PLC Programming Languages

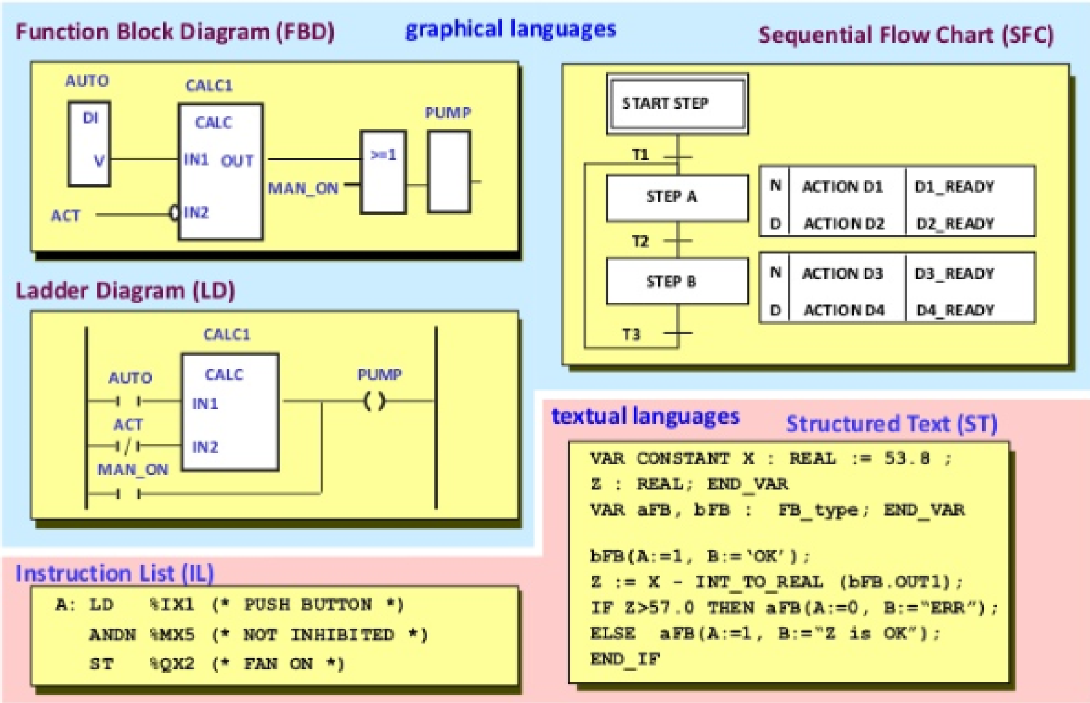
INTRODUCTION TO THE IEC 1131

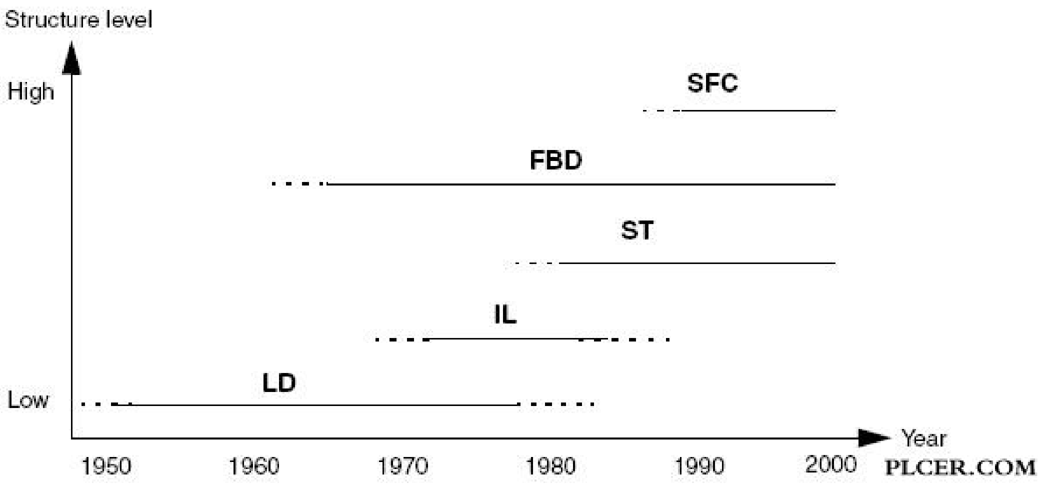
The International Electrotechnical Commission (IEC) SC65B-WG7 committee developed the IEC 1131 standard in an effort to standardize programmable controllers.

One of the committee's objectives was to create a common set of PLC instructions that could be used in all PLCs.

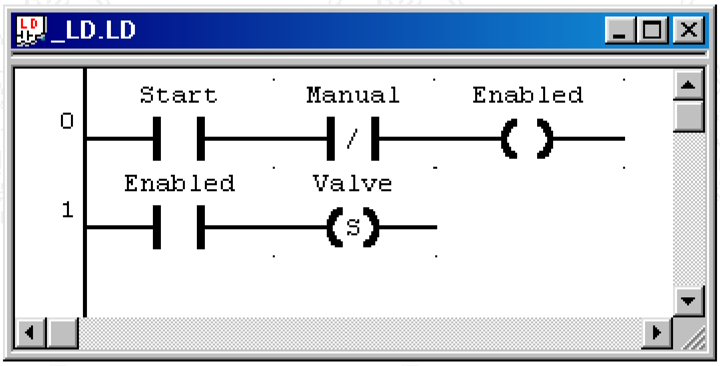
It Defines three graphical languages and two text-based languages
The graphical languages use symbols to program control instruction while text-based used character strings to program the instructions

The five IEC 61131-3 Programming languages

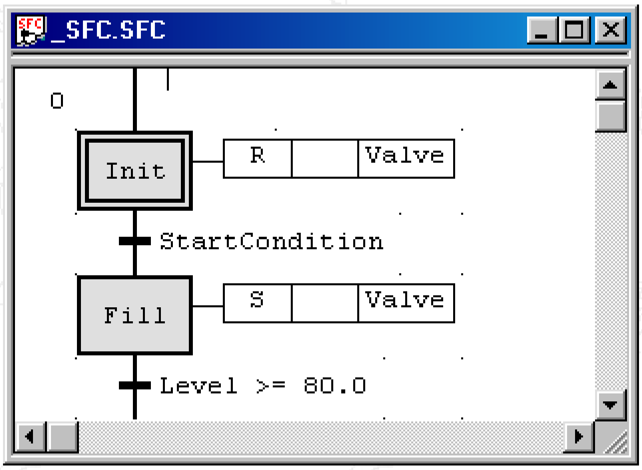




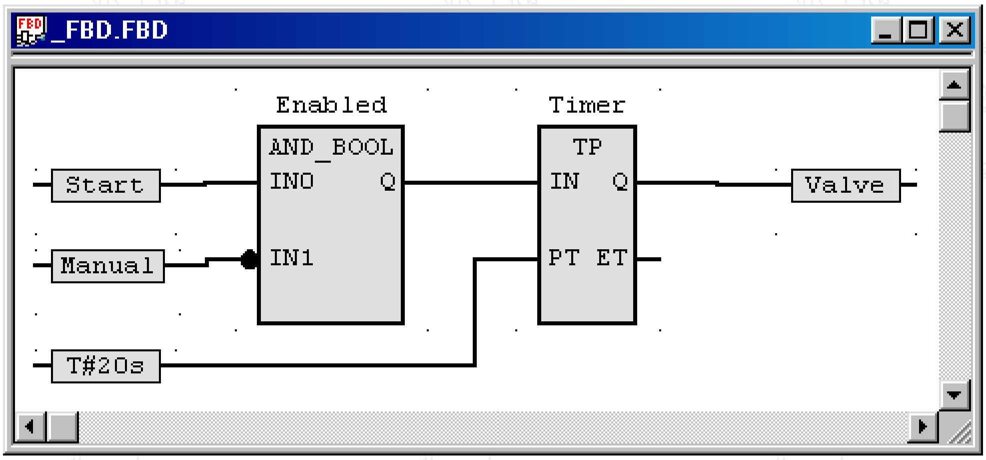
Programmers may choose from among five PLC languages.
Ladder diagram (LD) is best for programs controlled by multiple files, subroutines and code sectioning.



Sequential function charts (SFCs) are used to program systems that are more advanced than those run by LD.

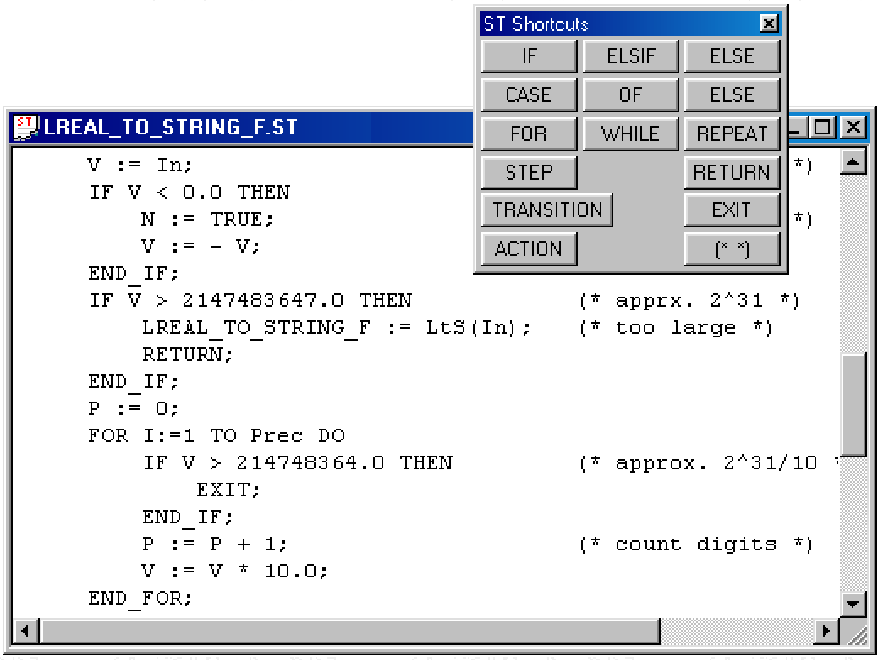


Function block diagram (FBD) is a graphical language that drives data from inputs to outputs by sending through blocks of nested data.



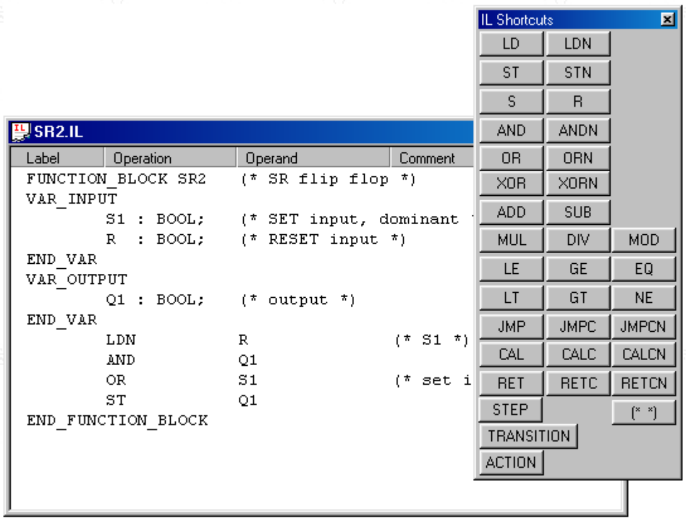
Structured text (ST) resembles Basic or Pascal programming languages, in that it uses statements such as "If-Then-Else," "While" and "Repeat."

