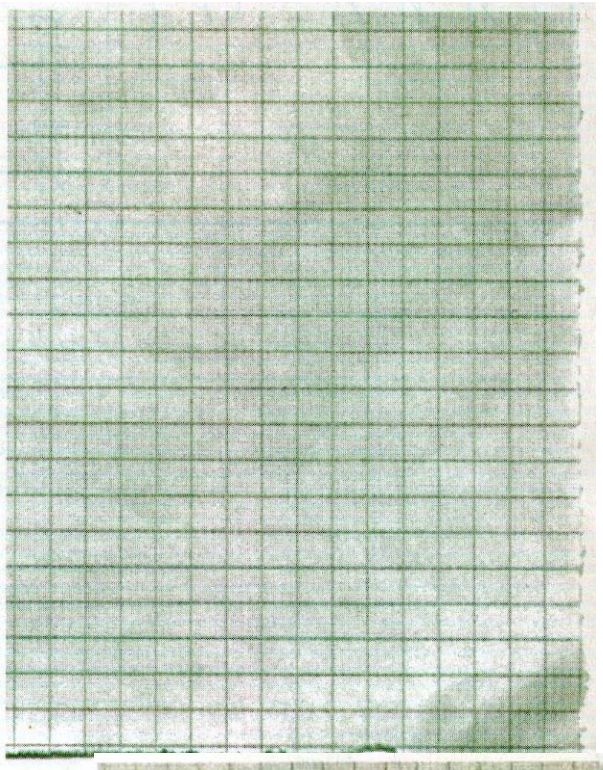
- Set the STOP/RUN switch to the RUN position and check the programme by following the indications on the PLC- system. Write a truth table.

49 Complete the Ladder Diagram and Function Block diagram with information from the following Instruction List:

```
LDI  X0  GO
ANI  X1  GO
ANI  X2  GO
OUT  Y0  GO
END  GO
```



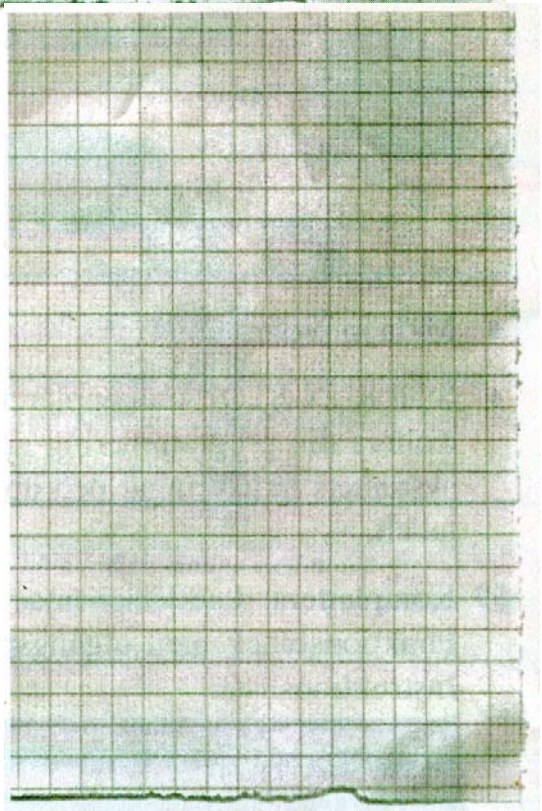
- Load the programme.
- Set the RUN/STOP switch to the RUN position and check the programme by following the indications on the PLC- system. Write a truth table.



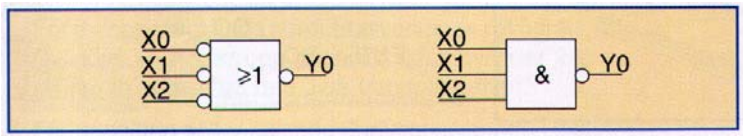
50 Complete the Ladder Diagram and Function Block diagram with information from the following Instruction List.

```
LD   X0  GO
OR   X1  GO
OR   X2  GO
OUT  Y0  GO
LDI  Y0  GO
OUT  Y1  GO
END  GO
```

- Load the programme.
- Set the RUN/STOP switch to the RUN position and check the programme by following the indications on the PLC-system. Write a truth table.



51 Compare the two Function Block diagrams below. Write a Ladder Diagram and Instruction List:



- Load the programme in the PLC – system from the Instruction List.

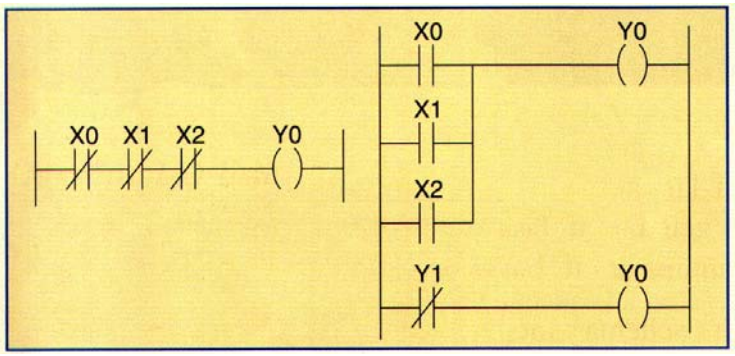
- Set the RUN/STOP switch to the RUN position and check the programme by following the indications on the PLC-system. What can be deducted from a comparison?

……..

……..

……..

52 Compare the two Ladder Diagrams below. What can be deducted from this comparison?



…….

……..

……..

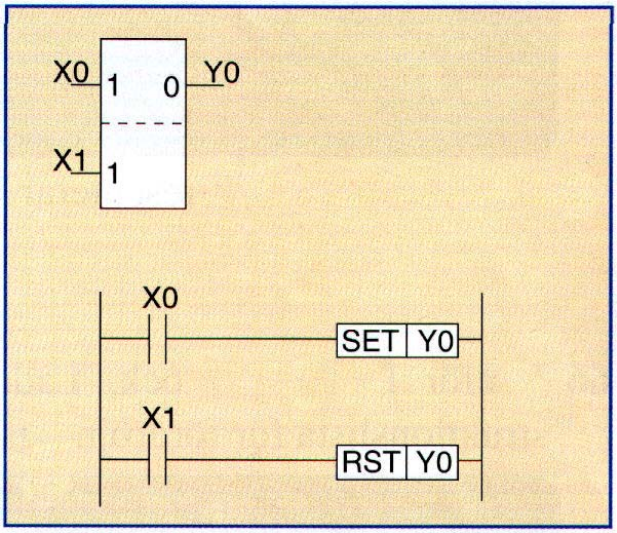
Summary of the Basic Instructions for the PLC-System

Instructions	Description
LD (LoaD)	Start of a branch with normally open contact
LDI (LoaD Inverse)	Start of a branch with normally closed contact
OUT	End of a branch. Transfer of status to the output. Memory cell
AND	Series connection with normally open contact
ANI (ANd Inverse)	Series connection with normally closed contact
OR	Parallel connection with normally open contact
ORI (OR Inverse)	Parallel connection with normally closed contact
END	End of programme

EXAMPLE 2

Programme the instructions for Memory Function, Time Delay and Counter function.

53 Compare the Function Block diagram, Ladder Diagram, and Instruction List with the Memory Function on the right.



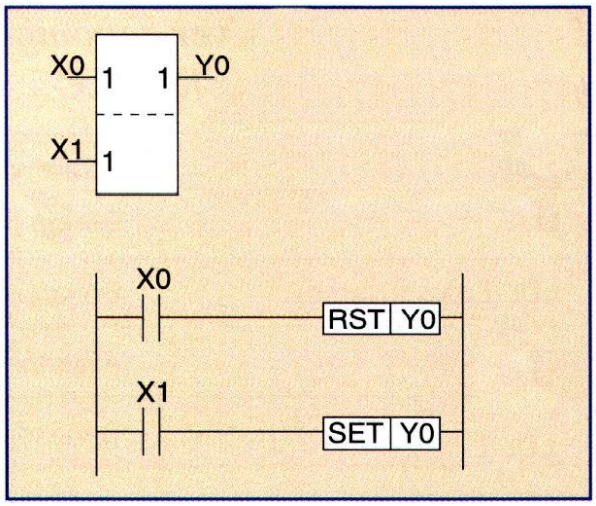

```
LD   X0   GO
SET  Y0   GO
LD   X1   GO
RST  Y0   GO
END  GO
```

- Load the programme with information from the Instruction List and check the function. How did the Memory Function react at the initial position, and when the signal is given for X0, X1 also, X2 and X0 simultaneously? Complete the truth table with the outer logic state.

X0	X1	Y0
0	0	
1	0	
0	1	
1	1	

54 Compare the following Instruction List, Function Block and Ladder Diagram with assignment 63.

```
LD   X0  GO
RST  Y0  GO
LD   X1  GO
SET  Y0  GO
END  GO
```



What is the difference?

…….

…….

55 Load the programme according to the Instruction List.

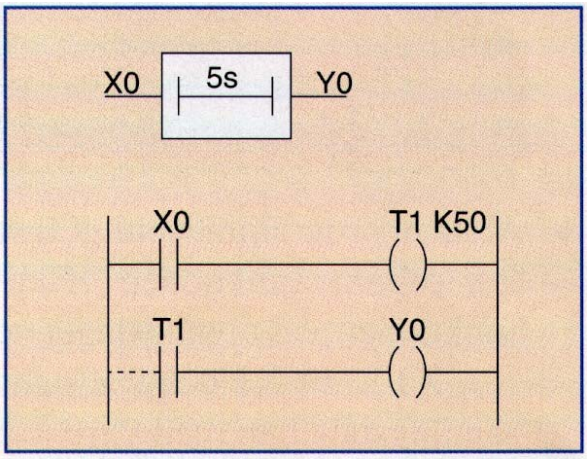
```
LD      X0  GO
OR      Y0  GO
ANI     X1  GO
OUT     Y0  GO
END     GO
```

Which function does the Instruction List represent?

……

56 Compare the Function Block, Ladder Diagram and Instruction List with the Delay Function below.

```
OUT    T1    SP
----   K/H   50  GO
LD     T1    GO
OUT    Y0    GO
END    GO
```



- Load the programme.
- Check the programme by following the indications on the PLC.

a) Is the delay at **switching on** or **switching off**?

…….

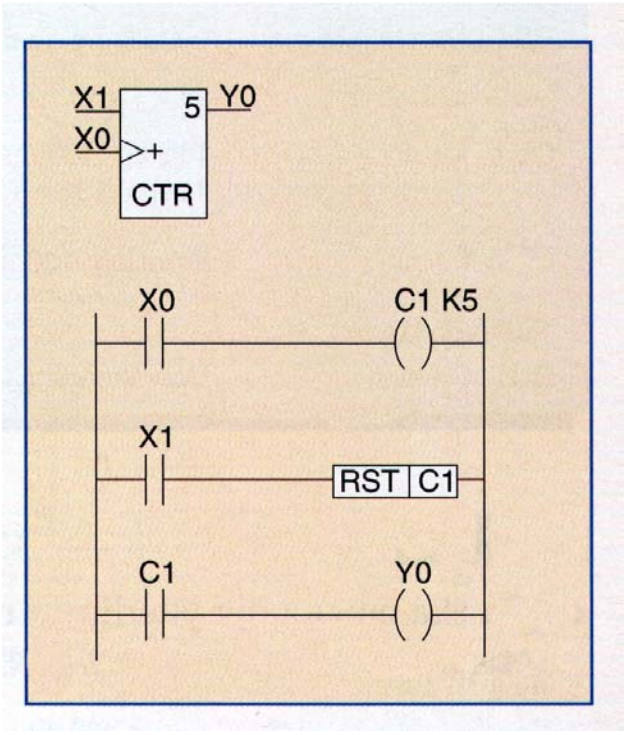
b) How should the Instruction List be changed to set a delay time of 2 seconds?

……

……

……

57 Compare the Function Block diagram, Ladder Diagram and Instruction list with the Counter Function below:




```
LD   X0   GO
OUT  C1   SP
---  K/H  5    GO
LD   X1   GO
RST  C1   GO
LD   C1   GO
OUT  Y0   GO
END  GO
```

- Load the programme.
- Check the programme by following the indications. Reset the counter using X1, then send single pulses from X0 until the counter gives out a 1-signal.

a) How many pulses did it require to give an output signal of 1?

……..

b) How should the Instruction List be changed so that the counter shall count to 14 before 1 output signal is given?

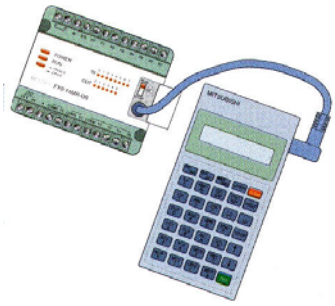
……..

……..

……..

…….

A summary of several base instructions for the PLC



INSTRUCTION	DESCRIPTION
Memory Function SET M + nr	Mo –M511, M8000 – M8255 1-setting of memory cell
RST (reset) M + nr	0-setting of memory cell
Time function OUT T + nr	T0 – T62, Switch on, 100ms T0 – T31
OUT T + nr	Switch off, 100ms T0 –T55
Count function OUT C + nr	Counter, C0 –C31

EXAMPLE 3

- A few more new instructions will now be given. Read the instruction squares for ANB and ORB below.

Instruction ANB

ANB (AND block) is an instruction that is used to connect two blocks in series, see Fig. 3.4. Here there are two blocks that are to be connected in series. One of these has an OR function with X0 and X1 and the second has an OR function with X2 and X3. By using the ANB as the fifth instruction it is possible to connect these two blocks in series, i.e. to make an AND function. Observe that each block must start with the instruction LD.

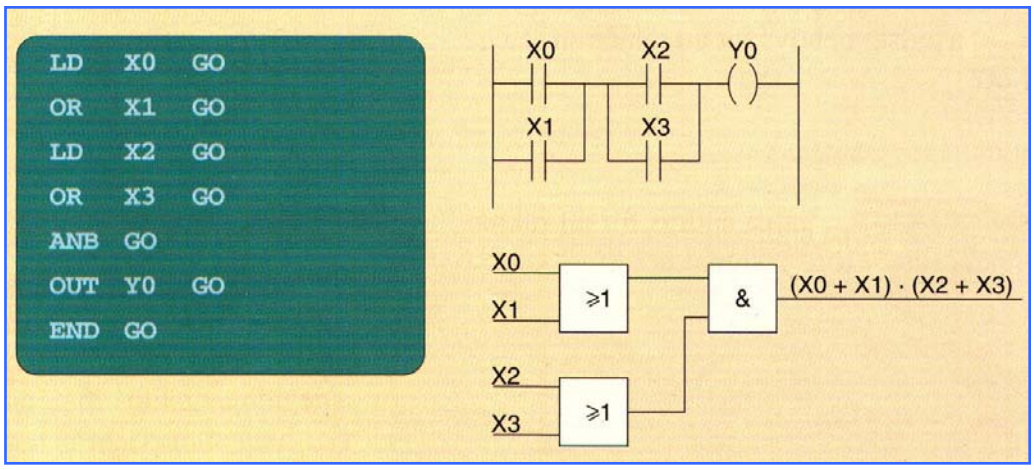


Fig. 3.4 Instruction ANB – joins two blocks together in series.

Instruction ORB

ORB (OR block) is an instruction that is used to connect two blocks in parallel, see Fig. 3.5. Here there are two blocks that are to be connected in Parallel. One of these has an AND function with X1 and X3 and the second has an AND function with X2 and X4. An OR function will be constructed using these two locks. This is achieved by writing ORB as the fifth instruction. The two blocks must be started with LD.

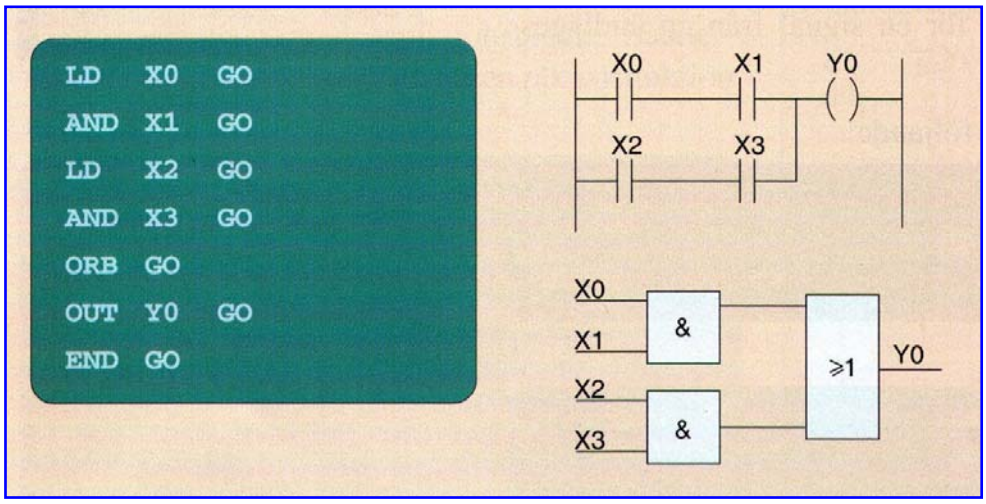


Fig. 3.5 Instruction ORB – joins two blocks in parallel.

