

# UNIT 11 Multi-Position Control

## OBJECTIVE

After completing this unit, you should be able to:

1. Explain the operation of multi-position control.
2. Write PLC programs to control the slide table for multi-position operation.

## DISCUSSION

### PLC Instructions Related to Table

This lab uses a table to save the data of three position settings before driving the slide table to run. The position data in the table is then removed when you want to drive the slide table to each of the specified positions. The following describes two table instructions: Add To Table (AD\_T\_TBL) and First-In-First-Out (FIFO).

### Add To Table Instruction (AD\_T\_TBL)

The AD\_T\_TBL instruction shown in Fig. 11-1 adds word values (DATA) to a table (TBL). The first value of the table is the maximum table length (TL). The second value is the entry count (EC), which specifies the number of entries in the table. New data are added to the table after the last entry. Each time new data are added to the table, the entry count is incremented. A table can have up to 100 data entries.

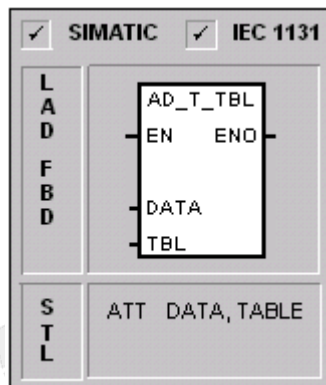


Fig. 11-1 AD\_T\_TBL instruction

An example program used to describe how to add new data to a table is shown in Fig. 11-2. On the first scan (SM0.1=ON), the table length (or maximum number of entries) stored in VW200 is set to 6. When the input I0.0 is activated, the value in the location VW100 will be written to the table.

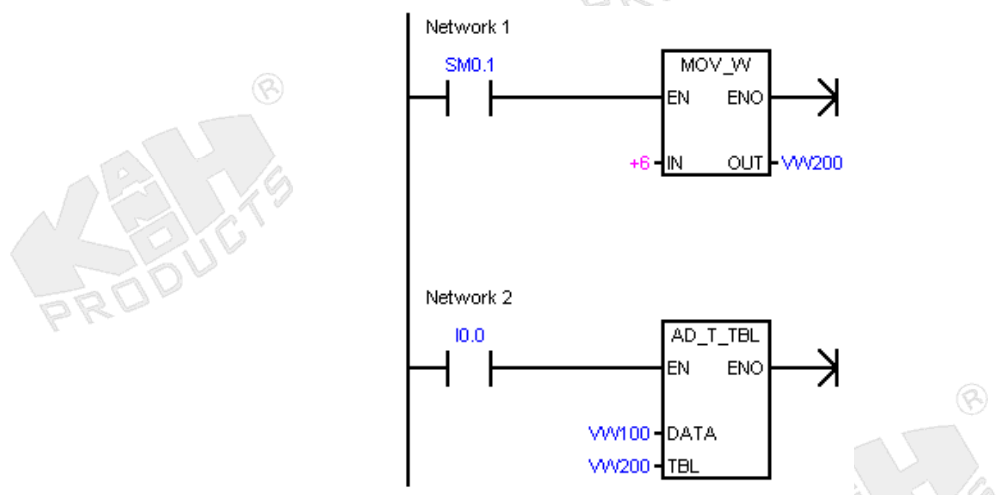


Fig. 11-2 Example program for AD\_T\_TBL instruction

The execution of the AD\_T\_TBL instruction is illustrated in Fig. 11-3. Since table length or maximum number of entries (V200) is specified to 6, therefore 6 data words can be added to the table in the memory locations VW204 to VW214. Before the execution of the AD\_T\_TBL instruction, there are 2 data words in the table, so the entry count in VW202 is 2. After the execution of the AD\_T\_TBL instruction, the data in VW100 is added to the table and stored in VW208 and the current count of entries (VW202) is incremented to 3.

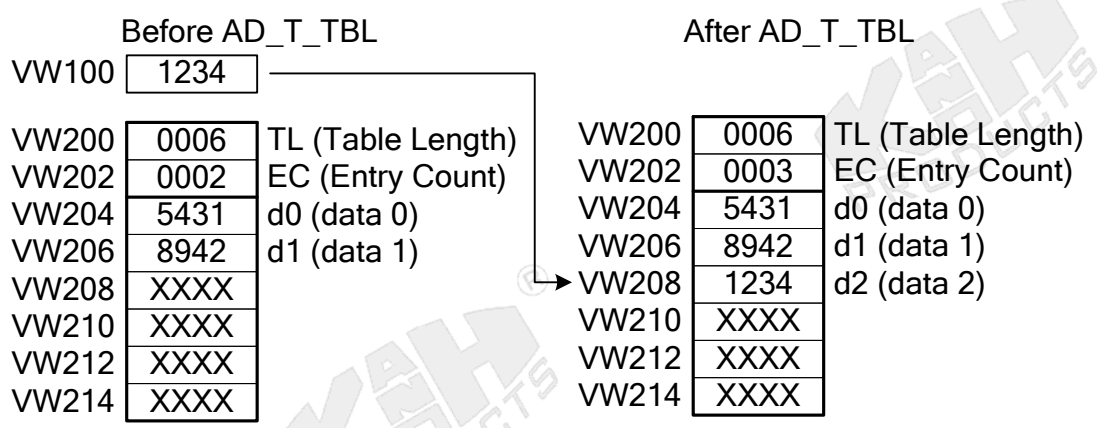


Fig. 11-3 The execution of AD\_T\_TBL instruction

### First-In-First-Out Instruction (FIFO)

First-In-First-Out (FIFO) instruction is usually used to remove data from a table. The FIFO instruction shown in Fig. 11-4 moves the first (or oldest) entry in a table to the output memory address by removing the first entry from the table (TBL) to the location specified by DATA. All other entries of the table are shifted up one location. The entry count in the table is decremented for each instruction execution.

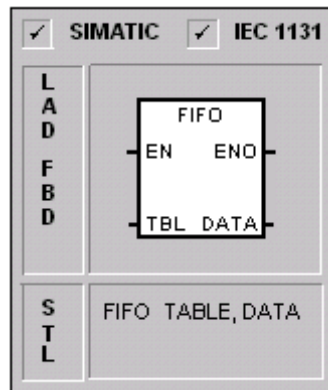


Fig. 11-4 FIFO instruction

An example program used to describe how to remove data from a table is shown in Fig. 11-5. In this example, when the input I4.1 is on, the first entry in the table will be removed from VW204 to VW400.

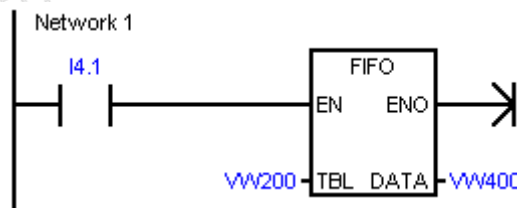


Fig. 11-5 Example program for FIFO instruction

The execution of the FIFO instruction is illustrated in Fig. 11-6. After execution of the FIFO instruction, the first data in the location V0W204 is removed and saved into the memory location VW400, and the current count of entries is decremented to 2. It should be noted that the value 0 is in other locations VW208 to VW214 of the table.

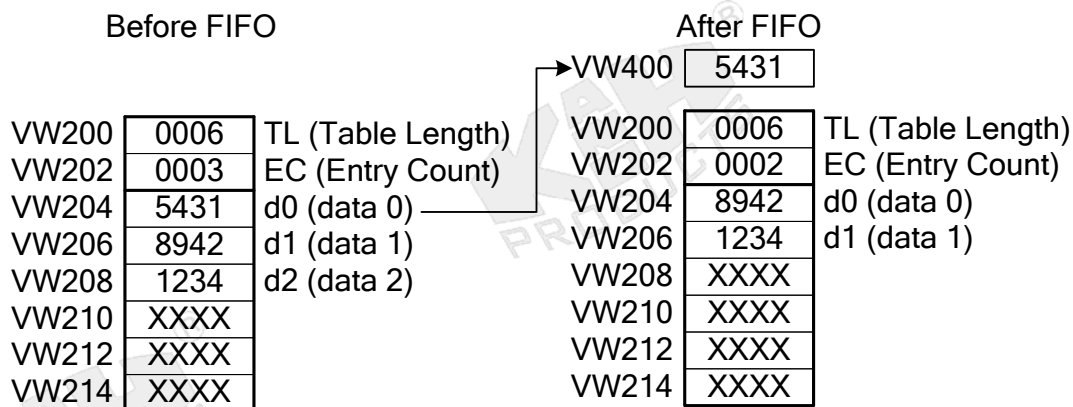


Fig. 11-6 The execution of FIFO instruction

### Functional Description

This lab uses thumbwheel switches and the Save switch to preset and save three desired positions sequentially, and control the slide table to implement the positioning tasks one by one.

### Operating Sequence

The sequence of operations for the entire control system is as follows:

1. The first position setting - Set the first position between 01 and 15 with thumbwheels and push the Start/Save switch (I1.5) to store the first position. The 7-segment display will display the setting value and blink 5 times, followed by "01" to indicate that the first position has been set. If the thumbwheel entry is invalid, the 7-segment display will have no response.
2. The second position setting - Set the second position between 01 and 15 with thumbwheels and push the Start/Save switch (I1.5) to store the second position. The 7-segment display will display the setting value and blink 5 times, followed by "02" to indicate that the second position has been set. If the thumbwheel entry is invalid, the 7-segment display will have no response.
3. The third position setting - Set the third position between 01 and 15 with thumbwheels and push the Start/Save switch (I1.5) to store the third position. The 7-segment display will display the setting value and blink 5 times, followed by "03" to indicate that the third position has been set. If the thumbwheel entry is invalid, the 7-segment display will have no response.

- The slide table will move to the first position, stay 2 seconds and return to the initial position. Then the slide table moves to the second position, stays 2 seconds, and then returns to the initial position. Finally the slide table moves to the third position, stays 2 seconds, and then returns to the initial position.

