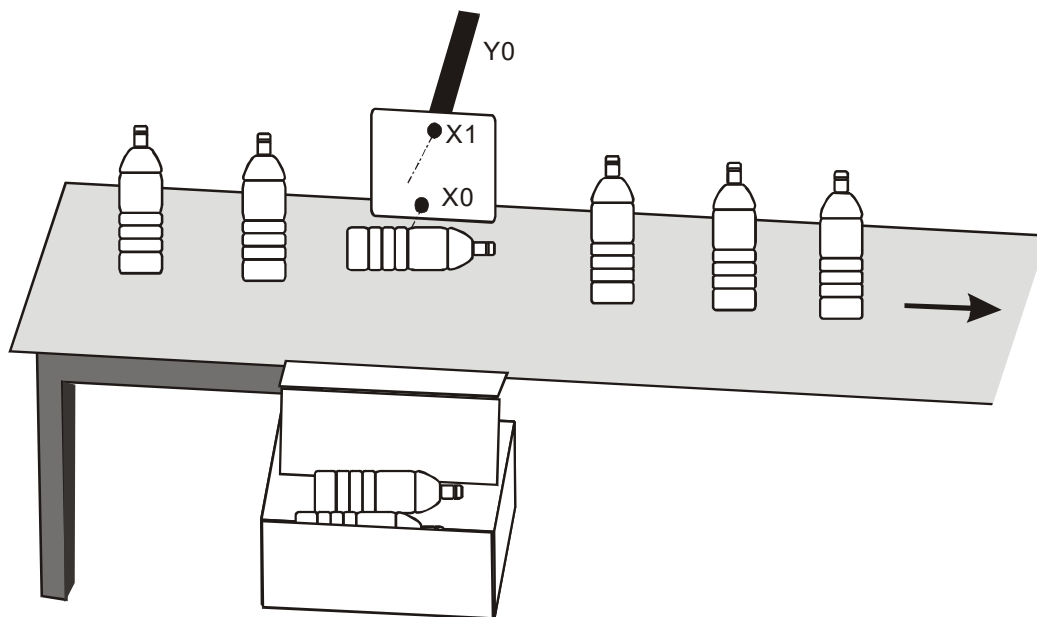# PLC Application Exercises

1.1 Normally Closed Contact in Series Connection
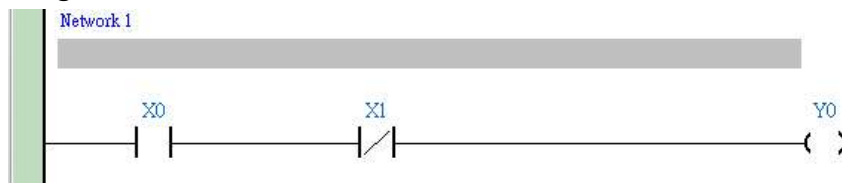

Control Purpose:

● Detecting the standing bottles on the conveyor and pushing the fallen bottles out

Devices:

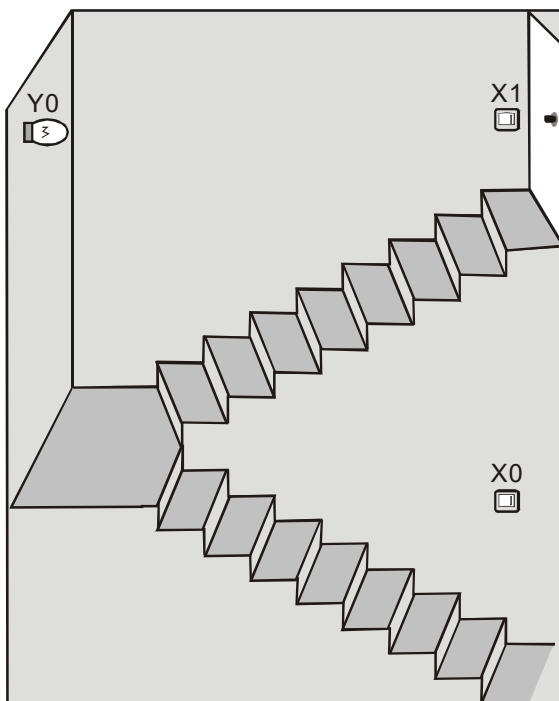| Device	Function
X0	X0 = ON when the detected input signal from the bottle-bottom is sheltered.
X1	X1 = ON when the detected input signal from the bottle-neck is sheltered.
Y0	Pneumatic pushing pole

Control Program:

Program Description:

● If the bottle on the conveyor belt is upstanding, the input signal from monitoring photocell at both bottle-bottom and bottle-neck will be detected. In this case, X0 = ON, and X1 = ON. The normally open (NO) contact X0 will be activated as well as the normally closed (NC) contact X1. Y0 remains OFF and pneumatic pushing pole will not perform any action.

● If the bottle from the conveyor belt is down, only the input signal from monitoring photocell at the bottle-bottom will be detected. In this case, X0 = ON, X1 = OFF. The state of output YO will be ON because the NO contact X0 activates and the NC contact X1 remains OFF. The pneumatic pushing pole will push the fallen bottle out of the conveyor belt.

1. Basic Program Design Examples
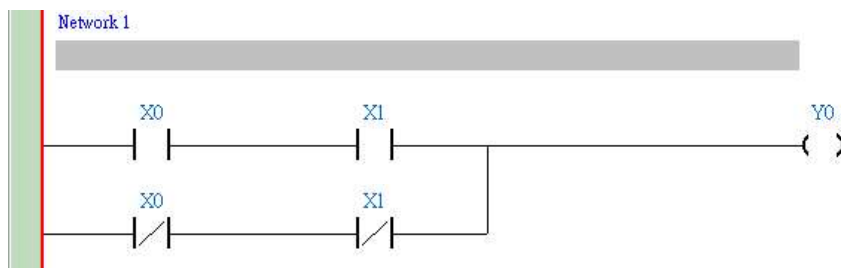
1.2 Block in Parallel Connection

Control Purpose:

- Setting up a lighting system for users to switch on/off the light whether they are at the bottom or the top of the stairs.

Devices:

Device	Function
X0	X0 turns ON when the bottom switch is turned to the right
X1	X1 turns ON when the top switch is turned to the right.
Y1	Stair light

Control Program:

Program Description:

- If the states of the bottom switch and the top switch are the same, both ON or OFF, the light will be ON. If different, one is ON and the other is OFF, the light will be OFF.
- When the light is OFF, users can turn on the light by changing the state of either top switch at the bottom switch of the stairs. Likewise, when the light is ON, users can turn off the light by changing the state of one of the two switches..

1.3 Rising-edge Pulse Output for One Scan Cycle

Control Purpose:

- Creating a pulse of one program scan cycle as the condition to trigger the indicator or other devices when the switch (X0) is turned on.
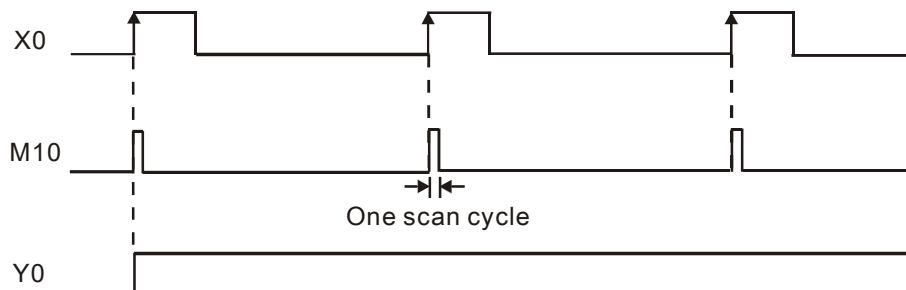
Devices:

Device	Function
X0	Switch (OFF→ON)
M10	Creating a trigger pulse for one program scan cycle
Y0	Indicator

Control Program:

Program Description:

- When X0 is turned on (Rising-edge triggered), PLS instruction will be executed, and M10 will send a pulse for one program scan cycle.

- When M10 = ON, [SET Y0] instruction will be executed and Y0 will be ON. In this case, the indicator will be lighted, and other devices will be activated as well.