Experiments with the PLC- and cylinder modules

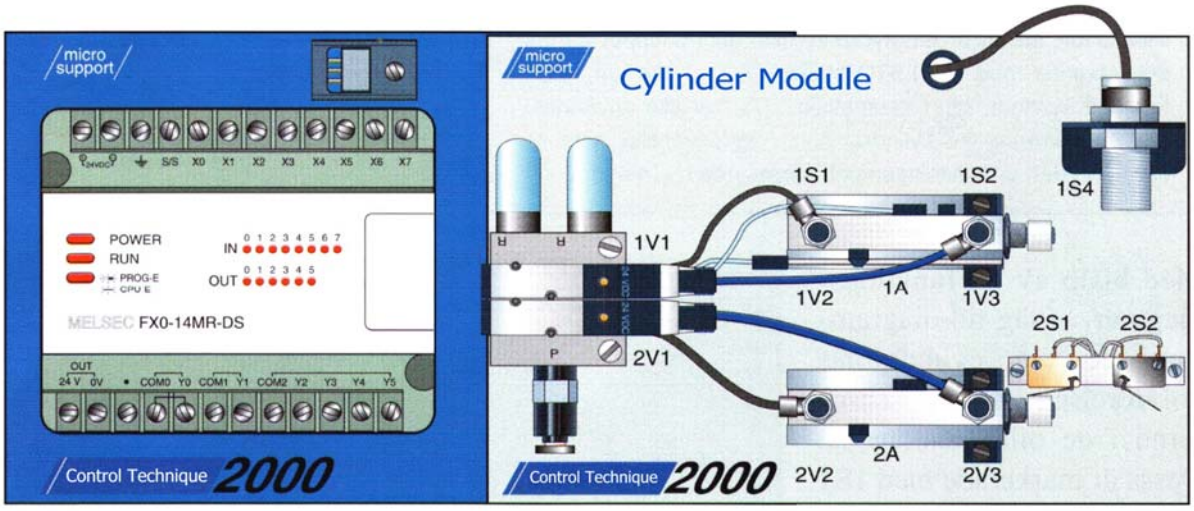


Fig. 3.6 PLC and cylinder modules

- Remove the simulation module and assemble the cylinder module.

- Connect the cylinder module to the compressed air.

Note that the working pressure should be between 0,6 and 0,7 bar.

To connect the cylinder module to the PLC module, the I/O list oposite is valid.

Valve	1V1	Y0
Valve	2V1	Y1
Sensor	1S4	X0
Sensor	1S1	X1
Sensor	1S2	X2
Sensor	2S1	X3
Sensor	2S2	X4

- Check the cylinder's function by activating an end position contact to give an outward movement.

Programme the following:

```
LD   X   004 GO
OUT  Y   000 GO
END  GO
```

Alternatively

```
LD   X   002 GO
OUT  Y   000 GO
END  GO
```

EXAMPLE 4

The following control problem is to be solved:

The work piece is fixed by cylinder 1A. Cylinder 2A then completes a press movement and the cylinders then return to their initial positions. During the return movement a new work piece is placed in the fixture. The process starts and stops with the RUN/STOP switch and should be continuous. Pneumatic cylinders will be used. To control the cylinders, valves are used. These are electrically controlled in one direction and pressure controlled in the other.

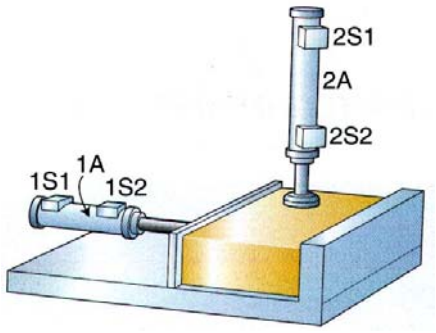


Fig. 3.7a Fixing and machining a work piece

With the help of a function diagram (path-time-diagram), draw the two cylinders piston movement, also the sensors in the different end positions. These are marked 1S1 and 1S2 for cylinder 1A and 2S1 and 2S2 for cylinder 2A.

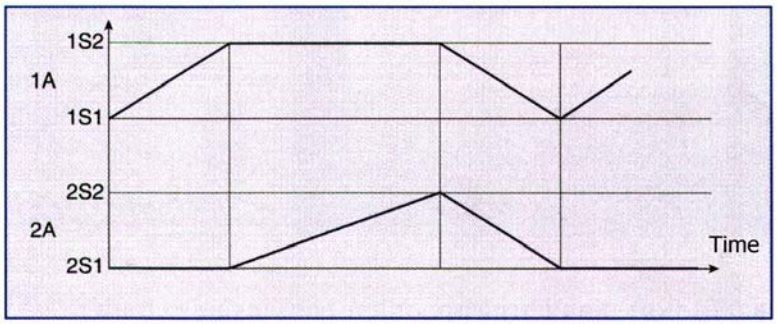


Fig. 3.7b Function diagram

Create an I/O list

For this assignment the following information applies:

I/O	Title	Comments
X1	1S1	Cylinder 1A back position Start clamping
X2	1S2	Cylinder 1A forward position Start to press together with X3
X3	2S1	Cylinder 2A back position Start to press together with X2
X4	2S2	Cylinder 2A forward position Start return movement and forward feeding of new material
Y0	1A	Cylinder 1A outward movement
Y1	2A	Cylinder 2A outward movement

Describe the sequence

It can be seen in the Function Diagram, that 1S1 starts an outward movement for cylinder 1A. When the plus position has been reached, 1S2 is activated, which, in turn starts an outward movement for 2A at a slower speed.

When 2A reaches the forward position, 2S2 activates both of the cylinders to an inward movement. This is summarised in the table below. The table also shows which PLC- ports are used

1S1 (X1)	Start	cylinder 1A (Y0)	Outward movement
IS2 (X2)	Start	cylinder 2A (Y1)	Outward movement
2S1 (X3)			
2S2 (X4)	Start	cylinder 1A and 2A	Inward movement

Select a specific status

A memory function is used to activate (SET) during the time that the cylinder does a plus movement or stays at the minus position.

With two cylinders two memory functions are required. Memory cells M1 and M2 that are built into the PLC-system are used.

M1	Memory cell for cylinder 1A
M2	Memory cell for cylinder 2A

Create a diagram with Function Blocks

Draw the two memory functions M1 and M2, along with their in-and outputs. To the different function blocks signals are given on the PLC system.

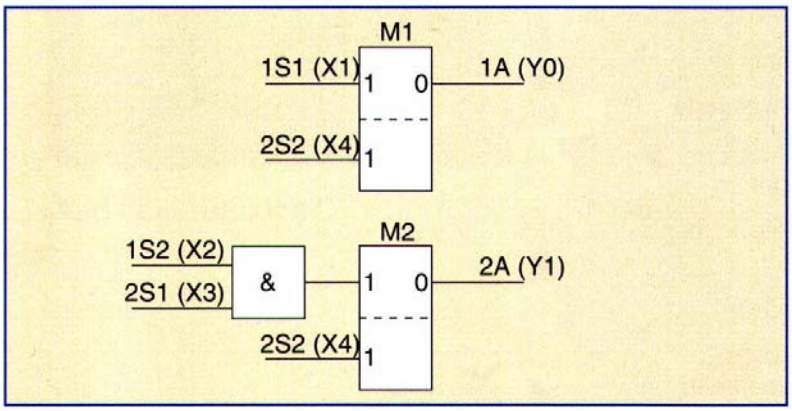


Fig. 3.7 Diagram of function blocks.

Create a Ladder Diagram

Programming of a branch must always begin with the instruction LD or LDI. The ladder diagram will include the control of the two memory functions and also signals from the memory that will control the output ports Y0 and Y1.

In order that M2 knows its position in the cycle an AND- function with X2 and X3 for SET M2 is used.

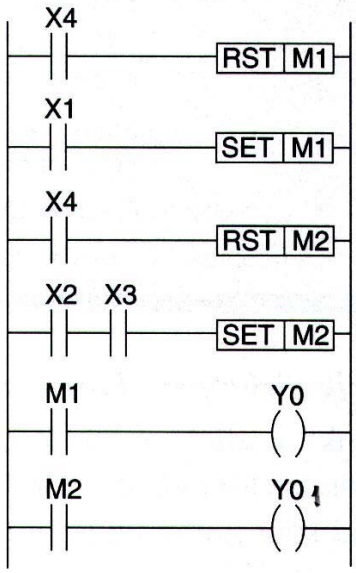


Fig. 3.7d The Ladder diagram

Set up an Instruction List

With the help of the Instruction list, the program that will be loaded to the programming-unit can be set up.

Loading the programme into the PLC

Set the RUN/STOP switch to the STOP position. Load the programme into the PLC via the programming unit.

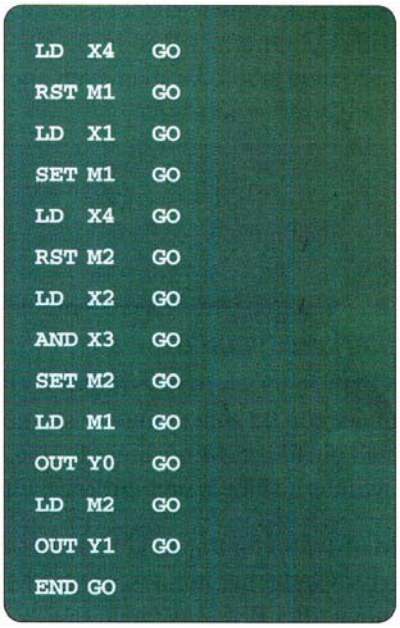
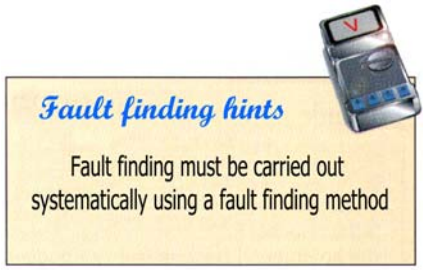


Fig. 3.7e Instructions List

Connection and test

Set the RUN/STOP switch to the START position and start the programmed cycle. Check the function of the semi-automatic cycle.



58 a) What type of information can be taken from a Function Diagram?

……

……

……

b) What type of information does a diagram with function block give?

……

……

……

c) What type of information can be taken from a Ladder diagram?

……

……

……

c) What task has the AND- function in the program? Check by changing the programme so that only X2 sets M2.

59 What is the AND-function's task in the programme?

……

……

……

EXAMPLE 5

The following task shall be completed.

Goods will be moved between two conveyor belts as shown in Fig. 3.8a. The goods arrive on belt 1 and, on reaching the end, are lifted up and pushed on to belt 2.

To complete this process, two double action cylinders are used. Cylinder 1A lifts up the goods and cylinder 2A pushes the goods on to conveyor belt 2.

The following Function diagram applies for this task. See Fig. 3.8b. Observe the cylinders piston movement and that 2A returns immediately after reaching the forward position while 1A returns after a 1 second delay after reaching the back end position. The cycle starts with sensor 1S4.

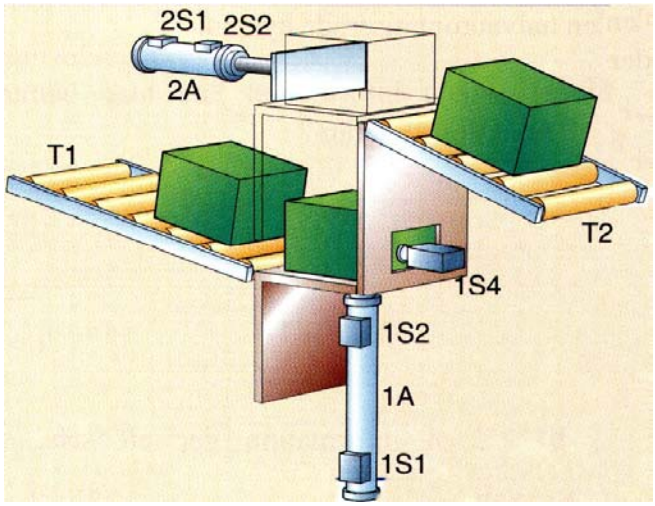


Fig. 3.8a The lifting device between two conveyors.

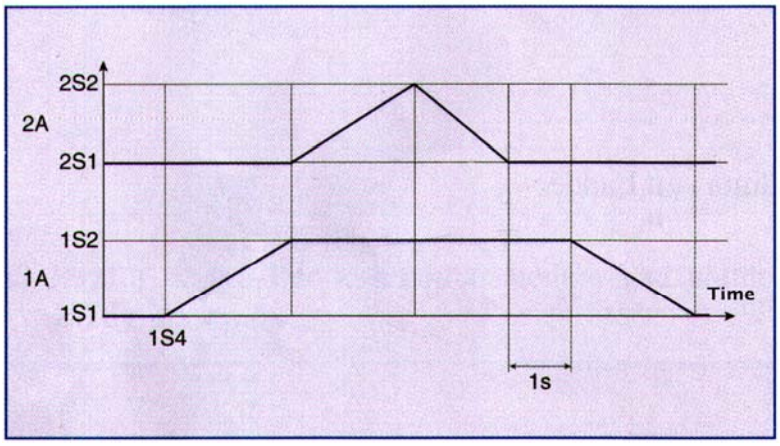
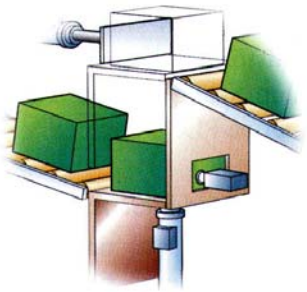


Fig. 3.8b Function Diagram.

Create an I/O List

I/O	Title	Comments
X0	1S4	Is activated by the box and starts the cycle with an outward movement for cylinder 1A
X1	1S2	Starts the outward movment for cylinder 2A
X4	2S2	Starts the inward movement for cylinder 2A and inward movement for cylinder 1A after a time delay of 1 second, after 2A has reached the back end position.
Y0	1A	Cylinder 1A outward movement
Y1	2A	Cylinder 2A outward movement

Describe the Process



The Function diagram shows that when the sensor 1S4 is in an AND function together with sensor 1S1, an outward movement of cylinder 1A, starts. (Note! To start this movement of the cylinder module, a metal object must be used to activate the inductive sensor).

When the plus position has been reached, sensor S2 is activated and starts a plus movement of cylinder 2A.

When cylinder 2A reaches the plus position, a minus movement starts for cylinder 2A, and after a time delay, also for cylinder 1A.

These two then stop in this position until a new box is placed on the conveyor belt T1. The box activates the start sensor 1S4 on the elevator plan. The table below gives a summary for this sequence along with the PLC ports.

1S4 (XO)	
AND 1S1 (X1)	**Starts cylinder 1A (Y0) outward movement**
1S2 (X2)	**Starts cylinder 2A (Y1) outward movement**
2S2 (X4)	**Starts cylinder 2A inward movement and after a time delay cylinder 1A inward movement**

Select specific states

To start up the installation a memory function that remembers that the start signal has been given is chosen. Memory cell M0 is selected.
To control the out- and inward movements a second memory is necessary. With two cylinders, two memory cells are needed. M1 and M2 are selected.
To remember that the time function must be activated, a fourth memory is required. M3 is selected.
Four memory cells will be used as follows:

MO	**Memory cell for start**
M1	**Memory cell for cylinder 1A**
M2	**Memory cell for cylinder 2A**
M3	**Memory cell for time delay**

In addition an initiating pulse from M8002 (internal memory in the PLC), is used.

Create a diagram with function blocks

Fig. 3.8 shows the drawing of the function blocks with the four memory functions, M0, M1, M2, and M3. The delay function T0 with in- an outputs is also shown. The signals are given as code titles and port numbers in the PLC system.

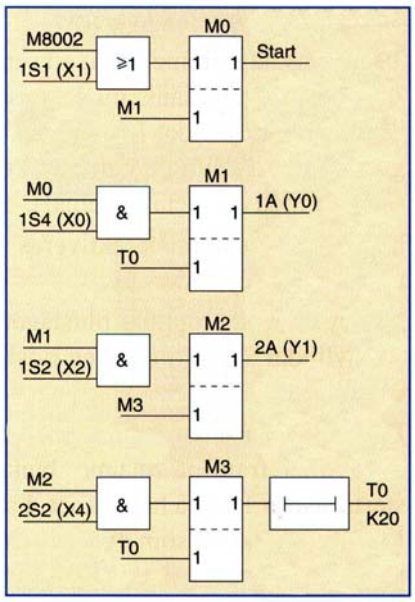


Fig. 3.8c Diagram of function blocks

Create a Ladder Diagram

The Ladder Diagram will include the control of the four memory cells, time delay and the signals that will control the output ports, Y0 and Y1.