## Electrical Connections

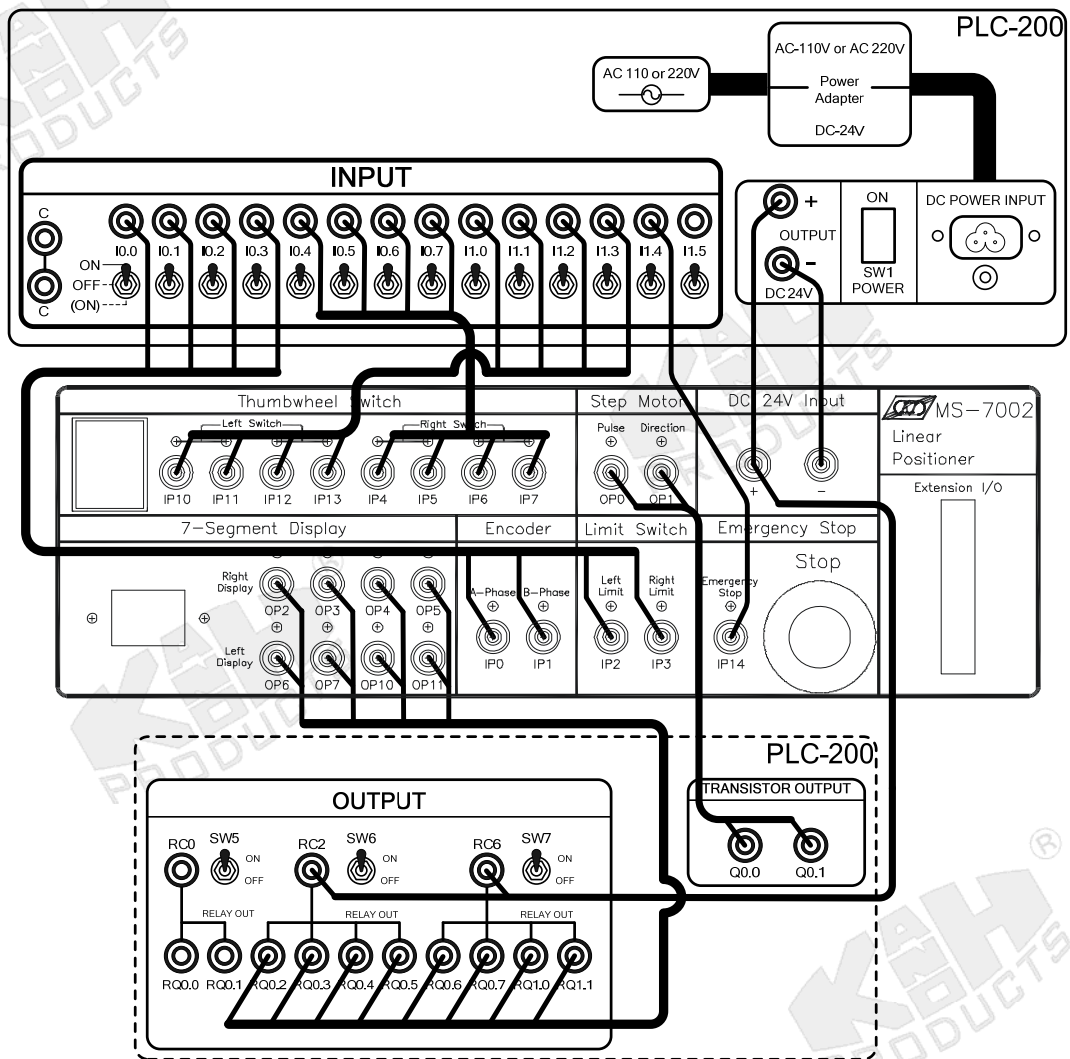


Fig. 11-7 Wiring diagram using safety connecting wires

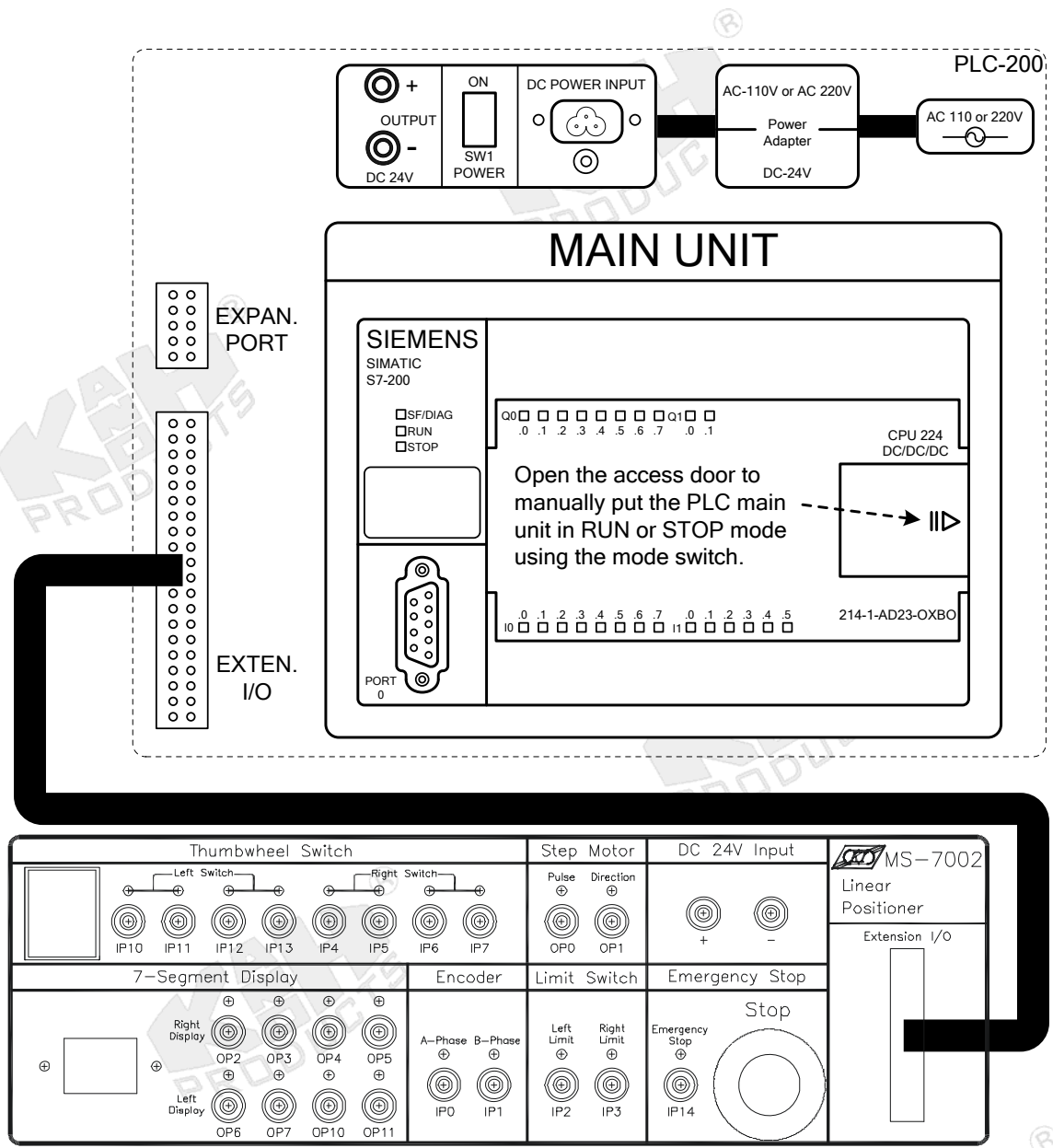


Fig. 11-8 Wiring diagram using flat cable

## PLC I/O Connections

Table 11-1 PLC I/O Connections

Input	Description	Output	Description
I0.0	Encoder A-phase	Q0.0	Pulse output
I0.1	Encoder B-phase	Q0.1	Step motor direction
I0.2	Left limit sensor	Q0.2	Bit 0 of units display
I0.3	Right limit sensor	Q0.3	Bit 1 of units display
I0.4	Bit 0 of units thumbwheel	Q0.4	Bit 2 of units display
I0.5	Bit 1 of units thumbwheel	Q0.5	Bit 3 of units display
I0.6	Bit 2 of units thumbwheel	Q0.6	Bit 0 of tens display
I0.7	Bit 3 of units thumbwheel	Q0.7	Bit 1 of tens display
I1.0	Bit 0 of tens thumbwheel	Q1.0	Bit 2 of tens display
I1.1	Bit 1 of tens thumbwheel	Q1.1	Bit 3 of tens display
I1.2	Bit 2 of tens thumbwheel		
I1.3	Bit 3 of tens thumbwheel		
I1.4	Stop (Emergency Stop)		
I1.5	Start/Save		