Structured Text (ST) is a Pascal-like textual PLC programming language.



Instruction list (IL) uses mnemonic instructions from the ladder diagrams and sends the instructions to the PLC via a programming terminal.

Instruction List is one of the oldest, textual programming methods for PLCs. Large (and mostly incompatible) sets of instructions have been crea
Instruction list reduced this set to a minimum and favours the usage of functions and function blocks for more complex tasks.



PLC DVP ES (Delta Comp.)

2.1 ES2/EX2 Memory Map

<table>
<tr><th colspan="6">Specifications</th></tr>
<tr><td colspan="4">Control Method</td><td colspan="2">Stored program, cyclic scan system</td></tr>
<tr><td colspan="4">I/O Processing Method</td><td colspan="2">Batch processing method (when END instruction is executed)</td></tr>
<tr><td colspan="4">Execution Speed</td><td colspan="2">LD instructions – 0.54μs, MOV instructions – 3.4μs</td></tr>
<tr><td colspan="4">Program language</td><td colspan="2">Instruction List + Ladder + SFC</td></tr>
<tr><td colspan="4">Program Capacity</td><td colspan="2">15872 steps</td></tr>
<tr><td rowspan="5">Bit Contacts</td><td>X</td><td colspan="2">External inputs</td><td>X0~X377, octal number system, 256 points max, (*4)</td><td rowspan="2">Total 256+16 I/O</td></tr>
<tr><td>Y</td><td colspan="2">External outputs</td><td>Y0~Y377, octal number system, 256 points max, (*4)</td></tr>
<tr><td rowspan="3">M</td><td rowspan="3">Auxiliary relay</td><td>General</td><td>M0~M511, 512 points, (*1)
M768~M999, 232 points, (*1)
M2000~M2047, 48 points, (*1)</td><td rowspan="3">Total 4096 points</td></tr>
<tr><td>Latched</td><td>M512~M767, 256 points, (*2)
M2048~M4095, 2048 points, (*2)</td></tr>
<tr><td>Special</td><td>M1000~M1999, 1000 points, some are latched</td></tr>
</table>

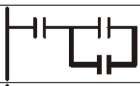
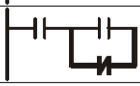
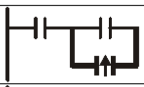
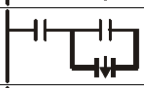
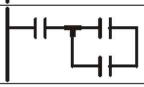
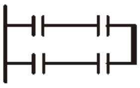
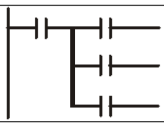
	T	Timer	100ms (M1028=ON, T64~T126: 10ms)	T0~T126, 127 points, (*1) T128~T183, 56 points, (*1)	Total 256 points
				T184~T199 for Subroutines, 16 points, (*1)	
				T250~T255(accumulative), 6 points (*1)	
			10ms (M1038=ON, T200~T245: 1ms)	T200~T239, 40 points, (*1)	
				T240~T245(accumulative), 6 points, (*1)	
			1ms	T127, 1 points, (*1) T246~T249(accumulative), 4 points, (*1)	
	C	Counter	16-bit count up	C0~C111, 112 points, (*1) C128~C199,72 points, (*1)	Total 232 points
				C112~C127,16 points, (*2)	
			32-bit count up/down	C200~C223, 24 points, (*1)	
				C224~C231, 8 points, (*2)	

Specifications						
			32bit high-speed count up/down	Soft-ware	C235~C242, 1 phase 1 input, 8 points, (*2)	Total 23 points
					C232~C234, 2 phase 2 input, 3 points, (*2)	
				Hard-ware	C243~C244, 1 phase 1 input, 2 points, (*2)	
					C245~C250, 1 phase 2 input, 6 points, (*2)	
					C251~C254 2 phase 2 input, 4 points, (*2)	
	S	Step point	Initial step point		S0~S9, 10 points, (*2)	Total 1024 points
			Zero point return		S10~S19, 10 points (use with IST instruction), (*2)	
			Latched		S20~S127, 108 points, (*2)	
			General		S128~S911, 784 points, (*1)	
			Alarm		S912~S1023, 112 points, (*2)	
	T	Current value			T0~T255, 256 words	
	C	Current value			C0~C199, 16-bit counter, 200 words	
					C200~C254, 32-bit counter, 55 words	

Word Register	D	Data register	General	D0~D407, 408 words, (*1) D600~D999, 400 words, (*1) D3920~D9999, 6080 words, (*1)	Total 10000 points
			Latched	D408~D599, 192 words, (*2) D2000~D3919, 1920 words, (*2)	
			Special	D1000~D1999, 1000 words, some are latched	
			For Special mudules	D9900~D9999，100 words， (*1), (*5)	
			Index	E0~E7, F0~F7, 16 words, (*1)	
Pointer	N	Master control loop		N0~N7, 8 points	
	P	Pointer		P0~P255, 256 points	
	I	Interrupt Service	External interrupt	I000/I001(X0), I100/I101(X1), I200/I201(X2), I300/I301(X3), I400/I401(X4), I500/I501(X5), I600/I601(X6), I700/I701(X7), 8 points (01: rising-edge trigger _|‾, 00: falling-edge trigger ‾|_)	

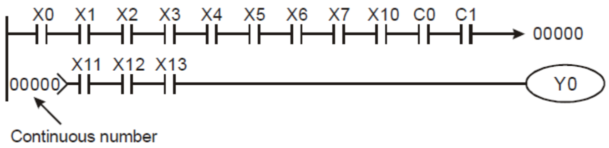
			Specifications
		Timer interrupt	I602~I699, I702~I799, 2 points (Timer resolution = 1ms)
		High-speed counter interrupt	I010, I020, I030, I040, I050, I060, I070, I080,8 points
		Communication interrupt	I140(COM1), I150(COM2), I160(COM3), 3 points, (*3)
Constant	K	Decimal	K-32,768 ~ K32,767 (16-bit operation), K-2,147,483,648 ~ K2,147,483,647 (32-bit operation)
	H	Hexadecimal	H0000 ~ HFFFF (16-bit operation), H00000000 ~HFFFFFFFF (32-bit operation)
Serial ports			COM1: built-in RS-232 ((Master/Slave) COM2: built-in RS-485 (Master/Slave) COM3: built-in RS-485 (Master/Slave) COM1 is typically the programming port.
Real Time Clock			Year, Month, Day, Week, Hours, Minutes, Seconds
Special I/O Modules			Up to 8 special I/O modules can be connected

The structure of a ladder diagram:

Structure	Explanation	Instruction	Devices Used
	Normally open, contact A	LD	X, Y, M, S, T, C
	Normally closed, contact B	LDI	X, Y, M, S, T, C
	Normally open in series connection	AND	X, Y, M, S, T, C
	Normally closed in series connection	ANI	X, Y, M, S, T, C
	Normally open in parallel connection	OR	X, Y, M, S, T, C
	Normally closed in parallel connection	ORI	X, Y, M, S, T, C
	Rising-edge trigger switch	LDP	X, Y, M, S, T, C
	Falling-edge trigger switch	LDF	X, Y, M, S, T, C
	Rising-edge trigger in series connection	ANDP	X, Y, M, S, T, C
	Falling-edge trigger in series connection	ANDF	X, Y, M, S, T, C
	Rising-edge trigger in parallel connection	ORP	X, Y, M, S, T, C
	Falling-edge trigger in parallel connection	ORF	X, Y, M, S, T, C
	Block in series connection	ANB	-
	Block in parallel connection	ORB	-
	Multiple output	MPS MRD MPP	-
	Coil driven output instruction	OUT	Y, M, S

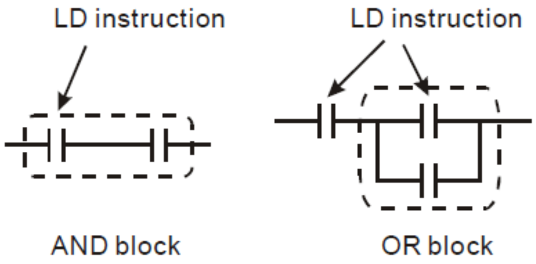
How to Edit a PLC Ladder Diagram

The editing of the program should start from the left power line and ends at the right power line, a row after another. The drawing of the right power line will be omitted if edited from WPLSoft. A row can have maximum 11 contacts on it. If 11 is not enough, you can continuously connect more devices and the continuous number will be generated automatically. The same input points can be used repeatedly. See the figure below:

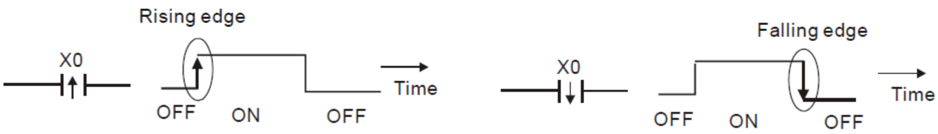


Explanations on the basic structures in the ladder diagram:

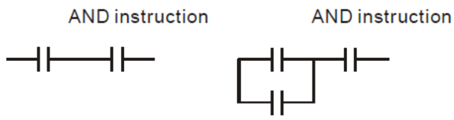
1. LD (LDI) instruction: Given in the start of a block.



The structure of LDP and LDF instructions are the same as that of LD instruction, and the two only differ in their actions. LDP and LDF instructions only act at the rising edge or falling edge when the contact is On, as shown in the figure below.

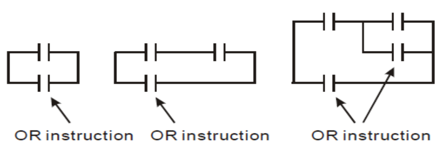


2. AND (ANI) instruction: A single device connects to another single device or a block in series



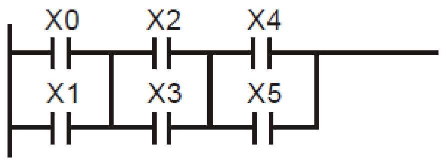
The structure of ANDP and ANDF instructions are the same. ANDP and ANDF instructions only act at the rising edge or falling edge.

3. OR (ORI) instruction: A single device connects to another single device or a block



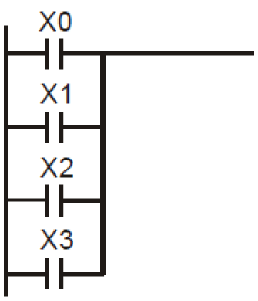
The structure of ORP and ORF instructions are the same. ORP and ORF instructions only act at the rising edge or falling edge.