60 Complete the Ladder Diagram with the missing information.

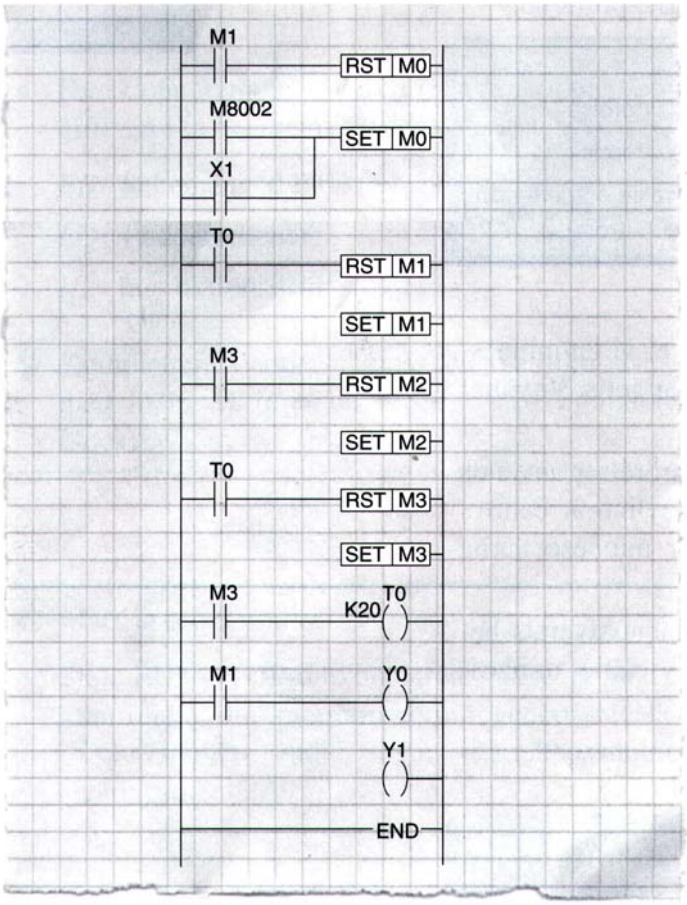


Fig. 3.8d Ladder Diagram

Create an Instruction List

The instructions list to the right can be used for programming.

61 Complete the Instruction List with the missing instructions.

Load the programme into the PLC

Check that the START/RUN switch is in the RUN position. Load the programme to the PLC via the programming unit.

Connection and Test

Set the START/RUN switch to RUN and start the programme cycle. To start, the inductive sensor for cylinder 1A, at the forward end position, must be activated by the presence of a metal object

Check that the function follows the cycle plan.

62 When the RUN/STOP switch is set to the RUN position, the memory cell M0 is activated by M8002. The cycle then starts when 1S4 is activated. M8002 is part of an OR function together with 1S1.
What happens if the other branch in the OR-function is removed?

……

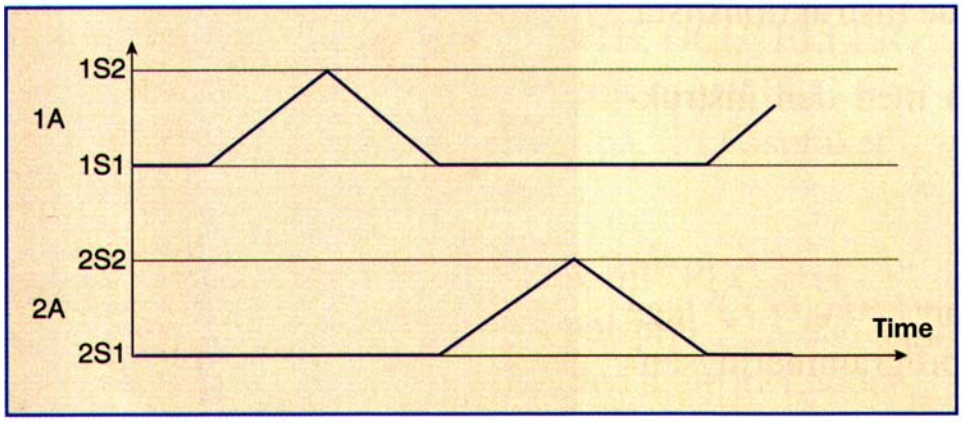
……

……

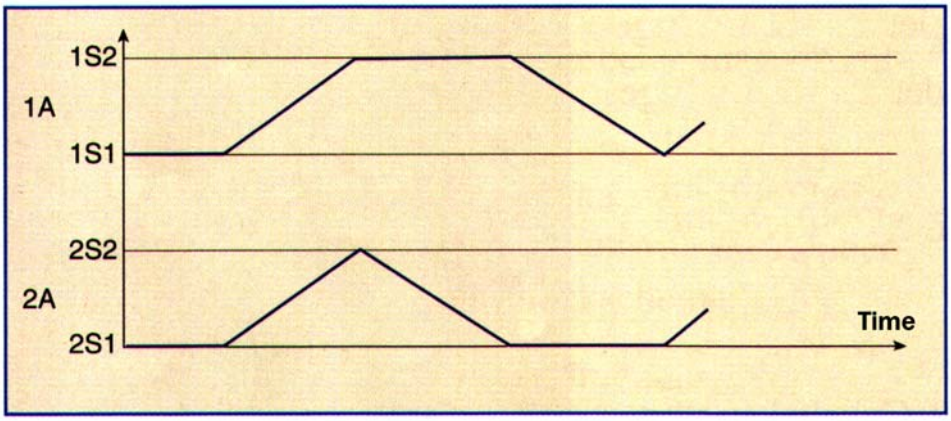
LD	M1	GO
RST	M0	GO
LD	M8002	GO
OR	X1	GO
SET	M0	GO
LD	T0	GO
RST	M1	GO
LD	_____	GO
AND	_____	GO
SET	M1	GO
LD	M3	GO
LD	_____	GO
AND	_____	GO
SET	M2	GO
LD	T0	GO
RST	M3	GO
LD	_____	GO
AND	_____	GO
SET	M3	GO
LD	M3	GO
OUT	T0	K20 GO
LD	M1	GO
OUT	Y0	GO
LD	_____	GO
OUT	Y1	GO
END	GO	

Fig. 3.8e The Instruction List

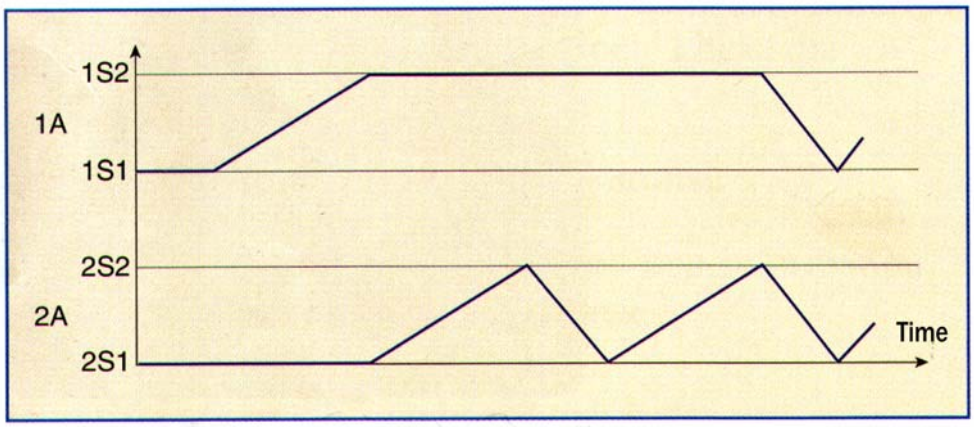
63 Write a programme for the following automation assignment.



64 Write a programme for the following automation assignment



65 Write a programme for the following automation assignment.



Summary

The PLC system is the central component in automation. It has the main responsibility to control and check that the machines and processes operate safely and effectively.
The PLC system manages its control system by means of:

- The PLC programme that been loaded. This describes the logical rules and regulations that the PLC must adhere to.

- The state of each respective sensor.

The PLC programme determines which outputs shall be ON or OFF. The task for the programmer is to design a programme that is safe and effective.

To “talk” to the PLC a symbol language is used. The most common are the Ladder Diagram and Function Block diagram.

With the help of six different functions, most of the machine control problems can be solved. The functions are:

- **AND**
- **OR**
- **NOT**
- **Memory**
- **Delay**
- **Counter**

To make the programme more effective, some additional functions may be necessary.

- LD, is that used at the start of a normally open contact in one branch.

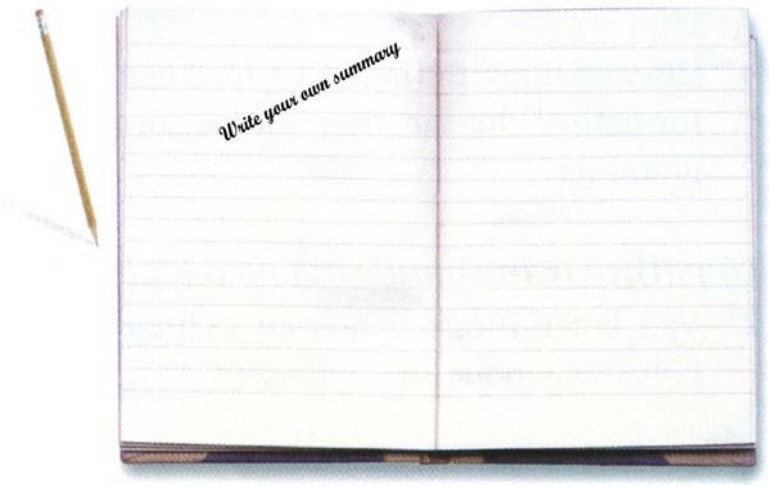
- LDI, is that used at the start of a normally closed contact in one branch.

- ANB, is that used when connecting in series in a block.

- ORB, is that used when connecting in parallel in a block.

- OUT, is that used when ending a branch.

- END, is that used when ending a programme.



TRAFFIC LIGHTS and PEDESTRIAN CROSSING

EXPERIMENT 4

This experiment is designed to teach the student how to build up a PLC- programme. With the PLC module, different functions for traffic lights and pedestrian crossing shall be programmed.

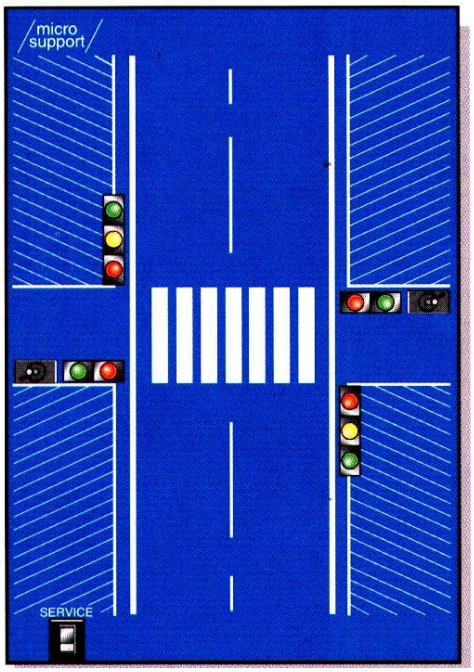


Fig. 4.1 Traffic Module

EQUIPMENT
Base-unit 2000
PLC module
Programming unit
Traffic module

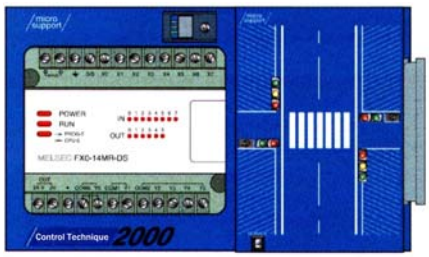
- Take up the traffic light module and study its construction. It can be seen that for pedestrians there are green and red signals and for vehicles green, yellow and red signals.

At the start point the crossing has a red signal for pedestrians and a green signal for vehicles.

The crossing shall give preference for the pedestrians and stop the traffic from crossing, by changing from green to red. The lights can also change from green to green & yellow to yellow & red to red.

The order of changing is dependent on the programme in the PLC that is part of the control system.

Experiments with the Traffic Module



- Mount the PLC-module on the base-unit.
- Press the traffic module into the PLC's contacts.

With the traffic module connected to the PLC- module the following I/O list applies:

I/O	*Title*	*Comments*
X0	Furthest button	Push button for furthest pedestrians
X1	Nearest button	Push button for nearest pedestrians
X2	Service contact	Push button for service
Y0	Red car	Red light for cars
Y1	Yellow car	Yellow light for cars
Y2	Green car	Green light for cars
Y3	Red foot	Red light for pedestrians
Y4	Green foot	Green light for pedestrians

Traffic Lights Signal Changing

EXAMPLE 1

When activating one of the optional push buttons for pedestrians, the vehicle traffic lights will change as follows:

- The green light is switched off after 2 seconds
- The yellow light is switched on for 4 seconds
- The red light is switched on and is lit for 15 seconds, after which the red light changes to green

Create an I/O list

The following input signals shall be connected to the PLC.

- Push button for pedestrians at the furthest side of the street
- Push button for pedestrians at the nearest side of the street
- Service contact in the left corner of the traffic module

The following output signals shall be connected to the PLC

- Green light for vehicles
- Yellow light for vehicles
- Red light for vehicles

The following I/O list applies for the different in- and output signals:

I/O	*Title*	*Comments*
X0	Furthest button pedestrians	Push button for furthest
X1	Nearest button pedestrians	Push button for nearest
X2	Service contact	Push button for service
Y0	Red car	Red light for cars
Y1	Yellow car	Yellow light for cars
Y2	Green car	Green light for cars

Description

First we must explain the conditions that apply for each output. In this assignment there are three outputs.

Y0 The green light shall be ON or OFF, 2 second after the changing signal has been given.

Y1 The yellow light shall be switched ON when the green light is switched OFF and be lit for 4 Seconds.

Y2 The red light shall be switched ON when the yellow light is switched OFF. The red light shall be lit for 15 seconds.

Seek specific states

For each state, a memory function is used. This memory function will be started by a certain conditions and stopped by the next state. The following memory cells will be used in the PLC:

MO The green light shall be ON.

M1 The green light shall be switched OFF 2 seconds after one of the push buttons for the pedestrian crossing, has been pushed.

M2 The yellow light shall be switched ON when the green light is switched OFF. The yellow light shall be lit for 4 seconds.

M3 The red light shall be switched ON when the yellow light is switched OFF. The red light shall be lit for 15 seconds, after which the green light shall be switched ON.

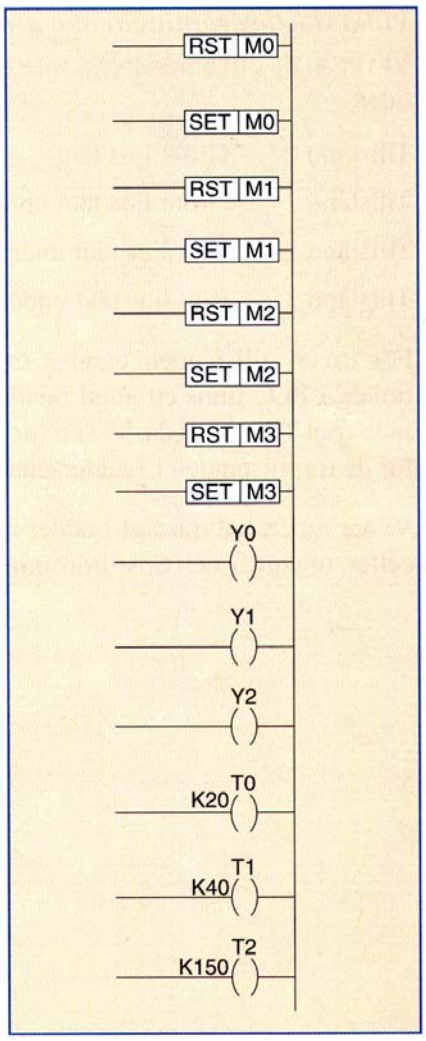
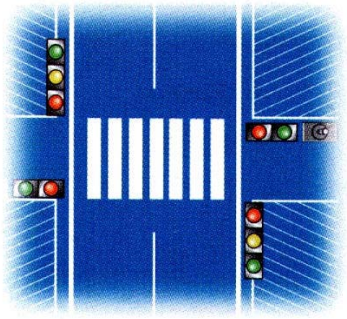


Fig. 4.4 Part of the Ladder diagram with four memory cells. (M0, M1, M2, M3) three outputs (Y0, Y1, Y2) also three time delays (T0, T1, T2)

Draw the four memory cells M0, M1, M2 and M3 in the Ladder diagram (see Fig. 4.4) Start with RST M0 and SET M0 etc. All contacts that activate the memory cells shall be left out until later.

Which outputs will be affected?

From the following I/O list it is possible to see which outputs will be affected.



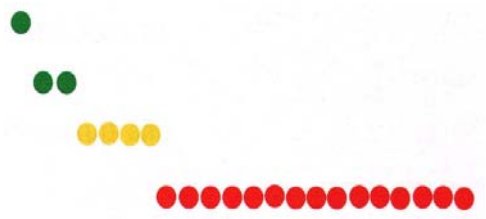
Y2	Green light	Green light for vehicles
Y1	Yellow car	Yellow light for vehicle
Y0	Red car	Red light for vehicles

Write in the three outputs in the Ladder diagram, as shown in Fig. 4.4.