## Flow Chart

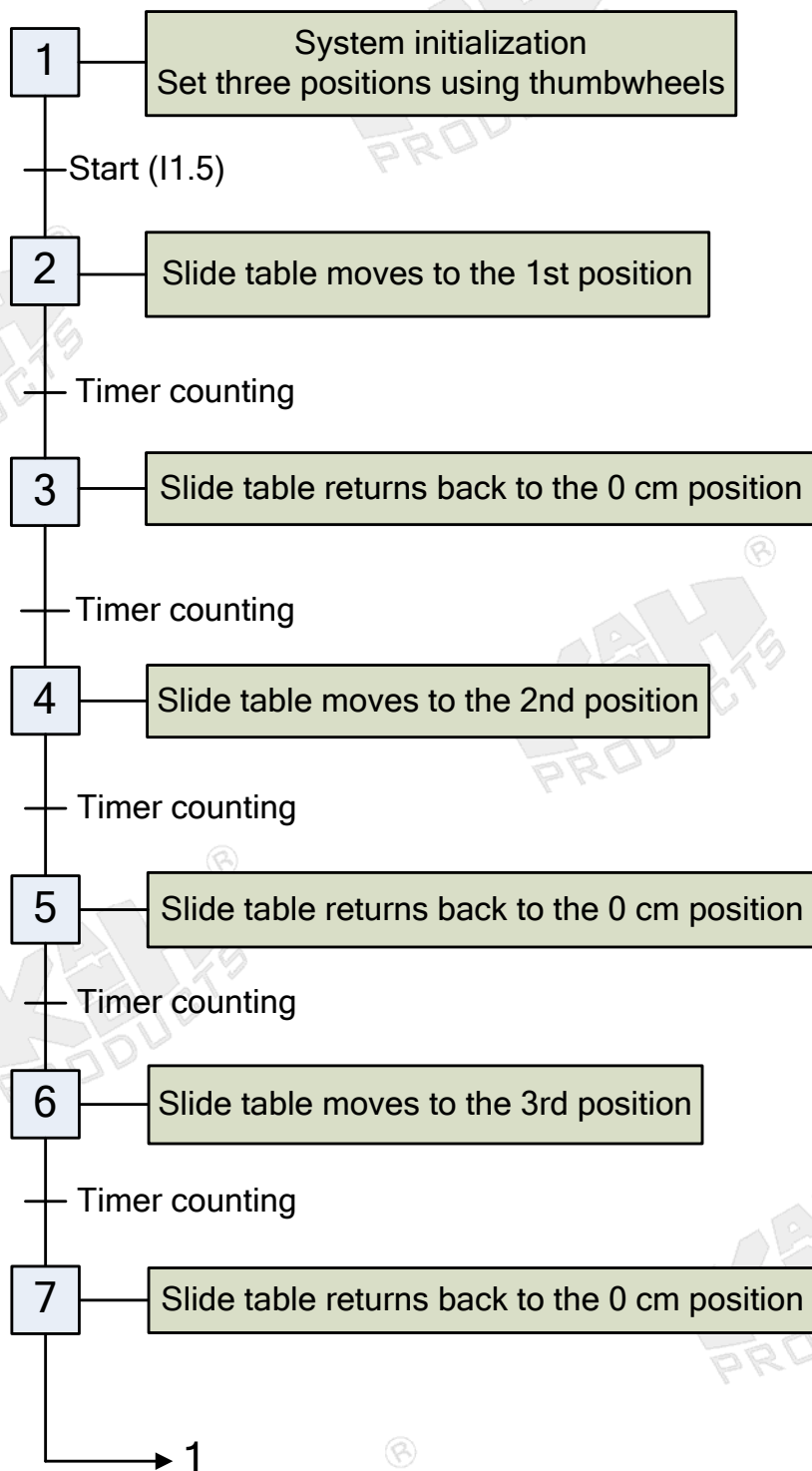
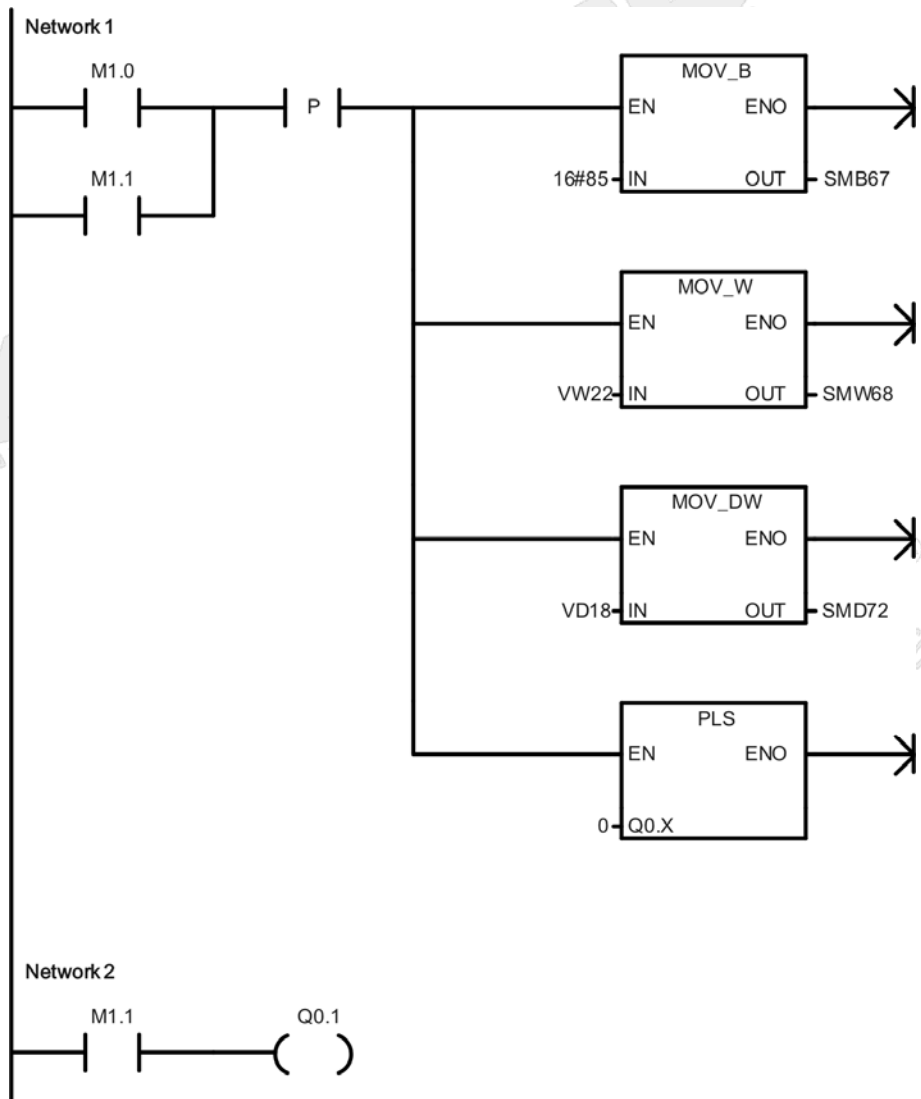


