13 Step ladder diagram instruction

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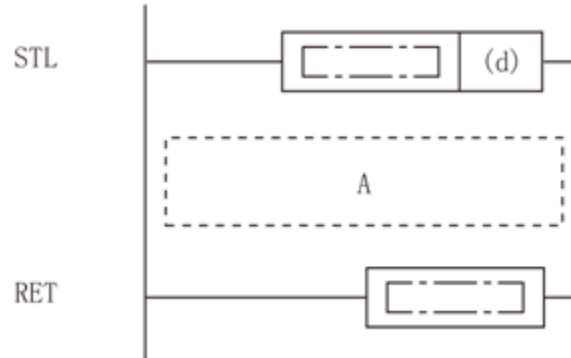
Table of Contents

STL/RET step ladder diagram instruction

STL: step ladder diagram starts

RET: step ladder diagram ends

Content, range and data type

| Parameter	Content	Range	Data type	Data type(Label)
(d)	State assigns the number of destination step relay	0 to 4,095	bit	ANY_BOOL

Device used

Instruction	Parameter	Device S	Offset modification [D]	Pulse expansion XXP
STL	Parameter 1	●		

Features

① Programs that use step ladder diagram are based on the mechanical actions, and assign step relay S according to each process. It acts as a loop connected in the state contact (STL contact), and carries on the sequential control programming of input condition and output control.

② In step ladder diagram, consider step relay S as a control process and carries on the sequential control programming of input condition and output control. As the process operates, the previous process would be not executed. Therefore, the mechanical control could be performed by the simple sequential control of each process.

③ For a series of step ladder diagram, start with the initialization state, and program in the order of the states to be transferred.
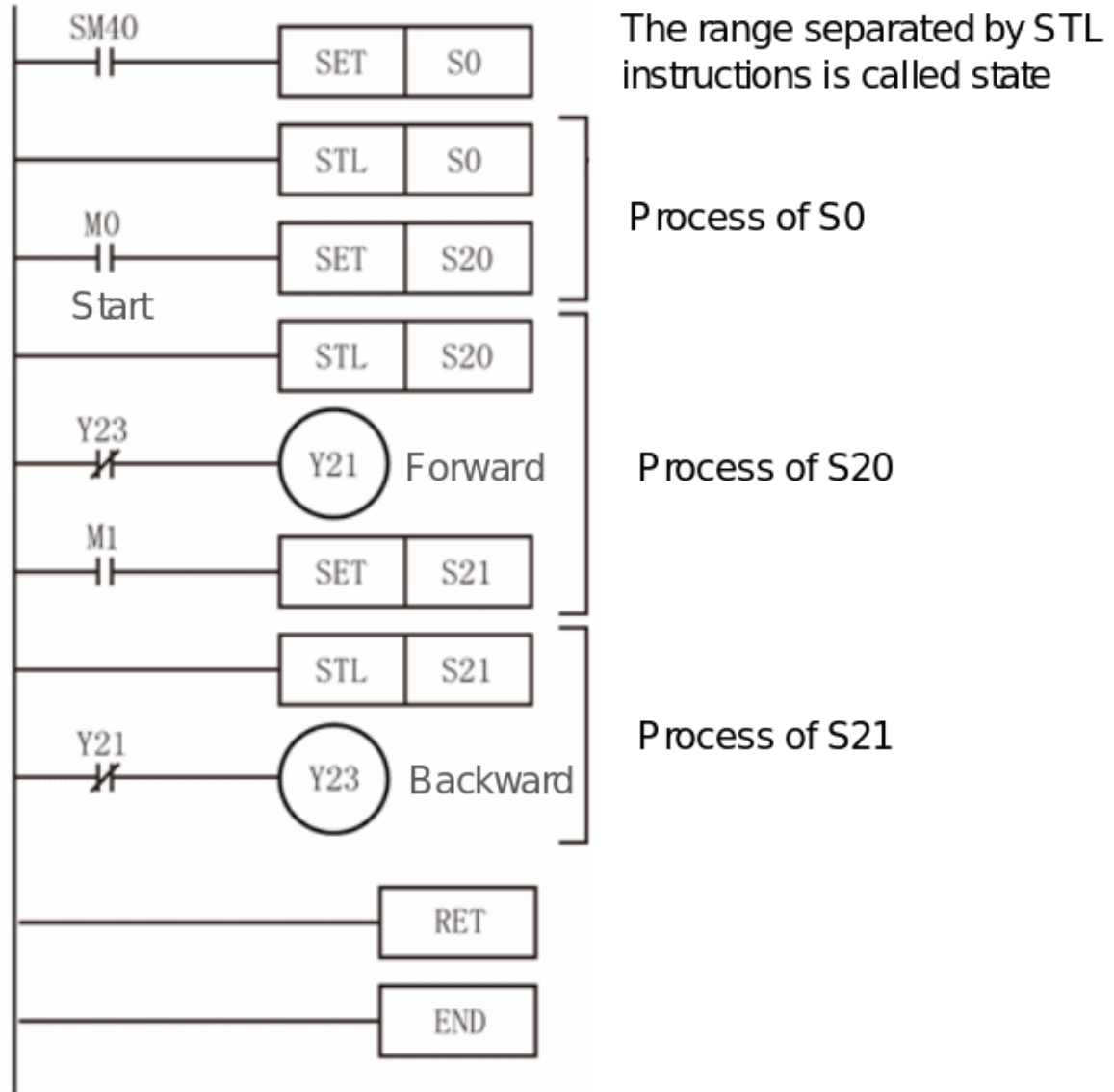
Step ladder diagram exhibits relay ladder program, you could use state to program according to the flow of mechanical control. It could be thought of that state and relay are the same, which consist of drive coil and contact(STL contact).

Coil drives use SET instruction and OUT instruction, and contacts use STL instruction.

The internal loop actions connect to the status are as follows.