What time delay will be used?

The lights will be ON during the following times:

State 0	Green light ON
State 1	Green light lit for 2 seconds
State 2	Yellow light lit for 4 seconds
State 3	Red light lit for 15 seconds



For these three states it is necessary to have three time delay functions. The PLC system has a number of time delays numbered from T0. Write in the time delays for the three states in the Ladder drawing.

The Ladder drawing is now half finished with memory cells, outputs, and time delays as shown in Fig. 4.4.

Draw the contacts in the Ladder Diagram

The Ladder diagram shall now be completed with all the contacts that shall set and reset the memory cells, start the time delays and activate the outputs.
Complete with the following information:
See Fig. 4.5. Compare with the Ladder diagram.

Green light

The memory cell M0 is set off by M3 AND time delay T2 OR M8002 which is the initiating pulse.

M0 shall switch ON the green light and is reset by M1.

Green light 2 seconds delay

M1 is set off by M0 AND an OR- function with X0 and X1.

M1 shall hold the green light lit for 4 seconds and is reset by M3.

Yellow light 4 seconds delay

M2 is set off by M1 AND T0. M2 shall hold the yellow light lit for 4 seconds and is reset by M3.

Red light 15 seconds delay

M3 is set off by M2 and T1. M3 shall hold the red light lit for 15 seconds and is reset by M0.

T0 resets M2, RST, M2, and switches OFF the red light and also resets M0, SET M0, which switches the green light ON.

Start and Stop

Each push on X0 or X1 will give a signal change from green – red – green. From then on a further change requires an additional push.

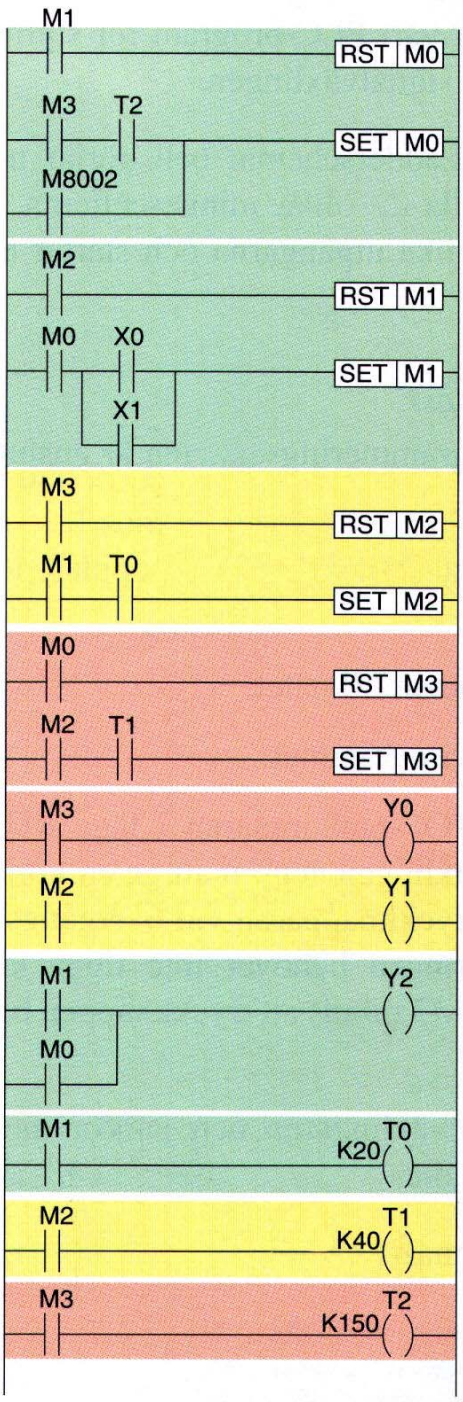


Fig. 4.5 Ladder diagram for signal changing of traffic lights.

Create an Instruction List

Using the Ladder diagram as a base, write an Instruction List that will be the PLC programme for control of the continuously changing signals.

The list is written from the Ladder diagram and starts by resetting and setting the different memory cells. The memory cells then set the various outputs, and starts the time delays.

Connection and Test

- Check that the programming unit is connected to the PLC module.
- Check that the RUN/STOP switch is in the STOP position.
- Connect the base-unit to the mains supply.
- Write in the PLC- programme.
- Set the RUN/STOP switch to the RUN position. By giving a short pulse from one of the push buttons for the pedestrians, the signal change can start.
  Note that it is only necessary to push the button once and then release it; the memory cell remembers that it has been activated.

  Study the signal changes and compare with the programme times.

66 How is the signal changing started?

……..

……..

67 Describe how the signals change.

……

……..

……..

……

……

```
LD   M1     GO
RST  M0     GO
LD   M3     GO
AND  T2     GO
LD   M8002  GO
ORB  GO
SET  M0     GO
LD   M2     GO
RST  M1     GO
LD   M0     GO
LD   X0     GO
OR   X1     GO
ANB  GO
SET  M1     GO
LD   M3     GO
RST  M2     GO
LD   M1     GO
AND  T0     GO
SET  M2     GO
LD   M0     GO
RST  M3     GO
LD   M2     GO
AND  T1     GO
SET  M3     GO
LD   M3     GO
OUT  Y0     GO
LD   M2     GO
OUT  Y1     GO
LD   M1     GO
OR   M0     GO
OUT  Y2     GO
LD   M1     GO
OUT  T0     SP
---  K/H    20     GO
LD   M2     GO
OUT  T1     SP
---  K/H    40     GO
LD   M3     GO
OUT  T2     SP
---  K/H    150    GO
END  GO
```

Fig. 4.6 Instruction List for signal changing of traffic lights.

68 The start conditions for the signal changing shall be extended so that the changes can also be started from the service button. How can this modification be completed?

……..

……..

69 Make the changes to the programme by setting all the time delays to 1 second. Check your suggestion. Note that all changes shall be written with the RUN/STOP switch in the STOP position.

What actions are necessary to change the programme?

……..

……..

……..

……..

……..

Insertion of additional instructions

- Set the RUN/STOP switch to the STOP position. Press button RD/WR so that R is shown in the left corner of the display.
- Search for the programmed OR- function on the display of the programming unit by pressing on one of the arrows. Set the marker on the row that follows OR X001. The marker now shows SET M3, i.e. the row where the new instruction shall come in.
- Press once on INS/DEL- button. In the displays left corner the letter “I” (insert) will appear.
- Write in the new instruction OR X2 GO. When GO is pressed, the instruction above is moved and the following instruction comes forward.
- Check the instruction by testing the programme in the RUN position.

Delete part of an instruction

- Set the RUN/STOP switch to the STOP position. Press button RD/WR.
- Search for the programmed OR- function on the display of the programming unit by pressing on one of the arrows. Set the marker on the row that is to be deleted.
- Press the INS/DEL- button twice. In the displays left corner the letter “D” (delete) will appear.
- Press button GO and the marked row will be deleted.
- Check the instruction by testing the programme in the RUN position.

By using the examples below it is possible to continue training with programming of traffic lights. These complimentary instructions for inserting and deleting instructions make it easy to alter a programme.

70 EXAMPLE 2

After activating one of the optional buttons for pedestrians, the go signal shall, after 5 seconds, change from red to green. The green signal shall remain lit for 10 seconds, after which it will return to red.

71 EXAMPLE 3

By activating the service contact, the vehicle signal shall change from green to red. After 10 seconds the signal shall change back to green

72 EXAMPLE 4

By activating the service contact, the vehicle signal shall, after 5 seconds change from green – yellow – red. After 10 seconds the signal shall change back to red – yellow – green.

73 EXAMPLE 5

After activating the signal for vehicles, the light changes from green – yellow – red, then the pedestrian signal changes from green to red. The changes shall take 5 seconds and after 10 seconds the signal shall change back to the initial position.

74 EXAMPLE 6

By activating the service contact the yellow vehicle light and the green pedestrian light shall blink for 10 seconds.

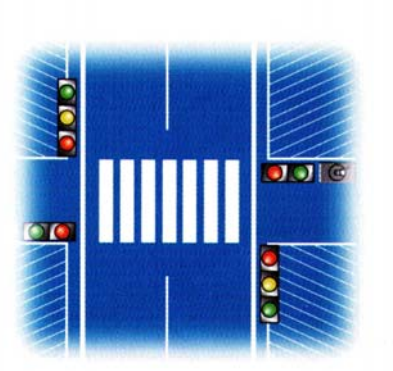
75 EXAMPLE 7

By activating the service contact the signals for vehicles shall change from green to blinking yellow for 5 seconds then to red. After a further 10 seconds they shall change back to the initial position.

76 EXAMPLE 8

After activating, the vehicle signals shall change from green to blinking yellow for 5 seconds, followed by the pedestrian signal change from red to green. After a further 10 seconds the signal shall change back to the initial position.

Programming a pedestrian crossing



A complete programme for a pedestrian crossing shall now be loaded into the PLC. Check the programme with the traffic module connected. For information use the I/O list, ladder diagram and also the ready written PLC programme. Your teacher can issue an alternative programme.

Your work plan should be as follows:

- Study the written material
  I/O list
  Ladder diagram
  Instruction list
- Load the programme into the PLC.
- Start up
- Test the programme
- Present your programme to your teacher.

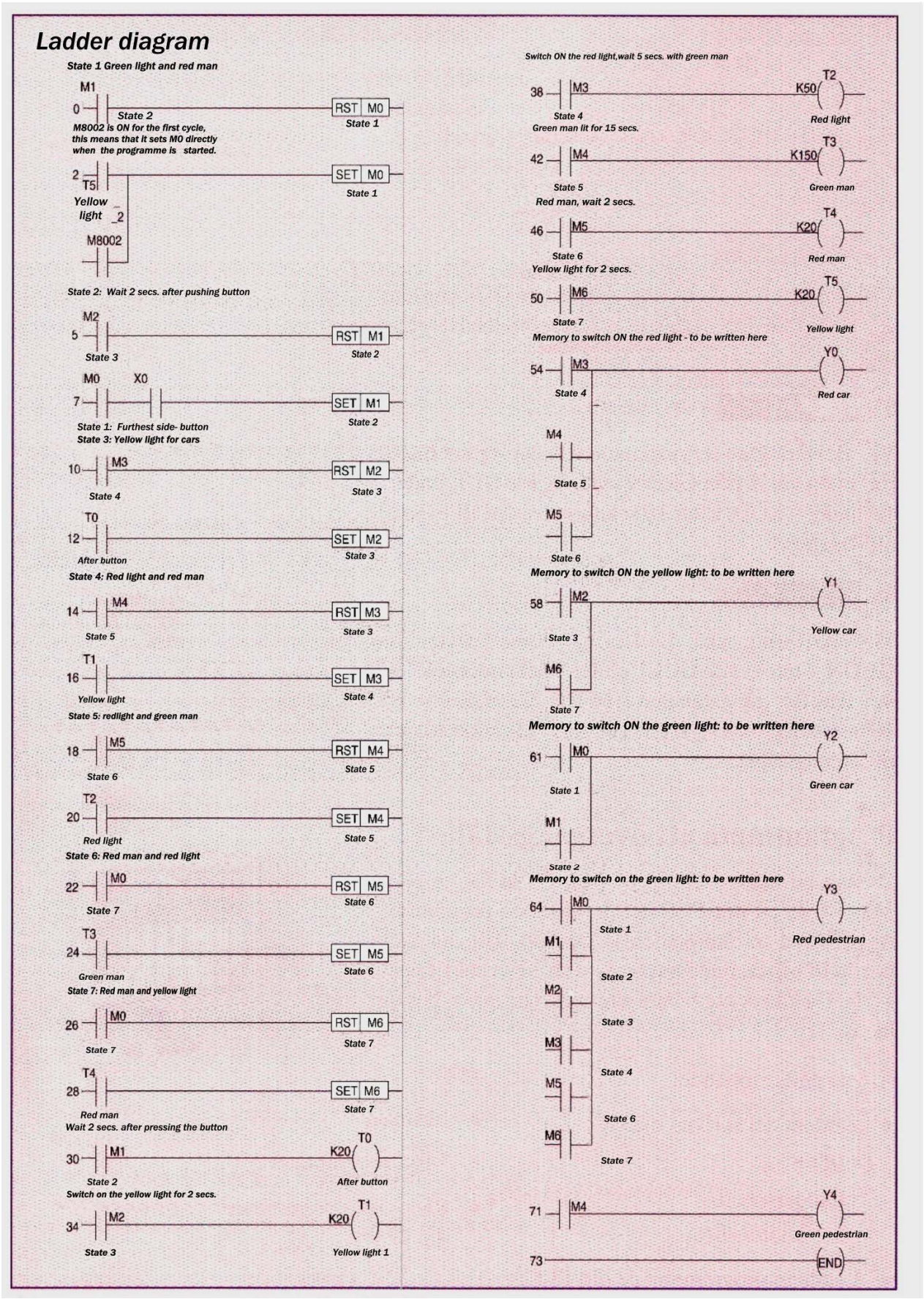


Fig. 4.7 Ladder diagram – Programming of pedestrian crossing

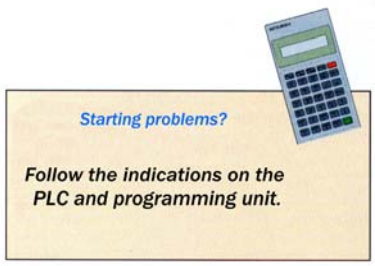
```
        State 1: Green light and red man

0   LD      M1      STATE  2
1   RST     M0      STATE 1
    M8002 is ON for the first cycle, this means that
    M0 starts directly programme is started.
2   LD      T5      YELLOW LIGHT 2
3   OR      M8002
4   SET     M0      STATE 1

        State 2: Wait 5 secs. after button is pressed
5   LD      M0      STATE 3
6   RST     M1      STATE 2
7   LD      M0      STATE 1
8   AND     X0      FURTHEST SIDE BUTTON
9   SET     M1      STATE 3

        State 3: Yellow light for cars

10  LD      M4      STATE 4
11  RST     M2      STATE 3
12  LD      T0      AFTER BUTTON
13  SET     M2      STATE 3

        State 4: Red light and red man

14  LD      M4      STATE 5
15  RST     M3      STATE 4
16  LD      T1      YELLOW LIGHT 1
17  SET     M3      STATE 4

        State 5: Red light and green man

18  LD      M5      STATE 6
19  RST     M4      STATE 5
20  LD      T2      RED LIGHT
21  SET     M4      STATE 5

        State 6: Red man and red light

22  LD      M6      STATE 7
23  RST     M5      STATE 6
24  LD      T3      GREEN MAN
25  SET     M3      STATE 6

        State 7: Red man and yellow light

26  LD      M0      STATE 1
27  RST     M6      STATE 7
28  LD      T4      RED MAN
29  SET     M6

        Wait 2 secs. after pushing button
30  LD      M2      STATE 2
31  OUT     T0      AFTER BUTTON
                K20

        Yellow light to be lit 2 secs.
34  LD      M2      STATE 3                 State 3
35  OUT     T1      YELLOW LIGHT 1          Green light lit
                K20

        Switch ON the red light, wait 5 secs. with green man

38  LD      M3      STATE  4
39  OUT     T2      RED LIGHT
                K50

        Green man shall be lit 15 secs.
42  LD      M4      STATE 5
43  OUT     T3      GREEN MAN

        Red man, wait 2 secs.
46  LD      M5      STATE 6
47  OUT     T4      RED MAN
                K20

        Yellow light for 2 secs.

50  LD      M6      STATE 7
51  OUT     T5      YELLOW LIGHT 2

        Memory to switch ON the red light: to be written here
54  LD      M3      STATE 4
55  OR      M4      STATE 5
56  OR      M5      STATE 6
57  OUT     Y0      RED CAR

        Memory to switch ON the yellow light: write here

58  LD      M2      STATE 3
59  OR      M6      STATE 7
60  OUT     Y1      YELLOW CAR

        Memory to switch ON the green light: write here

61  LD      M0      STATE 1
62  OR      M1      STATE 2
63  OUT     Y2      GREEN CAR

        Memory to switch ON the red man: to be written here

64  LD      M0      STATE 1
65  OR      M1      STATE 2
66  OR      M2      STATE 3
67  OR      M3      STATE 4
68  OR      M5      STATE 6
69  OR      M6      STATE 7
70  OUT     Y3      RED PEDESTRIAN

        Memory to switch ON the green man: write here

71  LD      M4      STATE 5
72  OUT     Y4      GREEN PEDESTRIAN
73  END
```

Fig. 4.8 The PLC instruction programme for pedestrian crossing.

I/O List

For the following assignments, the list below, of inputs, outputs, memory cells and time delays, can be used.