Fig. 11-9 Flow chart

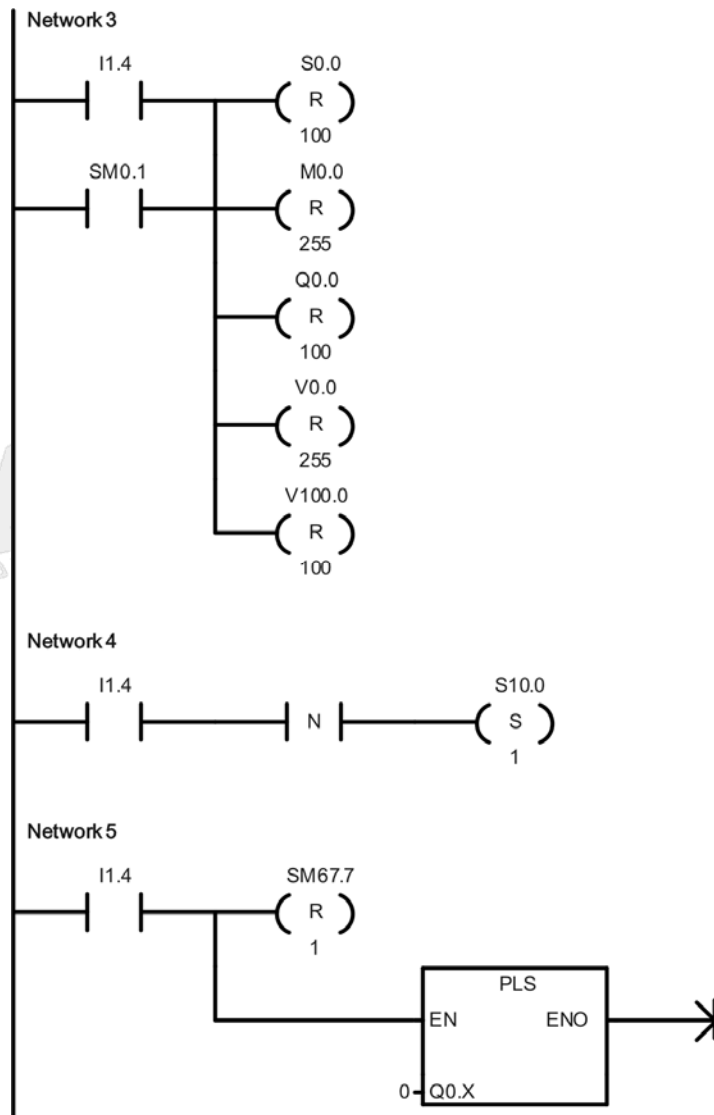


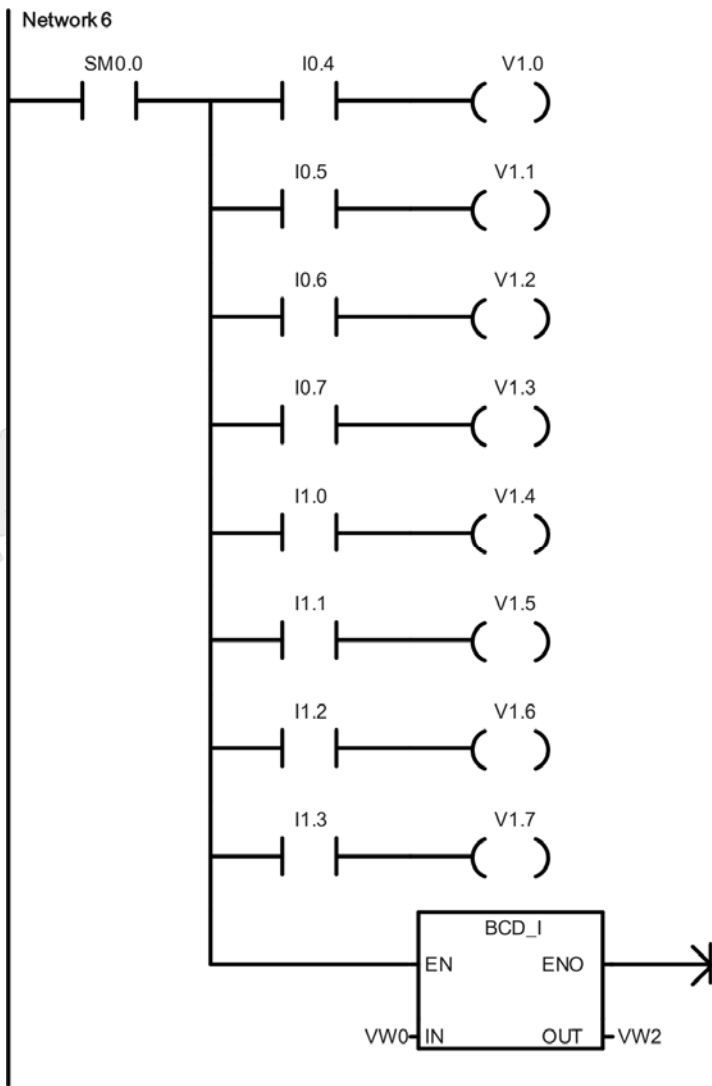
# Ladder Program



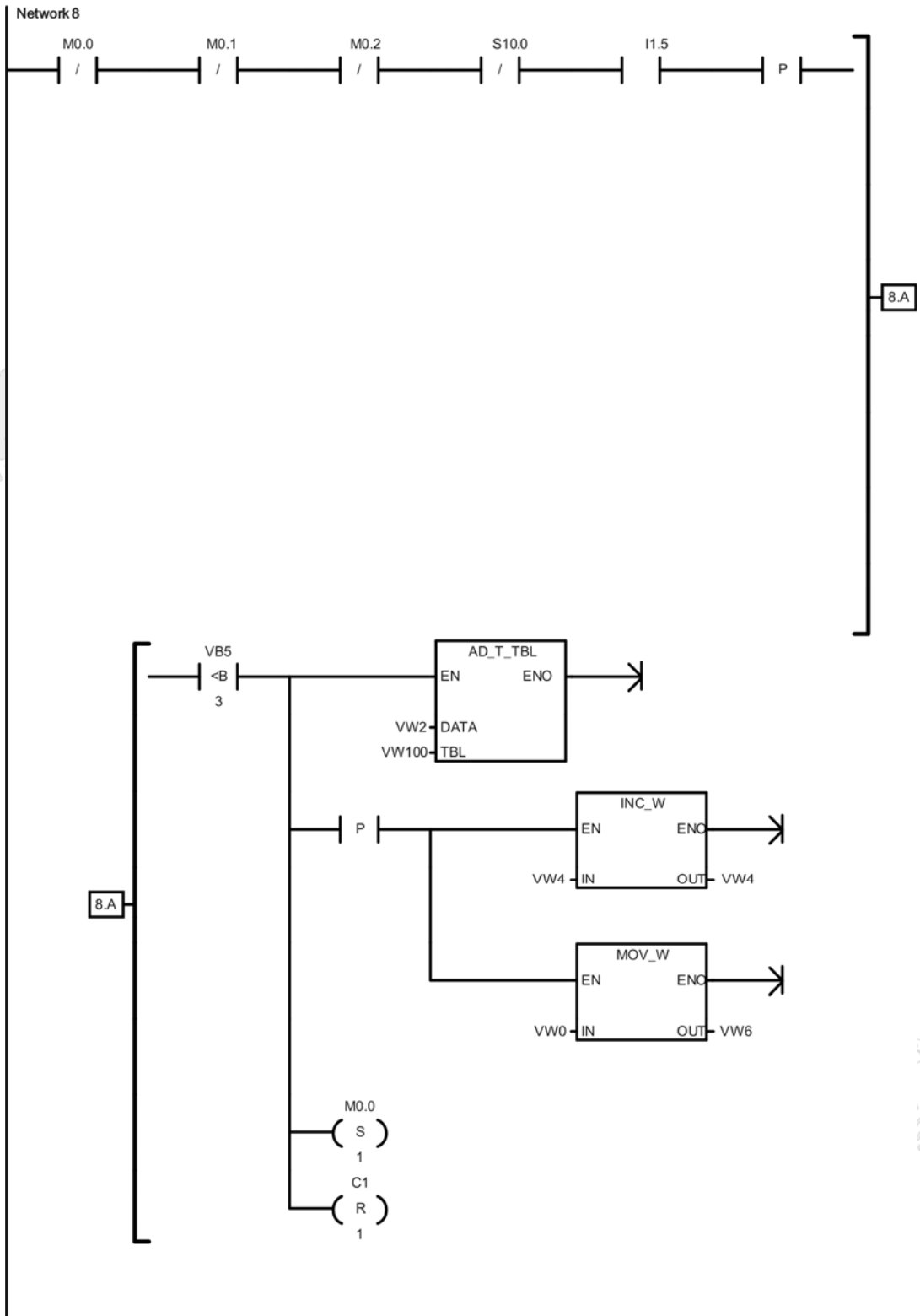
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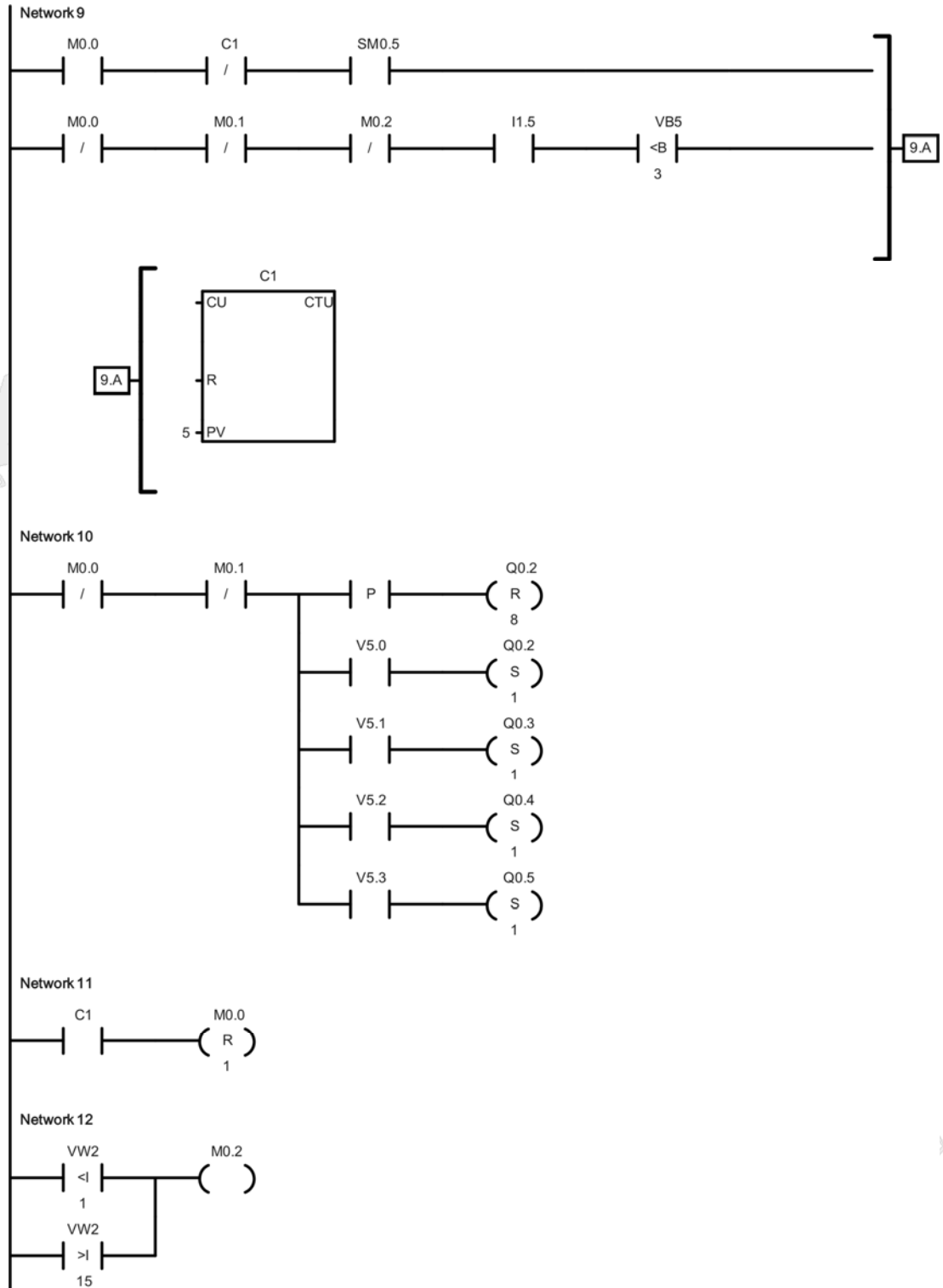