Internal loop action

|	
ON execution	If the status is ON, the loop that connected to this outputs actions by STL.
OFF execution (one operation cycle)	If the condition set in the transition of the state (transition condition) is satisfied, the next state is set to ON, and the state previous ON is turned OFF(reset). (Transition action) During state transition, only one operation cycle will both states be ON at the same time. After the transition, the state before the transition is turned OFF(reset) in the next operation cycle. Regardless of the state

of the contact before the drive command, the drive instruction connected to the bus in the OFF state is only executed when it is OFF for one operation cycle (the same action as when the contact is OFF).

However, when the transition state is used by the contact instruction, the contact image is turned OFF and executed after the transition condition is satisfied.

No execution   After the next operation cycle that after OFF is executed, the action of OFF execution of the instruction is not performed. (jump state)

The sequence chart of the state (internal loop)execution state is as below.
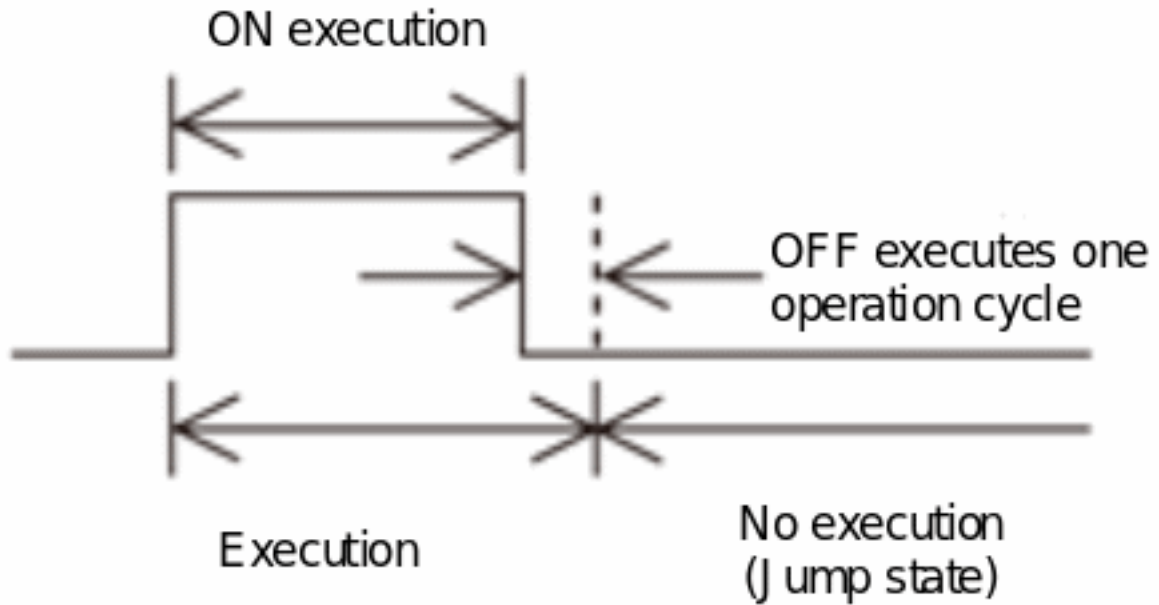
Each state has three functions of drive processing on the load, specifying the transition target, and specifying its transition conditions. As shown below, execute the drive processing on the load first, and then execute the sequential execution of the transfer processing. In the state without load, no drive processing is required
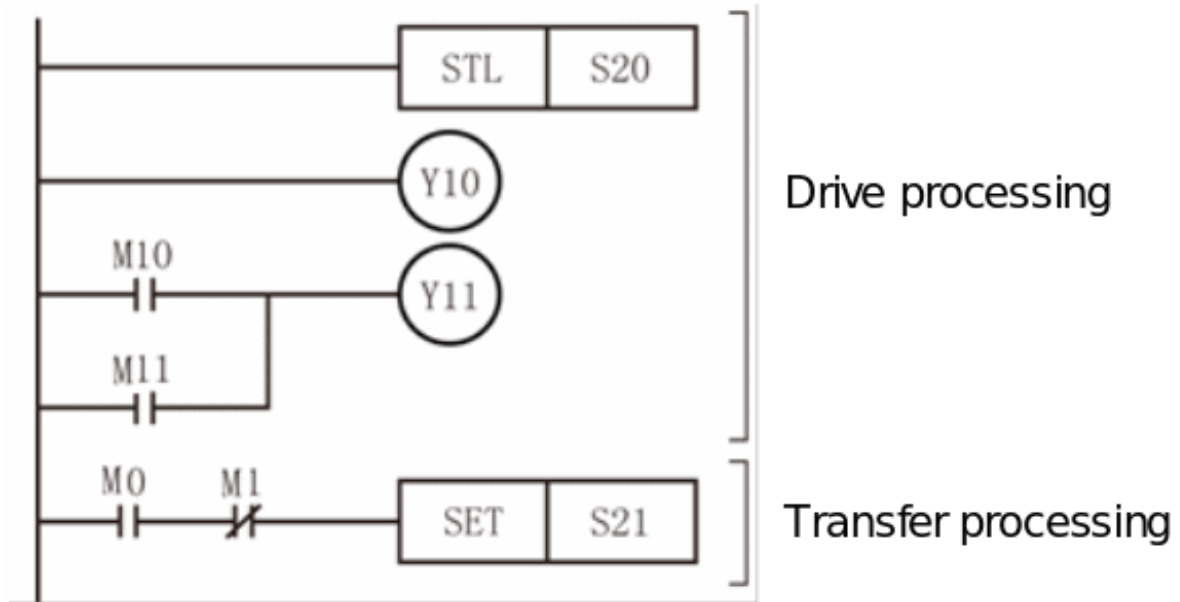
Step ladder programs execute the following actions

The process of S31

After M1 is ON, S32 turned ON, and S31 will reset automatically.

The process of S2

Even if S31 is reset, the Y31 programmed with the SET instruction will keep the original output unchanged.