I/O	Title	Comments
X0	Furthest side button .	Push button for pedestrians on the furthest side
X1	Nearest side button .	Push button for pedestrians on the nearest side
X2	Service button	Button for service
Y0	Red car	Red light for vehicles
Y1	Yellow car	Yellow light for vehicle
Y2	Green car	Green light for vehicles
Y3	Red pedestrian	Red light for pedestrians
Y4	Green pedestrian	Green light for pedestrians
M0	State 1	Green light and red man
M1	State 2	Wait 2 secs. after pressing button
M2	State 3	Yellow light for vehicles
M3	State 4	Red light and red man
M4	State 5	Red light and green man
M5	State 6	Red man and red light
M6	State 7	Red man and yellow light
T0	After button	Wait after pressing button
T1	Yellow light 1	Yellow light lit during this period
T2	Red light	Red light lit during this period
T3	Green man	Green man lit during this period
T4	Red man	Red man lit during this period
T5	Yellow light 2	Yellow light lit during this period



Summary

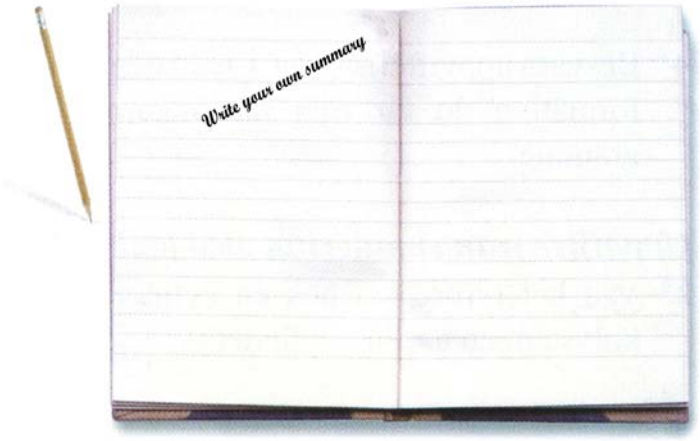
The control of traffic lights at a pedestrian crossing requires many branches when writing a programme.

Most of the problems could be solved by using five or six basic functions, AND, OR, NOT, MEMORY, DELAY and COUNTER. If the student can understand and also combine them, to construct safe and effective functions, then there is a good chance that the student will be a successful programmer.

To create a programme the following were studied:

- Function description
- Setting up an I/O list
- Description explanations
- Which outputs will be affected?
- Seek specific states

- What time delays must be used?
- Setting up a Ladder diagram
- Setting up an Instruction list
- Connection and test



COMPONENTS

EXPERIMENT 5

Together with the various controlling devices, the PLC can have a strong influence over its surroundings.
Examples of controlling devices are cylinders and motors. Sensors give information on what is happening.

- The exercise will now start.

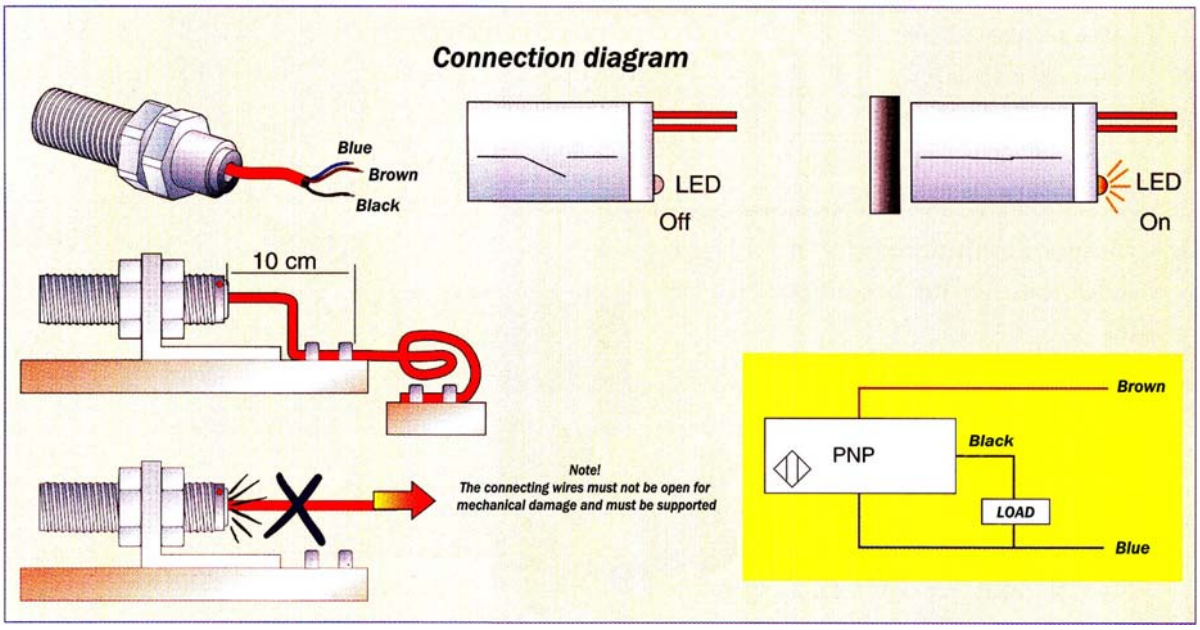
EQUIPMENT
Base-unit 2000
Logic module
Cylinder module
Plinth module
Ball selection machine
PLC module
Programming unit

Experiment with sensors

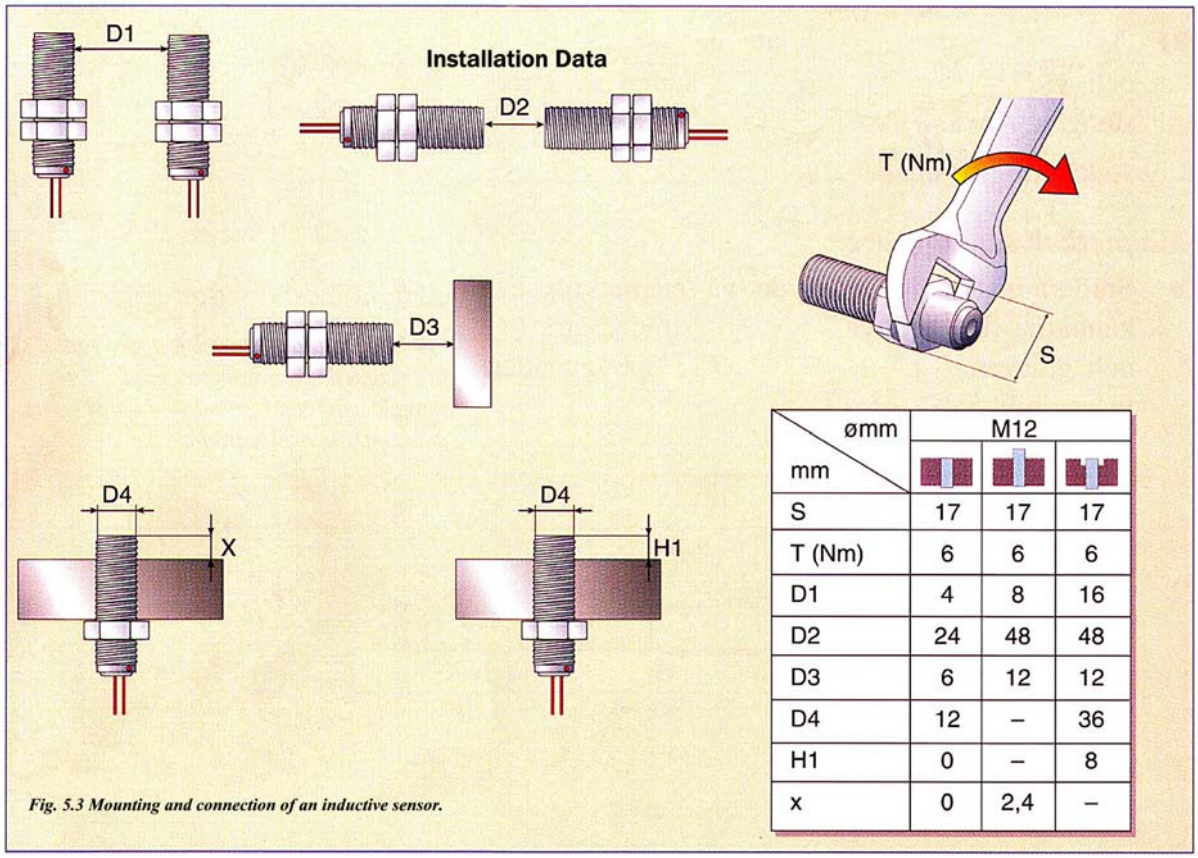
- Mount the logic module on the base-unit.

Fig. 5.2 The base-unit with logic module

Inductive sensor



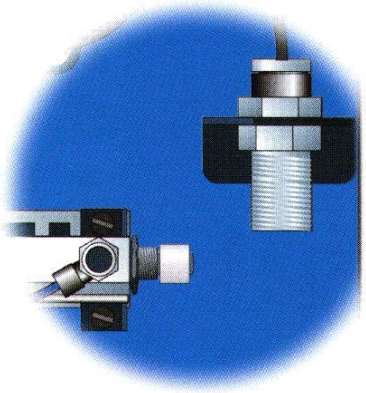
- Take up the cylinder module and examine the inductive sensor. It has three connections that will be connected as shown in Fig. 5.3.



ømm / mm	M12		
S	17	17	17
T (Nm)	6	6	6
D1	4	8	16
D2	24	48	48
D3	6	12	12
D4	12	–	36
H1	0	–	8
x	0	2,4	–

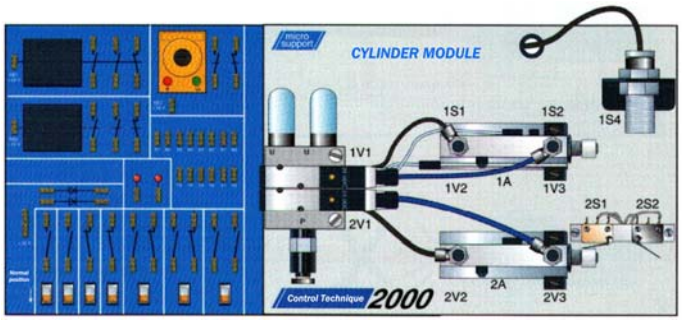
Fig. 5.3 Mounting and connection of an inductive sensor.

77 Collect information from the manufacturers data sheets and fill in the table below.



Spanner width	
Tightening torque	
Voltage	
Max load current	
Internal current consumption	
Sensing distance	
Free zone area compared with the sensor diameter	

- Mount the cylinder module on the logic module. Connect the base-unit to the mains supply.
- Pull the cylinder piston out to its outer position. Observe that when the eccentric piston rod is turned and the LED studied at the same time, it can be seen when the sensor gives a 1 respective 0 signal.



78 Measure the sensing distance between the sensing surface and the different settings at the end of the piston rod. Use a calliper.

Sensing distance = ……

Magnetic rod sensor

Study the installation of the two magnetic rod sensors. They have two connections: grey (+) and grey/black (-). The electrical construction is shown in Fig. 5.4

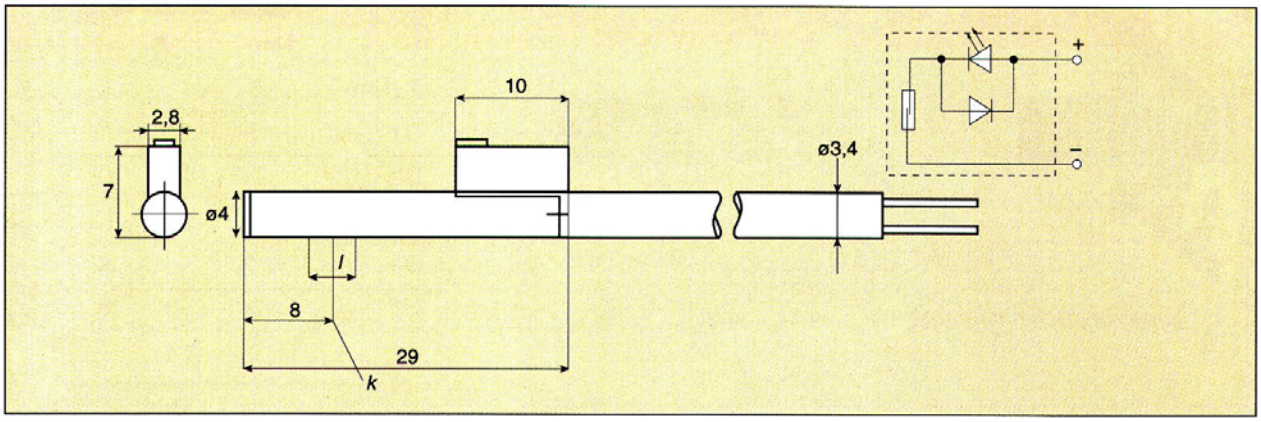
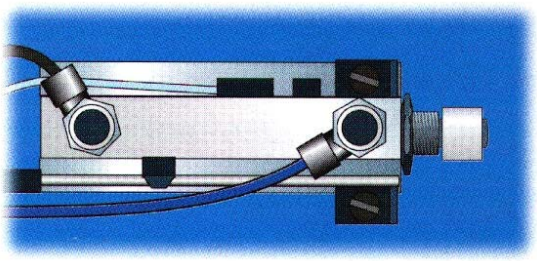


Fig. 5.4 Dimension sketch and electrical construction of the magnetic rod sensor. K = The most sensitive part and I = the operating area.

79 Fill in the data for the magnetic piston rod sensor in the table below.

Voltage	
Load current	
Response time	
Max shock load	
Temperature range	
Insulation resistance between the cables and frame	



- The magnetic field from the rod reacts with the sensor. The most sensitive and operating zones are shown in Fig. 5.4.

80 Measure the operating area for one of the sensors at the following settings:

i. Set the cylinder rod in an intermediate position

ii. Move the sensor and check when it indicates state 1 respective 0.

iii. Measure the operating area by using the side of the cylinder as a reference point

……...

- Adjust the installation of the to magnetic rod sensors to the following settings:

1. Set the rod in the end position

2. Push the sensor back in the direction the rod came from. Note when the LED switches off.

3. Move the sensor until the LED switches on.

4. Tighten it in place.

- Take up the ball selection machine and study the sensors mounted on the shuttle cylinder.

81 Collect data from the manufacturers data sheets for the magnetic rod sensor 322-20. Enter the information in the table below.

Output type	
Voltage	
Max load current	
Voltage drop	
Internal current consumption	

Fibre photo cell

- Mount the plinth module on the logic module.
- Place the ball selection machine beside the base-unit with the plinth module facing forward.
- Connect the ball selection machine to the plinth module according to the I/O list. Connect 24V DC to the plinth as shown in Fig. 5.5.

Input	**Signal**	**Comment**
X0	**1S1**	**Shuttle cylinder in right position**
X1	**1S2**	**Shuttle cylinder in mid position**
X2	**1S3**	**Shuttle cylinder in left position**
X3	**2S1**	**Right ejector minus position**
X4	**3S1**	**Left ejector minus position**
X5	**4S1**	**Inductive sensor, metal sensed**
X6	**4S2**	**Photo-electric sensor, ball sensed**
Output	**Signal**	**Comment**
Y0	**1V1 $_{14}$**	**Shuttle cylinder right**
Y1	**1V1 $_{12}$**	**Shuttle cylinder left**
Y2	**2V1**	**Cylinder right ejector**
Y3	**3V1**	**Cylinder left ejector**

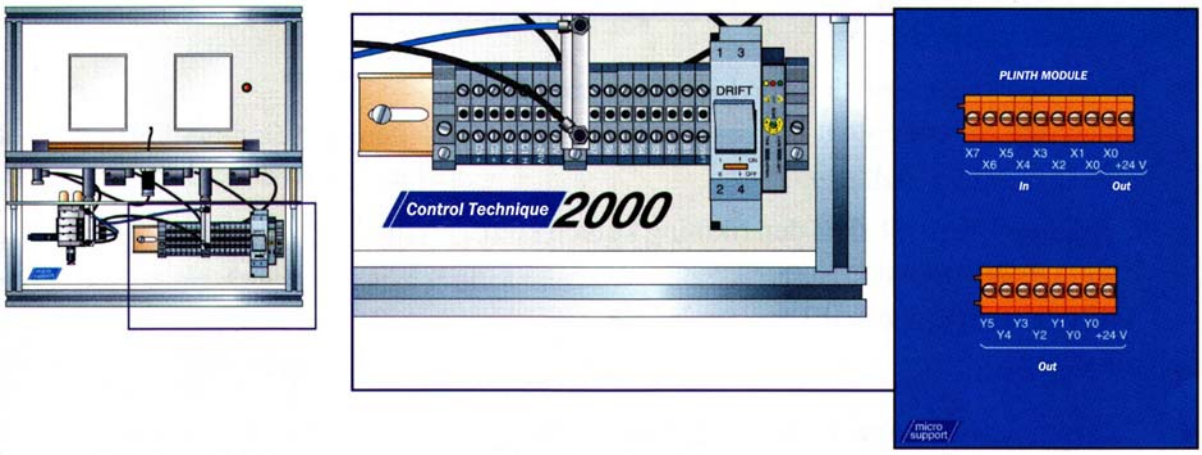
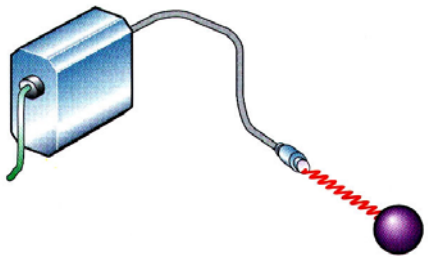


Fig. 5.5 Connection of the Ball selection machine to the plinth module.