1. Basic Program Design Examples

1.4 Falling-edge Pulse Output for One Scan Cycle
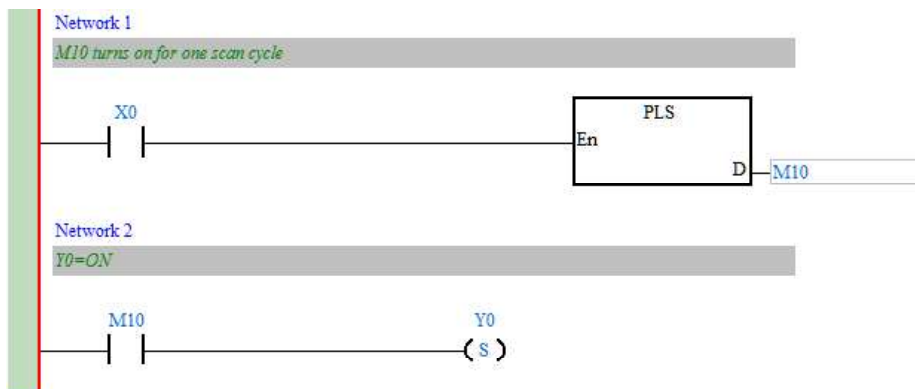

X0   Y0(Electromagnetic valve)

Control Purpose:

- Creating a pulse of one program scan cycle as the condition to trigger the electromagnetic valve or other devices when the switch is turned off.
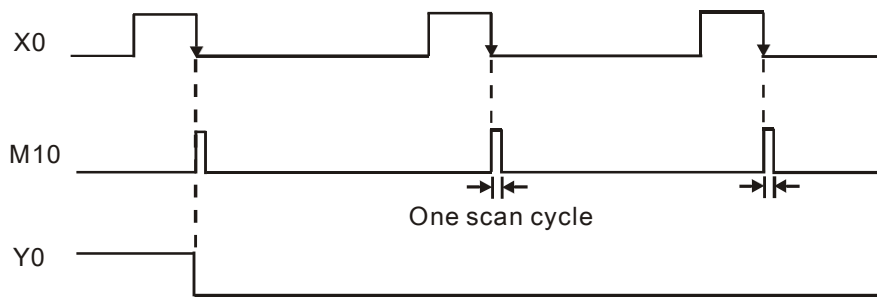
One scan cycle

Devices:

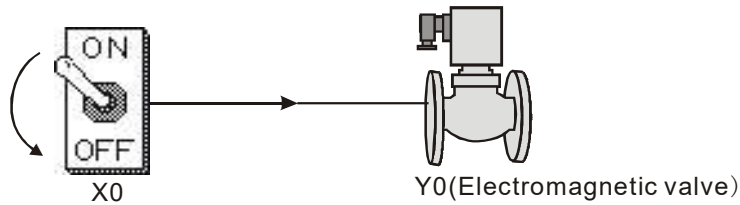| Device	Function
X0	Switch(ON→OFF)
M10	Creating a trigger pulse for one program scan cycle
Y0	Electromagnetic valve

Control Program:
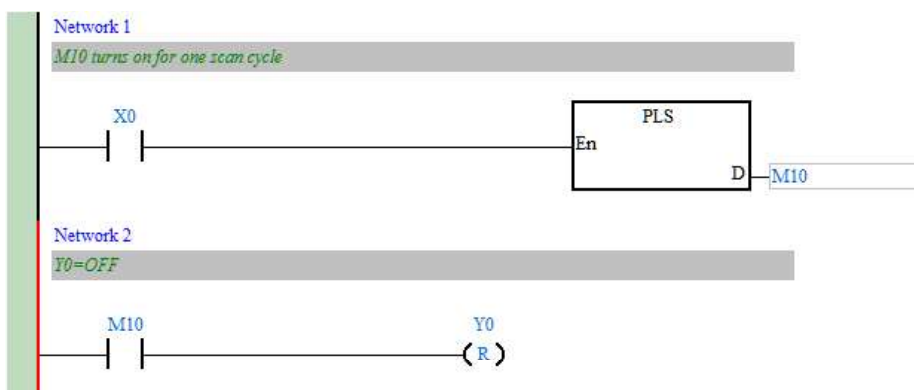
Program Description:

- When X0 is turned on (Falling-edge triggered), PLF instruction will be executed, and M10 will send a pulse for one program scan cycle.
- When M10 = ON, [RST Y0] instruction will be executed and Y0 will be OFF. In this case, the electromagnetic valve will be shut down.

1.5 Latching Control Circuit

Control Purpose:

- Controlling the running state of the ceiling-fan by pressing START and STOP.
- Checking if the ceiling-fan is running normally by pressing TEST.

Devices:

Device	Function
X0	Press START, X0 = ON.
X1	Press STO, X1 = ON.
X2	Press TEST, X2 = ON.
X3	Error signal
Y1	Ceiling-fan motor control signal

Control Program:
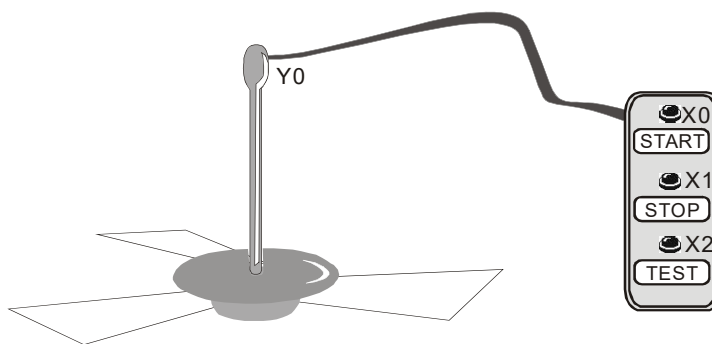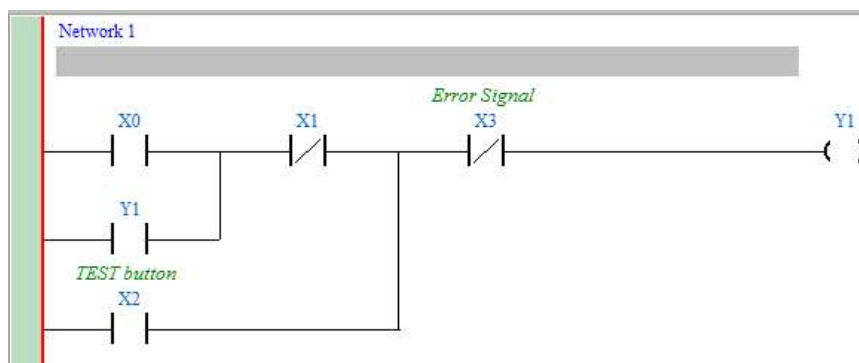

Program Description:

- Press START lightly and X0 = ON. The ceiling-fan will keep running if no error occurred (X3 = OFF). The action can be practiced by a latching circuit which takes output Y1 as one of the input condition to keep the fan running even if the START button is not pressed.
- When STOP is pressed, X1 = ON and Y1 = OFF. The ceiling-fan will stop running.
- If error occur (X3 = ON), Y1 will be OFF and the ceiling-fan will stop running.
- When TEST is pressed (X2 = ON), Y1 = ON. The ceiling-fan will start running if no error occurred (X3 = OFF). On the contrary, when TEST is released, the ceiling-fan will stop running. The testing function is performed by this process.

1.6 Interlock Control Circuit
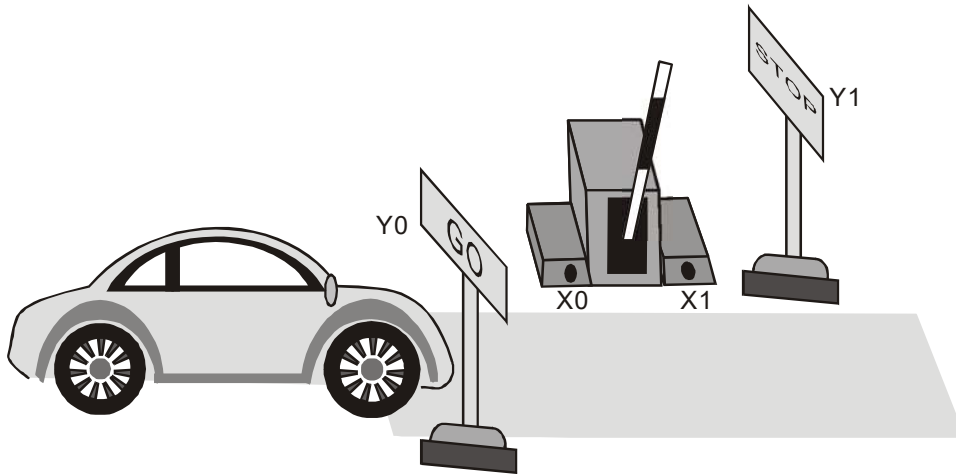
Control Purpose:

- The Entry/Exit of the parking lot is a single lane passage. By controlling the indicators, the program ensures that only one car can pass through the Entry/Exit so as to prevent car accident between entering and leaving cars

Devices:

Device	Function
X0	Car entering sensor. When a car passes through the sensor, X0 = ON.
X1	Car leaving sensor. When a car passes through the sensor, X1 = ON.
Y0	Entering car indicator（ON means "GO", OFF means "STOP"）
Y1	Leaving car indicator（ON means "GO", OFF means "STOP"）

Control Program
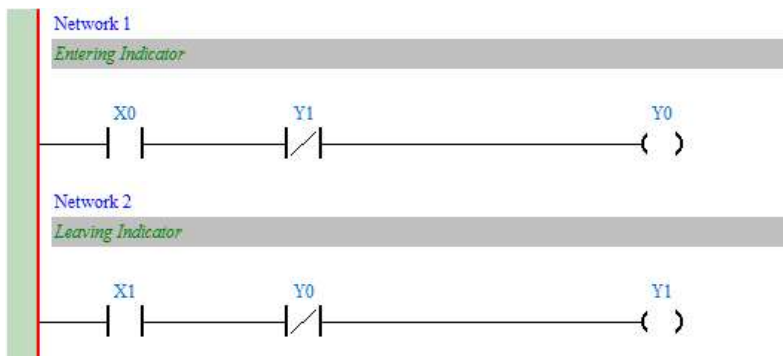
Program Description:

- In the parking lot, there are two indicators individually directing the entering and leaving cars. By the interlock control circuit, only one indicator will show "GO" signal and the car accident will thus be prevented.
- When an entering car draws near the vehicle control barrier, X0 will be ON and so will Y0. The entering car indicator will show "GO". At the same time, the leaving car indicator will show "STOP." Car entering is allowed but leaving is prohibited in this case.