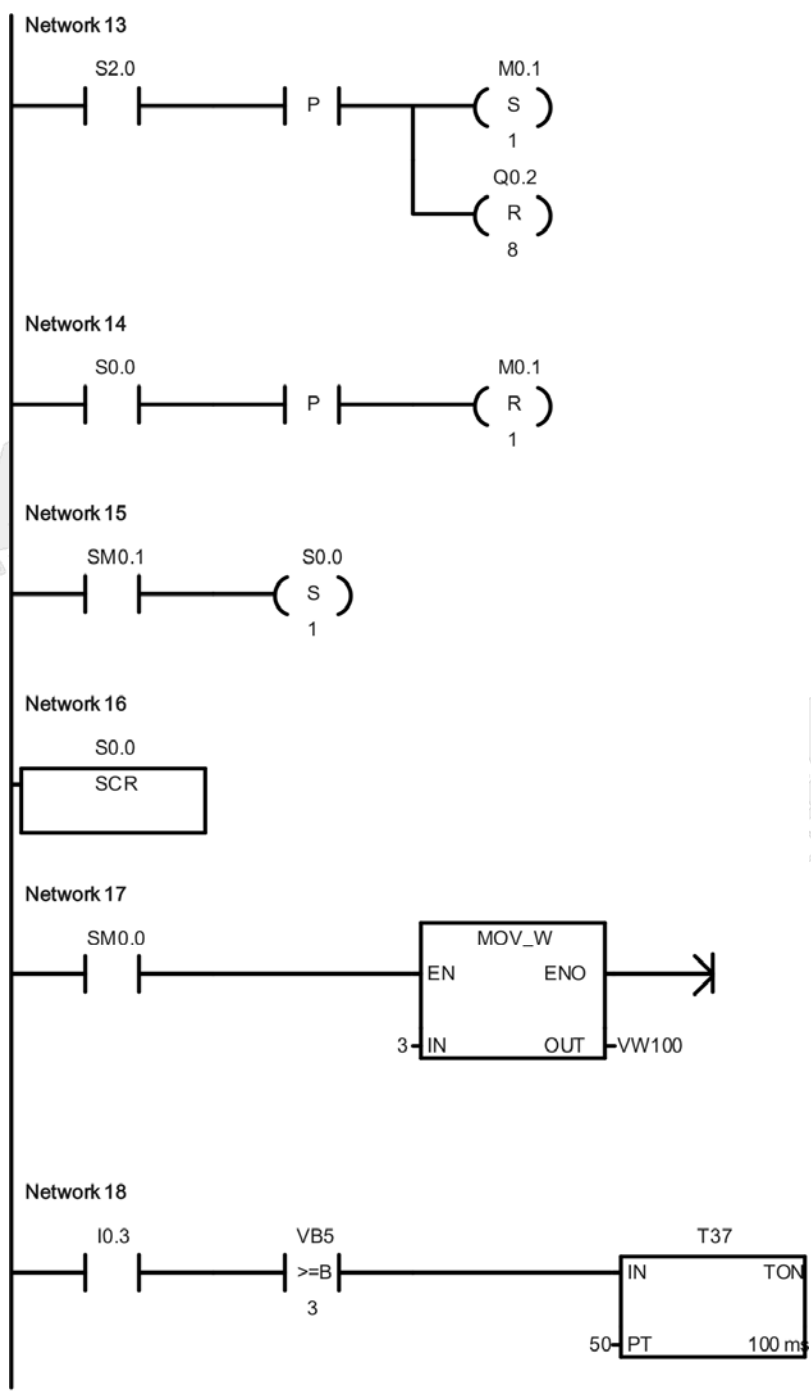


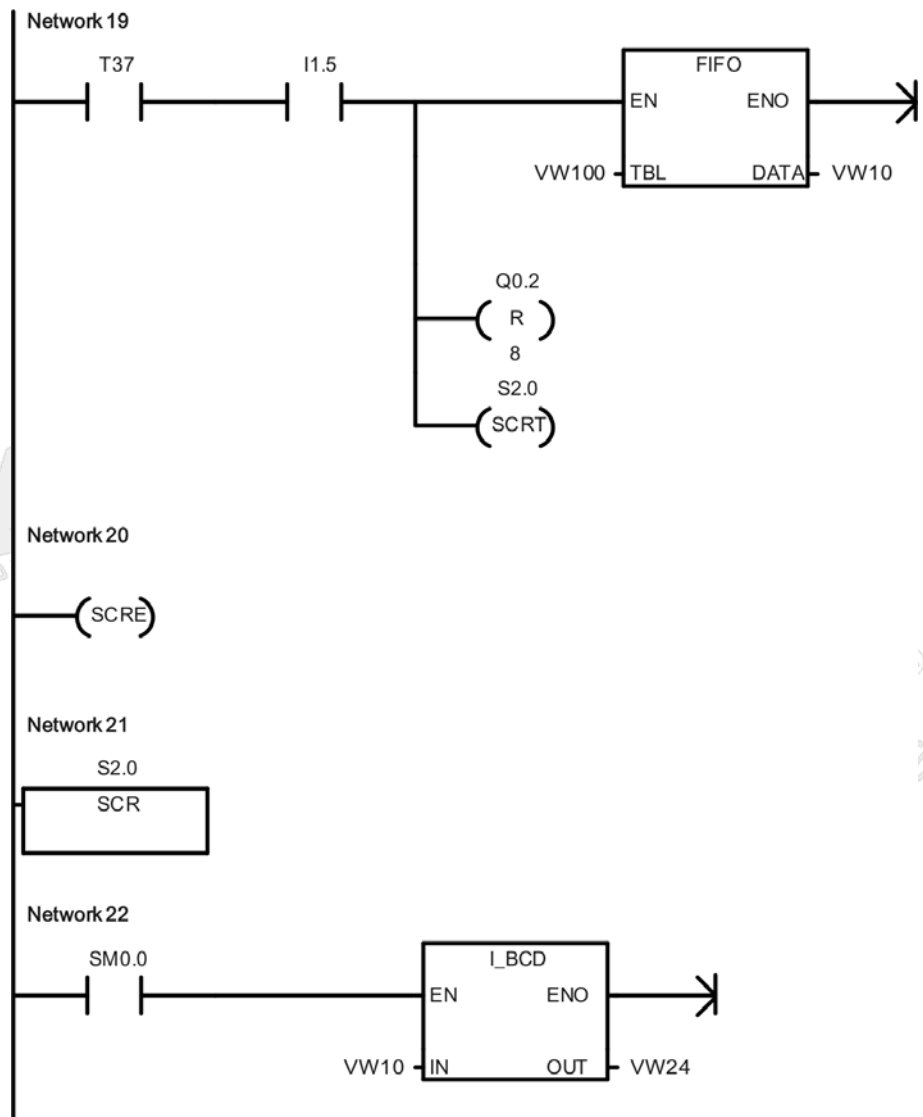




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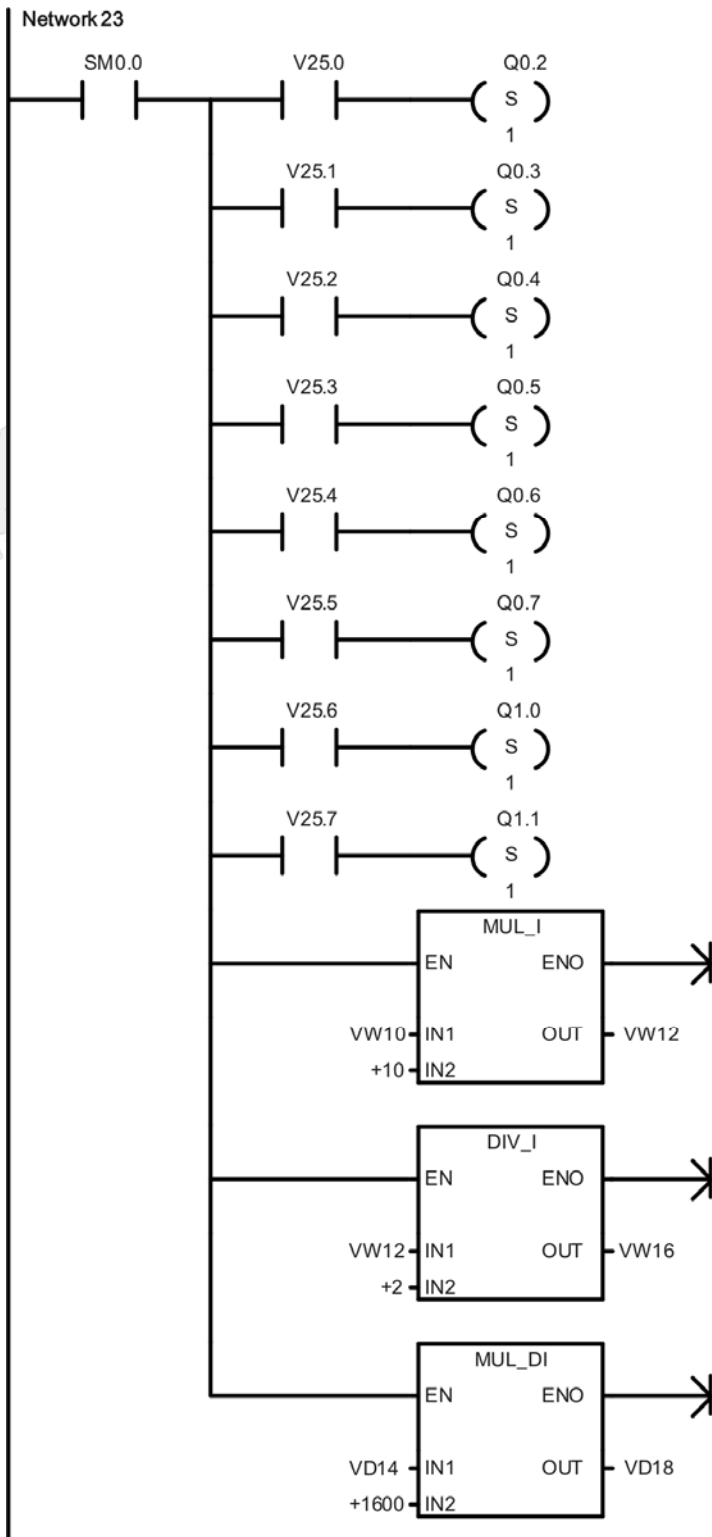