82 Collect data from the manufacturers data sheets. Fill in the information in the table below.

Fibre photo cell type F1R	
Voltage	
Internal current consumption	
Output	
Max load current	
Indication	
Light source	
Sensitivity	
Fibre conductor FR510	
Length	
Material	
Sensing distance with Photo cell F1R	
Smallest detectable object	

- The sensitivity of the fibre photo cell shall be adjusted according to the following guide lines:



Green LED = Approved signal, 120% light received

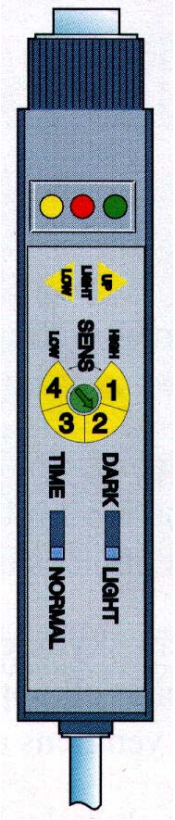
Red LED = Uncertain signal, 100% light received

Yellow LED = Not approved signal, 80% light received

The best sensitivity adjustment is 120% light received. This is when both the green and red LED's are switched on at the same time.

83 Check that the change over switch from light to dark is set at the LIGHT position, and that the switch for time delay is set to the NORMAL position. Set the sensitivity adjustment to the following:

i. Place an object in the fixture for measuring.
ii. Turn the 4 rotations potentiometer clockwise until a point is found where the sensitivity is adjusted in relation to the reflected light. Read the level of sensitivity.
iii. Remove the object from the measuring fixture and complete the same adjustment with the reflection from the background. Read the level of sensitivity.
iv. Set the ideal sensitivity as an intermediate value.



Sensitivity adjustment with measured object =…….

Sensitivity adjustment without measured object =…..…….

Ideal sensitivity =……..

Fig. 5.6 Fibre photo cells adjustments

Experiments with the shuttle cylinder

Normally a shuttle cylinder has both chambers under pressure. When a movement of the shuttle is required, one of the chambers is ventilated. To stop the shuttle the valve is reset so that the pressure in both chambers is the same. With the same pressure and same rod area, the shuttle must stop.

This assignment can be proved by either using two 5/2 valves or one 5/3 valve. See Fig. 5.7.

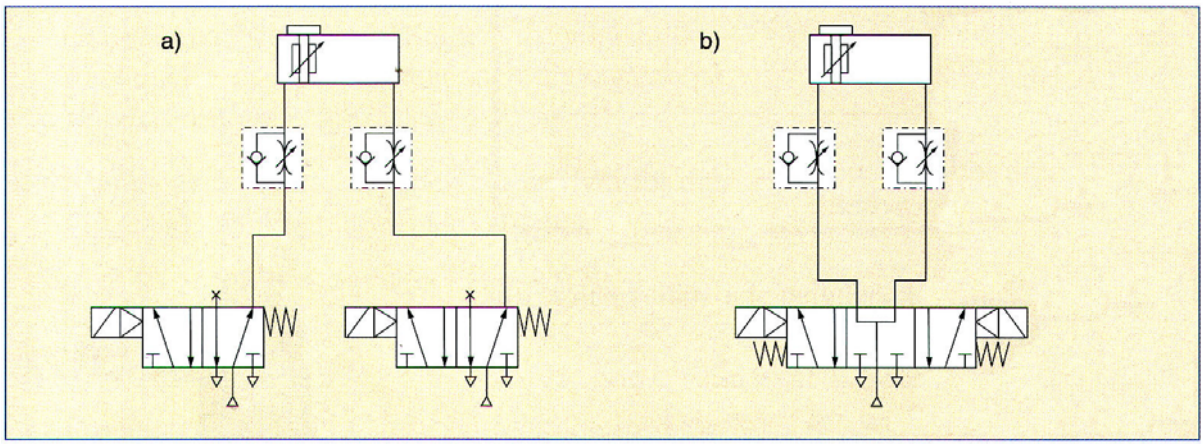


Fig. 5.7 Control of a shuttle cylinder with: a) two 5/2 valves b) one 5/3 valve.

- Connect the ball selection machine to the compressed air supply. Note! The working pressure should be set at 0,6 – 0,7 bar.

- Connect the valve for the shuttle cylinder to two electric switches. See Fig. 5.8. (Observe: Connections via the plinth terminals Y0 and Y1.)

- Check the shuttle cylinder movements by setting the two electric switches manually. The setting can also be made by pushing the orange button on the valves.

84 How is the shuttle cylinder set, if, via the valves, the cylinder can be manoeuvred in different directions? Try to stop the cylinder in different positions between the end positions.

……

……..

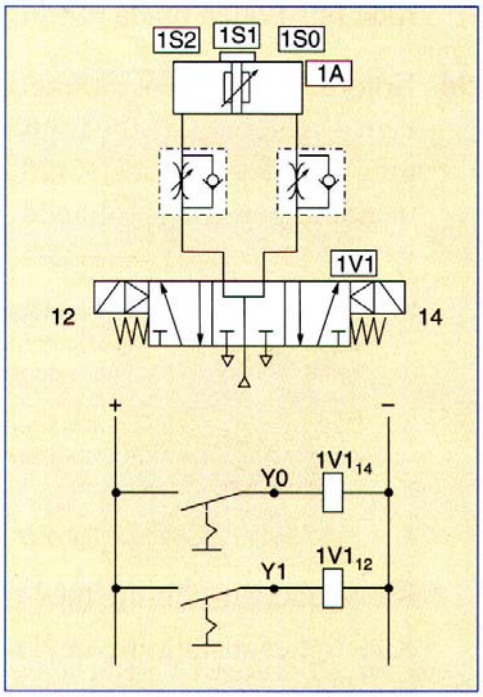


Fig. 5.8 Pneumatic diagram and control circuit diagram for connecting the shunt cylinder.

85 What is the difference between controlling a shuttle cylinder and a double action valve?

……

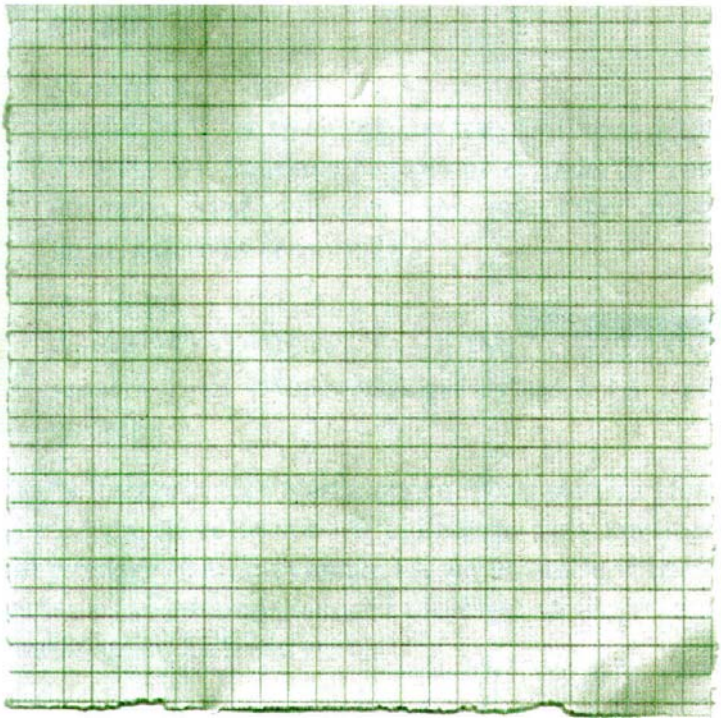
……

86 Can the rod be moved by hand after it has stopped and both chambers are under pressure?

……

- Mount the PLC module on the base-unit.
- Set the plinth module with connections to the ball selection machine to the PLC modules two contacts.
- To be able to run the shuttle the PLC must be loaded with a programme as seen in Fig. 5.9
- Connect the programming unit to the PLC system. Rite the programme and test run.

87 Draw the function block diagram for the control of the shuttle cylinder.



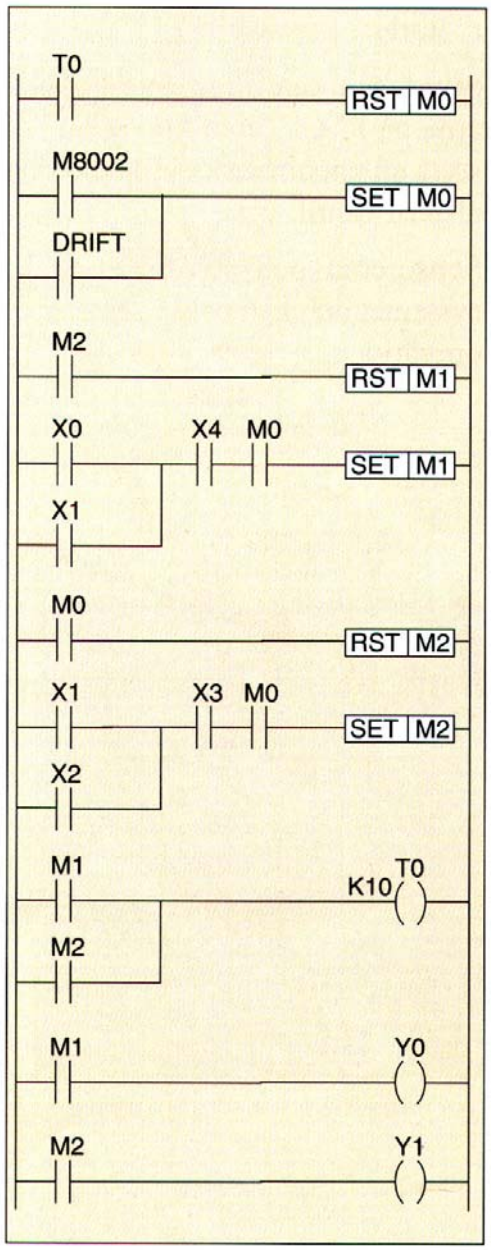


Fig. 5.9 Ladder diagram for control of the shuttle cylinder.

Summary

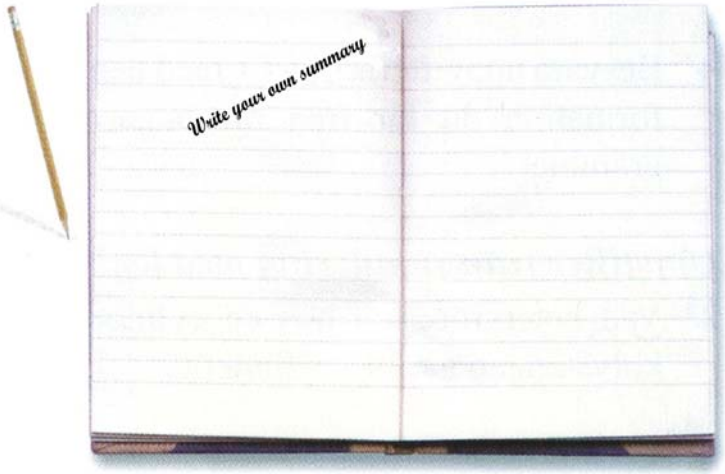
A sensor converts position, movement etc to an electric signal.

There are different types of sensor that measure using different techniques and are used in different situations. An inductive sensor reacts between 0 and 30-40 mm, while an optical sensor can react over several meters.

The purpose of the different types of control devices is to set machines in motion. There are two forms of movement, liner and rotational. Linear movements are made mostly by pneumatic cylinders and rotational by electric motors.

The control device cannot normally be connected directly to an output from a PLC, but requires a converter. To control a pneumatic cylinder, it is connected via an electrically controlled valve to the output.

Sensors and control devices are components in the control system. They can also be seen as the tentacles of a PLC that reach out to the world.



BALL SELECTION MACHINE

EXPERIMENT 6

The ball selection machine has a reservoir containing different kinds of balls. These balls are measured in a fixture and then transported to different stores. The ball selection machine is one application of machine control. The programme to complete these tasks must be written and loaded into the PLC so that the machine operates correctly.

EQUIPMENT
Base-unit 2000
PLC module
Programming unit
Plinth module
Ball selection machine
PC + Learning programme
Control Technique 2000

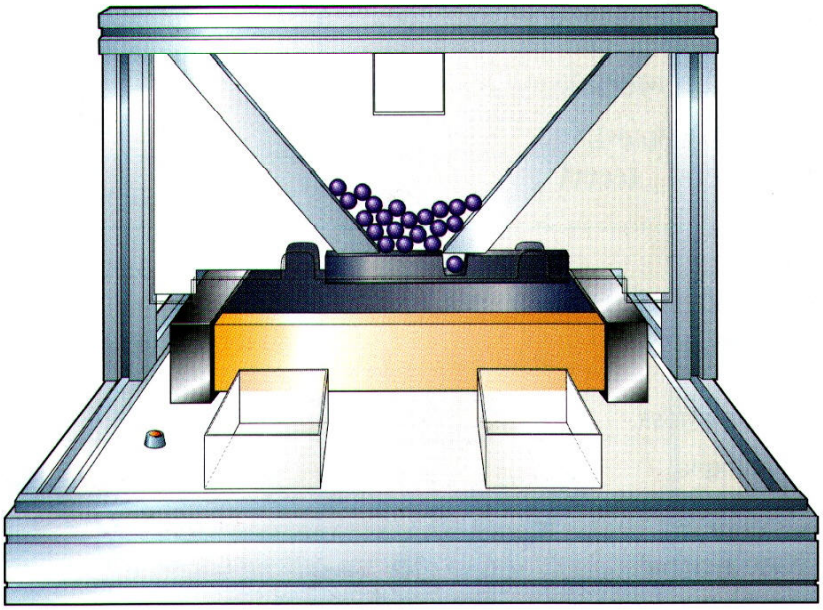


Fig. 6.1 Ball selection machine

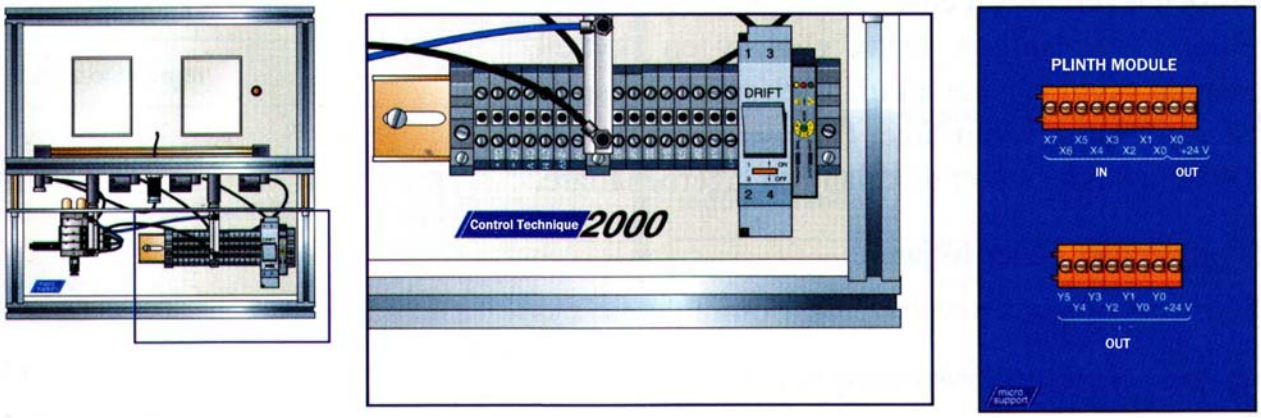


Fig. 6.2 Ball selection machine connections to the plinth module

- Mount the PLC module on to the base-unit.
- Mount the plinth module on to the PLC module.
- Place the ball selection machine on the table beside the base-unit. Connect the ball selection machine via the plinth module to the PLC module in accordance with the I/O list on page 80. Fig. 5.5.

The ball selection machine – a model for machine control

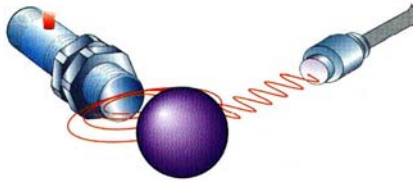
The ball selection machine consists of:

- One funnel shaped reservoir
- One collection position with measuring fixture
- Two output feeding positions
- Two stores

In the reservoir there are many balls of the same size but of different materials. Some are of metal and other non- metal. The assignment for the selection machine is to select the balls according to the material of which they are produced.

Forward feeding is set in motion when the balls fall down to the measuring fixture. The balls are selected as follows:

Type of balls in the reservoir?	**Inductive**	**Photo electric**
Metal ball	**Gives signal**	**Gives signal**
Glass ball	**No signal**	**Gives signal**
No ball	**No signal**	**No signal**



The fixture can also be regarded as a collection store as the balls are collected and delivered to one of the two stores depending on the material. A shuttle cylinder carries out this process. A cylinder that ejects the ball into a store reservoir carries out the output feeding.