Operation

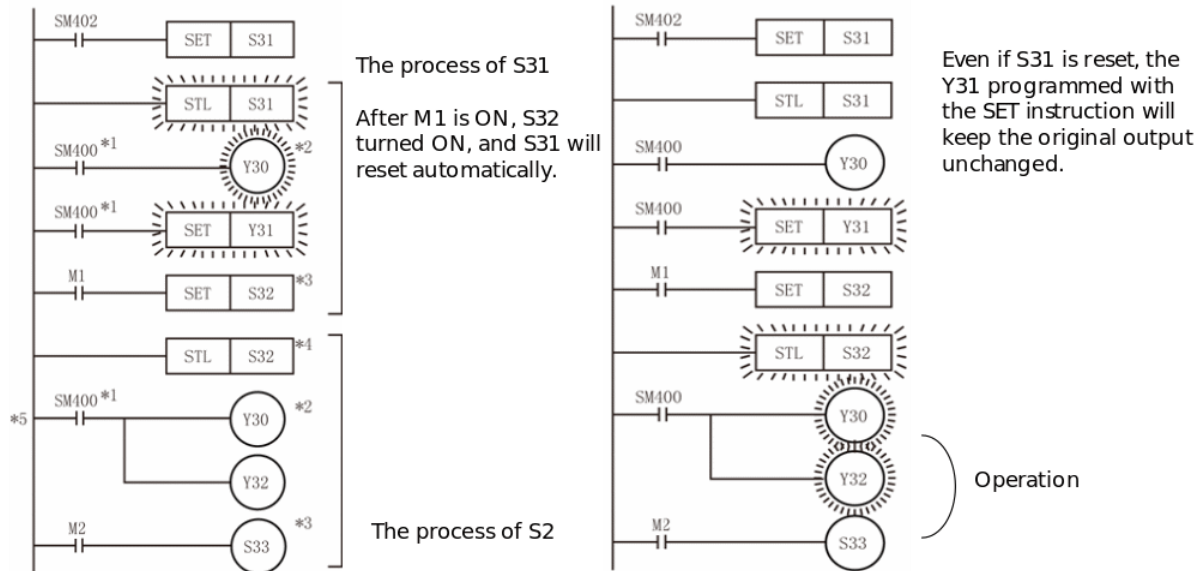1. It is recommended that contacts be programmed in the output drive.
2. The output coil could be programmed repeatedly in different states.
3. The OUT and SET instructions of stepping relay automatically reset the state before the transfer.
4. It is not recommended to use the same stepping relay (S) number repeatedly
5. Pointers(P) cannot be configured immediately after STL instruction. If configured, a program error occurs.

Key points

The action state of stepping relay set to be saved after power-off is backed up by the non-volatile memory. These stepping relays are used when a power failure occurs in the middle of the mechanical operation, and when the power is turned on again and you want to continue the operation from there. Besides, since these stepping relays keep operating even from RUN to STOP, when RUN is executed again, the operation will be restarted from the state before STOP.

1. STL instruction can not be used in Interrupt routine, event routine and subroutine.

2. When using STK instruction in interrupt routine, please do not use SET instruction or the driving state S of the OUT instruction.
3. It is not that the use of jump instructions (CJ/CJP) in the state is prohibited. It is recommended to not use it as much as possible because it will cause complex actions.
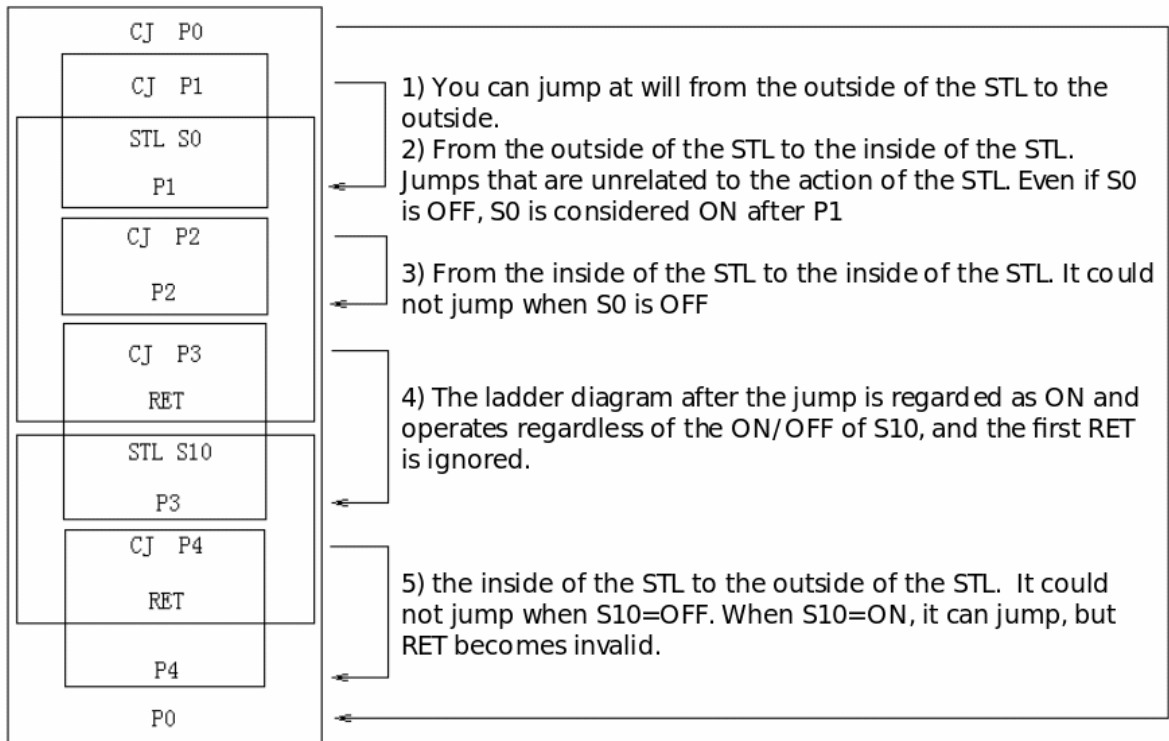
#Note: The pointer P could be set to the first instruction in STL without contacts, so the first instruction is regarded as irrelevant to the STL action below.