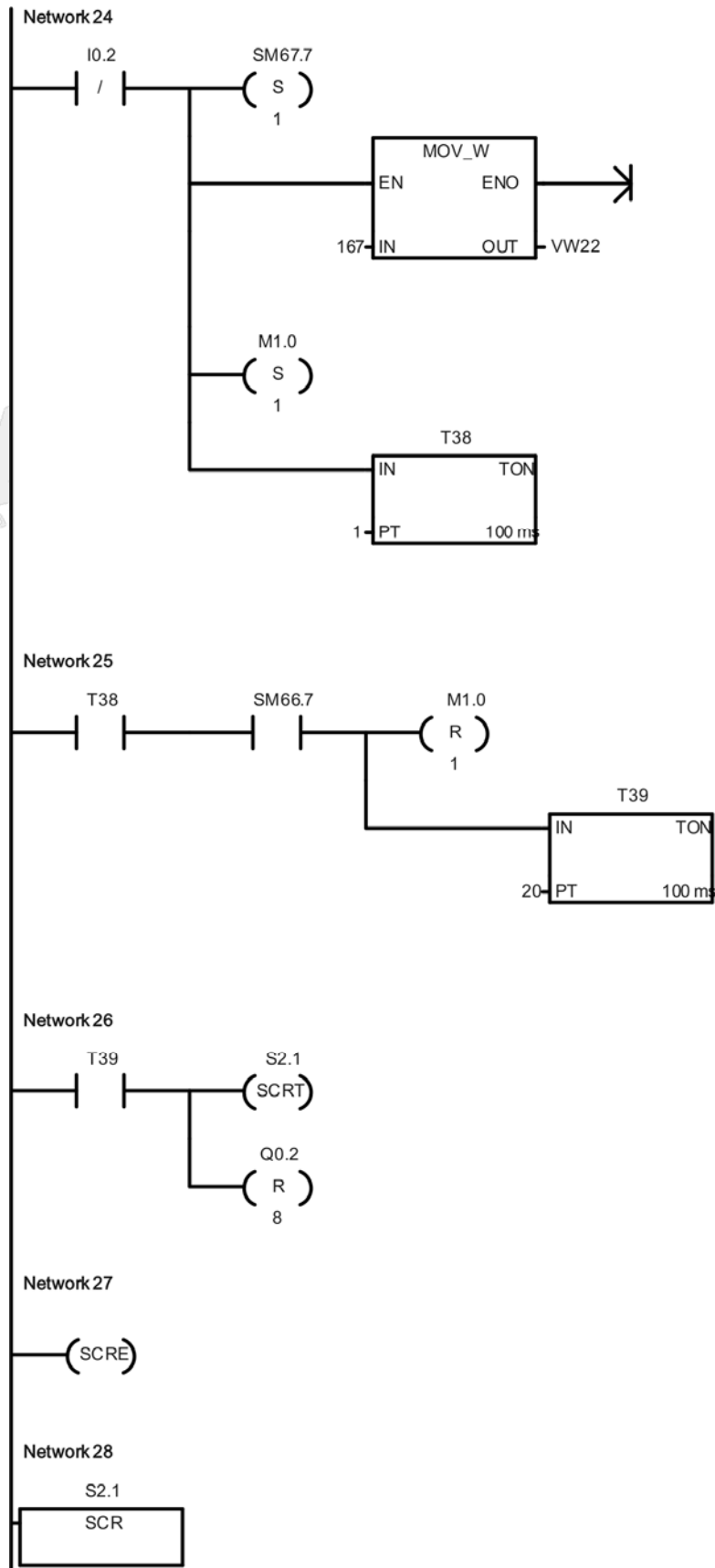
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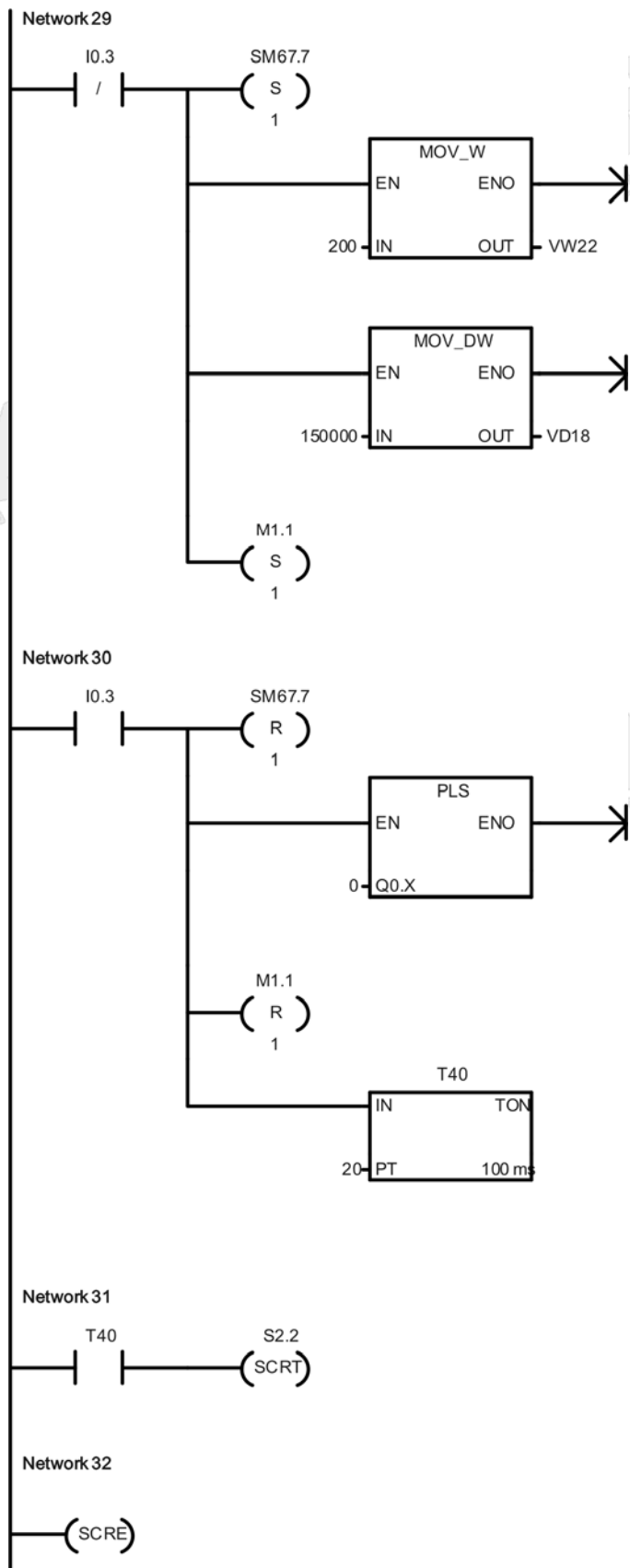
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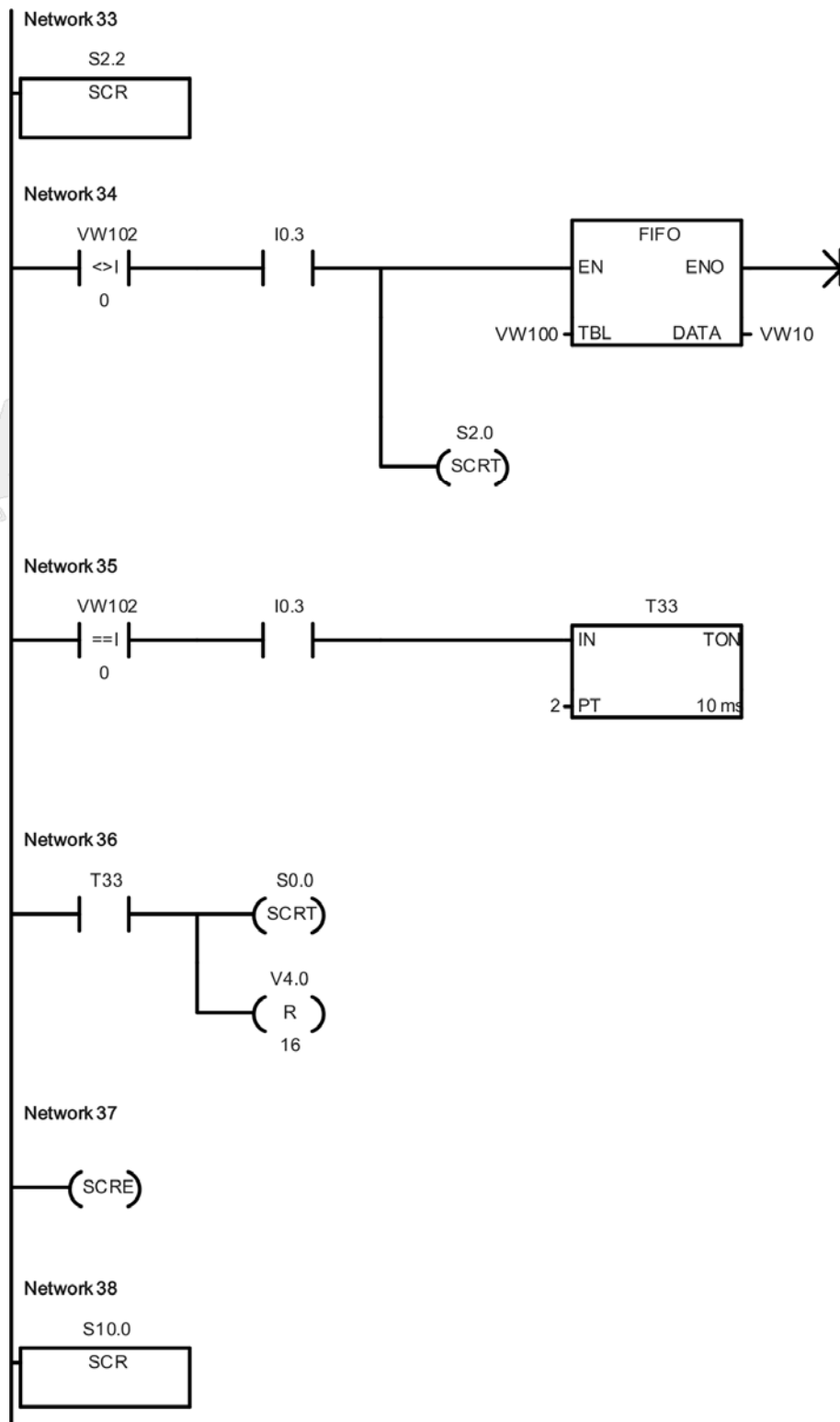
KAH<sup>®</sup>  
PRODUCTS