EX 1



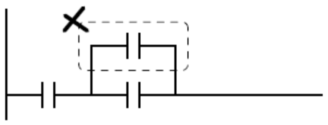
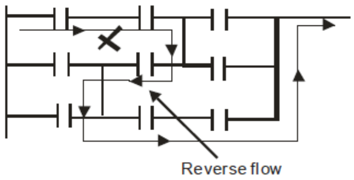
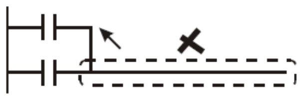
Ideal way	
LD	X0
OR	X1
LD	X2
OR	X3
ANB	
LD	X4
OR	X5
ANB	

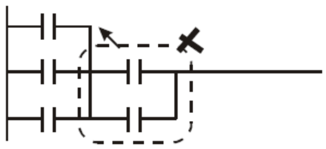
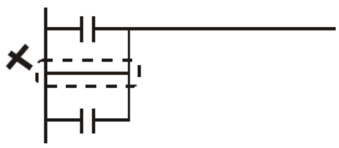
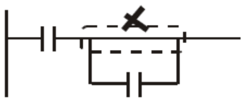
EX2

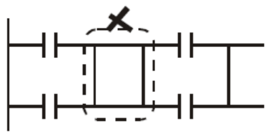
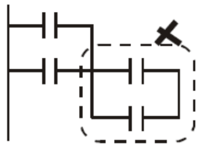
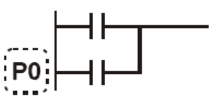


Ideal way	
LD	X0
OR	X1
OR	X2
OR	X3

Incorrect Ladder

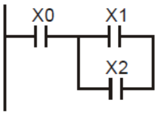
	OR operation upward is not allowed.
	"Reverse flow" exists in the signal circuit from the beginning of input to output.
	The up-right corner should output first.

	Combining or editing should be done from the up-left to the bottom-right. The dotted-lined area should be moved up.
	Parallel operation with empty device is not allowed.
	Empty device cannot do operations with other devices.

	No device in the middle block.
	Devices and blocks in series should be horizontally aligned.
	Label P0 should be in the first row of a complete network.

Simplified Ladder

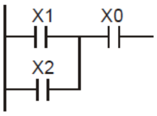
■ When a series block is connected to a parallel block in series, place the block in the front to omit ANB instruction.



Ladder diagram complied into instruction

LD	X0
LD	X1
OR	X2
ANB	

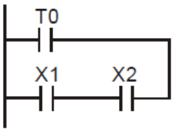
⇩



Ladder diagram complied into instruction

LD	X1
OR	X2
AND	X0

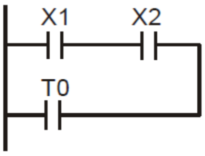
■ When a single device is connected to a block in parallel, place the block on top to omit ORB instruction.



Ladder diagram complied into instruction

LD	T0
LD	X1
AND	X2
ORB	

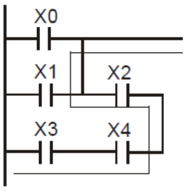
⇩



Ladder diagram complied into instruction

LD	X1
AND	X2
OR	T0

■ In diagram (a), the block on top is shorter than the block in the bottom, we can switch the position of the two blocks to achieve the same logic. Due to that diagram (a) is illegal, there is a "reverse flow" in it.

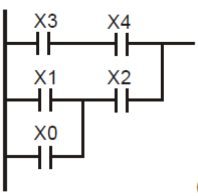


(a)

Ladder diagram complied into instruction

LD	X0
OR	X1
AND	X2
LD	X3
AND	X4
ORB	

⇩

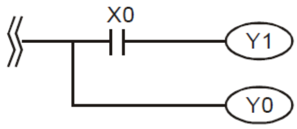


(b)

Ladder diagram complied into instruction

LD	X3
AND	X4
LD	X1
OR	X0
AND	X2

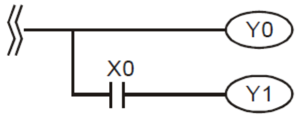
■ MPS and MPP instruction can be omitted when the multiple outputs in the same horizontal line do not need to operate with other input devices.



Ladder diagram complied into instruction

MPS	
AND	X0
OUT	Y1
MPP	
OUT	Y0

⇩



Ladder diagram complied into instruction

OUT	Y0
AND	X0
OUT	Y1

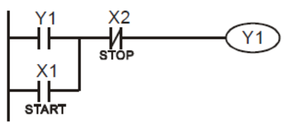
Basic Program Designing Examples

■ **Start, Stop and Latched**

In some application occasions, we need to use the transient close/open buttons for the start and stop of an equipment. To maintain its continuous action, you have to design latched circuits.

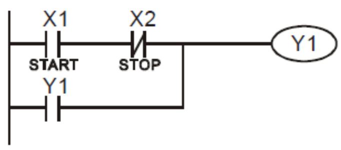
Example 1: Stop first latched circuit

When the normally open contact X1 = On and the normally closed contact X2 = Off, Y1 will be On. If you make X2 = On at this time, Y1 will be Off. It is the reason why this is called "stop first".



Example 2: Start first latched circuit

When the normally open contact X1 = On and the normally closed contact X2 = Off, Y1 will be On and latched. If you make X2 = On at this time, Y1 will continue to be On because of the latched contact. It is the reason why this is called "start first".



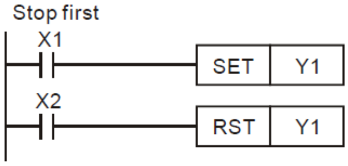
Example 3: Latched circuit for SET and RST instructions

See the diagram in the right hand side for the latched circuit consist of RST and SET instructions.

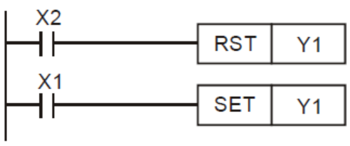
In the stop first diagram, RST is placed after SET. PLC executes the program from up to down, so the On/Off of Y1 will be determined upon its status in the end of the program. Therefore, when X1 and X2 are enabled at the same time, Y1 will be Off. It is the reason why this is called "stop first".

In the start first diagram, SET is placed after RST. When X1 and X2 are enabled at the same time, Y1 will be On. It is the reason why this is called "start first".

Stop first

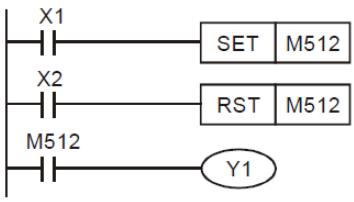


Start first



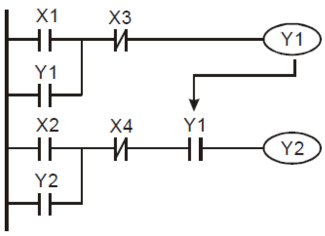
Example 4: Power shutdown latched

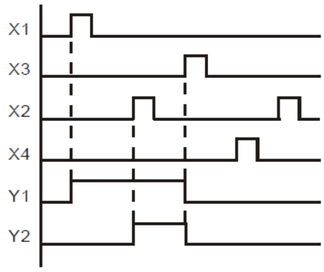
The auxiliary relay M512 is latched (see instruction sheets for DVP series PLC MPU). The circuit can not only be latched when the power is on, but also keep the continuity of the original control when the power is shut down and switched on again.



Frequently Used Control Circuit

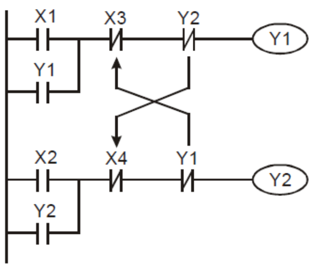
Example 5: Conditional control

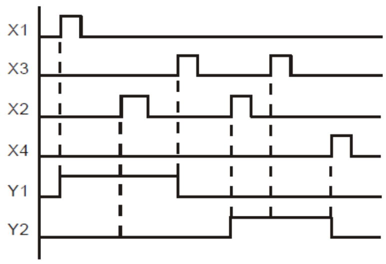




X1 and X3 enables and disables Y1; X2 and X4 enables and disables Y2, and all are latched. Due to that the normally open contact of Y1 is connected to the circuit of Y2 in series, Y1 becomes an AND condition for Y2. Therefore, only when Y1 is enabled can Y2 be enabled.

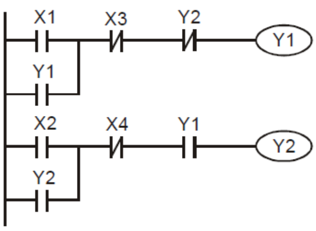
Example 6: Interlock control





Which of the X1 and X2 is first enabled decides either the corresponding output Y1 or Y2 will be enabled first. Either Y1 or Y2 will be enabled at a time, i.e. Y1 and Y2 will not be enabled at the same time (the interlock). Even X1 and X2 are enabled at the same time, Y1 and Y2 will not be enabled at the same time due to that the ladder diagram program is scanned from up to down. In this ladder diagram, Y1 will be enabled first.

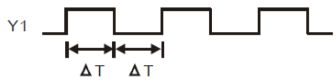
Example 7: Sequential control



If we serially connect the normally closed contact of Y2 in example 5 to the circuit of Y1 as an AND condition for Y1 (as the diagram in the left hand side), the circuit can not only make Y1 as the condition for Y2, but also allow the stop of Y1 after Y2 is enabled. Therefore, we can make Y1 and Y2 execute exactly the sequential control.

Example 8: Oscillating circuit

An oscillating circuit with cycle △T+△T



The ladder diagram above is a very simple one. When the program starts to scan the normally closed contact Y1, Y1 will be closed because coil Y1 is Off. When the program then scan to coil Y1 and make it On, the output will be 1. When the program scans to the normally closed contact Y1 again in the next scan cycle, because coil Y1 is On, Y1 will be open and make coil Y1 Off and output 0. The repeated scans will result in coil Y1 outputs oscillating pulses by the cycle △T(On)+△T(Off).

An oscillating circuit with cycle nT+△T

Functions of timers:

The units of the timer are 1ms, 10ms and 100ms and the counting method is counting up. When the present value in the timer equals the set value, the output coil will be On. The set value should be a K value in decimal and the data register D can also be a set value.

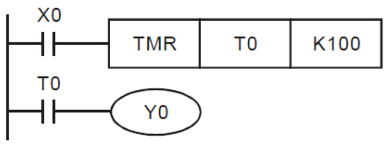
The actual set time in the timer = timing unit × set value

There are three types of timers:

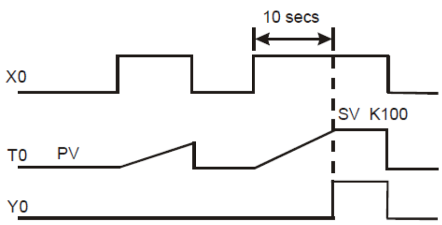
1. **General purpose timer:**

   For ES/SA series MPU: The timer executes once when the program reaches END instruction. When TMR instruction is executed, the output coil will be On when the timing reaches its target.

   For EH2/SV/EH3/SV2 series MPU: The timer executes once when the program reaches TMR instruction. When TMR instruction is executed, the output coil will be On when the timing reaches its target.



- When X0 = On, The PV in timer T0 will count up by 100ms. When the PV = SV K100, the output coil T0 will be On.

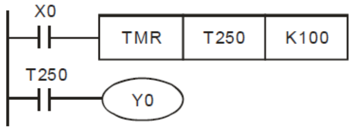


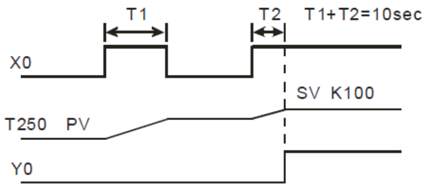
- When X0 = Off or the power is off, the PV in timer T0 will be cleared as 0, and the output coil T0 will be Off.