● When a leaving car draws near the vehicle control barrier, X1 will be ON and so will Y1. The leaving car indicator will show "GO" and the entering car indicator will show "STOP."

1. Basic Program Design Examples

1.7 Automatic Parameter Initialization When Powered Up

Initialization button
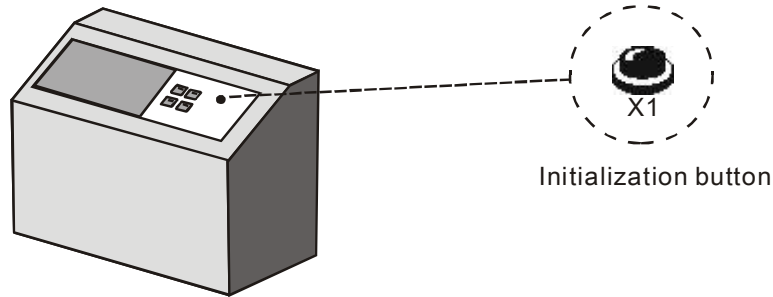
Control Purpose:

- When the machine is powered up, all the parameters will be initialized automatically and the machine will be ready. Users don't need to set the parameters manually.
- Users can initialize parameters by pressing Initialization button at any time when the machine is running.

Devices:

Device	Function
X1	Initialization button. X1 will be ON when pressed
M1002	Creating a pulse when PLC is powered on
M10	Creating a trigger pulse for one scan cycle
D1120	PLC COM2 communication protocol
D1121	PLC communication address
Y0	Parameter initialization completed signal

Control Program:
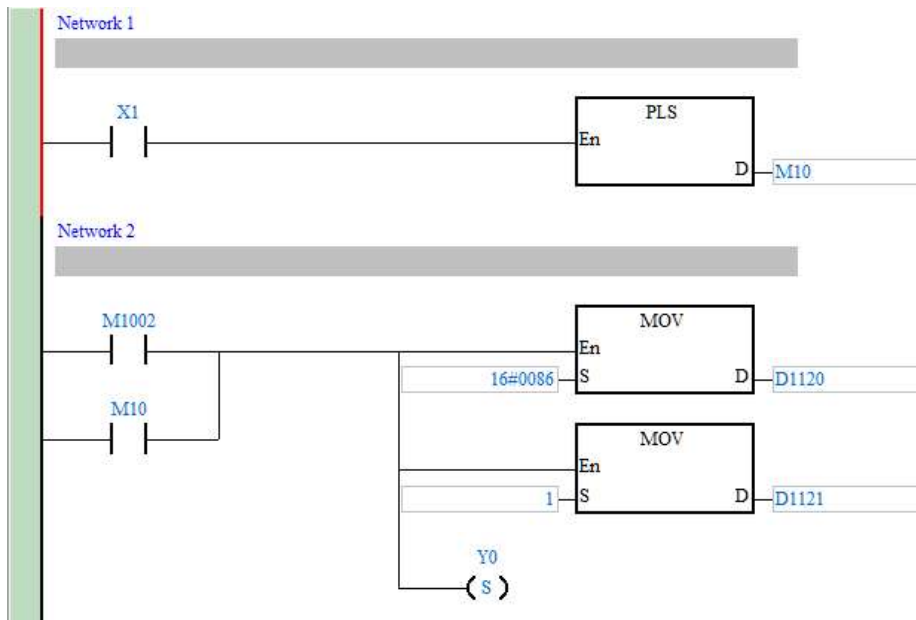
Program Description:

- When PLC begins running, M1002 will be ON once and create a pulse with the width of one scan cycle. This action will be executed for just once during the PLC running process and is generally used to initialize devices such as D (data register), C (counter) and S (step point)
- By pressing X1, users can initialize parameters at any time during the program running process, that is, setting PLC Slave ID as No. 1, COM2 communication format as 9600, 7, E, 1 and Y0 to be ON.

1. Basic Program Design Examples

1.8 Common Latched Circuit and SET/RST Instructions Application

Control Purpose:

- Turn on the switch, the light will be ON; turn off the switch, the light will be OFF.

Devices:

Device	Function
X0	Switch-on button. X0 will be ON when pressed
X1	Switch-off button. X1 will be ON when pressed
Y0	Indicator

Control Program:

- Common Latched Circuit
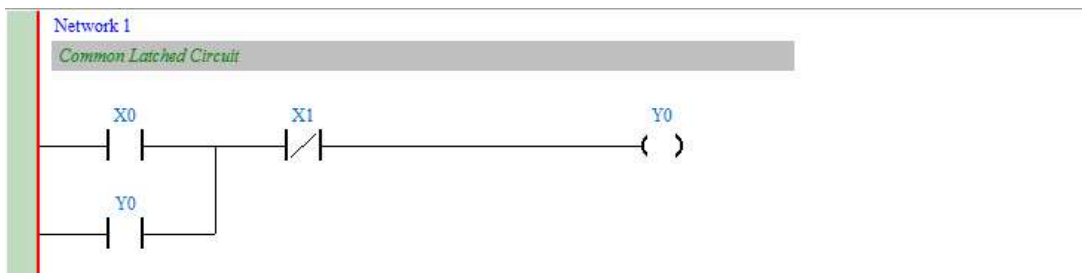
- Latched Circuit for SET/RST Instructions
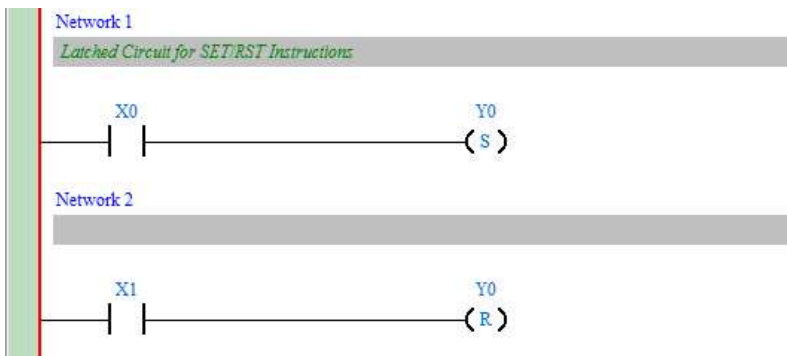
Program Description:

- In the above examples, when X0 goes from OFF to ON, Y0 will stay in ON state. When X1 goes from OFF to ON, Y1 will stay in OFF state
- When X0 and X1 are enabled at the same time, it will be "Stop First", that is, Y1 and the indicator will be OFF.

1.9 SET/RST - Latched and Unlatched Circuit
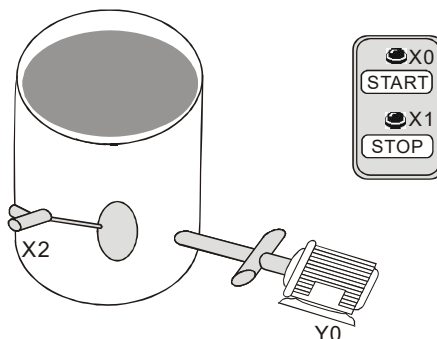
Control Purpose:

- Press START, the pump begins to pump out the water; press STOP or when the water is empty, the pump stops working.

Devices:

Device	Function
X0	START button. X0 will be ON when pressed
X1	STOP button. X1 will be ON when pressed
X2	Level detector. X2 will be ON if there is water in the container
M0	Trigger pulse for one scan cycle
Y0	Pump motor

Control Program:
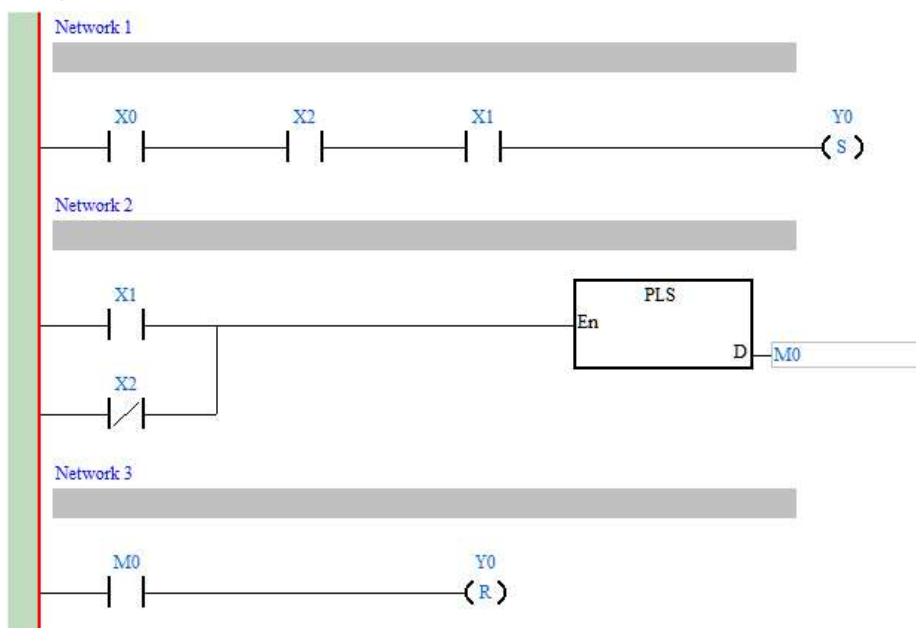
Program Description:

- X2 will be ON If there is water in the container. When START is pressed, X0 = ON, and SET instruction will be executed. Y0 will be set, and the pump motor begins pumping the water.
- There are two situations for stopping the motor. First, when STOP is pressed, X1 = ON. PLS instruction will be executed and M0 will be ON for one scan cycle. RST instruction will thus

be executed, and Y0 will be reset to stop pumping.　 Second, when the water in the container is empty, X2 will be OFF and PLS instruction will be executed to trigger M0 for resetting Y0. In this case, the pump motor will stop pumping as well.