Device used

Device	Name	Content
SM240	Transfer prohibited	If SM240 is set ON, all the transfers between the states are prohibited.
SM246	STL operation	If SM247 and stepping relay (device S) are both ON, SM246 will be ON automatically.
SM247	STL valid monitoring	If SM247 is set to ON, the number of stepping relay in operating in stepping relay would be stored in SD240 to SD247 from least to most.
SD240 to SD247	ON stepping relay number	The number of the stepping relay to be ON is stored in SD240 to SD247 (up to 8)from least to most.

#Note:

Stepping relay(S) without setting lock is cleared by turning the power ON to OFF and RUN to STOP. If the power is turned ON to OFF and RUN to STOP while the status is valid, the process cannot be restarted from the middle.

Error code

No errors.

Program

Open M2, state relay S1is set to ON, the programs in STL S1 are executed normally.

Open M4, if S1 is ON, the state S11/S12 can be selected for transition according to the OFF/ON of M7, and the state S1 can be reset.

When M7 is OFF, transfer to S11

When M7 is ON, transfer to S12
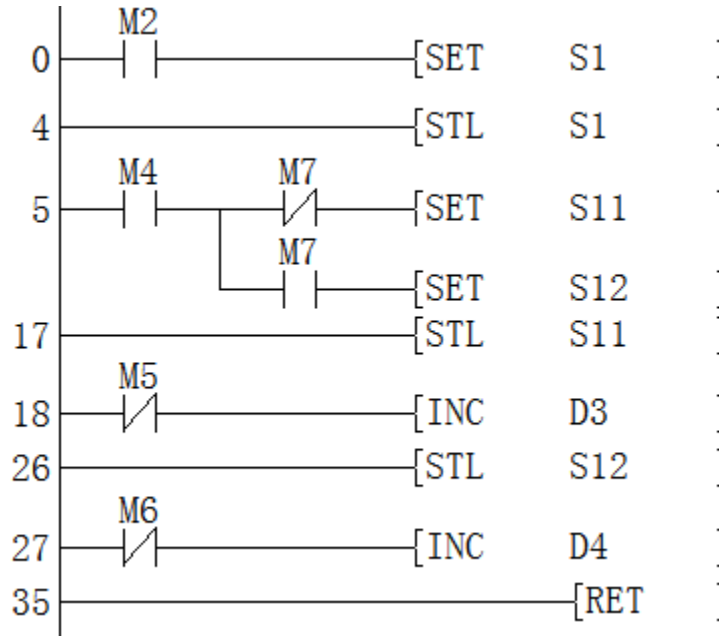
IST/Initialization state

In the program that using stepping ladder diagram, the initialization state and special relays are automatically controlled.

Stepping ladder diagram program

Content, range and data type

Parameter	Content	Range	Data type	Data type(label)
(s)	Start bit device number of the run mode switch	--	bit	ANYBIT_ARRAY (element number: 8)
(d1)	The minimum state number of the useful state in automatic mode ((d1)<(d2))	--	bit	ANY_BOOL
(d2)	The maximum state number of the useful state in automatic mode ((d1)<(d2))	--	bit	ANY_BOOL
EN	Execution condition	--	bit	BOOL

ENO	Execution result	--	bit	BOOL	

Device used

Instruction	Parameter	Device						Offset modification	Pulse expansion
		X	Y	M	S	SM	D.b	[D]	XXP
IST	(s)	●	●	●		●	●		
	(d1)				●				
	(d2)				●				

Only device S could be used.

Features

(1) IST

1) Specify the start input of run mode in (s).

2) The switch for selecting the run mode occupies 8 points from the start bit device.

3) The device specified by the switch for selecting the run mode.The switch functions in the following table and X20 are separately assigned to the devices specified by the switch for selecting the run mode. Under the circumstances, to prevent X20 to X24 from being ON at the same time, a rotary switch must be used. Switches that are not in use need no wiring. However, these switches cannot be used for other purposes because they are occupied by IST instructions,

Device number address (example)	Switch function	Content
X20	Individual run	Uses each button to turn the each load on or off.
X21	Origin reset	Press the origin reset button to automatically return the
X22	Stepping	Each time the start button is pressed, it advances one p
X23	Cycle run once	If the start button is pressed at the origin, it will stop at th
		If the stop button is pressed in the middle, the process
X24	continuous run	If the start button is pressed at the origin position, contin
X25	Start origin reset	Uses each button to turn the each load on or off.
X26	Start automatically	Start stepping, cycle run once, continuous run
X27	Stop	Stop run

4) he minimum state number of the useful state in (d1).(automatic mode)

5) The maximum state number of the useful state in (d2).(automatic mode)

6) When the instructions are When the instruction input is ON, the following devices are automatically switched and controlled. It does not change when the instruction input is OFF.

Device number	Content	ON/OFF condition	
SM240	Transfer prohibited	ON condition	Always ON during individual run
			Always ON Except that when the start button is pressed during stepping
			When the stop button is pressed during origin reset and cycle run once.
		OFF condition	When the start button is pressed during stepping.