2. **Accumulative type timer:**

For ES/SA series MPU: The timer executes once when the program reaches END instruction. When TMR instruction is executed, the output coil will be On when the timing reaches its target.

For EH2/SV/EH3/SV2 series MPU: The timer executes once when the program reaches TMR instruction. When TMR instruction is executed, the output coil will be On when the timing reaches its target.



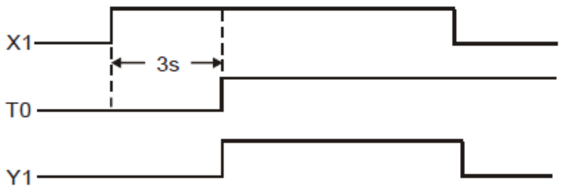


- When X0 = On, The PV in timer T250 will count up by 100ms. When the PV = SV K100, the output coil T0 will be On.
- When X0 = Off or the power is off, timer T250 will temporarily stop the timing and the PV remain unchanged. When X0 is On again, the timing will resume and the PV will count up and when the PV = SV K100, the output coil T0 will be On.

3:1 Delay ON Program

Control Purpose:

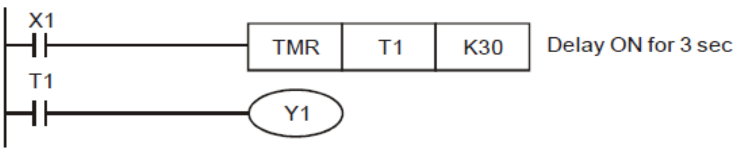
- Enabling the indicator to be ON after a 3 sec delay and OFF immediately by the switch



Devices:

Device	Function
X1	X1 = ON when the switch is turned on
T1	3 sec timer, time base = 100ms
Y1	Output indicator

Control Program:

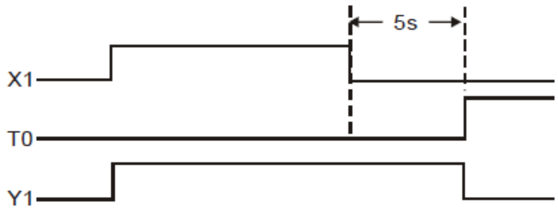


3:2

3.1 Delay OFF Program

Control Purpose:

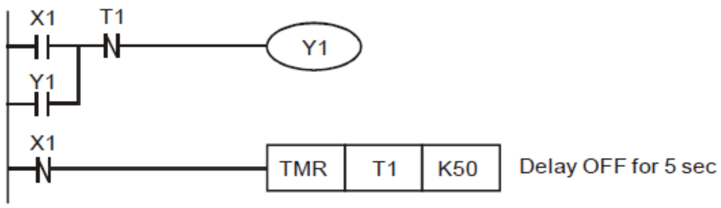
- Enabling the indicator to be ON immediately and OFF after a 5 sec delay by the switch



Devices:

Device	Function
X1	X1 = OFF when the switch is turned off
T1	5 sec timer. Time base = 100ms
Y1	Output indicator

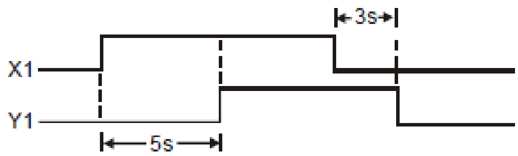
Control Program:



3.3 Delay ON/OFF Program

Control Purpose:

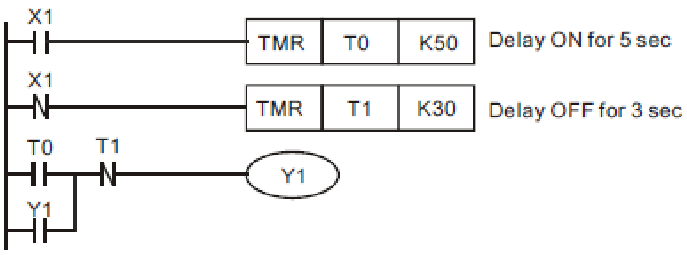
- Enabling the indicator to be ON after a 5 sec delay and OFF after a 3 sec delay by the switch



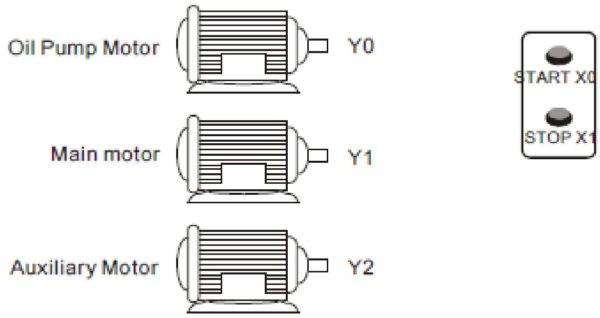
Devices:

Device	Function
X1	X1 = ON when the switch is turned on.
T0	5 sec timer, time base = 100ms
T1	3 sec timer, time base = 100ms
Y1	Output indicator

Control Program:

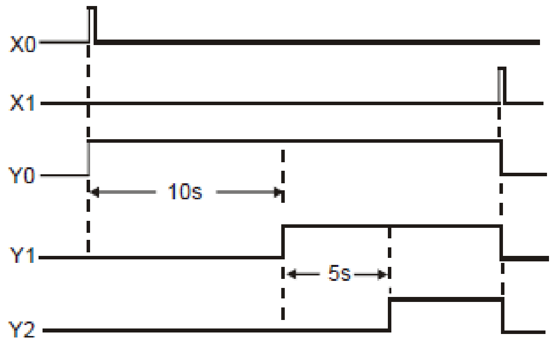


3.4 Sequential Delay Output (Starting 3 Motors Sequentially)



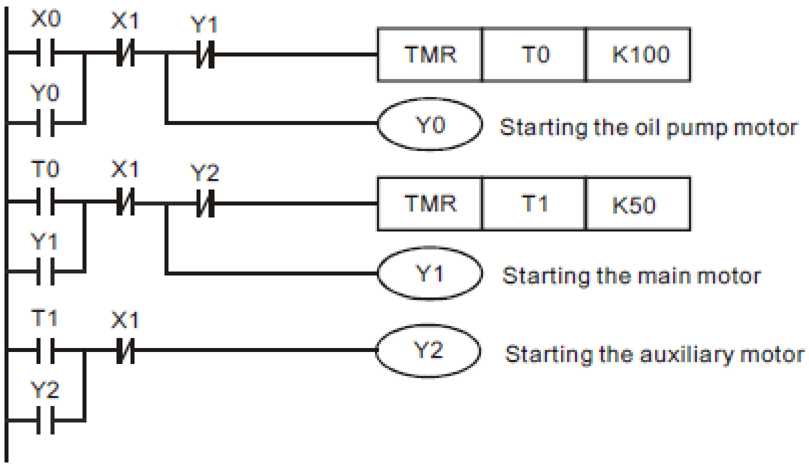
Control Purpose:

- Starting the oil pump motor immediately when START is pressed. The main motor will be started after a 10 sec delay and then the auxiliary motor after a 5 sec delay. In addition, stopping all motors immediately when STOP is pressed.



Device	Function
X0	X0 = ON when START is pressed.
X1	X1 = ON when STOP is pressed.
T0	10 sec timer. Time base: 100ms
T1	5 sec timer. Time base: 100ms
Y0	Starting the oil pump motor
Y1	Starting the main motor
Y2	Starting the auxiliary motor

Control Program:

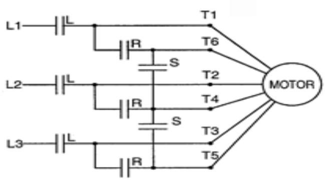


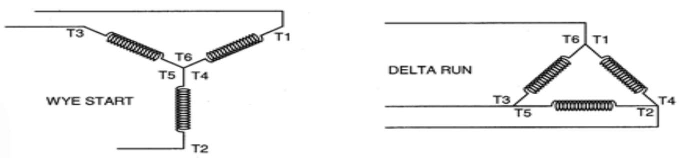
Program Description:

- When START is pressed, the NO contact X0 will be activated, which makes Y0 to be ON and latched. The oil pump motor will start the lube system. At the same time, [TMR T0 K100] instruction will be executed. When T0 reaches its set value of 10 sec, the NO contact T0 will be ON.
- When the NO contact T0 is ON, Y1 will be ON and latched, which starts the main motor and stops timer T0. At the same time, [TMR T1 K50] is executed, and the NO contact T1 will be ON when timer T1 reaches its set value.
- When the NO contact T1 is ON, Y2 will be ON and latched, which starts the auxiliary motor and stops T1.
- When STOP is pressed, the NC contact X1 will be activated, which makes Y0, Y1 and Y2 OFF. The oil pump motor, main motor and auxiliary motor will stop working.

Start Delta Run

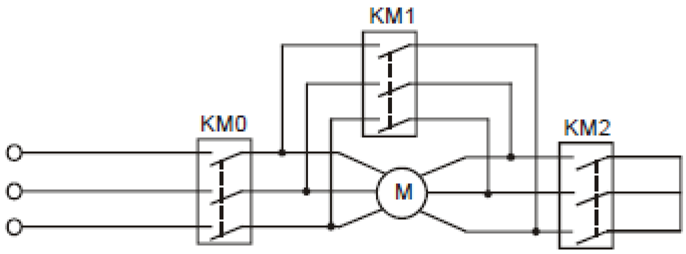
This method is actually reduced voltage but is accomplished by changing the motor phase connections such that a winding that is designed to run with phase voltage equal to line voltage on delta connection is wye connected for starting to put less than line voltage on each phase. Effectively, the voltage is reduced by 1.732 factor. The impedance seen by the power system is 3 times the impedance of the delta run connection.



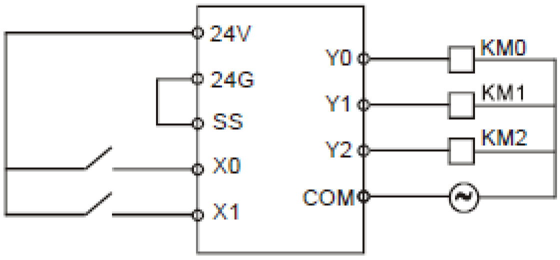


START: R OPEN, L & S CLOSED
RUN: R & L CLOSED, S OPEN

Star-Delta Reduced Voltage Starter Control



Reduced Voltage Starting Main Circuit



PLC External Wiring

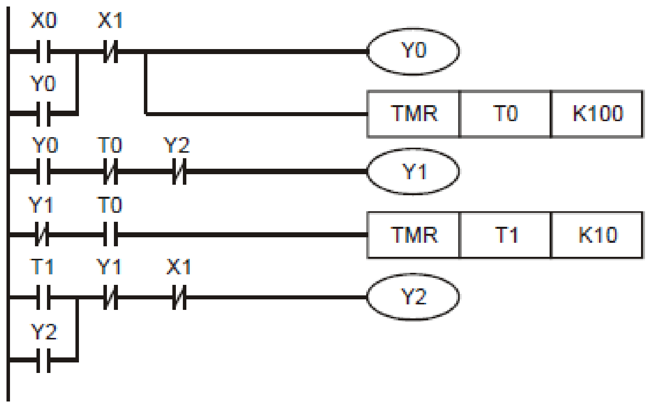
Control Purpose:

- Usually the starting current of the three-phase AC asynchronous motor is 5 ~7 times larger than the rated current. To reduce the effect of the starting current on the electrified wire fence, a star-delta reduced voltage starter should be applied.
- Starting process of a star-delta reduced voltage starter:
  When the switch is turned on, the contactors of both motor starter and "Star Reduced Voltage Starter" will be enabled first. After a 10 sec delay, the contactor of "Star Reduced Voltage Starter" will be disabled. Finally, the contactor of "Delta Reduced Voltage Starter" will be enabled after 1 sec, which operates the main motor circuit normally. The control purpose in this process is to assure the contactor of "Star Reduced Voltage Starter" is disabled completely before the contactor of "Delta Reduced Voltage Starter" is enabled.