1.10 Alternate Output Circuit (With Latched Function)

Control Purpose:

- Setting the light ON by pressing the switch for the 1st time, the 3rd time, 5th time, etc.; setting the light OFF by pressing the switch for the 2nd time, 4th time, 6th time, etc.
- Restoring the indicator to the state before power off when the device is powered up again.

Devices:

Device	Function
X1	Light switch. X1 will be ON when the button is pressed
M10	Trigger pulse for one scan cycle
M512	If X1 is pressed for odd number of times, M512 ON, M513 = OFF.
M513	If X1 is pressed for even number of times, M512 = OFF, M513 = ON.
Y1	Indicator

Control Program:
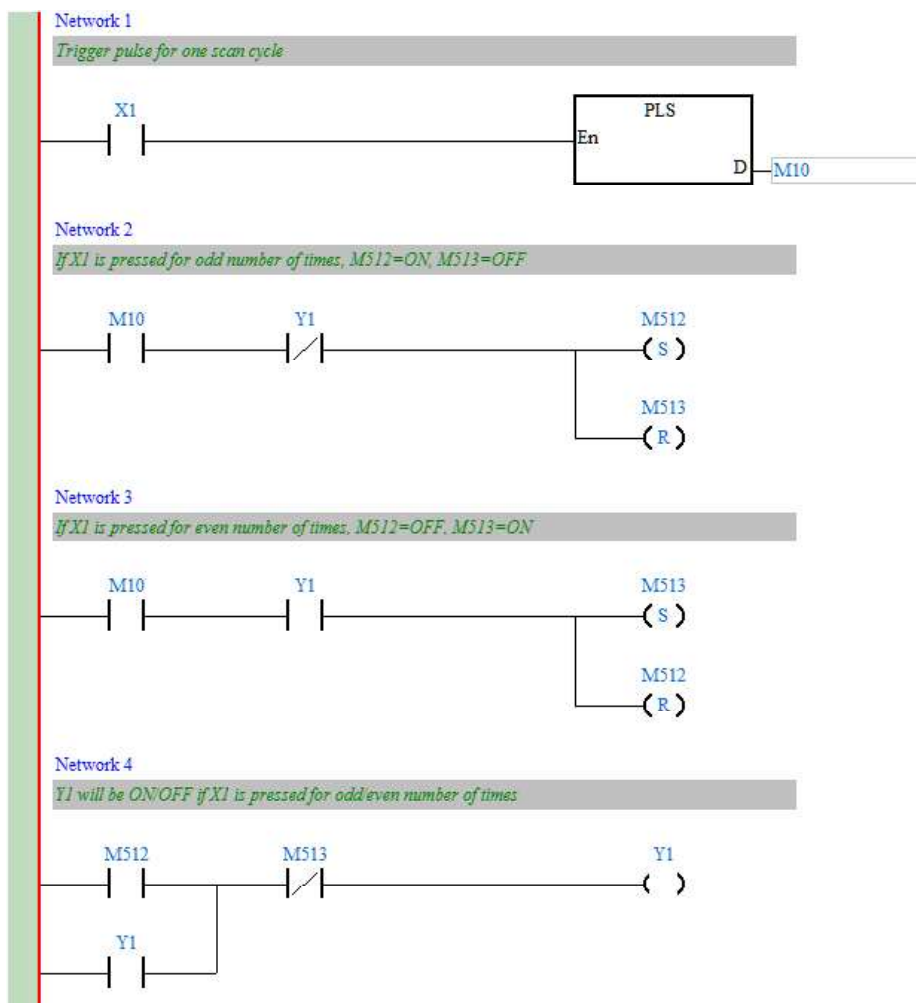
Program Description:

- Pressing X1 for the 1st time (or odd number of times):

When the switch X1 is pressed, X1 will be ON and the [PLS M10] instruction will be executed for triggering M10 to be ON for one scan cycle. In this case, M10 is ON and Y1 is OFF, SET and RST instructions at line 2 will thus be executed. On the contrary, SET and RST instructions at line 3 will not be executed due to the open loop of Y1. At line 4, coil Y1 is ON because of the results of Line 2: M512 is ON and M513 is OFF. When the 2nd scan cycle is started, SET/RST at both line 2 and line 3 will not be executed because M10 is OFF in this scan cycle. As a result, the light will be ON until the switch is pressed next time.

- Pressing X1 for the 2nd time (or even number of times):
  When the switch X1 is pressed again, X1 will be ON and M10 will be ON for one scan cycle. According to the result of pressing X1 for the first time, the state of Y1 has been ON. SET/RST instructions at line 3 will thus be executed. In addition, SET/RST instructions at line 2 won't be executed due to the open loop of Y1. In this case, M513 will be ON and M512 will be OFF. When the 2nd scan cycle is started, SET/RST at both line 2 and line 3 will not be executed because M10 is OFF in this scan cycle. As a result, the light will remain OFF until the switch is pressed next time.

- Alternate output(ON/OFF) function can also be performed by using API 66 ALT instruction

1.11 Conditional Control Circuit
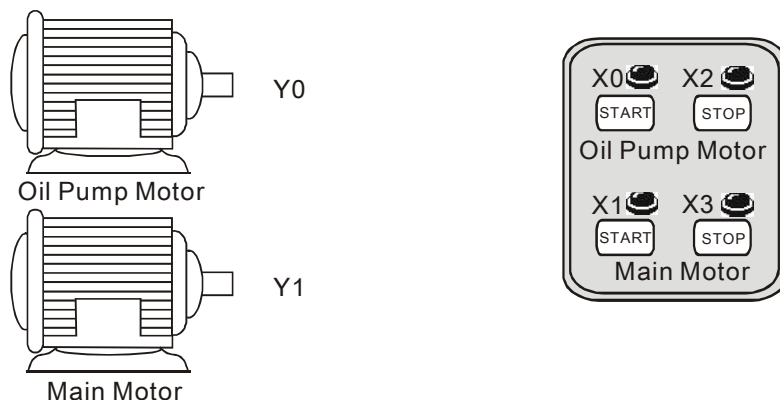
Control Purpose:

- Providing lube for the gear box before the lathe spindle starts to run which aims to ensure that the oil pump motor starts first and the main motor starts subsequently.

Devices:

Device	Content
X0	Oil pump START button. X0 will be ON when pressed.
X1	Main motor START button. X0 will be ON when pressed.
X2	Oil pump STOP button. X2 will be ON when pressed.
X3	Main motor STOP button. X3 will be ON when pressed.
Y0	Oil pump motor
Y1	Main motor

Control Program:
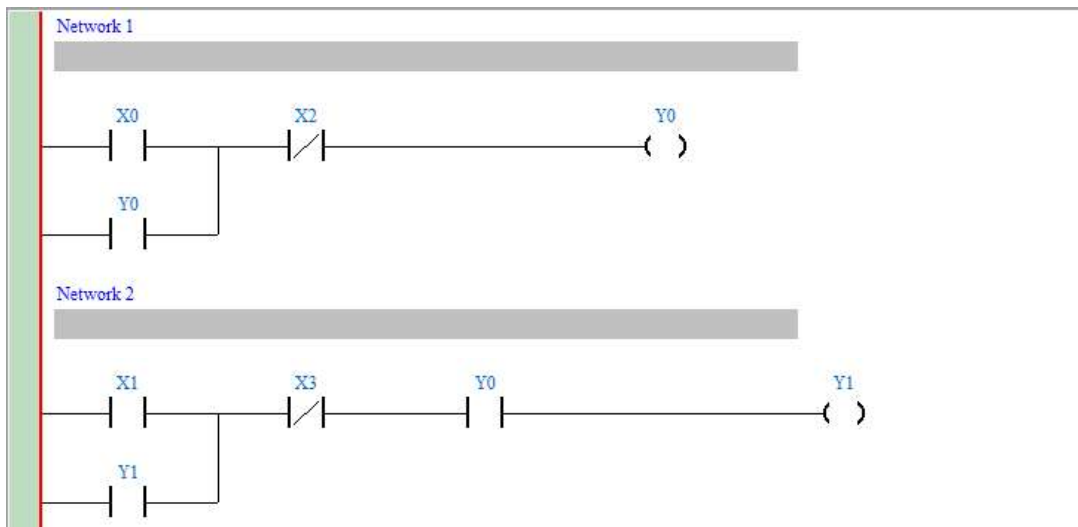
Program Description:

- This program is a typical application of the conditional control circuit. Y0 = ON when Oil Pump START button is pressed. Therefore, the oil pump will start to provide lube for the gear box of main motor(Y1)

- Under the precondition of the operating state of the Oil pump, the main motor (Y1) will be ON when the Main motor START button is pressed.
- During the operation of main motor (Y1), oil pump (Y0) needs to provide lube continuously.
- The oil pump will be stopped when Oil pump STOP button X2 is activated, and the main motor will be stopped when Main motor STOP button X3 is activated.