The control system shall be as follows:

- The control system consists of three cylinders. These are known as working elements.
- It is the shuttle cylinder that collects and transports. There are three fixed positions – the collection position and the two delivery stores.
- There are also two double action cylinders that operate as ejectors. These are mounted in each delivery position.
- The control element shall control the cylinders. The control element used is an electrically controlled direction valve.

With the two chambers are under pressure, the shuttle cylinder stands in a stop position. When the valve is set to one of the outer positions and one chamber is ventilated the shuttle starts to move.

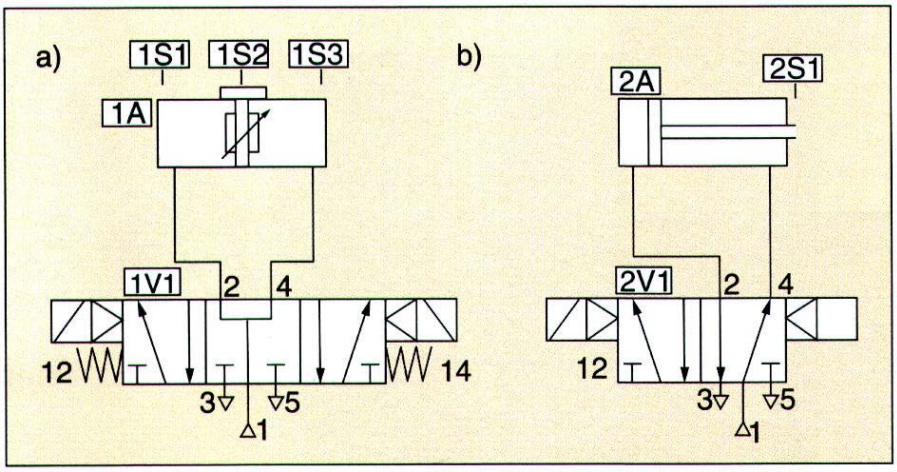


Fig. 6.3a Control of a shuttle cylinder by a 5/3 electrically controlled direction valve having spring return and pressure to the intermediate position.

For control of the cylinder, a valve having five port and three positions (5/3) is used. The valve is electrically controlled in both directions and has a spring return to the middle position. In the middle position port 1 is connected to ports 3 and 5. See Fig. 6.3a.

Two double action cylinders are used for the ejection. Mono-stable valves that are electrically controlled with pressure return, control these. See Fig. 6.3b.

Three magnetic rod sensors detect the fixed positions for the shuttle cylinder. There are also sensors in the minus position for the two ejector cylinders.

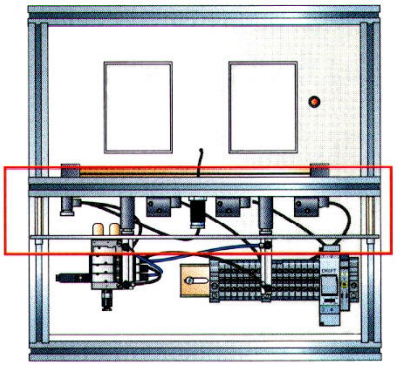


Fig.6.3b Control of the ejector cylinder by means of a 5/2 mono-stable valve that is electrically controlled.

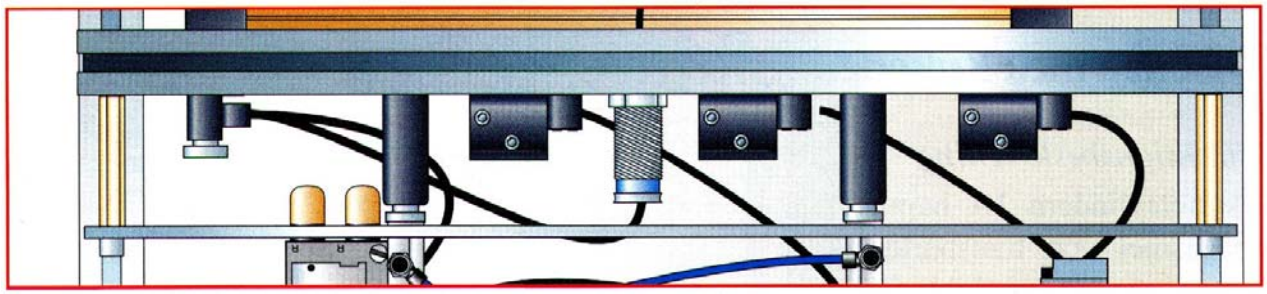


Fig. 6.4 Detailed view of the sensor location for shuttle cylinder control.

Experiments with the Ball Selection Machine

Function description

The shuttle cylinder 1A collects the ball that is in the reservoir and transports it to one of the delivery positions at two separate stores.

At each delivery position, a double action cylinder 2A carries out the forward feeding and cylinder 3A ejects the ball into the store.

After ejection, with both of the double action cylinders in the minus position, the shuttle cylinder returns to its collection point.

Fig. 6.6 shows the function diagram for the cylinders in the ball selection machine.

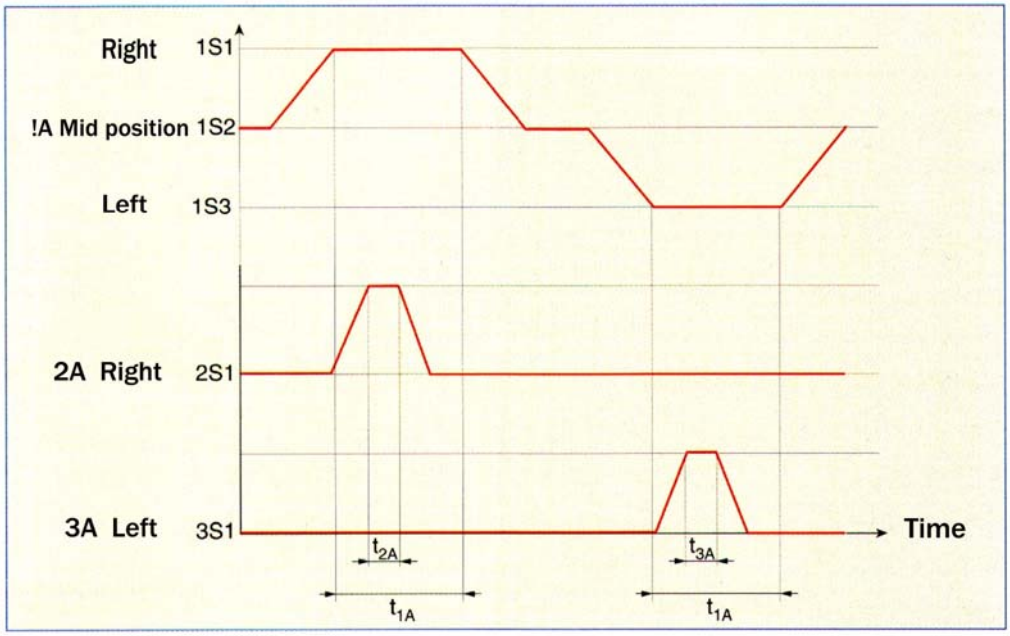


Fig. 6.6 Function diagram for the ball selection machine

88 What is the purpose of the shuttle cylinder and the two double action cylinders?

……..
……..

……

89 What is the difference between optical and inductive sensing?

……..

……..

……

Choice of equipment

The equipment used in the ball selection machine consists of the following:

1A	**Shuttle cylinder 16 – 140**
1V1	**5/3 power valve, electrically controlled with spring return to the ventilated middle position**
1V2	**Variable throttle non-return valve**
1V3	**Variable throttle non-return valve**
1S1	**Sensor, magnetic rod sensing**
1S3	**Sensor, magnetic rod sensing**
2A	**Double action cylinder 10 – 30**
2V1	**5/2 Power valve mono-stable electrically controlled with pressure return**
2V2	**Variable throttle non-return valve**
2V3	**Variable throttle non-return valve**
2S1	**Sensor, magnetic rod sensing**
3A	**Double action cylinder 10 – 30**
3V1	**5/2 Power valve mono-stable electrically controlled with pressure return**
3V2	**Variable throttle non-return valve**
3V3	**Variable throttle non-return valve**
3S1	**Sensor, magnetic rod sensing**
4S1	**Sensor, inductive sensing**
4S2	**Sensor, fibre photo electrical sensing**

- Study the information in the manufacturers data sheets for the components used. See also Fig. 6.7.

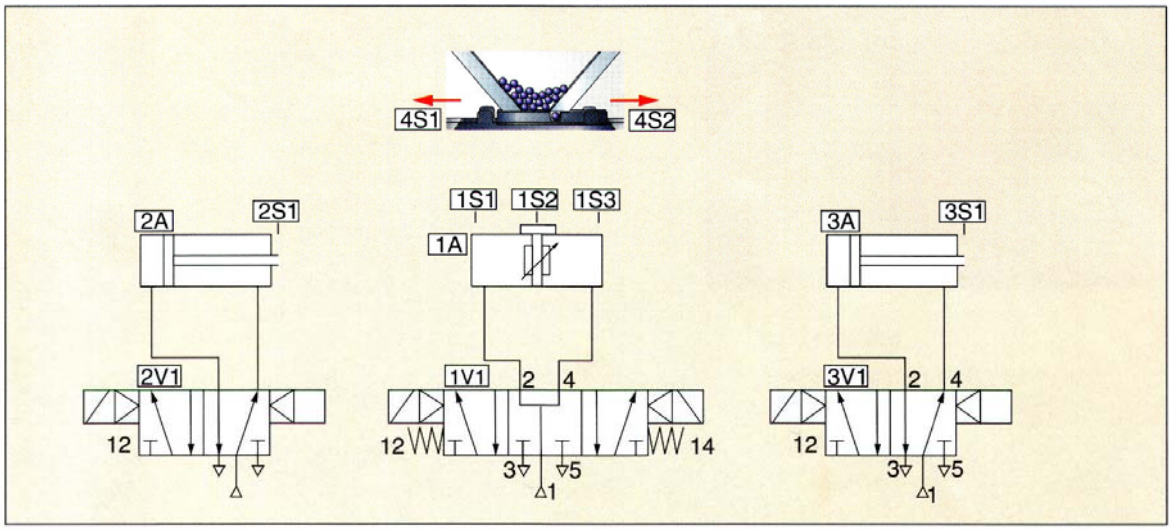


Fig. 6.7 Pneumatic circuit diagram for the ball selection machine. Note that the variable non-return throttle valves for the three cylinders are not shown.

Create an I/O list

Input	Title	Comments
X0	1S1	Shuttle cylinder right position
X1	1S2	Shuttle cylinder middle position
X2	1S3	Shuttle cylinder left position
X3	2S1	Right ejector, minus position
X4	3S1	Left ejector, minus position
X5	4S1	Inductive sensor, metal sensing
Output	**Title**	**Comments**
Y0	1V14	Shuttle cylinder right
Y1	1V112	Shuttle cylinder left
Y2	2V1	Cylinder right ejector
Y3	3V1	Cylinder left ejector

- Check where the components in the I/O list are placed in the ball selection machine. Study the assembly and connections. See Fig. 6.8

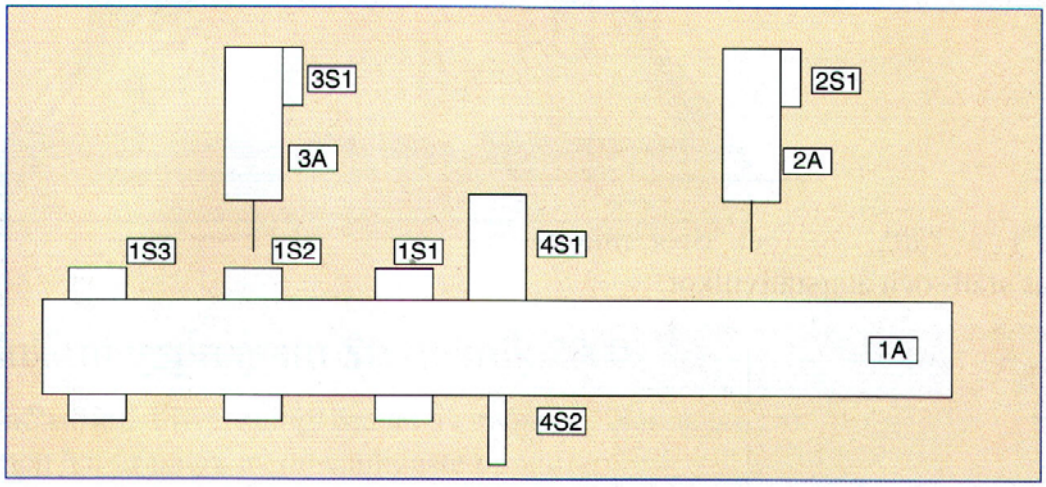


Fig. 6.8 Location drawing of the components in the ball selection machine.

Description

The sequence of events for the three cylinders:

Y0 **The output shall activate the shuttle cylinder 1A in an outward movement to the right. The conditions are that the left ejector cylinder has been activated and that the left ejector cylinders sensor is in the minus position X4, giving a 1 signal. OR that there is a glass ball in the measurement fixture, i.e. X6 gives a 1 signal while X5 gives a 0 signal.**

Y1 **The output shall activate the shuttle cylinder 1A in an outward movement to the left. The conditions are that the right ejector cylinder has been activated and that the right ejector cylinders sensor is in the minus position X3, giving a 1 signal. OR that there is a metal ball in the measurement fixture, i.e. X6 and X5 give a 1 signal.**

Y2 **The output shall be activated when the shuttle has an order to move to the right AND the sensor in the outer position X0 gives a 1 signal. These two signals start a memory function that together with a time delay, controls the right ejector cylinder in an outward movement.**

Y3 **The output shall be activated when the shuttle has an order to move to the left AND the sensor in the outer position X2 gives a 1 signal. These two signals start a memory function that together with a time delay, controls the left ejector cylinder in an outward movement**

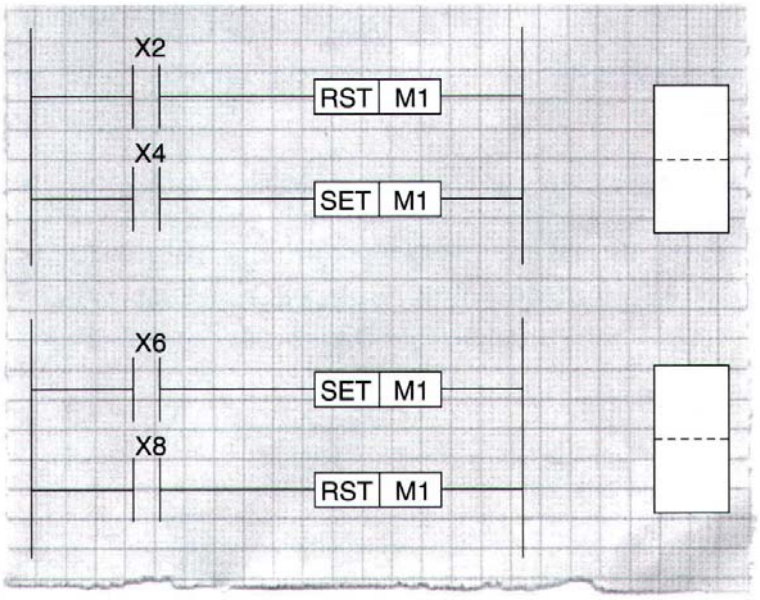
90 How many outputs have to be used and what are the cylinder movements that will occur?

……..

……..

……..

91 Complete the function block for the setting and resetting of the memory functions.



Search for specific states

The outputs Y0 and Y1 both have two states. Either the signal is given from the measuring fixture to start the transport of a ball, or a ball has been left in the store and the shuttle shall return to the middle position.

The shuttle cylinders movements require four memory functions. The ejection by Y0 and Y4 constitutes one state each. In addition, one memory function is required as a measuring stage and one memory as a start stage. All together eight-memory cells will be used in the PLC.