Devices:

Device	Function
X0	X0 = ON when START is pressed.
X1	X1 = ON when STOP is pressed.
T1	10 sec timer. Time base: 100ms
T2	1 sec timer. Time base: 100ms
Y0	Motor starting contactor KM0
Y1	"Star Reduced Voltage Starter" contactor KM1
Y2	"Delta Reduced Voltage Starter" conntactor KM2

Control Program:



Program Description:

- X0 = ON when START is pressed. Y0 will be ON and latched. The motor starting contactor KM0 will be ON and the timer T0 will start to count for 10 sec. At the same time, because Y0 = ON, T0 = OFF and Y2 = OFF, Y1 will be ON. The "Star Reduced Voltage Starter" contactor KM1 will be activated.
- When timer T0 reaches its set value, T0 will be ON and Y1 will be OFF. Timer T1 will start to count for 1 sec. After 1 sec, T1 = ON and Y2 = ON. "Delta Reduced Voltage Starter" contactor KM2 will be activated.
- X1 = ON when STOP is pressed. Y0, Y1 and Y2 will be OFF and the motor will stop running no matter it is in starting mode or running mode.

Numbering and Functions of Counters [C]

No. of counters (in decimal)

▪ **ES/EX/SS series MPU:**

Counter C	16-bit counting up, for general purpose	C0 ~ C111, 112 points. Fixed to be non-latched.	Total 141 points
	16-bit counting up, for latched	C112 ~ C127, 16 points. Fixed to be latched.	
32-bit counting up/down high-speed counter C	1-phase 1 input	C235 ~ C238, C241, C242, C244, 7 points. Fixed to be latched.	
	1-phase 2 inputs	C246, C247, C249, 3 points. Fixed to be latched.	
	2-phase 2 inputs	C251, C252, C254, 3 points. Fixed to be latched.	

Functions of counters:

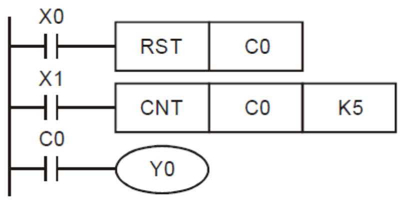
When the pulse input signals of the counter go from Off to On and the present value in the counter equals the set value, the output coil will be On. The set value should be a K value in decimal and the data register D can also be a set value.

16-bit counters C0 ~ C199:

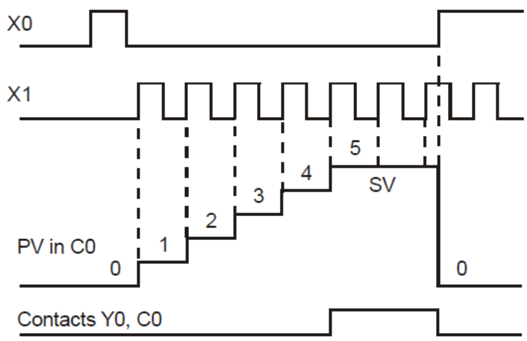
1. The setup range of 16-bit counter: K0 ~ K32,767. K0 is the same as K1. The output contact will be On immediately when the first counting starts.
2. PV in the general purpose counter will be cleared when the power of the PLC is switched off. If the counter is a latched type, the counter will retain the PV and contact status before the power is off and resume the counting after the power is on again.
3. If you use MOV instruction, WPLSoft or HPP to send a value bigger than the SV to the present value register of C0, next time when X1 goes from Off to On, the contact of counter C0 will be On and its PV will equal SV.
4. The SV in the counter can be constant K (set up directly) or the values in register D (set up indirectly, excluding special data registers D1000~ D1999).
5. If you set up a constant K as the SV, it should be a positive value. Data register D as SV can be positive or negative. When the PV reaches up to 32,767, the next PV will turn to -32,768.

Example:

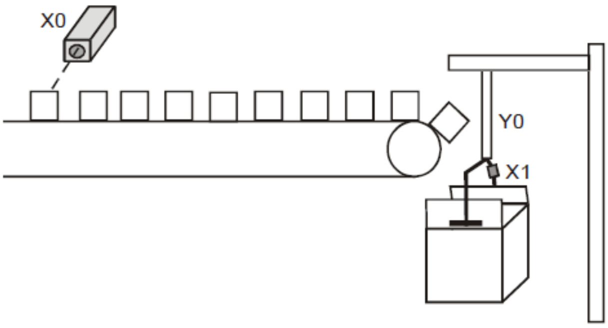
```
LD   X0
RST  C0
LD   X1
CNT  C0  K5
LD   C0
OUT  Y0
```



a) When X0 = On, RST instruction will be executed, PV in C0 will be “0” and the output contact will be reset to Off.
b) When X1 goes from Off to On, the PV in the counter will count up (plus 1).
c) When the counting of C0 reaches SV K5, the contact of C0 will be On and PV of C0 = SV = K5. The X1 trigger signal comes afterwards will not be accepted by C0 and the PV of C0 will stay at K5.



Product Mass Packaging

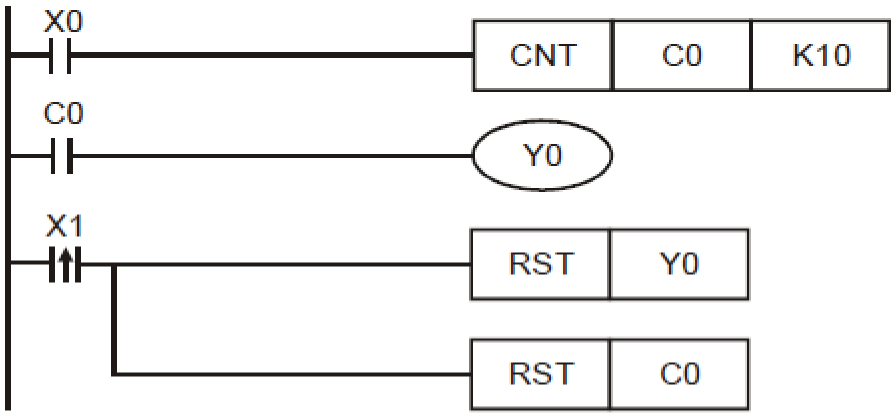


Control Purpose:

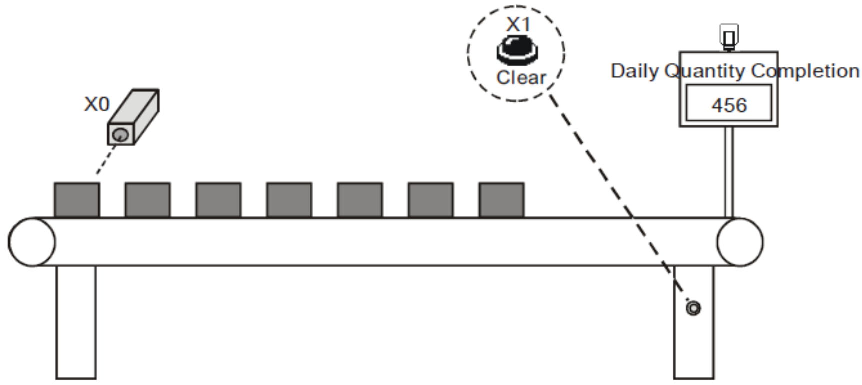
- Once the photoelectric sensor detects 10 products, the robotic arm will begin to pack up. When the action is completed, the robotic arm and the counter will be reset.

Devices:

Device	Function
X0	Photoelectric sensor for counting products. X0 = ON when products are detected.
X1	Robotic arm action completed sensor. X1 = ON when packing is completed.
C0	Counter: 16-bit counting up (general purpose)
Y0	Robotic arm for packing



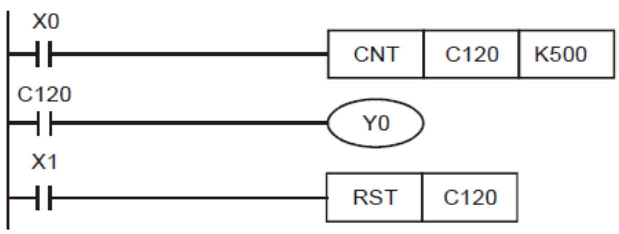
Daily Production Record (16-bit Counting Up Latched Counter)



Control Purpose:

- The production line may be powered off accidentally or turned off for noon break. The program is to control the counter to retain the counted number and resume counting after the power is ON again.
- When the daily production reaches 500, the target completed indicator will be ON to remind the operator for keeping a record.
- Press the Clear button to clear the history records. The counter will start counting from 0 again.

Device	Function
X0	Photoelectric sensor. Once detecting the products, X0 will be ON.
X1	Clear button
C120	Counter: 16-bit counting up (latched)
Y0	Target completed indicator



Up/Down Counters

DCNT instruction enables the 32-bit high-speed counters C200 ~ C255.

For general purpose addition/subtraction counters C200~C234. When DCNT instruction is set from "Off" to "On", the present value in the counter will count up (plus 1) or count down (minus 1) according to the modes set in special M1200 ~ M1234.

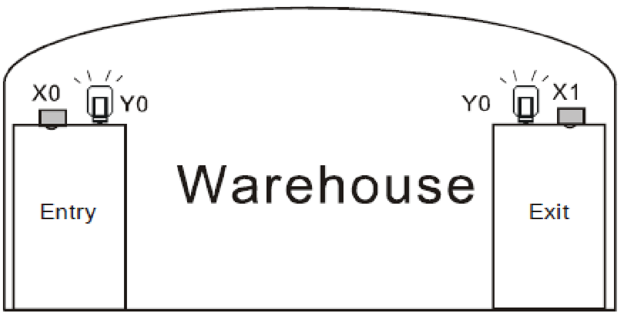
For high-speed addition/subtraction counters C235 ~ C255. When the high-speed counter pulses go from "OFF" to "ON", the counter is executed.