1.12 First-in Priority Circuit
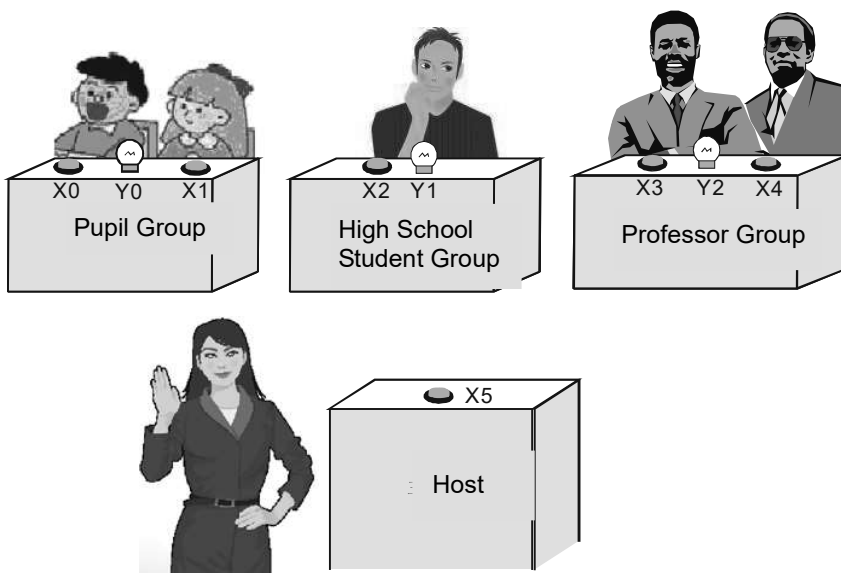
Control Purpose:

- There are 3 groups participating in the quiz game: pupils, high school students and professors. If they want to get the chance of answering the question from the host, they must press the answer button on their table first. Other groups' pressing will be invalid if any group gets the chance successfully

- There are 2 answer buttons for the pupil group and professor group and 1 answer button for the high school student group. In order to give preferential treatment to the pupil group, Y0 will be ON if any one of X0 or X1 is pressed. However, in order to limit the professor group, Y2 will be ON when X3 and X4 are pressed at the same time. For the high school student group, Y1 will be ON when X2 is pressed.

- If the host presses X5 (Reset button), Y0, Y1 and Y2 will be OFF.

Devices:

Device	Function
X0	Answer button for pupil group
X1	Answer button for pupil group
X2	Answer button for high school student group
X3	Answer button for professor group
X4	Answer button for professor group
X5	Reset button for host
Y0	Indicator for pupil group
Y1	Indicator for high school student group
Y2	Indicator for professor group

Control Program:

1. Basic Program Design Examples
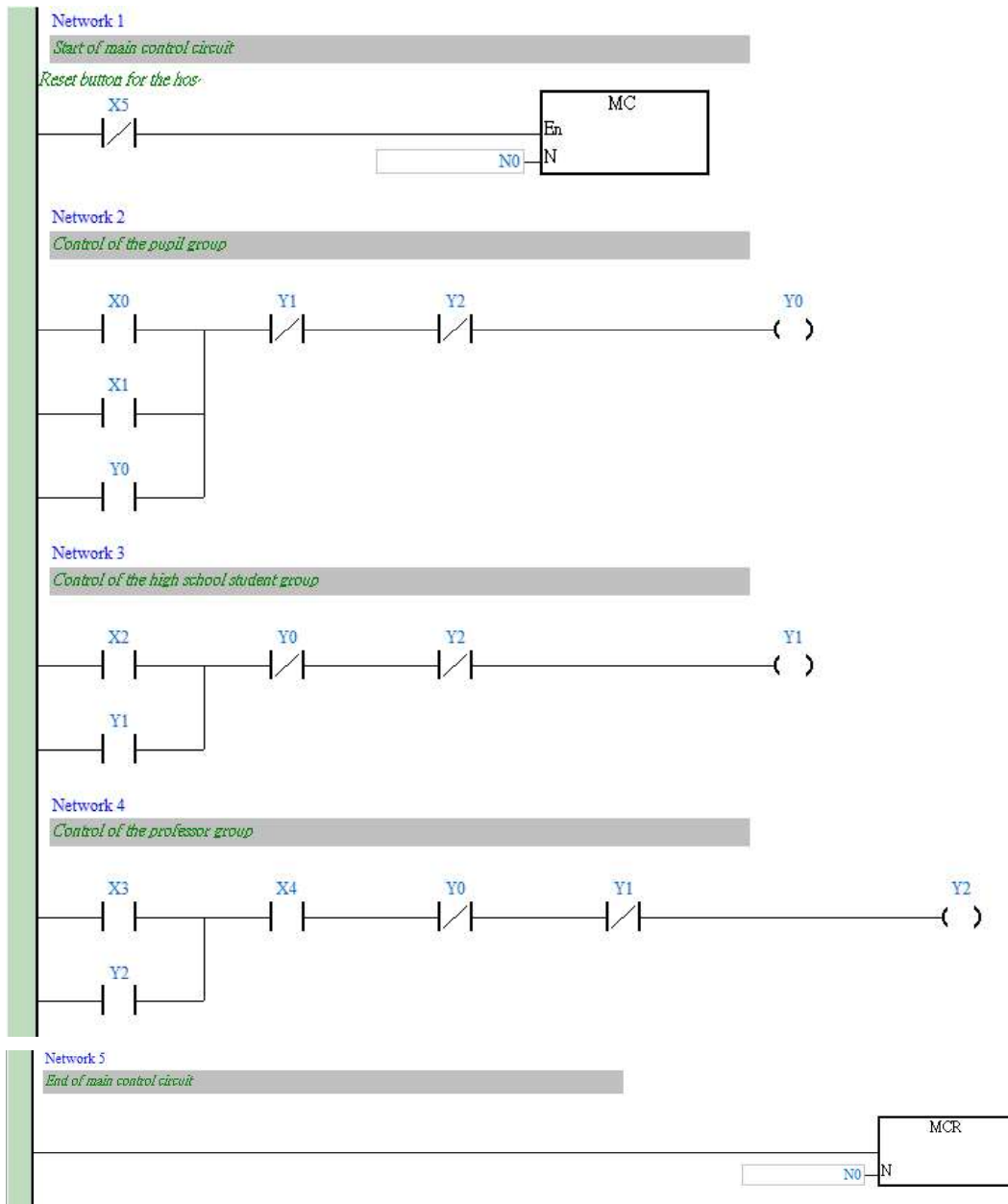
Program Description:

- If the host didn't press the reset button X5, [MC N0] instruction will be executed and the program between MC and MCR will also be executed normally.
- The answer buttons are connected in parallel connection for the pupil group, and in series connection for the professor group. For the high school student group, there is only one answer button. If one group presses the answer button successfully, its indicator will form a latching circuit, that is, the indicator will be ON even the button is released.
- Through the interlock circuit, any other button pressings will be invalid as long as one indicator is ON
- When the host presses the reset button, X5 = ON. [MC N0] instruction and the program between MC and MCR will not be executed. Y0, Y1 and Y2 will be out of power, and all the indicators for the 3 groups will be OFF. When the host releases the button, X5 = OFF. The

program between MC and MCR will be executed normally again, and the new round will begin as well.

1. Basic Program Design Examples

1.13 Last-in Priority Circuit

Control Purpose:

- There are 4 buttons corresponding to 4 indicators. The program is to turn on the indicators corresponding to pressed buttons and to turn off the previous ON indicators.

Devices:

Device	Function
X0	Button 1. X0 will go from OFF to ON when pressed
X1	Button 2. X1 will go from OFF to ON when pressed
X2	Button 3. X2 will go from OFF to ON when pressed
X3	Button 4. X3 will go from OFF to ON when pressed
Y0	Indicator 1
Y1	Indicator 2
Y2	Indicator 3
Y3	Indicator 4