			After the stop button is pressed during origin reset and cycle run once.
SM241	Start transfer	ON condition	When the start button is pressed during origin reset and cycle run once.
			After the start button is pressed during continuous run
		OFF condition	When it is from RUN to STOP
			Always ON during individual run and origin reset
			After the stop button is pressed during continuous run
SM242	Start pulse	ON condition	Only at the moment when the start button is pressed
		OFF condition	Except when it is ON
SM243	Origin reset completion	ON condition	When the origin reset is completed (user program)
		OFF condition	When it is from RUN to STOP
			When the origin reset is not completed
SM244	Origin condition	ON condition	When the origin condition is satisfied (user program)
		OFF condition	When it is from RUN to STOP
			When origin reset is not completed
SM245	All the output reset prohibited	ON condition	When not executing all the output resets (user program)
		OFF condition	When executing all the output resets (user program)
SM246	STL state ON	ON condition	When STL monitoring valid is ON and any of the stepping relay(device S) is ON
		OFF condition	When STL monitoring valid is OFF, or when STL monitoring valid is ON and all the stepping relays(device S) are ON
SM247	STL monitoring valid	ON condition	When issuing IST instruction
		OFF condition	When stepping ladder diagram ends(user program)
Device number	**Content**	**ON/OFF condition**	
S0	Initialization state of individual run	ON condition	When it is individual mode
		OFF condition	Except the individual mode
S1	Initialization state of origin state	ON condition	When it is origin reset mode
		OFF condition	Except the origin reset mode
S2	Initialization state of automatic run	ON condition	When it is automatic run mode
		OFF condition	Except the automatic run mode

7) Do not program the following states as normal states.

Device number	**Content**	**ON/OFF condition**

S0 to S9	Occupied as initialization state	ON condition	When the step relay (S device) is selected as the initialization state.
#S0 to S2 are used for individual run, origin reset and automatic run.		OFF condition	When the step relay (S device) is not selected
#S3 to S9 could be used freely.			
S10 to S19	Occupied as origin reset	ON condition	When the step relay (S device) is selected as the origin reset.
		OFF condition	When the step relay (S device) is not selected

8) When origin reset completion(SM243) is not ON, if switching between individual run(X20), origin reset(X21) and automatic run(X22,X23,X24), then all the output would be OFF. Automatic operation could be restarted after origin reset completion.

#**Note:**

1. Mode selection switches don't need to be all used. Unused switches should be set to empty (cannot be used for other purposes). It is necessary to write the program of the IST instruction before a series of STL loops such as states S0 to S2.
2. S10 to S19 should be used for the state of the origin reset operation. In the final state of the origin reset operation, self-reset should be performed after SM243 is set
3. Only one IST instruction can be written in the program.

(2) IST instruction equivalent loop

1) The details of the special relay (SM) and initialization state (S0 to S9) that are automatically controlled by the IST instruction are shown in the following equivalent circuit. (Please read it as a reference.) This equivalent circuit could not be programmed.
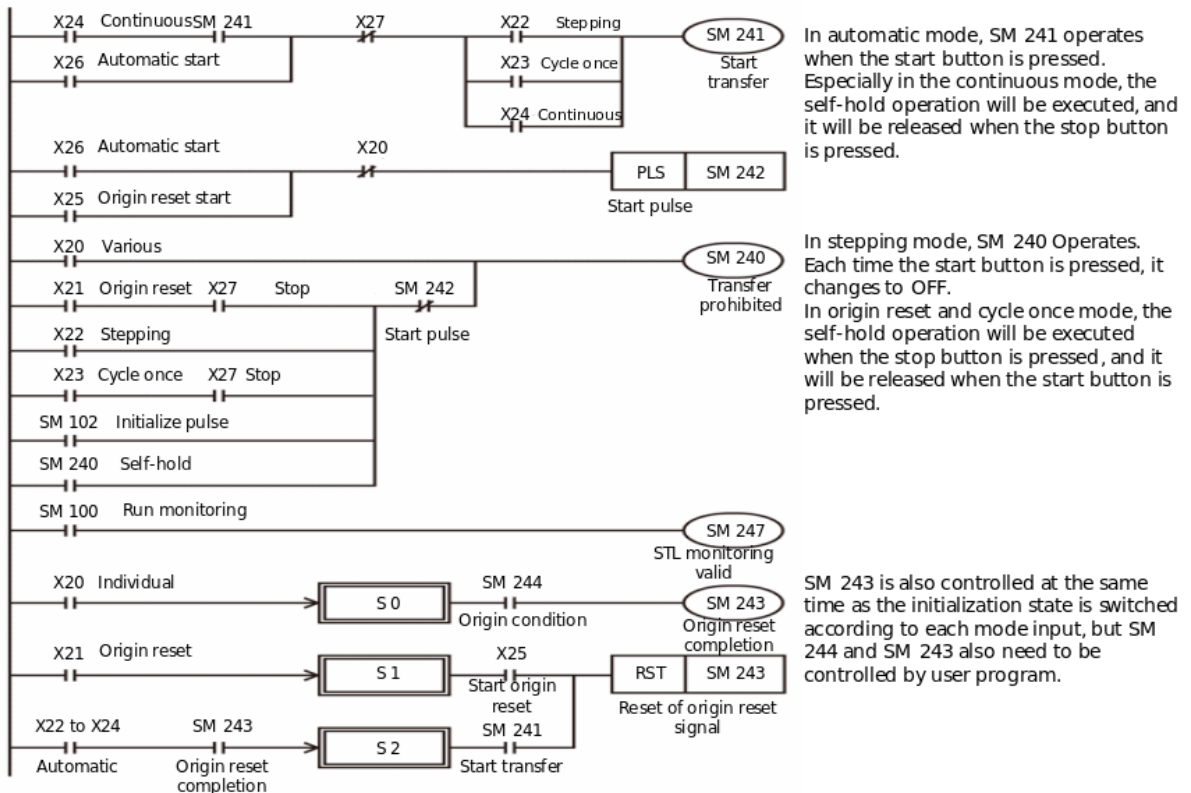
2) If the mode is switched between each, origin reset and automatic, when the machine is outside the origin position, all the outputs (output (Y) not driven by state and output (Y) driven by status by OUT and SET instructions) and the old state are reset in batches. The SM245 drive does not reset all outputs
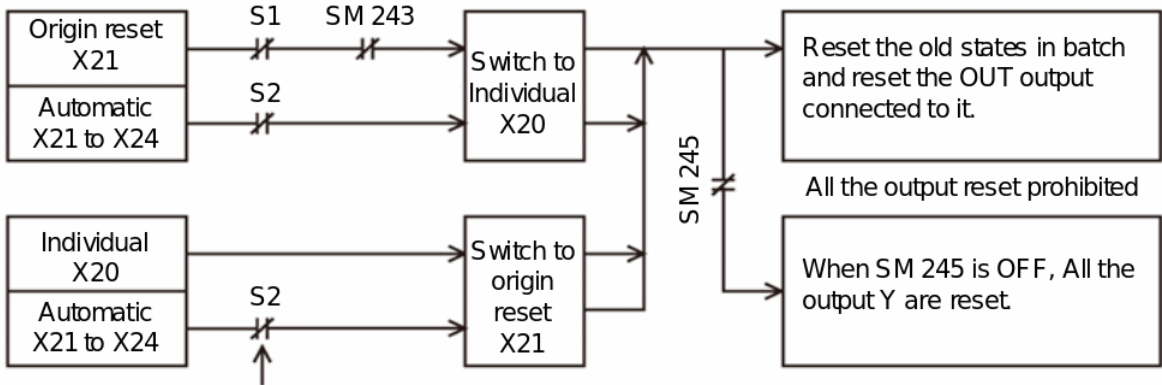
state would not be reset.