High-speed counter pulse input device: X0 ~ X17

Counting actions: Counting up (present value plus "1"); counting down (present value minus "1")

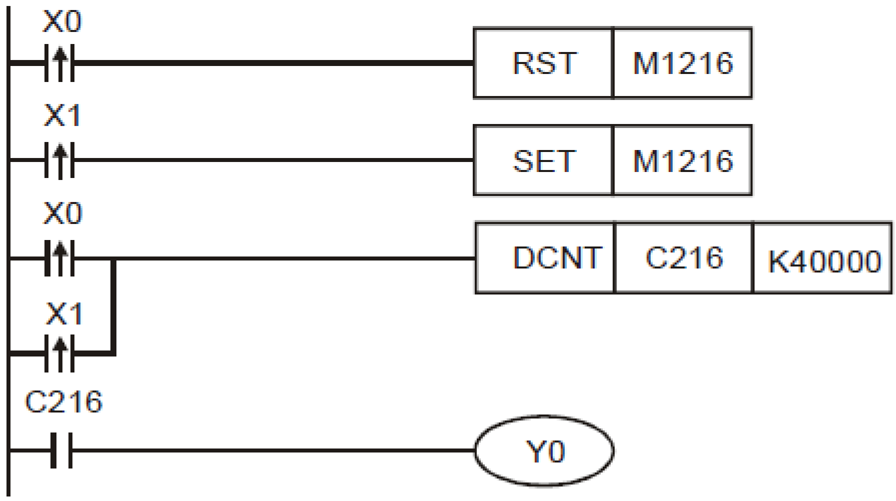
When DCNT instruction goes "OFF", the counter stops counting, but the present value will not be cleared. RST C2XX instruction is for clearing the present values and contacts. High-speed addition/subtraction counters C235 ~ C254 can use assigned external input terminals to clear the present value and contacts.

Products Amount Calculation (32-bit Counting Up/Down Counter)

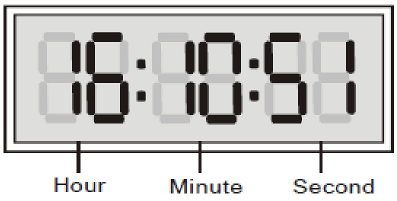


- This program is used for monitoring the product amount in the warehouse by photoelectric sensors at both entry and exit. When the amount reaches 40,000, the alarm will be enabled.

Device	Function
X0	Photoelectric sensors for monitoring incoming goods. X0 = ON when incoming detected.
X1	Photoelectric sensors for monitoring outgoing goods. X1 = ON when outgoing detected.
M1216	Counting mode of C216(ON: counting down)
C216	32-bit counting up/down counter
Y0	Alarm

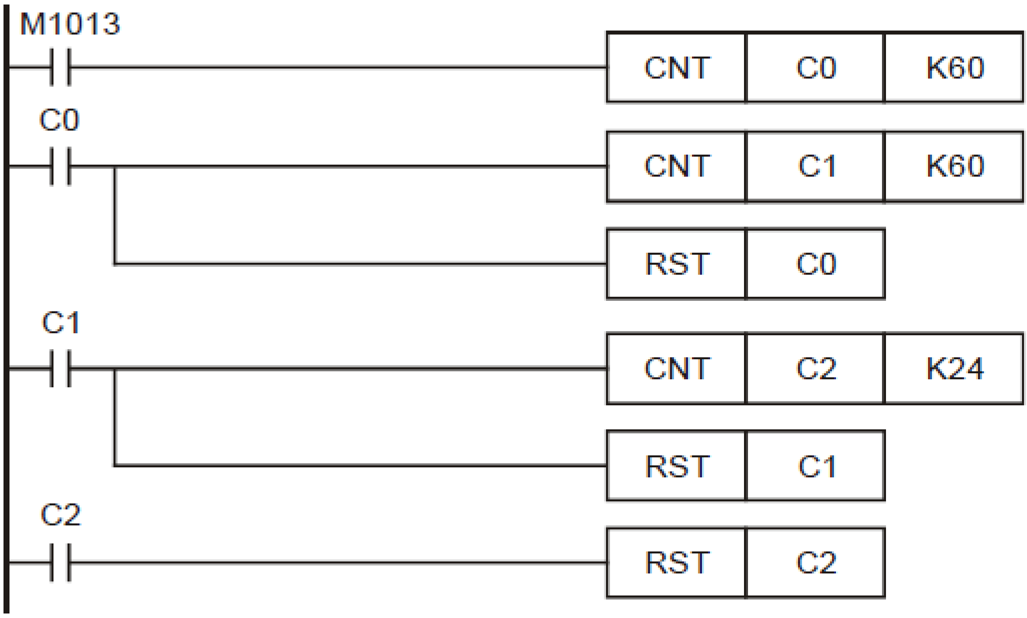


24-hour Clock Operated by 3 Counters



- Using 3 counters together with the flag of M1013 (1s clock pulse) to operate a 24-hour clock.

Device	Function
C0	count per second
C1	count per minute
C2	count per hour
M1013	1s clock pulse



32-bit high-speed addition/subtraction counters C235 ~ C255:

1. The setup range of 32-bit counter: K-2,147,483,648 ~ K2,147,483,647
2. Addition or subtraction of C235 ~ C244 is designated by On/Off status of special auxiliary relays M1235 ~ M1244. For example, when M1235 = Off, C235 will be an addition counter; when M1235 = On, C235 will be a subtraction counter.
3. Addition or subtraction of C246 ~ C255 is designated by On/Off status of special auxiliary relays M1246 ~ M1255. For example, when M1246 = Off, C246 will be an addition counter; when M1246 = On, C246 will be a subtraction counter.
4. The SV can be constant K or data register D (excluding special data registers D1000 ~ D1999). Data register D as SV can be a positive or negative value and an SV will occupy two consecutive data registers.
5. If using DMOV instruction, WPLSoft or HPP to send a value which is large than the setting to any high-speed counter, next time when the input point X of the counter goes from Off to On, this contact will remain unchanged and it will perform addition and subtraction with the present value.
6. When the PV reaches up to 2,147,483,647, the next PV will turn to -2,147,483,648. When the PV reaches down to -2,147,483,648, the next PV will turn to 2,147,483,647.

- **High-speed counters for ES/EX/SS series MPU, total bandwidth: 20kHz**

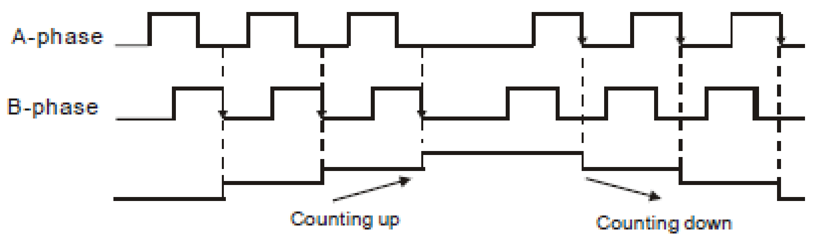
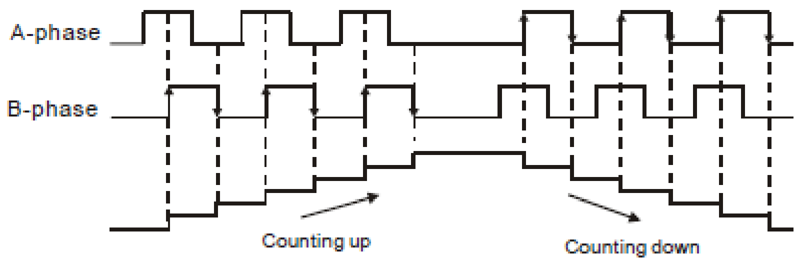
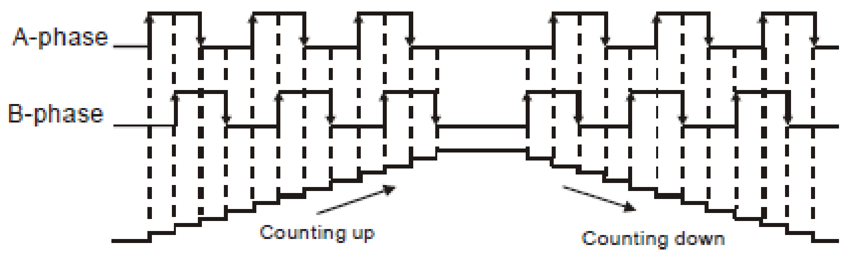
Type / Input	1-phase input							1-phase 2 inputs			2-phase 2 inputs		
	C235	C236	C237	C238	C241	C242	C244	C246	C247	C249	C251	C252	C254
X0	U/D				U/D		U/D	U	U	U	A	A	A
X1		U/D			R		R	D	D	D	B	B	B
X2			U/D			U/D			R	R		R	R
X3				U/D		R	S			S			S

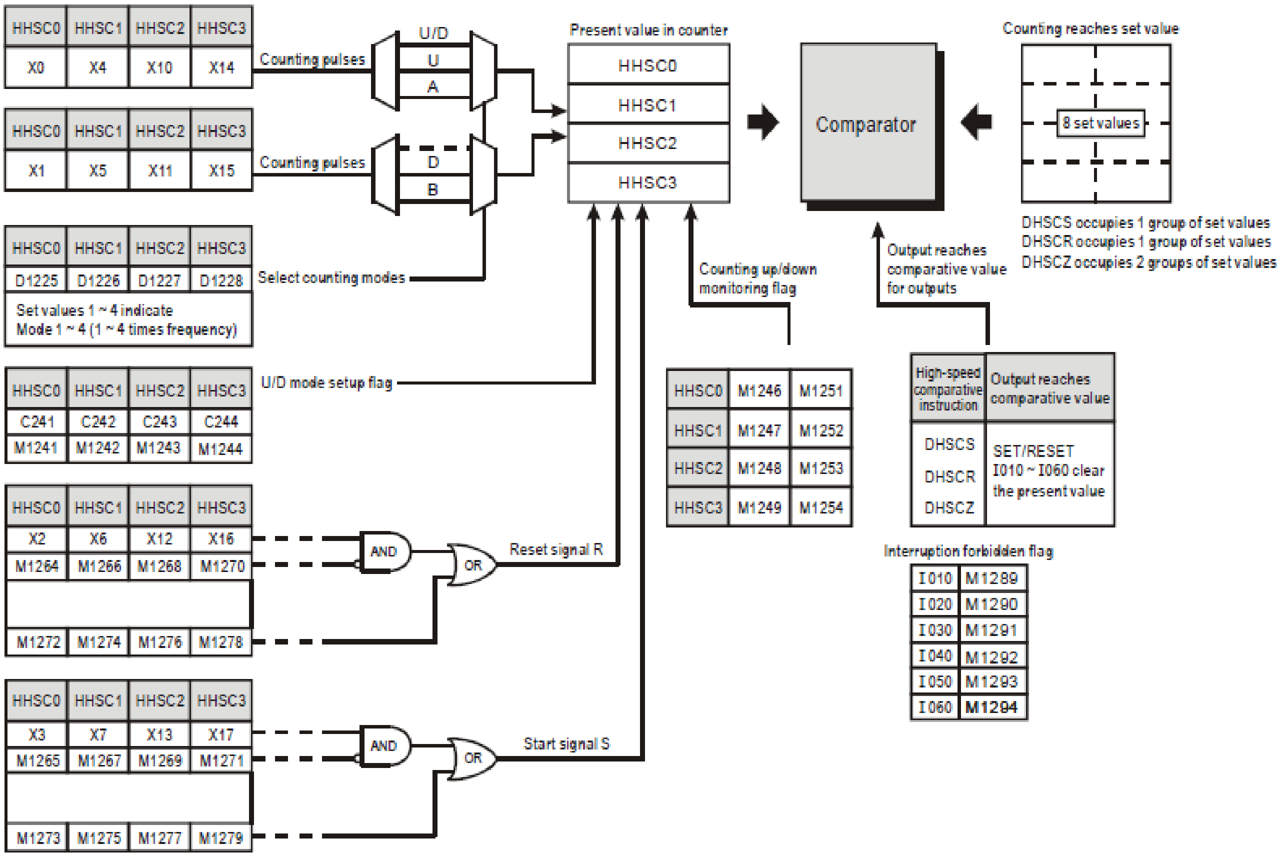
U: Progressively increasing input
D: Progressively decreasing input
A: A phase input
B: B phase input
S: Input started
R: Input cleared