Control Program:
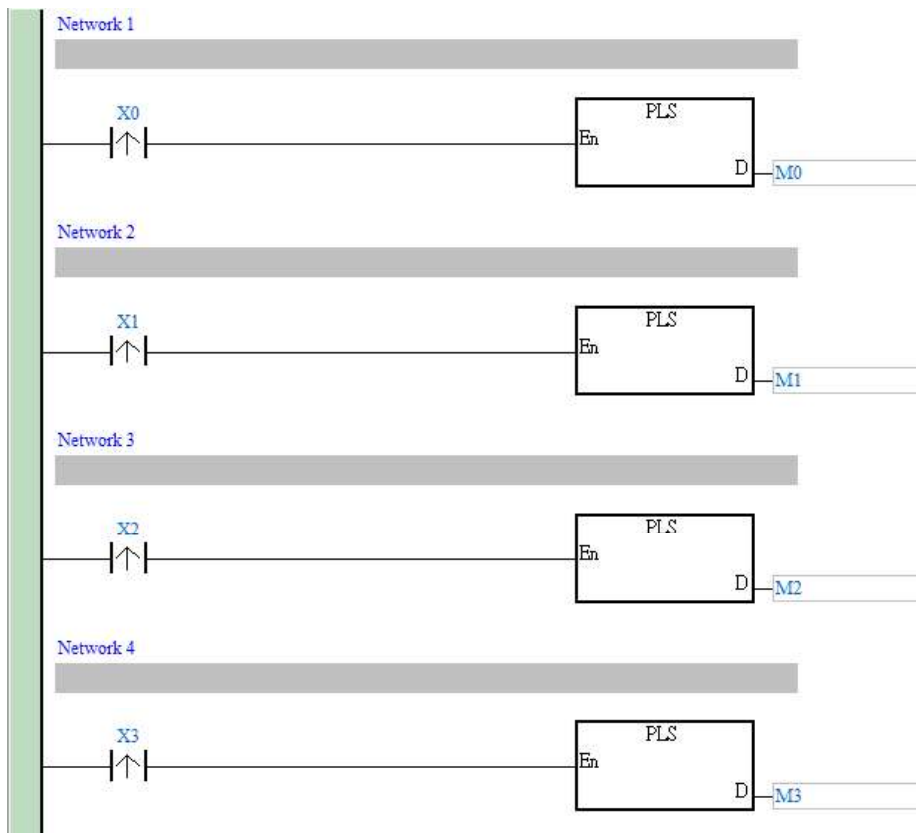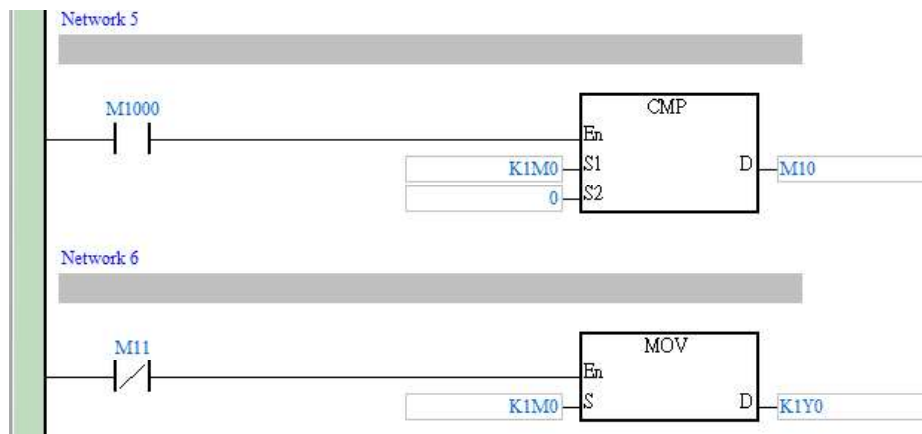
Program Description:

- When a button is pressed, the corresponding device X will go from OFF to ON. In this scan cycle, PLS instruction is executed, and the corresponding internal relay M is enabled as well. CMP instruction will be executed and the compared result is K1M0>0 which makes M10 ON but M11 OFF. [MOV K1M0 K1Y0] instruction will then be executed and sent out the state of M to its corresponding output Y.   At the same time, the previous ON indicator(Y) will be turned off.

- When it comes to the 2nd scan cycle, PLS instructions will not be executed and the value of M0~M3 will be 0. Therefore, the CMP instruction will be executed and set M11 to be ON (K1M0 = 0). [MOV K1M0 K1Y0] instruction will not be executed, and the 0 state of device M will not be sent out, either. In this case, Output Y will remain its original state until any other button is pressed next time.

1.14 Entry/Exit Control of the Underground Car Park
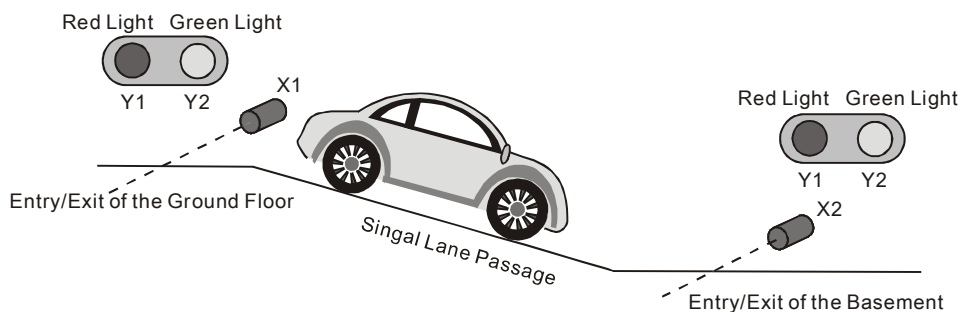
Control Purpose:

- The entry/exit of the underground car park is a single lane passage which needs the traffic lights to control the cars. Red lights prohibit cars entering or leaving while green lights allow cars to enter or leave.

- When a car enters the passage from the entry of the ground floor, the red lights both on the ground floor and the basement will be ON, and the green lights will be OFF. Any car entering or leaving is prohibited during the process till the car passes through the passage completely. When the passage is clear, the green lights will be ON again and allow other cars entering from the ground floor or the basement.

- Similarly, when a car leaves the basement and enters the passage, any other car entering or leaving is prohibited till the car passes from the passage to the ground completely.

- When PLC runs, the initial setting of traffic lights will be green lights ON and red lights OFF.

Devices:

Device	Function
X1	Photoelectric switch at the ground floor entry/exit. X1 will be ON when a car passes.
X2	Photoelectric switch at the basement entry/exit. X2 will be ON when a car passes.
M1	M1 will be ON for one scan cycle when a car from the ground floor passes X1.
M2	M2 will be ON for one scan cycle when a car from the basement passes X1.
M3	M3 will be ON for one scan cycle when a car from the basement passes X2.
M4	M4 will be ON for one scan cycle when a car from the ground floor passes X2
M20	M20 = ON during the process of a car entering the passage from the ground floor.
M30	M30 = ON during the process of a car entering the passage from the basement.
Y1	Red lights at the entry/exit of the ground floor and the basement
Y2	Green lights at the entry/exit of the ground floor and the basement

Control Program:

Network 1

The green lights will be ON and the red lights will be OFF when the program is started

```
    M1002                              Y1
  ──┤ ├──────────────────┬──────────(R)

                                       Y2
                         └──────────(S)
```

Network 2

M1 will be ON for one scan cycle when a car from the ground floor passes X1.

```
     X1                        ┌──────────────┐
  ──┤ ├─────────────────────En│     PLS      │
                               │            D │─── M1
                               └──────────────┘
```

Network 3

M2 will be ON for one scan cycle when a car from the basement passes X1.

```
     X1                        ┌──────────────┐
  ──┤ ├─────────────────────En│     PLF      │
                               │            D │─── M2
                               └──────────────┘
```

Network 4

M20=ON during the process of a car entering the passage from the ground floor.

```
     X1                            M20
  ──┤ ├────────────────────────(S)
```

Network 5

M3 will be ON for one scan cycle when a car from the basement passes X2.

```
     X2                        ┌──────────────┐
  ──┤ ├─────────────────────En│     PLS      │
                               │            D │─── M3
                               └──────────────┘
```

Network 6

M4 will be ON for one scan cycle when a car from the ground floor passes X2.

```
     X2                        ┌──────────────┐
  ──┤ ├─────────────────────En│     PLF      │
                               │            D │─── M4
                               └──────────────┘
```

Network 7

M30=ON during the process of a car entering the passage from the basement.

```
     X2                            M30
  ──┤ ├────────────────────────(S)
```

Network 8

When a car runs in the passage, the red lights will be ON and green lights will be OFF.

```
     M1        M30                 Y1
  ──┤ ├──────┤/├──────┬────────(S)

     M3        M20     │            Y2
  ──┤ ├──────┤/├──────┘────────(R)
```

Network 9

When a car leaves the passage, the red lights will be OFF and green lights will be ON.

```
      M4              M20                              Y1
     ─┤ ├──────────────┤ ├──────────┬──────────────( R )
                                     │
      M2              M30            │                Y2
     ─┤ ├──────────────┤ ├──────────┘──────────────( S )
```

Network 10

When a car leaves the passage, M20 and M30 will be reseted.

```
      M4              M20                             M20
     ─┤ ├──────────────┤ ├──────────┬──────────────( R )
                                     │
      M2              M30            │               M30
     ─┤ ├──────────────┤ ├──────────┘──────────────( R )
```

Program Description:

- The ground floor and the basement share the same red light signal Y1 and green light signal Y2.

- The key of the program is to identify that the car is entering or leaving the passage at the ground floor entry/exit when M1 is ON to activate Y1 because [PLS M1] will be executed in both entering and leaving conditions. Therefore, the confirming signal M20 is required for confirming that the car is entering the passage from the ground floor.

- Also, it needs to identify that the car is entering or leaving the passage at the basement entry/exit when M3 is ON because [PLS M3] will be executed in both entering and leaving conditions. Therefore, the confirming signal M30 is required for confirming that the car is entering the passage from the basement.

1.15 Forward/Reverse Control for the Three-Phase Asynchronous Motor
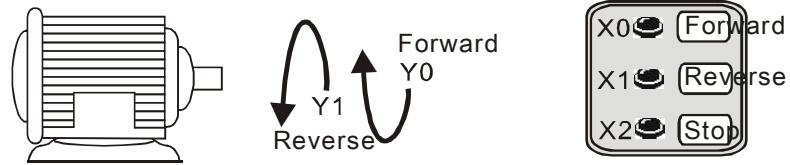
Control Purpose:

- Controlling the motor to run forward when Forward is pressed, run reverse when Reverse is pressed and stop when Stop is pressed.