(3) The example of importing IST instruction(workpiece transfer equipment)

Run mode

A device that uses a Manipulator to transfer workpieces from point A to point B
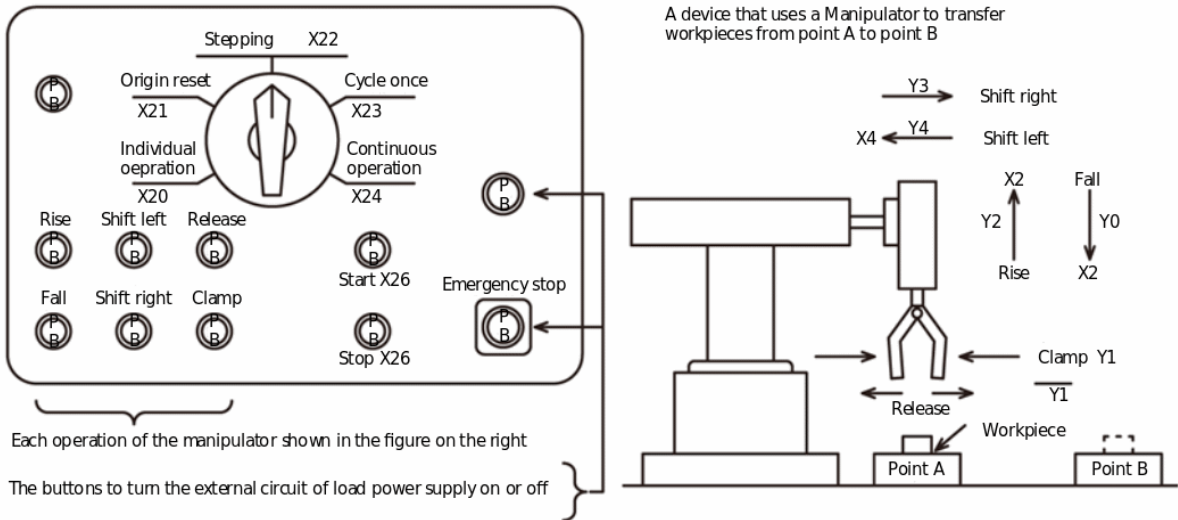
Each operation of the manipulator shown in the figure on the right

The buttons to turn the external circuit of load power supply on or off

Run mode		Operations
Manual	Individual run	Uses each button to turn the each load on or off.
	Origin reset	Press the origin reset button to automatically return the machine to the origin.
Automatic	Stepping	Each time the start button is pressed, it advances one process.
	Cycle once	If the start button is pressed at the origin, it will stop at the origin after executing one cycle of automatic operation.
		If the stop button is pressed in the middle, the process will be stopped, and

	if the start button is pressed again, the operation will continue from there, and then automatically stop at the origin.
Continuous run	If the start button is pressed at the origin position, continuous repeated run starts. If the stop button is pressed, the run will stop after reaching the origin.

Transfer equipment
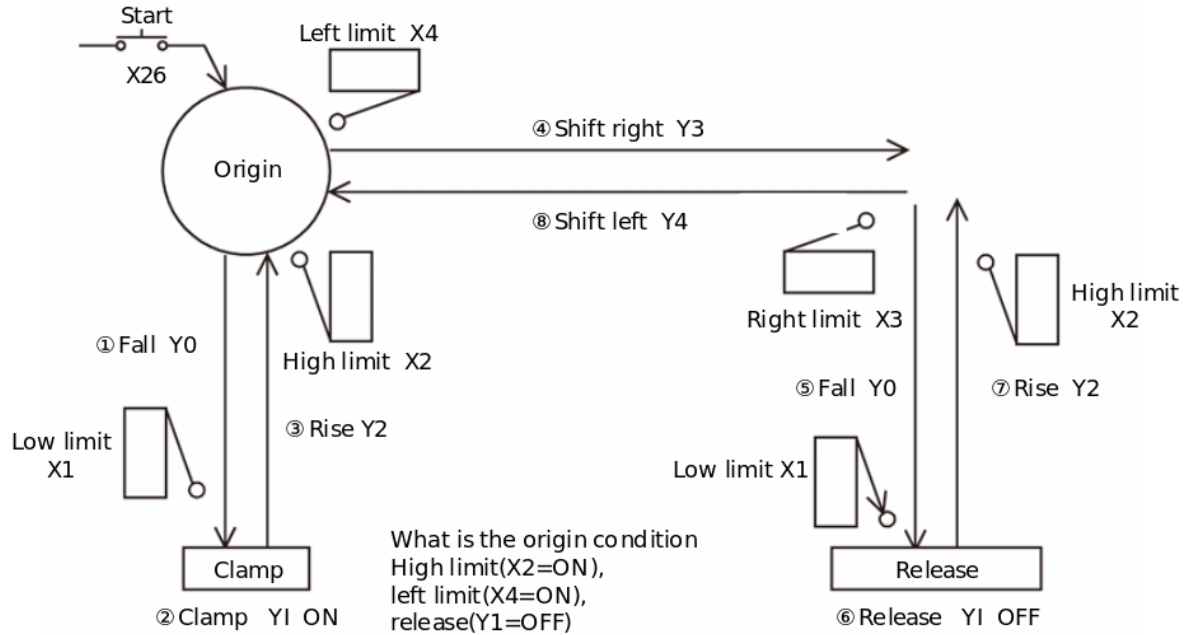
1) To use IST instructions, mode inputs need to be assigned consecutive number inputs as shown below. When the numbers are not consecutive or a part of the mode is omitted, use the auxiliary relay to change the arrangement as shown in the figure below, and use it as the start input for mode specification.