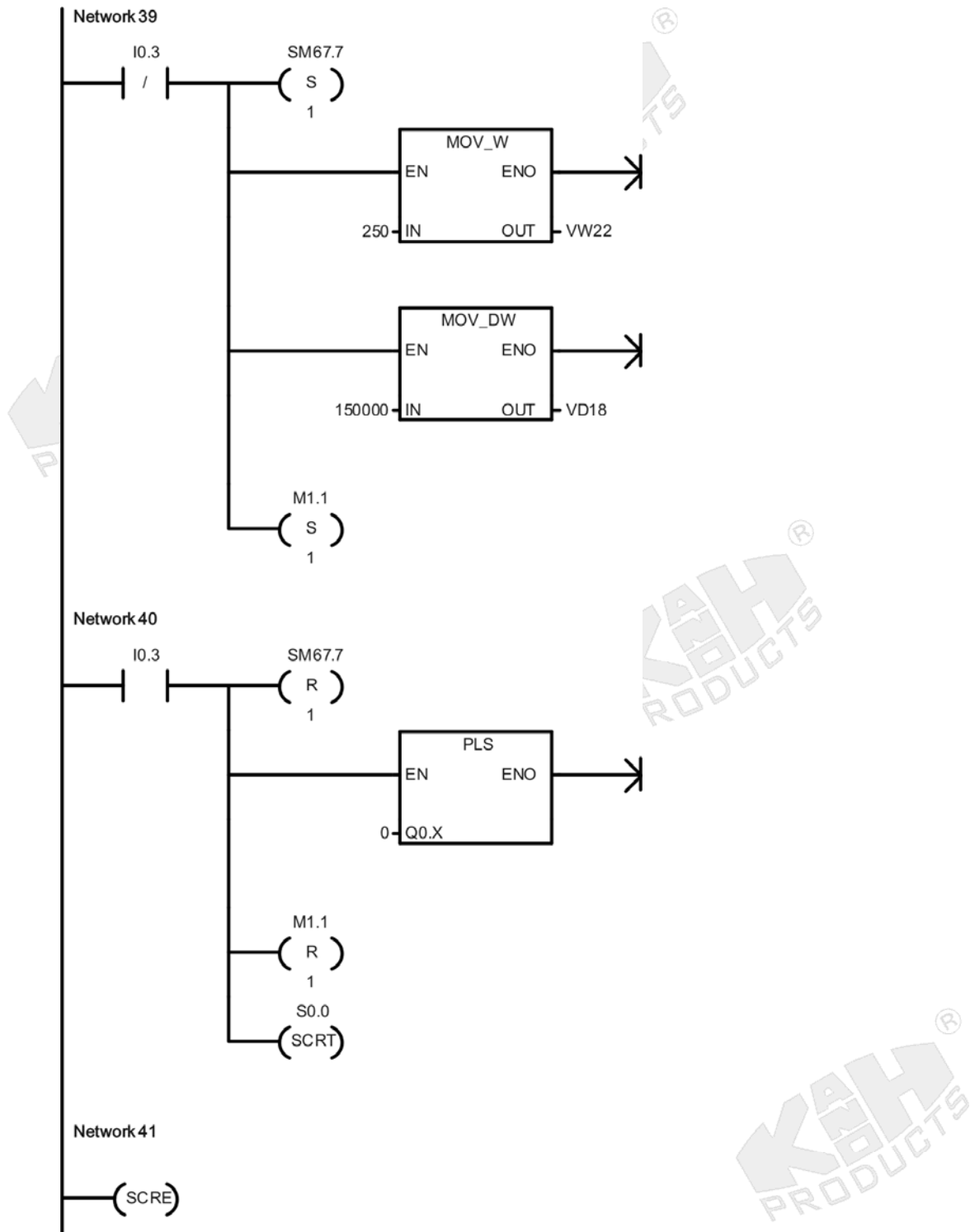


Fig. 11-10 Ladder diagram

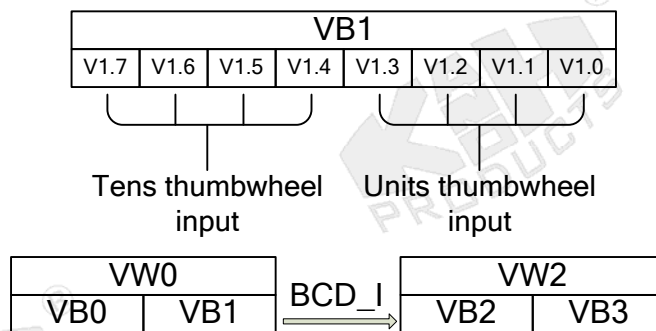
## Program Description

**Note:** There are many V memory locations used in the ladder program. For easy to read the ladder, the purpose of each V memory location is described below.

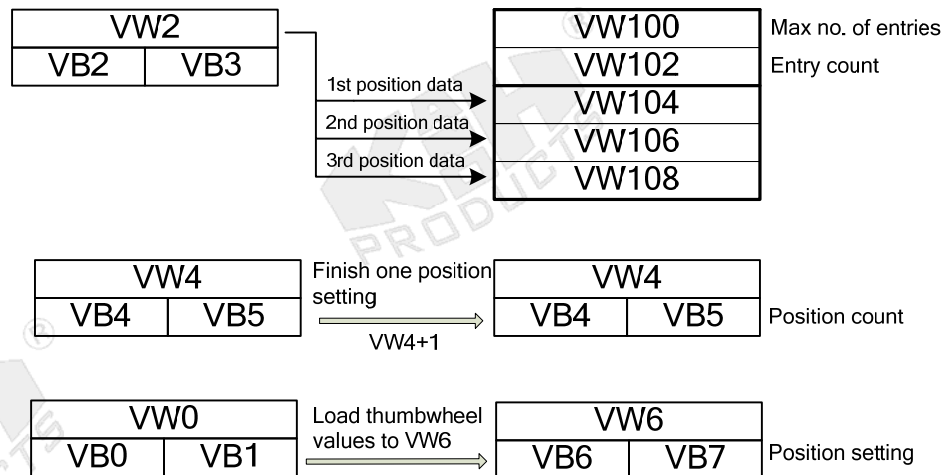
Address		Description
VW0		Position setting (BCD): input value of thumbwheels
VB0	VB1	
VW2		Position data (integer): conversion from the input of thumbwheels
VW4		Position count: position setting number
VB4	VB5	
VW6		Position setting: a copy of VW0
VB6	VB7	
VW10		Position data (cm): removed from the table
VW12		Position data (mm): the result of VW10 multiplied by 10
VW16		Number of revolutions: the result of VW12 divided by 2
VD18		Number of pulses or pulse count value: the result of VD14 multiplied by 1600
VW22		Cycle time (period) value
VW24		Position data to be displayed
VB24	VB25	
VW100		Table length: max number of entries of position data table

Network 1: On the positive edge of M1.0 (motor CW flag) or M1.1 (motor CCW flag), load the hex value 16#85 to SMB67 to configure PTO0: enable PTO, select PTO single-segment operation, set PTO time base=1 $\mu$ s/cycle (For more information, refer to Table 2-1). Load VW22 (cycle time value) to SMW68 to specify PTO cycle time, and load VD18 (pulse count value) to SMD72 to specify PTO pulse count. Q0.0 outputs the specified number of pulses at a specified pulse frequency.

- Network 2: When M1.1 (motor CCW flag) is on, turn on Q0.1 so that the step motor rotates CCW and the slide table shifts right.
- Network 3: When the Stop switch is activated (I1.4=ON) or on the first scan (SM0.1=ON), clear all S bits, auxiliary relays, output points and registers.
- Network 4: On the negative edge of the Stop switch (I1.4=ON to OFF), enable State S10.0.
- Network 5: When the Stop switch is activated (I1.4=ON), reset the PTO enable bit SM67.7 to disable the generation of PTO waveform.
- Network 6: The status bit SM0.0 is always on. Load the input value of thumbwheels (BCD-type position setting) to VB1, and convert the BCD value of VW0 to an integer value and load the result to VW2 (integer-type position data). See the process below.



- Network 7: When M0.0 (valid setting flag) is on and C1 bit is off and SM0.5 (0.5s OFF/0.5s ON) is off, set 7-segment display inputs (Q0.2-Q1.1) to 1 so that the 7-segment display is dark. On the positive edge of SM0.5, reset the 7-segment display inputs (Q0.2-Q1.1) to 0, all segment LEDs of the 7-segment display light for one scan, and then write the position setting value in (V7.0-V7.7) to 7-segment display input (Q0.2-Q1.1) to display the position setting when SM0.5 is on. Since the preset value of C1 counter, the 7-segment display blinks the position setting value 5 times.
- Network 8: When M0.0 (valid setting flag), M0.1 (motor rotating flag), M0.2 (invalid setting flag) and S10.0 are deactivated and VB5 (position count) <3, on the positive edge of I1.5 (Start/Save switch), add the value of VW2 (position data) to the position data table (starting address VW100), set M0.0 (valid setting flag) and reset the counter C1 current value, increment the value of VW4 (position count) and load the value of VW0 (position setting) to VW6. See the process below.



Network 9: When M0.0 (valid setting flag) is on and C1 bit is off and SM0.5 (0.5s OFF/0.5s ON) is on, the C1 counter increments the current value. When M0.0 (valid setting flag), M0.1 (motor rotating flag) and M0.2 (invalid setting flag) are off, and Start/Save switch is activated (I1.5=ON) and VB5 (position count) is less than 3, set M0.0 bit and reset the C1 bit and clear the current value of C1 counter.

Network 10: When M0.0 (valid setting flag) and M0.1 (motor rotating flag) are deactivated, write the value of V5.0-V5.3 (position count) to units display inputs (Q0.2-Q0.5). This displays the position count on the units display.

Network 11: When the C1 bit is turned on (C1 current value  $\geq 5$ ), reset M0.0 (valid setting flag).

Network 12: When  $VW2 < 1$  or  $VW2 > 15$ , activate M0.2 (invalid setting flag).

Network 13: On the positive edge of S2.0, set M0.1 (motor rotating flag) and reset the 7-segment display inputs (Q0.2-Q1.1).

Network 14: On the positive edge of S0.0, reset M0.1 (motor rotating flag).

Network 15: The status bit SM0.1 is on for the first scan cycle. On the first scan, enable State S0.0.

Network 16: Beginning of State S0.0 control region.

Network 17: The status bit SM0.0 is always on. Load 3 to VW100 (table length).

Network 18: When the right limit sensor is activated (I0.3=ON) and VB5 (position count) is less than or equal to 3, start the 5-second ON-delay timer T37.