Devices:

Device	Function
X0	Forward button of the motor. X0 will be ON when pressed
X1	Reverse button of the motor. X1 will be ON when pressed
X2	Stop button. X2 will be ON when pressed.
T1	1 sec timer
T2	1 sec timer
Y0	Forward contactor
Y1	Reverse contactor

1. Basic Program Design Examples

Control Program:
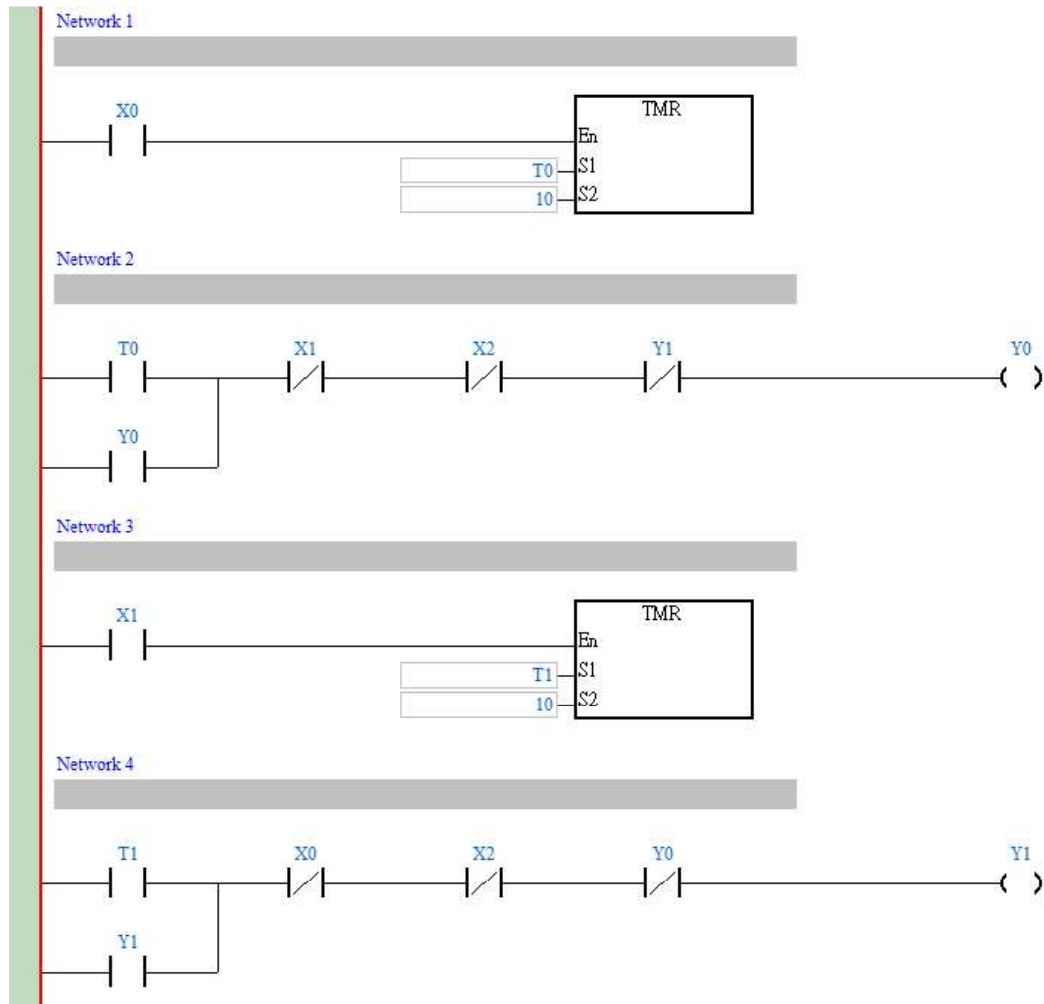
Program Description:

- X0 = ON when Forward is pressed. After 1 second, contactor Y0 will be enabled, and the motor begins to run forward. On the other hand, X1 = ON when Reverse is pressed. After 1 second, contactor Y1 will be enabled, and the motor begins to run reverse. Besides, Y0 and Y1 will be disabled and the motor will stop running when X2 is pressed.
- The two timers in the program are used to avoid the interphase short-circuit when the motor changes its running mode. The short circuit may occur if another contactor is enabled instantly while the electric arc in the disabled contactor still exists.

1.16 Selective Execution of Programs

Control Purpose:

- There are pigments of 3 colors. By controlling different switches, operators can fill the cans with corresponding pigments.

Devices:

Device	Function
X0	Filling Start switch. X0 will be ON when turned on.
X1	Yellow control switch. X1 will be ON when turned on.
X2	Blue control switch. Turn it on, X2 will be On
X3	Green (mixing of yellow and blue) control switch. X3 will be ON when turned on
Y0	Yellow control valve
Y1	Blue control valve

Control Program

Network 1
Filling yellow pigment

Network 2
Yellow control valve

Network 3

Network 4
Filling blue pigment

Network 5
Blue control valve

Network 6

Program Description:

- The master switch of filling control needs to be turned on (X0 = ON) before filling started. When both yellow and blue are filled at the same time, it will become green.
- When the switch of filling yellow pigment is turned on, X1 = ON. The first MC ~ MCR instruction will be executed. Y0 = ON, and the system begins to fill the yellow color.
- When the switch of filling blue pigment is turned on, X2 = ON. The second MC ~ MCR instruction will be executed. Y1 = ON, and the system begins to fill the blue color.
- When the switch of filling green pigment is turned on, X3 = ON, both of the two MC ~ MCR instructions will be executed, and the system begins to fill the green color.

1.17 MC/MCR - Manual/Auto Control

Conveyor A
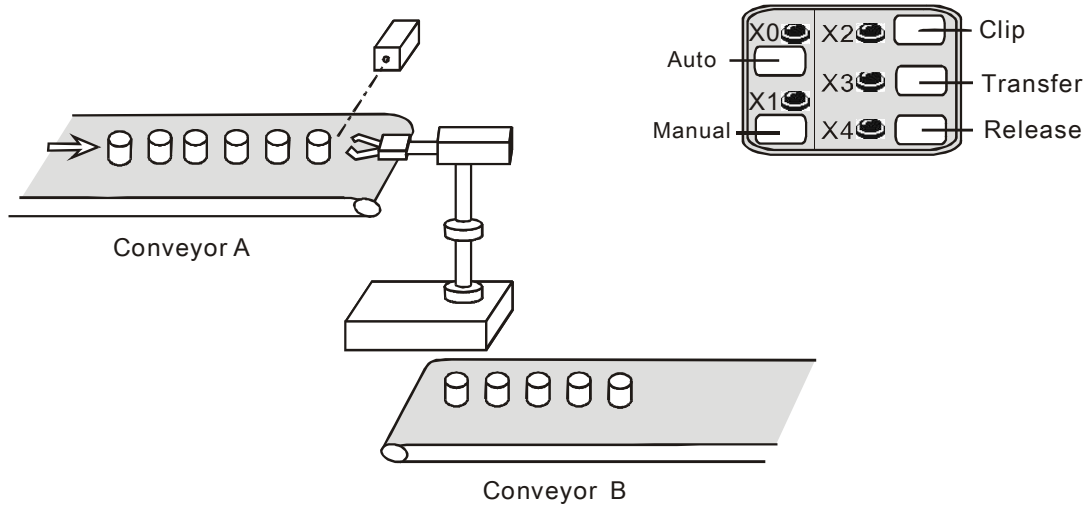
Conveyor B

Control Purpose:

- When the button Manual is pressed, the robotic arm will begin to execute the manual control process: pressing Clip to clip the product from conveyor A, pressing Transfer to move the product to the conveyor B, and pressing Release to release the product and send it away by conveyor B.

- When the button Auto is pressed, the robotic arm will begin to execute the auto control process once: clip product (keep holding this product before releasing) → transfer product (the action takes 2 sec) → release the product. Auto control process can be performed one more time if the button Auto is pressed again.

- Manual control process and auto control process are interlocked.