Input device	X20	X21	X22	X23	X24	X25	X26	X27
Assignment	Individual run	Origin reset	Stepping	Cycle run once	Continuous run	Origin reset start	Automatic start	Stop

When the numbers are not consecutive	Only in continuous or origin reset mode	Only in continuous or individual mode
Example: X30: Individual run X35: Origin reset X33: Stepping X40: Cycle run once X32: Continuous run X34: Origin reset start X26: Automatic start X41: Stop	Example: X30: Origin reset X31: Continuous run X32: Start to use Automatic start and Origin reset X33: Sop	Example: X30: Individual run X31: Continuous run X32: Automatic start X33: Sop

In this example, M0 is used as the start input for mode specification.
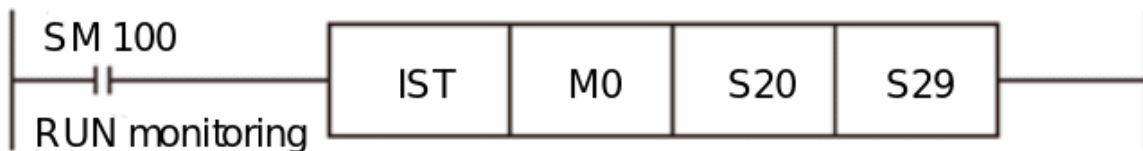
2) The special relay (SM) used in the IST instruction has different classifications. One is that the instruction itself is automatically controlled according to the situation and the other needs to be controlled by the program according to the preparation for operation and the purpose of control.

Special relay	Content	Remark
SM240 (Transfer prohibited)	Once the special relay is in operation, all the state transfers are prohibited. Individual: SM240 continues operating. Origin reset and cycle once: After pressing the stop button, the operation is held until the start button is pressed.	IST instructions execute automatic control

	Stepping: SM240 continues operating, but only when the start button is pressed, it does not operate and the transfer is executed.	
	When switching STOP to RUN, the operation of programmable controller is held, and unlocked when the start button is pressed. Even when the transfer state is prohibited, the output in the state continues the origin operation.	
SM241 (Start transfer)	An auxiliary relay as a transition condition from the initialization state S2 to the next state.	
	Individual and origin reset: No operation.	
	Stepping and cycle once: Only operates when the start button is pressed.	
	Continuous: The operation is held when the start button is pressed, and unlocked after pressing the stop button.	
SM242(Start pulse)	Only operates at the moment of pressing the start button.	
SM247 (STL monitoring valid)	After using the IST instruction, set SM247 to ON.When SM247 turns ON, the STL monitoring becomes valid, and the status numbers (S0 to S899) in operation are stored in the special registers SD240 to SD247 in ascending order.	
	Therefore, a maximum of eight operation states number can be monitored	
	Besides, if any of there states is in operation, special relay SM246 also operates.	
SM243 (Origin reset completion)	In origin reset mode, when the machine returns to the origin, operates the special relay (SM) with the user program.	Driven by sequential control program
SM244 (Origin condition)	The special relay should be driven after detecting the origin condition of the machine. It is valid signal in all the modes.	
SM245 (All the output reset prohibited)	If switching between individual run, origin reset and automatic mode, when the machine is not in the origin, reset all the outputs and operation states. But if SM245 is driven first, then only the operation state is reset.	