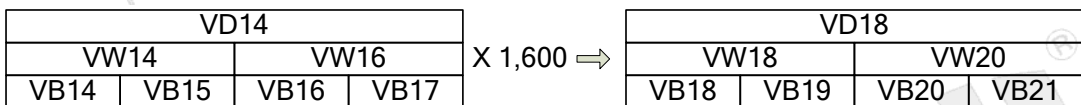
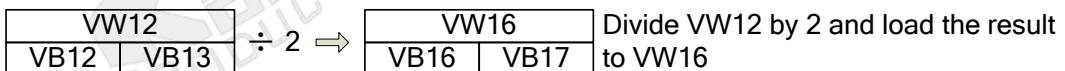
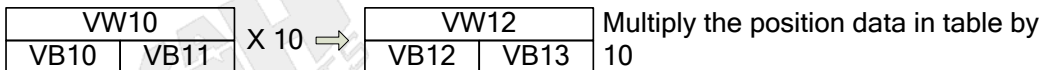
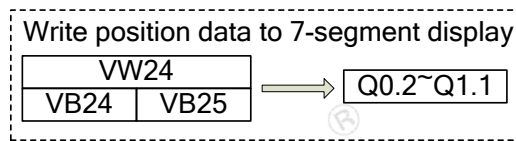
Network 19: After a 5-second delay, if the Start/Save switch is activated (I1.5=ON), remove the position data from VW104 to VW10, decrement the entry count in VW102, and shift up all other entries of the table one location. Reset the 7-segment display inputs (Q0.2-Q1.1) and transition to State S2.0.

Network 20: End of SCR region for State S0.0.

Network 21: Beginning of State S2.0 control region.

Network 22: The status bit SM0.0 is always on. Convert the integer value of VW10 to a BCD value and load the result to VW24.

Network 23: The status bit SM0.0 is always on. Write the BCD value of VW24 to 7-segment display inputs (Q0.2-Q1.1), multiply the integer value of VW10 by 10 (cm to mm) and load the result to VW12, divide the value of VW12 by 2 (screw pitch = 2mm) and load the result (number of revolutions) to VW16, multiply the value of VD14 by 1600 (drive pulses/rev in 8 microstepping) and load the result (the required number of pulses) to VD18. See the process below.



Multiply VD14 by 1,600 and load the result to VD18

Network 24: When the left limit sensor is deactivated (I0.2=OFF), set the PTO enable bit SM67.7 to enable the generation of PTO waveform, load 167 to VW22 (cycle time value) for specifying PTO cycle time=167 μs, pulse frequency= 6,000Hz). Set M1.0 (motor CW flag) and start the 0.1-second ON-delay timer T38.

- Network 25: The SM66.7 is the PTO idle bit: 0=PTO in progress, 1=PTO idle. After a 0.1-second delay, if the PTO idle bit SM66.7 is set (SM66.7=ON, completion of the programmed pulse train), reset M1.0 (motor CW flag) and start the 2-second ON-delay timer T39.
- Network 26: After a 2-second delay, transition to State S2.1, reset the 7-segment display inputs (Q0.2-Q1.1).
- Network 27: End of SCR region for State S2.0.
- Network 28: Beginning of State S2.1 control region.
- Network 29: When the right limit sensor is deactivated (I0.3=OFF), set the PTO enable bit SM67.7 to enable the generation of PTO waveform, load 200 to VW22 (cycle time value) for specifying PTO cycle time=200  $\mu$ s (pulse frequency=5,000Hz), load 150,000 to VD18 (pulse count value) for specifying PTO pulse count=150,000, and set M1.1 (motor CCW flag).
- Network 30: When the right limit sensor is activated (I0.3=ON), reset the PTO enable bit SM67.7 to disable the generation of PTO waveform, reset M1.1 (motor CCW flag) and start the 2-second ON-delay timer T40.
- Network 31: After a 2-second delay, transition to State S2.2.
- Network 32: End of SCR region for State S2.1.
- Network 33: Beginning of State S2.2 control region.
- Network 34: When VW102 (current entry count) is not equal to 0 (three position settings have not been removed) and the right limit sensor is activated (I0.3=ON), remove the first entry data (position data) from table to VW10, decrement the entry count in VW102, and shift up all other entries of the table one location. Transition to State S2.0.
- Network 35: When VW102 (current entry count) is equal to 0 (three position settings have been removed) and the right limit sensor is activated (I0.3=ON), start the 0.02-second ON-delay timer T33.
- Network 36: After a 0.02-second delay, transition to State S0.0, clear VW4 (position count).
- Network 37: End of SCR region for State S2.2.
- Network 38: Beginning of State S10.0 control region.
- Network 39: When the right limit sensor is deactivated (I0.3=OFF), set the PTO enable bit SM67.7 to enable the generation of PTO waveform, load 250 to VW22 (cycle time value) for specifying PTO cycle time=250  $\mu$ s (pulse frequency=4,000Hz), load 150,000 to VD18 (pulse count value) for specifying PTO pulse count=150,000, and set M1.1 (motor CCW flag).

Network 40: When the right limit sensor is activated (I0.3=ON), reset the PTO enable bit SM67.7 to disable the generation of PTO waveform, so the step motor and the slide table stop, reset M1.1 (motor CCW flag), and transition to State S0.0.

Network 41: End of SCR region for State S10.0.

## **EQUIPMENT REQUIRED**

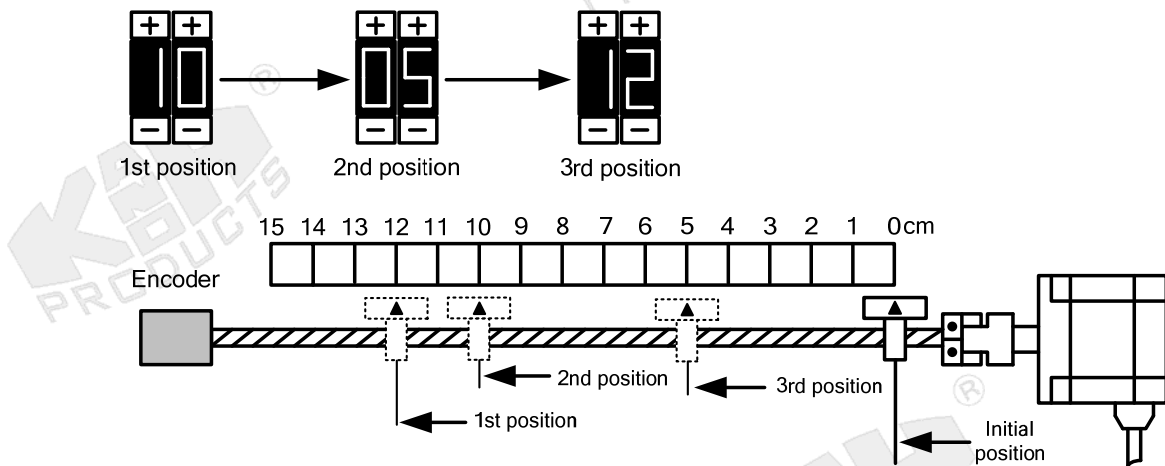
1. Personal Computer
2. PLC-200 PLC Trainer
3. USB/PPI Multi-Master Cable
4. AC Adapter
5. Safety Connecting Wires or Flat Cable
6. MS-7002 Linear Positioner

## **PROCEDURE**

1. With the power to the PLC-200 PLC Trainer OFF, place Enable switches SW2 to SW8 in OFF position. Set input switches I0.0 to I1.5 to OFF and Thumbwheel Switches to 0000.
2. On the 2PH Microstep Driver, set Mstep to 8 (SW5=OFF, SW6=OFF) for 8-microstepping drive mode (step angle=0.225°) and set PK Current to 0.71A (SW1=ON, SW2=OFF, SW3=ON) for the max starting frequency 7300Hz. **Note: Do not set a peak current greater than 2A.**
3. Connect PLC Trainer's Port 0 to your PC's USB port using the provided USB/PPI cable.
4. Complete the electrical connections by referring to the wiring diagram shown in Fig. 11-7 or Fig. 11-8. **Note: Do not use the safety connecting wires and the flat cables at the same time.**

5. Start the STEP 7-Micro/WIN.
6. Create a new project by selecting **File >> New** menu command. Complete the Ladder Program shown in Fig. 11-10.
7. Turn the PLC-200 PLC Trainer on. If electrical connections were completed using safety connecting wires, place Enable switches SW6 and SW7 in ON position.
8. Download the ladder program to PLC main unit by selecting **File >> Download** menu command.
9. Run the ladder program by selecting **PLC >> Run** menu command.
10. Use thumbwheel switches to set the first position between 01 and 15, and activate the Start/Save switch (I1.5). The 7-segment display should display the setting value and blink 5 times, and then display "01" to indicate the first position has been set. If thumbwheel input is invalid, the 7-segment display will have no response.
11. Use thumbwheel switches to set the second position between 01 and 15, and then activate the Start/Save switch (I1.5). The 7-segment display should display the setting and blink 5 times, and then display "02" to indicate that the second position has been set. If thumbwheel input is invalid, the 7-segment display will have no response.
12. Use thumbwheel switches to set the third position between 01 and 15, and then activate the Start/Save switch (I1.5). The 7-segment display should display the setting and blink 5 times, and then display "03" to indicate that the third position has been set. If thumbwheel input is invalid, the 7-segment display will have no response.
13. Activate the Start/Save switch (I1.5). The slide table should follow the sequence:
  - (1) Move to the first position and stays 2 seconds, and then returns to the initial position;

- (2) Move to the second position and stays 2 seconds, and then returns to the initial position;
- (3) Move to the third position and stays 2 seconds, and then returns to the initial position and stops.



## PROBLEM

1. Rewrite the PLC program to control the slide table to implement the sequence of operations: moving to the first position, staying 3 seconds, moving to the second position, staying 3 seconds, returning to the initial position, moving to the third position, staying 3 seconds, returning to the initial position. Keep the operations of 7-segment display and multiple-position setting unchanged.