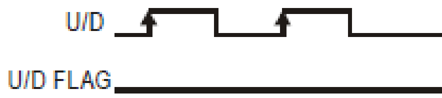
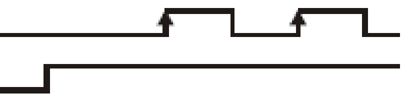
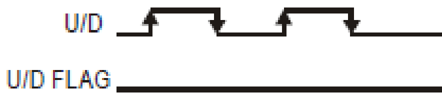
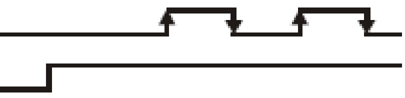
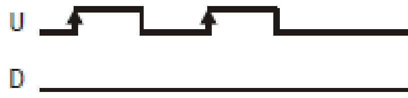
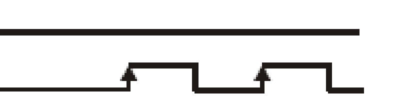
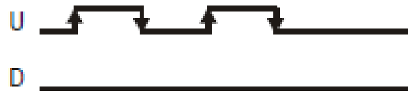
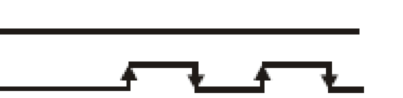
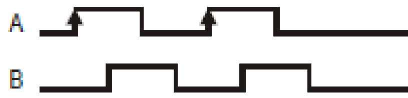
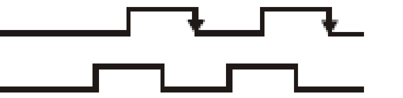
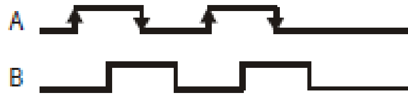
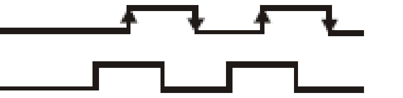
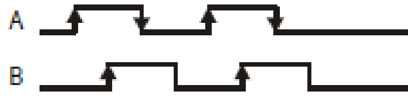
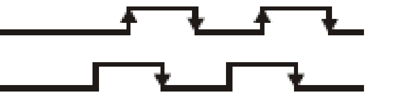
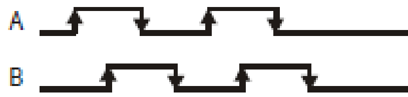
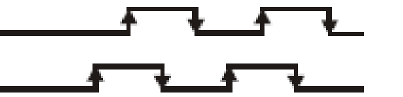
1. Input points X0 and X1 can be planned as counters of higher speed with 1-phase 1 input reaching 20kHz. But the two counting frequencies added together has to be smaller or equal 20kHz. If the input is a 2-phase 2 input signal, the counting frequency will be approximately 4kHz. The 1-phase input of high-speed counters X2 and X3 and reach 10kHz.

- **Features of counter:**

	16 bits counters	32 bits counters	
Type	General purpose	General purpose	High speed
Counting direction	Counting up	Counting up, counting down	
Set value	0 ~ 32,767	-2,147,483,648 ~ +2,147,483,647	
SV designation	Constant K or data register D	Constant K or data register D (designating 2 values)	
Present value	Counting will stop when the SV is reached.	Counter will continue when the SV is reached.	
Output contact	On and being retained when the counting reaches SV.	On and keeps being On when counting up reaches SV. Reset to Off when counting down reaches SV.	
Reset	PV will be return to 0 when RST instruction is executed and the contact will be reset to Off.		
Contact action	Acts when the scanning is completed.	Acts when the scanning is completed.	Acts immediately when the counting reaches its target, has nothing to do with the scan period.

Counting mode		Counting wave pattern
2-phase 2 inputs	1 (Normal frequency)	
	2 (Double frequency)	
	4 (4 times frequency)	

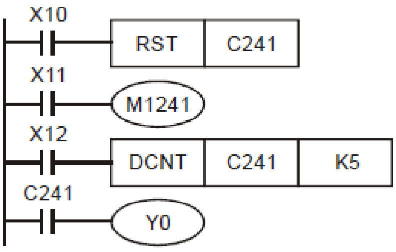

HHSC0 HHSC1 HHSC2 HHSC3
X0 X4 X10 X14
Counting pulses
U/D
U
A
X1 X5 X11 X15
D
B
D1225 D1226 D1227 D1228
Select counting modes
Set values 1 ~ 4 indicate
Mode 1 ~ 4 (1 ~ 4 times frequency)
C241 C242 C243 C244
M1241 M1242 M1243 M1244
U/D mode setup flag
X2 X6 X12 X16
M1264 M1266 M1268 M1270
M1272 M1274 M1276 M1278
AND
OR
Reset signal R
X3 X7 X13 X17
M1265 M1267 M1269 M1271
M1273 M1275 M1277 M1279
Start signal S
Present value in counter
Comparator
Counting reaches set value
8 set values
DHSCS occupies 1 group of set values
DHSCR occupies 1 group of set values
DHSCZ occupies 2 groups of set values
Counting up/down
monitoring flag
Output reaches
comparative value
for outputs
M1246 M1251
M1247 M1252
M1248 M1253
M1249 M1254
High-speed comparative instruction
Output reaches comparative value
DHSCS
DHSCR
DHSCZ
SET/RESET
I010 ~ I060 clear
the present value
Interruption forbidden flag
I010 M1289
I020 M1290
I030 M1291
I040 M1292
I050 M1293
I060 M1294

Counting modes		Wave pattern	
Type	Set value in special D	Counting up(+1)	Counting down(-1)
1-phase 1 input	1 (Normal frequency)		
	2 (Double frequency)		
1-phase 2 inputs	1 (Normal frequency)		
	2 (Double frequency)		
2-phase 2 inputs	1 (Normal frequency)		
	2 (Double frequency)		
	3 (Triple frequency)		
	4 (4 times frequency)		

1-phase 1 input high-speed counter

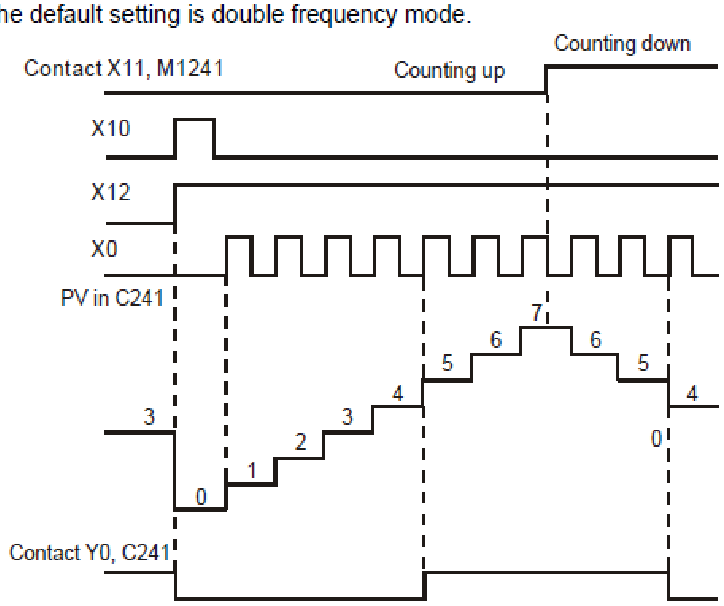
Example:

```
LD      X10
RST     C241
LD      X11
OUT     M1241
LD      X12
DCNT    C241   K5
LD      C241
OUT     Y0
```



1. X11 drives M1241 to determine whether C241 is an addition or subtraction counter.
2. When X10 is On, RST instsruction will be executed and the PV in C241 will be cleared to "0" and the contact will be Off.
3. In C241, when X12 is On and C241 receives the signals from X0, the PV in the counter will count up (plus 1) or count down (minus 1).
4. When the counting of C241 reaches SV K5, the contact of C241 will be On. If there are still input signals from X0, the counting will continue.
5. C241 in ES/EX/SS and SA/SX/SC series MPU has external input signals to reset X1.
6. C241 in EH/EH2/SV series MPU has external input signals to reset X2 and start X3.
7. The external input contact of reset signal of C241 (HHSC0) in EH/EH2/SV series MPU is disabled by M1264. The external input contact of start signal is disabled by M1265.
8. The internal input contact of reset signal of C241 (HHSC0) in EH/EH2/SV series MPU is disabled by M1272. The internal input contact of start signal is disabled by M1273.

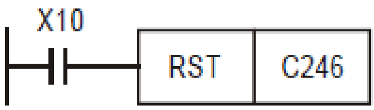
9. The counting modes (normal frequency or double frequency) of C246 (HHSC0) in EH/EH2/SV series MPU can be set up by D1225. The default setting is double frequency mode.



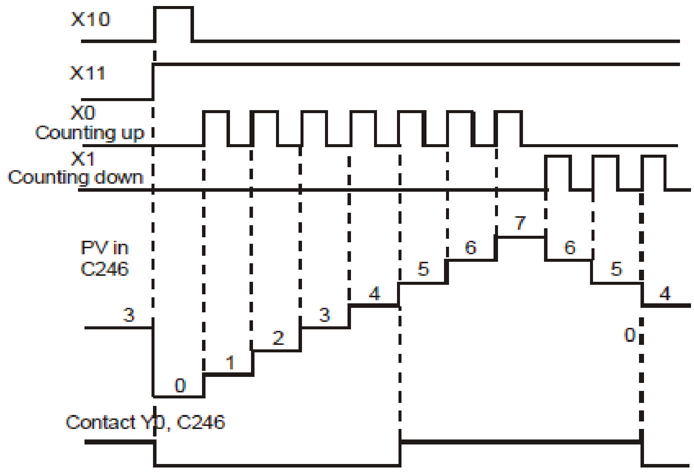
1-phase 2 inputs high-speed counter

Example:

```
LD    X10
RST   C246
```




```
LD    X11
DCNT  C246 K5
LD    C246
OUT   Y0
```

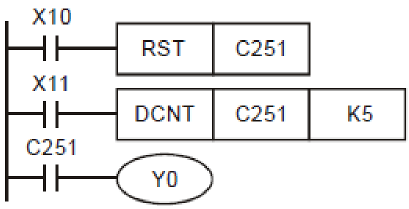


1. When X10 is On, RST instsruction will be executed. The PV in C246 will be cleared to "0" and the output contact will be reset to be Off.
2. In C246, when X11 is On and C246 receives the signals from X0, the PV in the counter will count up (plus 1) or count down (minus 1).
3. When the counting of C246 reaches SV K5, the contact of C246 will be On. If there are still input signals from X0, the counting will continue.
4. C246 in EH/EH2/SV series MPU has external input signals to reset X2 and start X3.
5. The counting modes (normal frequency or double frequency) of C246 (HHSC0) in EH/EH2/SV series MPU can be set up by D1225. The default setting is double frequency mode.
6. The external input contact of reset signal of C246 (HHSC0) in EH/EH2/SV series MPU is disabled by M1264. The external input contact of start signal is disabled by M1265.
7. The internal input contact of reset signal of C246 (HHSC0) in EH/EH2/SV series MPU is disabled by M1272. The internal input contact of start signal is disabled by M1273.