Program

3) When the machine is running, it could switch freely in "Automatic" mode (stepping/cycle once/continuous). In this case, to be safe, the switched mode becomes effective only after all outputs are reset once.(When SM245 (all the output reset prohibited) is set to ON, it will not be reset)

```
   X4        X2        Y1                      SM 244
  ──┤├──────┤├───────┤/├──────────────────────( )          Origin condition      As a condition for the start of
  Left limit High limit Release                                                   automatic run transfer after
                                                                                  detecting the origin state.
  SM 100
  ──┤├──────────────┌────┬─────┬─────┬─────┐               Initialization state
  RUN monitoring    │ IST│ X20 │ S20 │ S27 │
                    └────┴─────┴─────┴─────┘
```
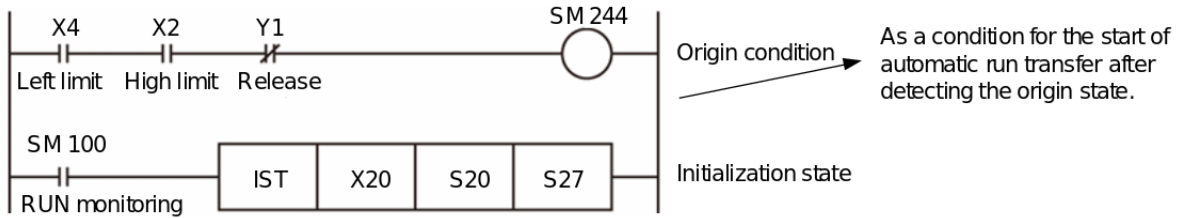
1. No programming is required if there is no individual run mode.

```
                                        ┌──────┬──────┐      Initialization state
                                        │ STL  │  S0  │      of individual run
                                        └──────┴──────┘
   X12  Clamp instruction
  ──┤├──────────────────────────────────┌──────┬──────┐
                                        │ SET  │  Y1  │      Clamp
                                        └──────┴──────┘
   X7   Release instruction
  ──┤├──────────────────────────────────┌──────┬──────┐
                                        │ RST  │  Y1  │
                                        └──────┴──────┘
   X5   Rise instruction      Y0                    Y2
  ──┤├───────────────────────┤/├────────────────────( )      Rise
   X10  Fall instruction      Y2                    Y0
  ──┤├───────────────────────┤/├────────────────────( )      Fall
   X6   Shift left instruction X2    Y3             Y4
  ──┤├────────────────────────┤├────┤/├──────────────( )      Shift left
   X11  Shift right instruction X2   Y4             Y3
  ──┤├────────────────────────┤├────┤/├──────────────( )      Shift right
                    High limit
                                        ┌──────────────┐
                                        │     RET      │
                                        └──────────────┘
```
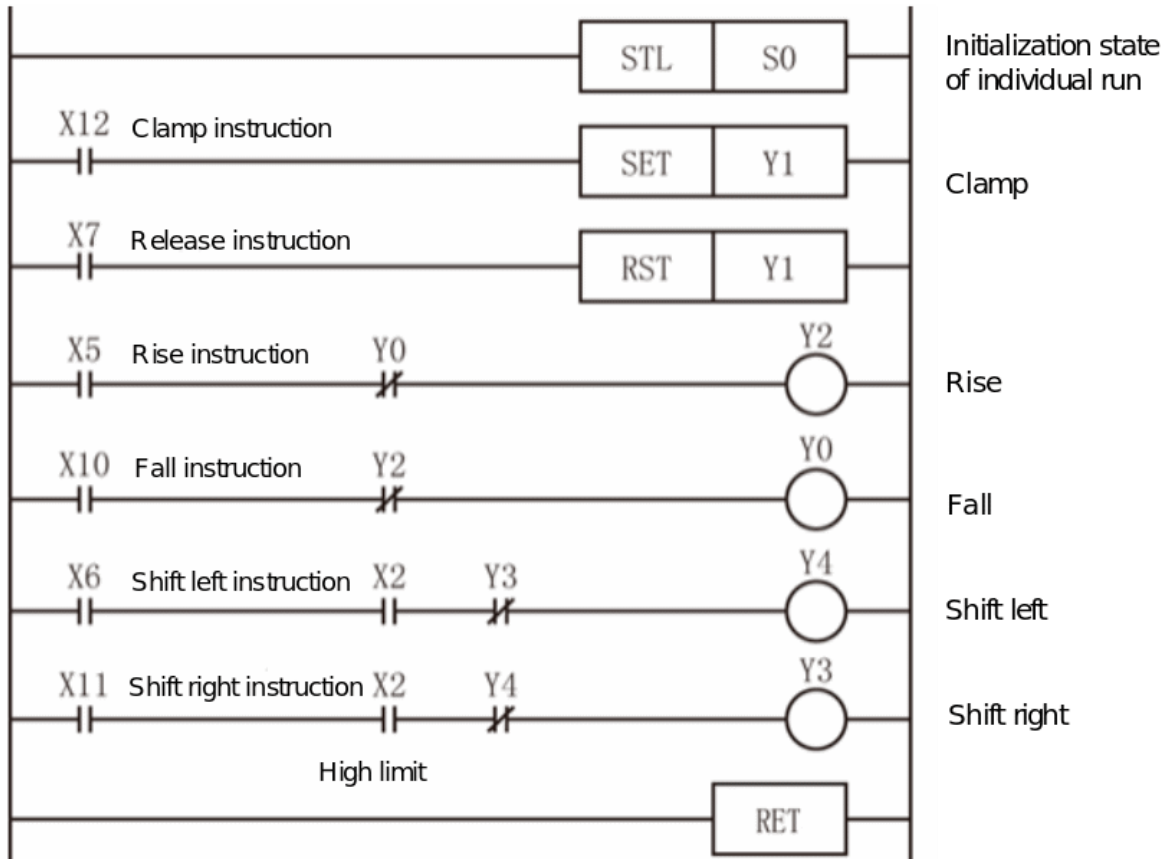
4) No programming is required if there is no origin reset mode. But before automatic run, You need to reset the origin first to complete the SM243 set once

	STL	S1	Initialization state of origin reset

X25
├┤
Start origin reset

SET	S10	

STL	S10	

S10
├┤

RST	Y1	Release

RST	Y0	Unlock the fall

Y2 ◯ Rise

X2
├┤
High limit

SET	S11	

STL	S11	

S11
├┤
Left limit

RST	Y3	Unlock shift right

Y4 ◯ Shift left

X4
├┤

SET	S12	

STL	S12	

SM400
├┤

SET	SM 243	Origin reset cpmletion

SM 243
├┤

RST	S12	

The Operation of origin Reset must use state S10 to S19, after driving SM 243 in the final state, self-reset should be executed.

RET	

5) Automatic run (stepping/cycle once/continuous)

		STL	S2	Initialization state

SM 241 — SM 244 → SET S20 — of automatic run
Start transfer — Origin condition

STL S20

SM400 —(Y0)— Fall

X1 — SET S21
Low limit

STL S21

SM400 — SET Y1 — Clamp

—(T0 K10)

T0 — SET S22

STL S22

SM400 —(Y2)— Rise

X2 — SET S23
High limit

STL S23

SM400 —(Y3)— Shift right

X3 — SET S24
Right limit

STL S24

SM400 —(Y0)— Fall

X1 — SET S25
Low limit

STL S25

S25 — RST Y1 — Release

—(T1 K10)

T1 — SET S26

STL S26

SM400 —(Y2)— Rise

X2 — SET S27
High limit

STL S27

SM400 —(Y4)— Shift right

X4 —(S2)
Left limit

RET

END

Error code

Error code	Content
4085H	When the device number specified by (d1) and (d2) is in the following case. (d1)>(d2)
	When the device specified in (s) couldn't reserve eight points.