Devices:

Device	Function
X0	Auto button. X0 goes from OFF to ON when pressed.
X1	Manual button. X1 goes from OFF to ON when pressed
X2	Clip button. X2 will be ON when pressed.
X3	Transfer button. X3 will be ON when pressed.
X4	Release button. X4 will be ON when pressed.
M0~M2	Auto control process
M3~M5	Manual control process
M10	Auto control selection
M11	Manual control selection
T0	2 sec timer
Y0	Product clipping/releasing. Y0 is ON/OFF when clipping/releasing the product.
Y1	Product transferring
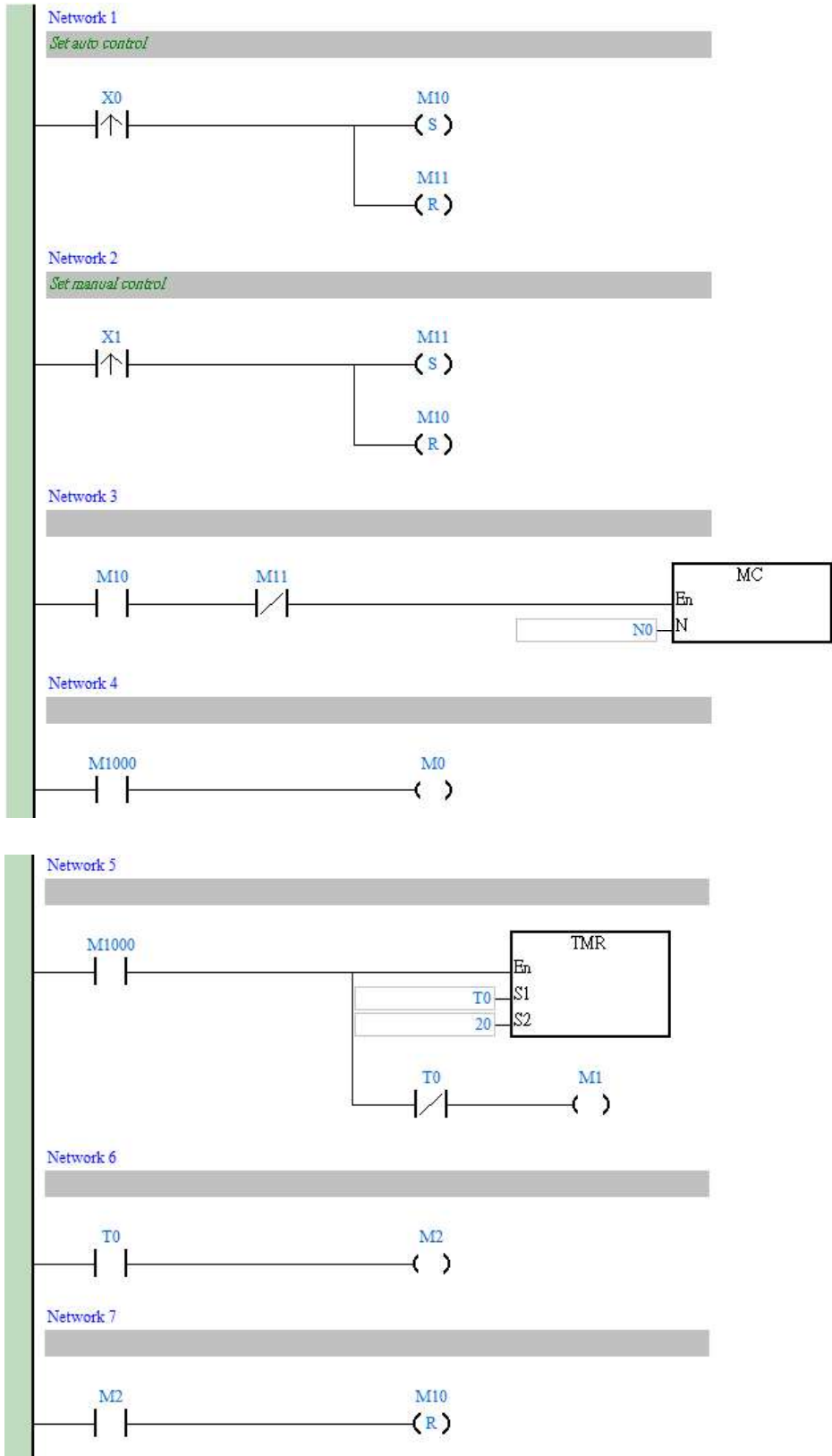
Control Program:

Network 8

```
                                                              ┌──────────┐
                                                              │   MCR    │
                                                              │          │
─────────────────────────────────────────────────────────────┤N0 ─┤N     │
                                                              └──────────┘
```

Network 9
Manual control process

```
     M11        M10                              ┌──────────┐
   ──┤ ├──────┤/├─────────────────────────────── │    MC    │
                                                  │En        │
                                          ┌──────┤N0 ─┤N     │
                                          └──────└──────────┘
```

Network 10

```
     X2                       M3
   ──┤ ├──────────────────────( )
```

Network 11

```
     X3                       M4
   ──┤ ├──────────────────────( )
```

Network 12

```
     X4                       M5
   ──┤ ├──────────────────────( )
```

Network 13

```
                                                              ┌──────────┐
                                                              │   MCR    │
                                                              │          │
─────────────────────────────────────────────────────────────┤N0 ─┤N     │
                                                              └──────────┘
```

Network 14
Product clipping

```
     M0                       Y0
   ──┤ ├───────┬──────────────( S )
     M3        │
   ──┤ ├───────┘
```

Network 15
Product Transferring

```
     M1                       Y1
   ──┤ ├───────┬──────────────( )
     M4        │
   ──┤ ├───────┘
```

Network 16
Product releasing

```
     M2                       Y0
   ──┤ ├───────┬──────────────( R )
     M5        │
   ──┤ ├───────┘
```
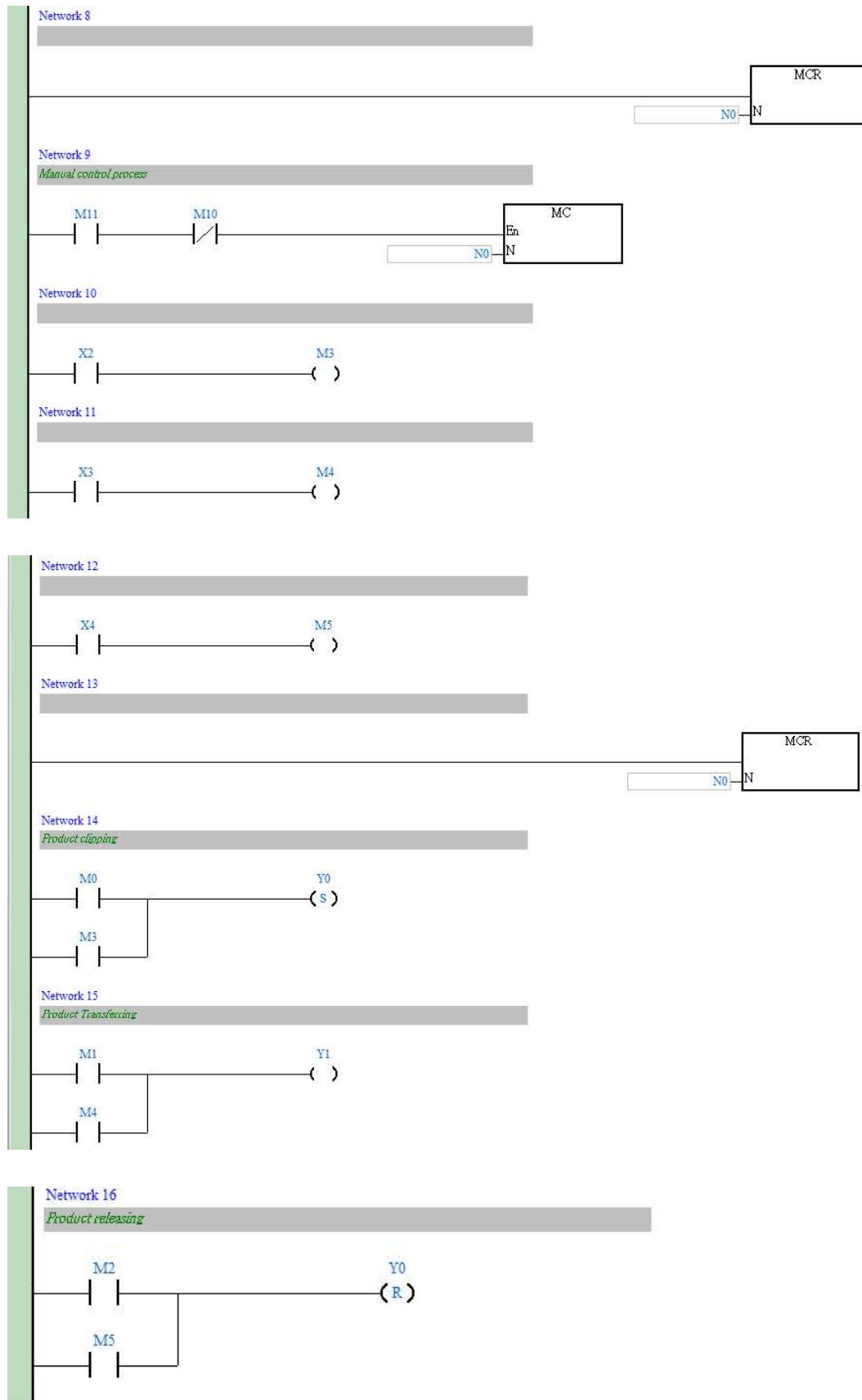
Program Description:

- When X0 goes from OFF to ON, the auto control process will be executed once, whereas when X1 goes from OFF to ON, the manual control process will be executed. In the manual control, the clipping and releasing actions require pressing the corresponding button for one time. However, the button Transfer should be pressed for 2 sec during the moving process till the product is moved to Conveyor B.

- X0 and X1 are interlocked. When the auto control process is executed, the robotic arm will perform the following actions: first "clipping", then "transferring" (for 2 sec.), and "releasing." When the manual control process is executed, the controlling actions will be performed by 3 corresponding buttons: clipping product by turning on Y0, transferring product by pressing Y1 and releasing product by turning off Y0.