M0	**Start stage after being activated by an initiating pulse from M8002 OR if the shuttle has earlier been instructed to go to the left position. AND a 1 signal is given from the sensor in the middle position OR the shuttle earlier has been instructed to go to the right position AND a 1 signal is given from the sensor in the middle position.**
M1	**The measuring stage that was set by M0 AND the sensor in the shuttles middle position.**
M2	**Shuttle 1A moving in an outward movement to the left after being activated by the previous stage M1 AND inductive sensor X5 AND photo electric sensor X6.**
M3	**The left ejection cylinder 3A in an outward movement after being activated by the previous stage M3 AND a 1 signal from the sensor in the shuttles left position.**
M4	**Shuttle 1A moving in an outward movement to the right after being activated by the previous stage M3 AND a 1 signal from the left ejection cylinders minus position.**
M5	**Shuttle 1A moving in an outward movement to the right after being activated by the measuring stage M1 AND a 0 signal from the inductive sensor X5 AND a 1 signal from the photoelectric sensor X6.**
M6	**The right ejection cylinder 2A in an outward movement after being activated by the previous stage M5 AND a 1 signal from the sensor in the shuttles right position.**
M7	**Shuttle 1A moving in an outward movement to the left after being activated by the previous stage M6 AND a 1 signal from the right ejection cylinders minus position.**

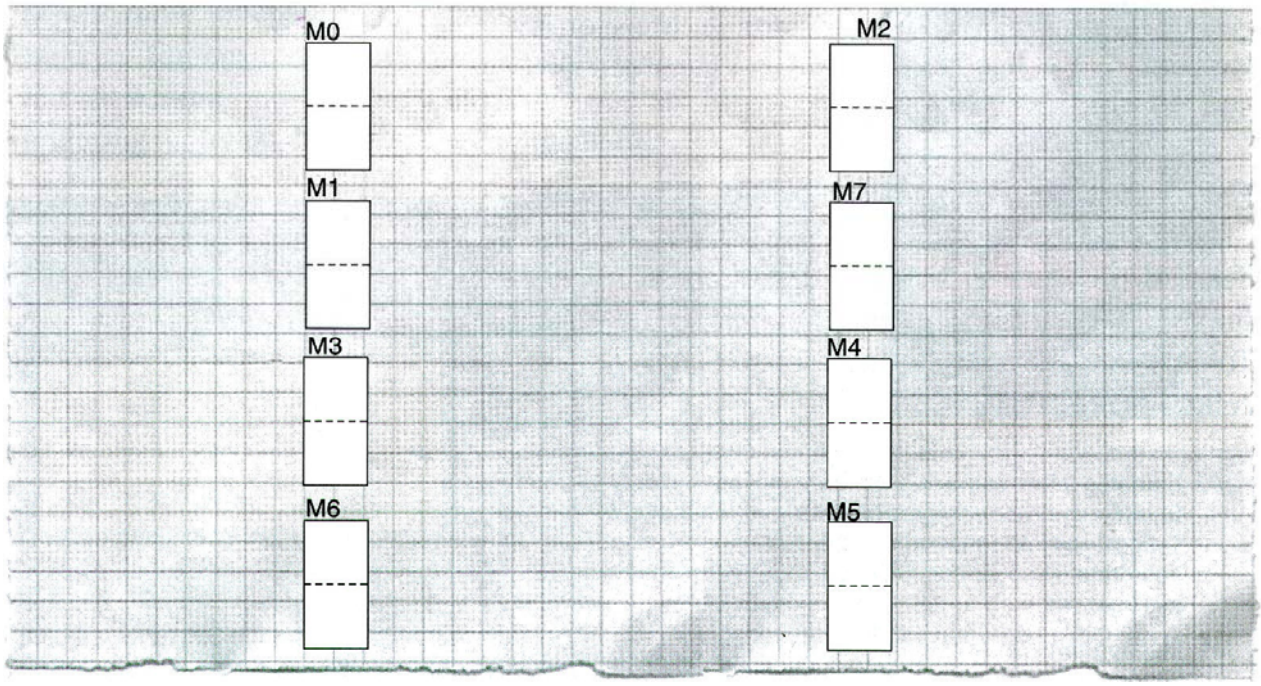
92 Why are eight memory cells required when there are only three cylinders?

……

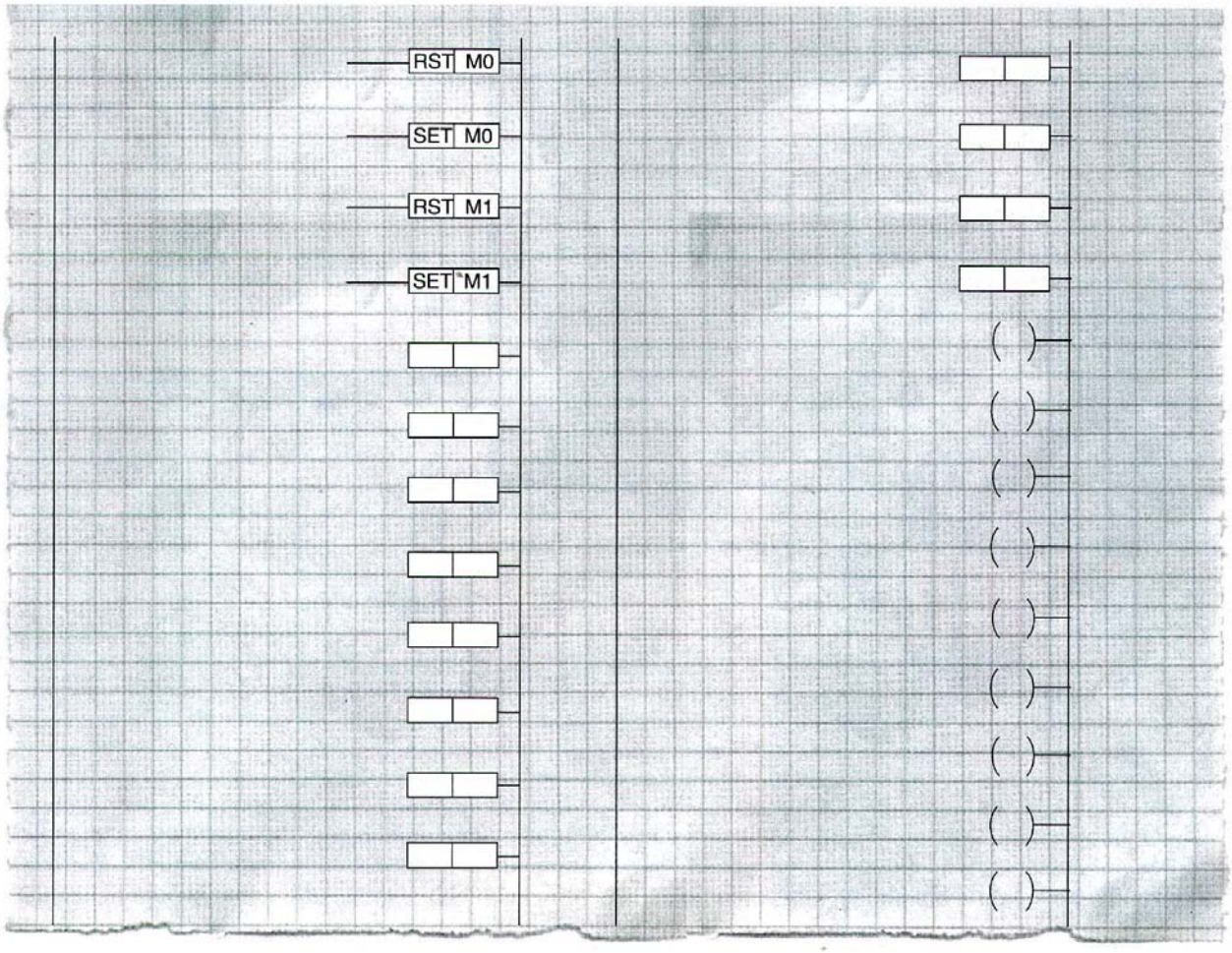
……

……

93 Complete the function block diagrams for the three cylinders and the eight memory cells.



94 Start the Ladder diagram by drawing in the memory cells. I.e. RST M0 , SET M0 etc. The contacts that activate the memory cells will be drawn in later.



95 How many branches have been started in the Ladder diagram?

…….

Which outputs will be affected?

The outputs that will be affected can be seen in the I/O list.

Y0	**1V14**	**Shuttle cylinder movement right**
Y1	**1V112**	**Shuttle cylinder movement left**
Y2	**2V1**	**Cylinder right ejector**
Y3	**3V1**	**Cylinder left ejector**

- Draw in the outputs in the Ladder diagram.

What time delays will be used?

The shuttle 1A cannot start its outward movement until the measurement has been accurately completed. To make allowances for this a time delay T0 is introduced to set M0 respective M5.

When the shuttle is in the right respective left position, it shall return to the middle position. In order that the shuttle does not return immediately, four time delays are introduced. T1 AND T2 for the shuttles right movement and T3 AND T4 for the shuttles minus movement.

State 0	Shuttle 1A, outward movement to the right respective left after measuring in the measurement fixture. The time delay is 1 second.
State 1 & 2	Shuttle 1A, return movement right to the collect position after this time.
State 3 & 4	Shuttle 1A, return movement left to the collect position after this time.

- Draw in the five time delays in the Ladder diagram. The ladder diagram should now contain memory cells, outputs and time delays.

Draw in the contacts in the Ladder diagram

- The contacts that shall set and reset the memory cells, start time delays and activate the outputs will now be added to the Ladder diagram. Observe that the sequence in programming where the previous stage is included in the conditions that set (SET) the next memory cell. Similarly, it is the next memory cell that resets (RST) the previous memory cell.

Study the text under the following headings:

1 Explain the sequence description

2 Which outputs will be affected?

3 What time delays will be used?

4 Where can the information needed to write a programme be found?

Create PLC Instructions

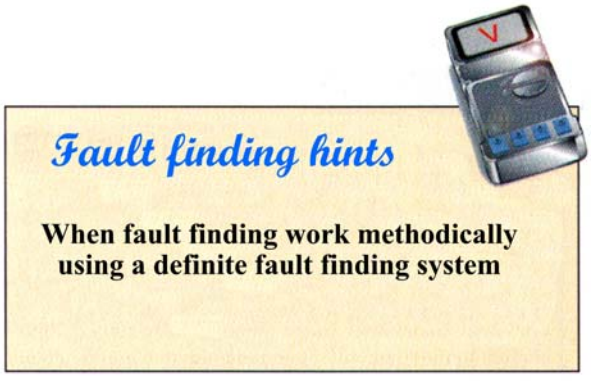
- First decide whether to programme the PLC system using a ladder diagram or first write out a PLC Instruction.

  For the ladder diagram go directly to the next stage and write in the programme in the PLC.

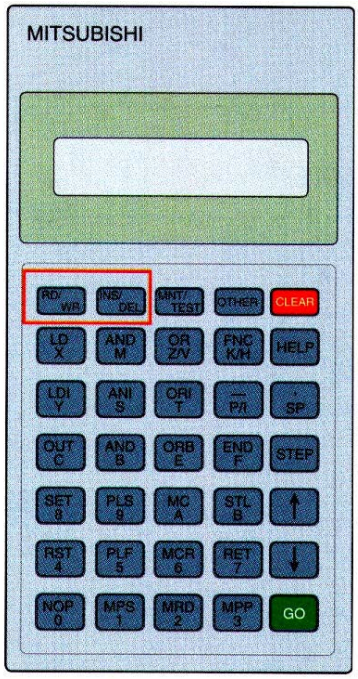
  If PLC instruction is chosen then an instruction list must first be written before the next stage of loading the programme via the programming unit.

Connection and Test

- Check that the programming unit is connected to the PLC module and that the RUN/STOP switch is in the STOP position.
- Connect the base-unit to the mains supply.
- Load the programme into the PLC.
- Set the RUN/STOP switch to the RUN position and start the control system for the ball selection machine.



- If there are difficulties in starting up according to the programme, compare with the Ladder diagram in Fig. 6.9.
- For correction to the programme use the programming unit RD/WR and INS/DEL.
- The ball selection machine shall operate smoothly and rhythmically. Adjust the speed of the shuttle cylinder and the two ejectors movements. This is a personal decision that depends on safety.



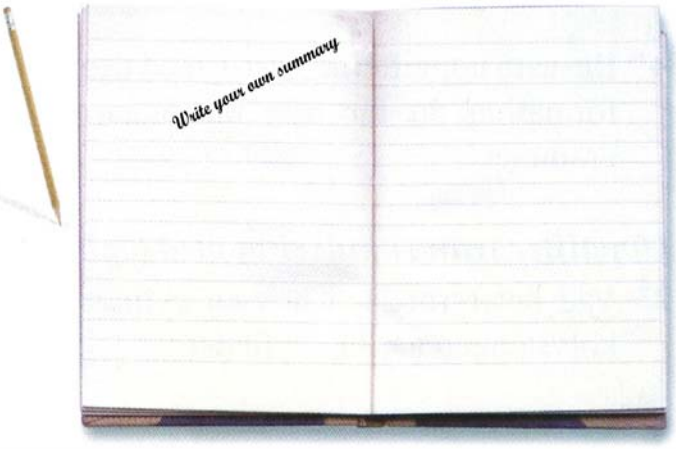
96 Prepare an account of the ball selection machine and present it to the teacher

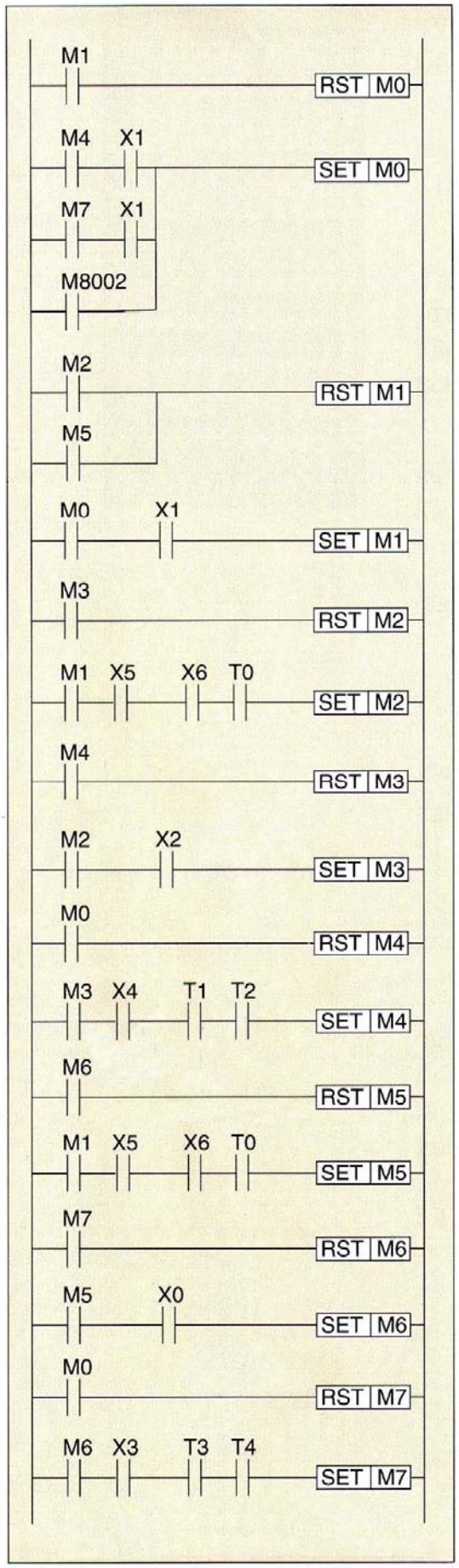
Summary

The Ball Selection Machine is a completely different type of control installation from the Traffic Lights project. In the traffic light project many actions followed each other.

In the ball selection machine there are substantially shorter sequences. First there was a choice of ball type and then a choice of direction.

From the safety point of view the demands are high for both applications. The programme that controls the traffic lights must operate without any errors, otherwise people can be injured. With the ball selection machine the risks are much less but the movement of the shuttle cylinder can be a risk factor.





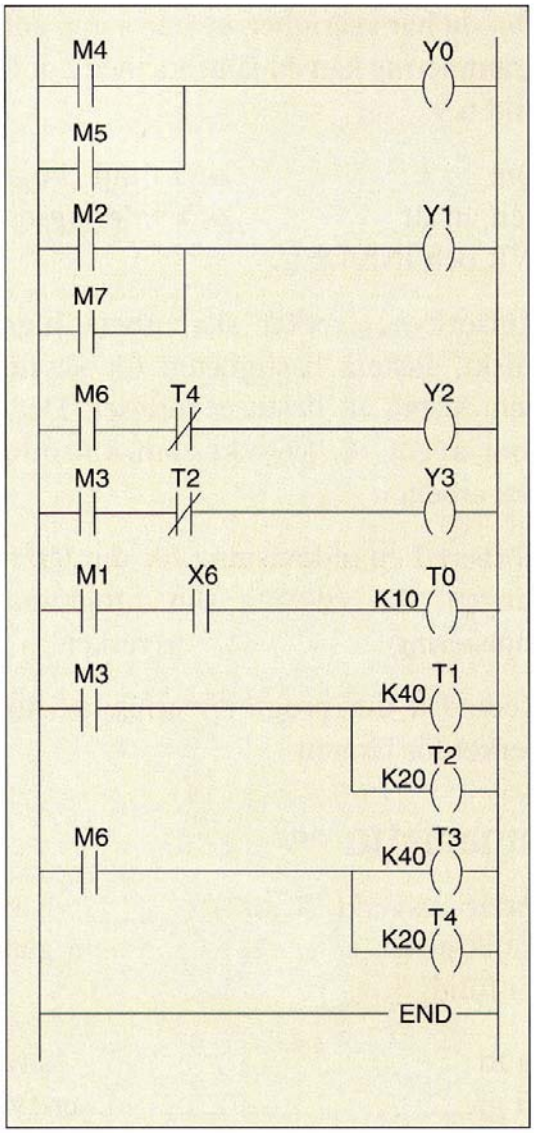


Fig. 6.9 Ladder diagram for the ball selection machine