2-phase AB input high-speed counter

Example:

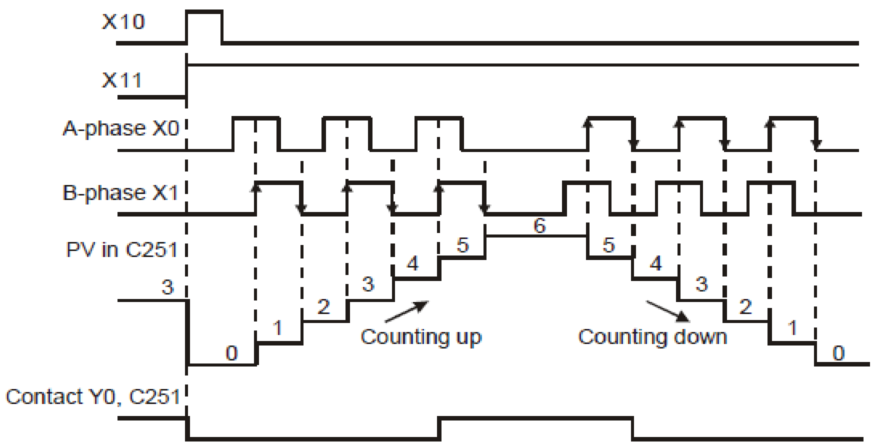
```
LD     X10
RST    C251
LD     X11
DCNT   C251 K5
LD     C251
OUT    Y0
```

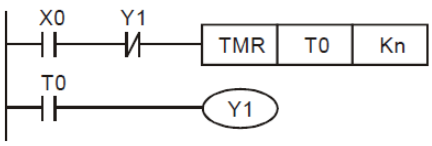


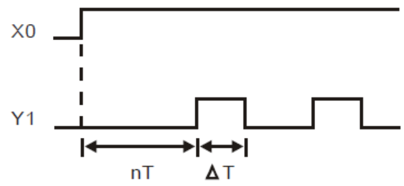
1. When X10 is On, RST instsruction will be executed. The PV in C251 will be cleared to "0" and the output contact will be reset to be Off.
2. In C251, when X11 is On and C251 receives the A-phase signals from X0 and B-phase signals from X1, the PV in the counter will count up (plus 1) or count down (minus 1). You can select different counting modes if you use EH/EH2/SV series MPU.
3. When the counting of C251 reaches SV K5, the contact of C251 will be On. If there are still input signals coming in, the counting will continue.
4. The counting modes (normal frequency, double frequency or 4 times frequency) of C251 (HHSC0) in ES/SA series MPU can be set up by D1022. The default setting is double frequency mode.

5. C251 in EH/EH2/SV series MPU has external input signals to reset X2 and start X3.
6. The counting modes (normal frequency, double frequency, triple frequency or 4 times frequency) of C251 (HHSC0) in EH/EH2/SV series MPU can be set up by D1225. The default setting is double frequency mode.
7. The external input contact of reset signal of C246 (HHSC0) in EH/EH2/SV series MPU is disabled by M1264. The external input contact of start signal is disabled by M1265.
8. The internal input contact of reset signal of C246 (HHSC0) in EH/EH2/SV series MPU is disabled by M1272. The internal input contact of start signal is disabled by M1273.

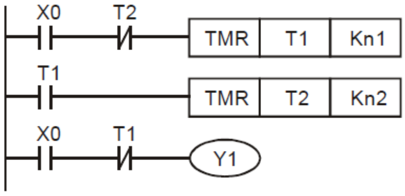
ES/EX/SS and SA/SX/SC series MPU (double frequency)

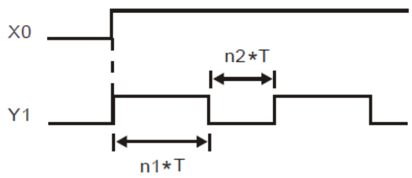




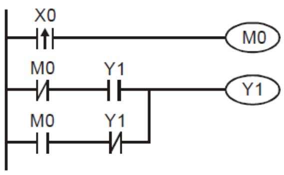


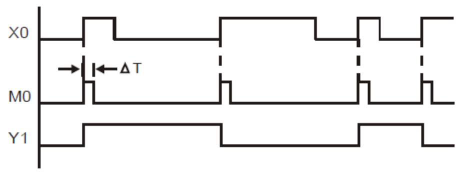
Example 9: Flashing circuit





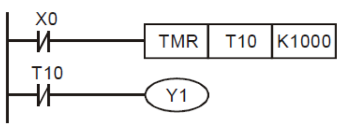
Example 10: Trigger circuit

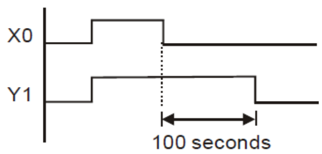




The rising-edge differential instruction of X0 makes coil M0 generate a single pulse of ΔT (one scan cycle). Coil Y1 will be On during this scan period. In the next scan period, coil M0 will be Off and the normally closed contact M0 and Y1 will all be closed, making coil Y1 continue to be On until another rising-edge arrives in input X0, making coil M0 On for another scan period and Y1 Off. Such kind of circuit relies on an input to make two actions execute interchangeably. Also from the timing diagram on the last page, we can see that input X0 are square pulse signals of the cycle T and coil Y1 output are square pulse signals of the cycle 2T.

Example 11: Delay circuit



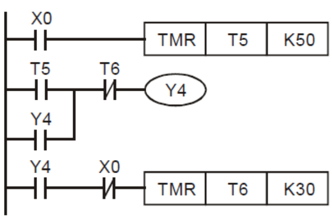


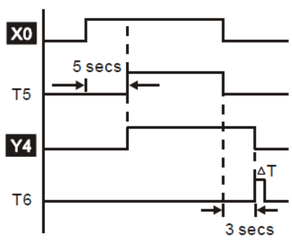
Time base: T = 0.1 sec

When input X0 is On, due to that its corresponding normally closed contact is Off, time T10 will be Off and the output coil Y1 will be On. T10 will be On and start to count until input X0 is Off. Output coil Y1 will be delayed for 100 seconds (K1,000 × 0.1 sec = 100 secs) and be Off. See the timing diagram above.

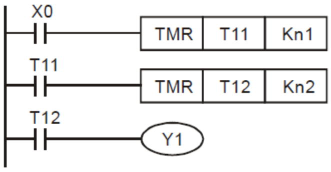
Example 12: Output delay circuit

The output delay circuit is the circuit composed of two timers. When input X0 is On and Off, output Y4 will be delayed.





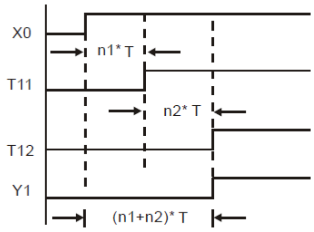
Example13: Timing extension circuit



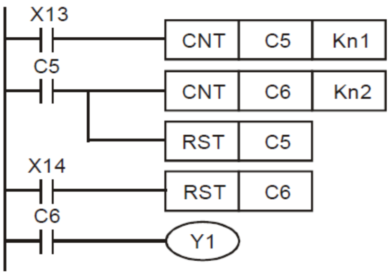
Timer = T11, T12

Clock cycle: T

The total delay time from input X0 is closed to output Y1 is On = (n1+n2)* T. T refers to the clock cycle.

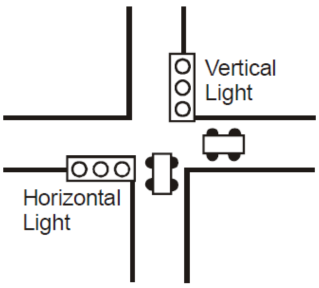


Example 14: How to enlarge the counting range



The counting range of a 16-bit counter is 0 ~ 32,767. As the circuit in the left hand side, using two counters can increase the counting range to n1*n2. When the counting of counter C5 reaches n1, C6 will start to count for one time and reset for counting the pulses from X13. When the counting of counter C6 reaches n2, the pulses from input X13 will be n1*n2.

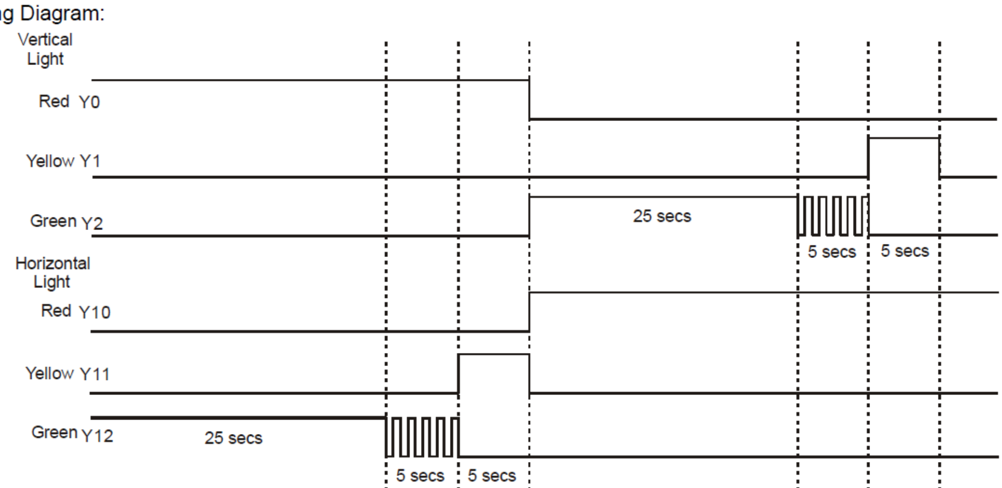
Example 15: Traffic light control (by using step ladder instruction)



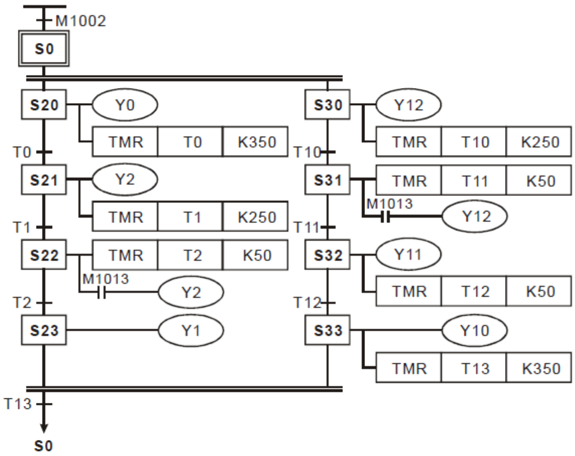
Traffic light control

	Red light	Yellow light	Green light	Green light flashes
Vertical light	Y0	Y1	Y2	Y2
Horizontal light	Y10	Y11	Y12	Y12
On time	35 secs	5 secs	25 secs	5 secs

Timing Diagram:



SFC Figure:



Ladder Diagram: