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Chapter I Welcome to Use KincoBuilder

1.1 Overview

IEC61131-3 is the only global standard for industrial control programming. Its technical implications are high, leaving enough room for growth and differentiation. It harmonizes the way people design and operate industrial controls by standardizing the programming interface. IEC 61131-3 has a great impact on the industrial control industry, and it is accepted as a guideline by most PLC manufacturers. With its far-reaching support, it is independent of any single company.

KincoBuilder is the programming software for Kinco-K5 series Micro PLC, and it's a user-friendly and high-efficient development system with powerful functions.

KincoBuilder is developed independently and accords with the IEC61131-3 standard. It becomes easy to learn and use because many users have acquired most of the programming skills through different channels.

KincoBuilder is provided with the following features:

- Accords with the IEC61131-3 standard
- Supports two standard programming languages, i.e. IL (Instruction List) and LD (Ladder Diagram)
- Powerful instruction set, build-in standard functions, function blocks and other special instructions
- Supports structured programming
- Supports interrupt service routines
- Supports subroutines
- Supports direct represented variables and symbolic variables, easy to develop and manage the user project.
- User-friendly and high-efficient environment
- Flexible hardware configuration, you can define all types of the hardware parameters

1.2 General Designation in the Manual

▪ Micro PLC (Programmable Logic Controller)

According to the general classification rules, micro PLC generally refers to the type of PLC with the control points below 128. This type of PLC usually adopts compact structure, that is, a certain number of I/O channels, output power supply, high-speed output/input and other accessories are integrated on the CPU module.

▪ CPU body

Namely, the CPU module, it's the core of the control system. The user program is stored in the internal storage of the CPU module after being downloaded through the programming software, and will be executed by the CPU. Meanwhile, it also executes the CPU self-test diagnostics: checks for proper operation of the CPU, for memory areas, and for the status of any expansion modules.

▪ Expansion module & expansion bus

The expansion module is used to extend the functions of the CPU body and it is divided into expansion I/O module (to increase the input/output channels of the system) and expansion functional module (to expend the functions of CPU).

The expansion bus connects the CPU and expansion modules, and the 16-core flat cable is adopted as the physical media. The data bus, address bus and the expansion module's working power supply are integrated into the expansion bus.

▪ KincoBuilder

The programming software for Kinco-K5 series PLC, accords with IEC61131-3 standard KincoBuilder, presently provides LD and IL languages for convenience and efficiency in developing the control programs for your applications. KincoBuilder provides a user-friendly environment to develop and debug the programs needed to control your applications.

▪ CPU firmware

It is the “operating system” of the CPU module, and is stored in the Flash memory. At power on, it starts operation to manage and schedule all the tasks of the CPU module.

▪ User program

It’s also called user project or application program, the program written by the user to execute some specific control functions. After the user program is downloaded to the CPU module, it is stored in the FRAM. At power on, the CPU module shall read it from FRAM into RAM to execute it.

▪ Main program and Scan Cycle

The CPU module executes a series of tasks continuously and cyclically, and we call this cyclical execution of tasks as *scan*.

The main program is the execution entry of the user program. In the CPU, the main program is executed once per scan cycle. Only one main program is allowed in the user program.

▪ Free-protocol communication

The CPU body provides serial communication ports that support the special programming protocol, Modbus RTU protocol (as a slave) and free protocols. Free-protocol communication mode allows your program to fully control the communication ports of the CPU. You can use free-protocol communication mode to implement user-defined communication protocols to communicate with all kinds of intelligent devices. ASCII and binary protocols are both supported.

▪ I/O Image Area

Including input image area and output image area. At the beginning of a scan cycle, signal status are transferred from input channels to the input image area; at the end of a scan cycle, the values stored in the output image area are transferred to output channels;

In order to ensure the consistency of data and to accelerate the program execution, the CPU module only access the image area during each scan cycle.

▪ Retentive Ranges

Through "Hardware" configuration in KincoBuilder, you can define four retentive ranges to select the areas of the RAM you want to retain on power loss. In the event that the CPU loses power, the instantaneous data in the RAM will be maintained by the internal battery, and on the retentive ranges will be left unchanged at next power on. The retaining duration is 3 years at normal temperature.

▪ Data backup

Data backup is the activity that you write some data into E^2PROM or FRAM through relevant instruction for permanent storage. *Notice: Every type of permanent memory has its own expected life, for example, E^2PROM allows 100 thousand of times of writing operations and FRAM allows 10 billions of times.*

Chapter II　How to Use KincoBuilder … A Quick Guide

In this chapter, you will learn how to install KincoBuilder on your computer and how to program, connect and run your Kinco-K5 PLC. The purpose of this chapter is to give you a quick guide, and further details will be presented in the following chapter.

2.1 Computer Requirements

2.1.1 Minimum hardware requirements to run KincoBuilder:

- CPU: 1 GHz or higher
- Hard disk space: at least 20M bytes of free space
- RAM: 512M or more
- Keyboard, mouse, a serial communication port
- 256-color VGA or higher, 1024*768 or higher

2.1.2 Minimum Software requirements to run KincoBuilder:

Operating system: Windows XP(32bit), Windows Vista(32bit), Windows7(32/64bit), Windows8 (32/64bit), Windows 8.1(32/64bit)

Someone may meet errors when running KincoBuilder on Windows 7 or above. And the following describes some possible errors and solutions:

2.1.3 Some Questions

- The [Port] list in the [Communications…] dialog is null.

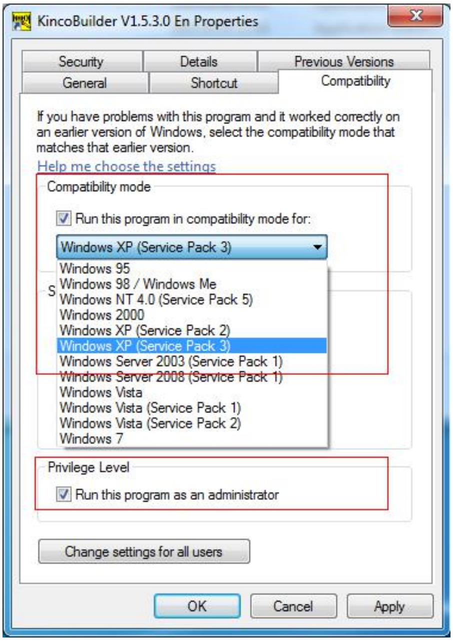
KincoBuilder detects available COM ports on a computer by reading the information in the Windows registry. In the previous versions, KincoBuilder requires to be authorized to run with the Administrator privilege, otherwise it will show a null port list.

In the latest version, KincoBuilder will automatically judge its own privilege. If KincoBuilder has not enough privilege to read registry information, it will list from COM1 to COM9 for user to choose manually.

- KincoBuilder is unable to run on some computers

You may run KincoBuilder using Compatibility Mode.The following is steps:

- Right click the shortcut of "KincoBuilder V1.5.x.x" in desktop and click [Properties];
- Click [Compatibility] in the dialog, and then set as shown in figure 2-1



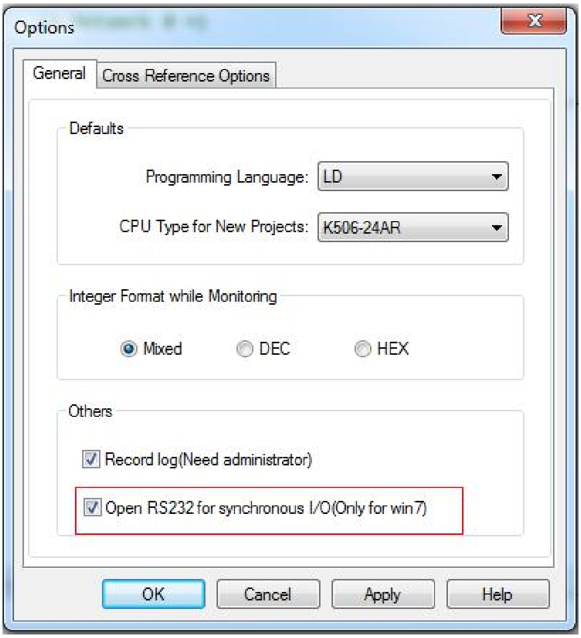


Figure 2-1 "Compatibility Mode" setting

Figure 2-2 Open RS232 for synchronous I/O

- Fail to communicate with PLC while using some USB to RS232 convertors

The failure is caused by the compatibility of the convertor's driver. Most of cases occur on 64-bit Windows 7. Kincobuilder provide the following way to solve this problem: Execute [Tools]-> [Options] menu command, and then check [Open RS232 for synchronous I/O] in [General] tab, then click "OK". See figure 2-2.

This setting will take effect immediately, and it will be saved permanently for future use.

In most cases, this way is helpful to solve this problem.

2.2 User Interface of KincoBuilder

The user interface uses standard Windows interface functionality along with a few additional features to make your development environment easy to use.

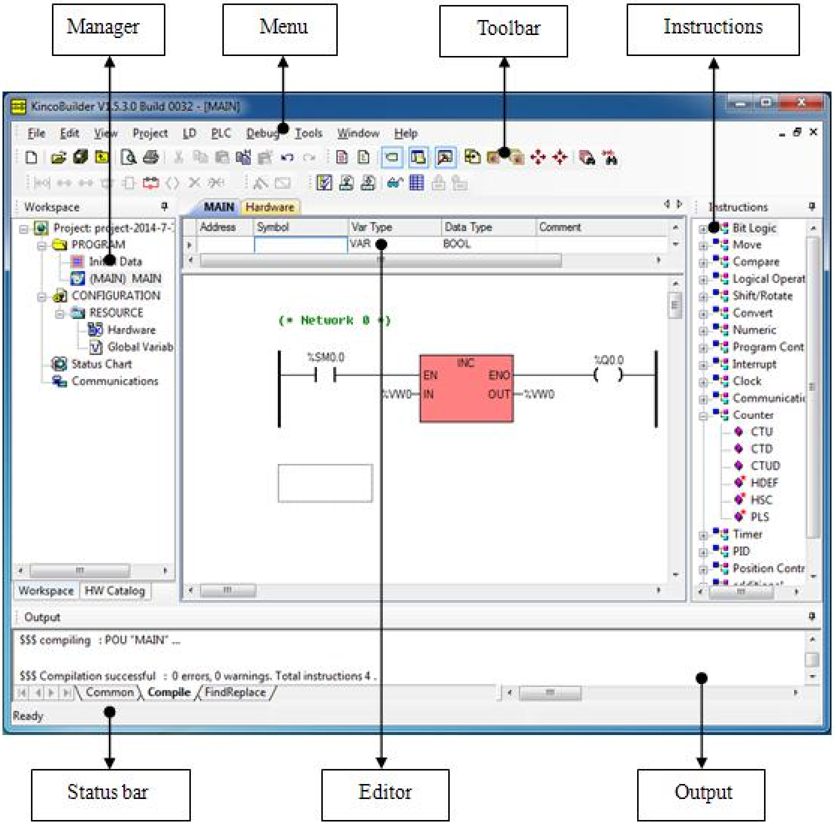


Figure 2-3 User Interface of KincoBuilder

▪ **Menu**: It contains all the operation commands in KincoBuilder.

▪ **Toolbar**: It provides easy mouse access to the most frequently used operation commands.

▪ **Statusbar**: It provides status information and prompts for the operations.

▪ **Manager**: The Manager window provides a tree view of all project objects, including *PROGRAM*, *Hardware*, *Global Variable*, etc, and this can assist you in understanding the structure of the project. The project manager is a convenient tool for program organization and project management. A context menu will pop up when you right click on any tree node.

▪ **Editor**: It includes the Variable Table and the Program Editor (IL or LD). You can programming in the Program Editor and declare the local variables and input/output parameters of the POU in the Variable Table.

▪ **Instructions**: LD instruction set and IL instruction set. Here a tree view of all the available instructions is provided.

▪ **Output**: The Output Window displays several types of information. Select the tab at the base of the window to view the respective information: the "**Compile**" window displays the latest compiling information and the "**Common**" window displays some information concerning the latest operations.

2.3 Using KincoBuilder to Create Programs for Your Applications

2.3.1 Project Components

In this manual, a *user program* and a *user project* have the same meaning.

While programming for a specific application, you need to configure the controllers used in your control system, define symbolic variables and write all kinds of POUs, etc. In KincoBuilder, all of these data (including POUs, hardware configuration, global variables, etc.) are organized to structure a user project. You can manage the project information consistently and easily.

The components of a project are described in the following table. The items marked with "Optional" are not essential components in the project, so you can ignore them.

PROGRAM	Initial Data (Optional)	You can assign initial numerical values to BYTE, WORD, DWORD, INT, DINT and REAL variables in V area. The CPU module processes the Initial Data once at power on and then starts the scan cycle.
	Main Program	It is the execution entry of the user program. The CPU module executes it once per scan cycle. Only 1 Main Program exists in a project.
	Interrupt routines (Optional)	They are interrupt service routines used to process the specific interrupt events. They are not invoked by the main program. You attach an interrupt routine to a predefined interrupt event, and the CPU module executes this routine only on each occurrence of the interrupt event. At most 99 interrupt service routines are allowable in a project.

	Subroutines (Optional)	The subroutines can only be executed when they are invoked by the main program or interrupt routines. Subroutines are helpful to better structure the user program. They are reusable, and you can write the control logic once in a subroutine and invoke it as many times as needed. Formal input/output parameters can be used in the subroutines. At most 99 subroutines are allowable in a project.
CONFIGURATION	Hardware	Here you can configure the KINCO-K5 modules used in your control system, including their addresses, function parameters, etc. The CPU module shall process the hardware configuration once at power on and then execute other tasks.
	Global variables (Optional)	Here you can declare the global variables required in the project.

Table 2-1 Project Components

2.3.2 Where to store the Project Files

When creating a project, KincoBuilder firstly ask you to specify a full path for the project file, and then an empty project file (with the ".kpr" extension) shall be created and saved in this path. In addition, a folder with the same name as the project shall be also created in this path; this folder is used to store all the program files, variable files and other temporary files of the project.

For example, if you create a project named “example” in “c:\temp” directory, the project file path is “c:\temp\example.kpr”, and other files are stored in the “c:\temp\example” folder.

2.3.3 Importing and Exporting a Project

KincoBuilder provides [**File**]>[**Import**…] and [**File**]>[**Export**…] menu commands for you to backup and manage a project.

- [**Export**…]

Compress all the files related to the current project into one backup file (with the ".zip" extension).

➢ Select the [**File**]> [**Export**…] menu command.

The dialog box "Export Project…" appears, as shown in Figure 2-4.

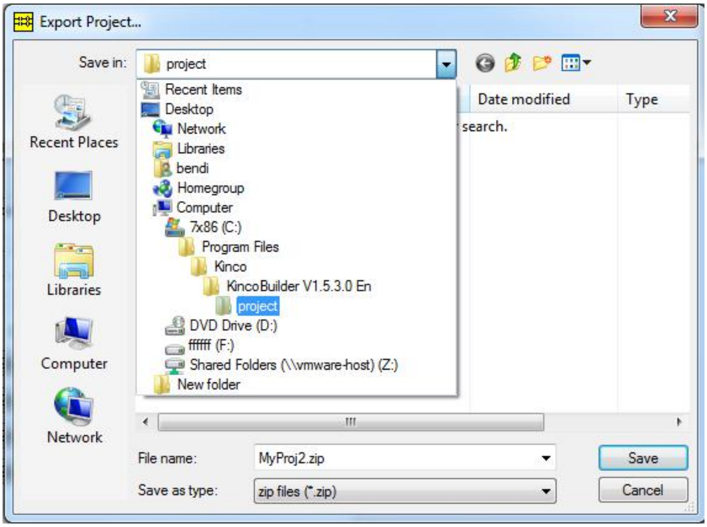


Figure 2-4 Export the Project

➢ Select the path and enter the filename, then click [**Save**].

The backup file for the current project shall be created.

➢ [**Import**…]

Import a project from an existing backup file (with the extension .zip) and open it.

➢ Select the [**File**]> [**Import**…] menu command.

The dialog box "Import Project…" appears, as shown in Figure 2-5.

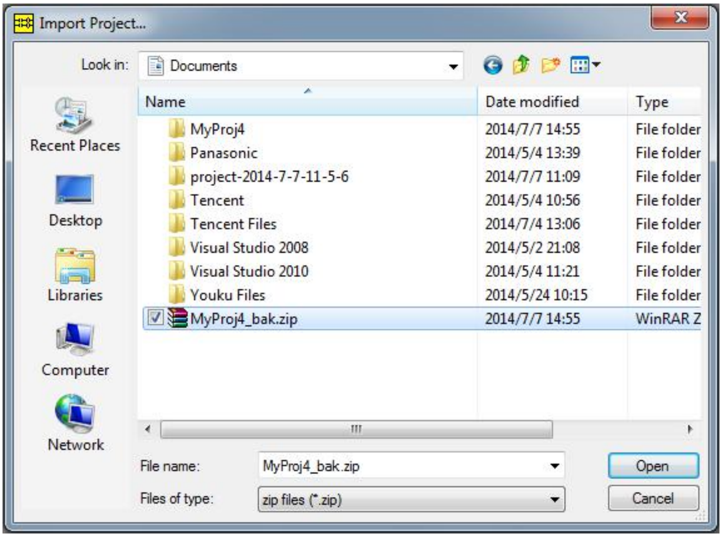


Figure 2-5 Import a Project: Select a backup file

➢ Select a backup file, and then click [**Open**].

The following dialog box appears for you to select the directory to save the restored project files.

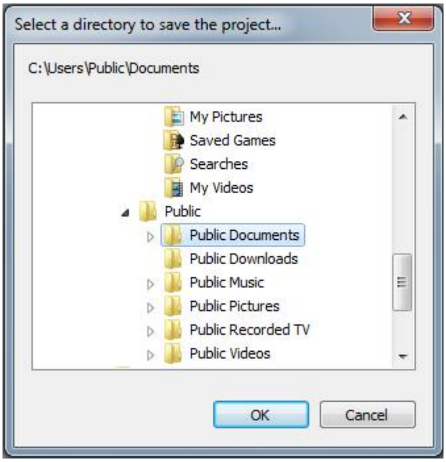


Figure 2-4 Import a Project: Select the destination directory

➢ Select a directory, then click [**OK**], and the project files shall be restored into the selected directory, with that the restored project shall be opened.

2.4 How The CPU Executes Its Tasks in a Scan Cycle?

The CPU module executes a series of tasks continuously and cyclically, and we call this cyclical execution of tasks as *scan*. Only can the main program and interrupt routines be executed directly in the CPU module. The main program is executed once per scan cycle; an interrupt routine is executed once only on each occurrence of the interrupt event associated with it.

The CPU module executes the following tasks in a scan cycle, as shown in Figure 2-7:

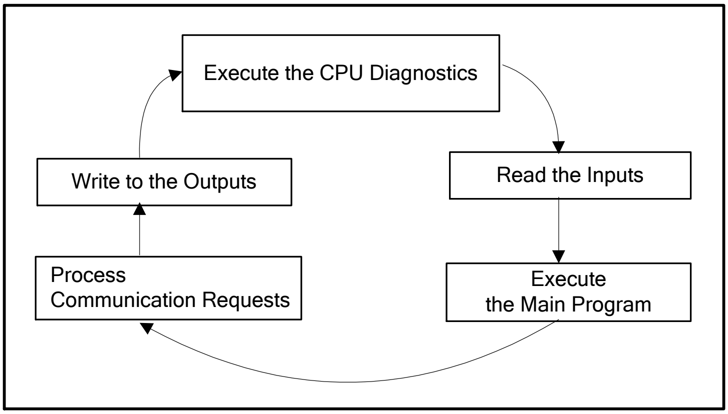


Figure 2-7 Scan Cycle

- Executing the CPU diagnostics: The CPU module executes the self-test diagnostics to check for proper operation of the CPU, for memory areas, and for the status of the expansion modules.
- Read the inputs: The Kinco-K5 samples all the physical input channels and writes these values to the input image areas.
- Executing the user program: The CPU module executes the instructions in the main program continuously and updates the memory areas.
- Processing communication requests
- Writing to the outputs: The Kinco-K5 writes the values stored in the output areas to the physical output channels.

Interrupt events may occur at any moment during a scan cycle. If you use interrupts, the CPU module will interrupt the scan cycle temporarily when the interrupt events occur and immediately execute the corresponding interrupt routines. Once the interrupt routine has been completed, control is returned to the scan cycle at the breakpoint.

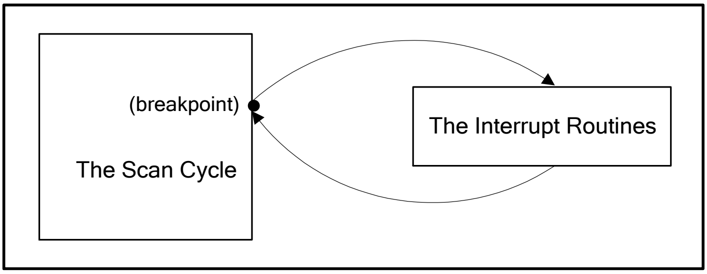


Figure 2-8 Execution of Interrupt Routines

2.5 How to connect the computer with the Kinco-K5

The CPU module provides an integrated RS232 or RS485 serial communication port to communicate with other equipments. Here we discuss how to connect a CPU module (with RS232 port) with the computer to start programming the Kinco-K5 PLC using KincoBuilder.

- Launch KincoBuilder, open an existing project or create a new project;

① Connect the serial port of the computer with that of the CPU module with a proper programming cable. *Notice: RS232 connections are not hot-swappable, so you must switch off the power supply for at least one side (the CPU module or the computer) before you connect/disconnect the cable. Otherwise, the port may be damaged.*

② Configure the parameters of the computer's serial communication port. *Notice: Communications can't be established unless the serial communication parameters of the computer's port are identical with those of the CPU's port.*

- Select [**Tools**]>[**Communications**…] menu command, or double-click the [**Communications**] node in the **Manager** window, or right-click the [**Communications**] node and select the [**Open**] command on the pop-up menu, then the "Communications" dialog box appears.

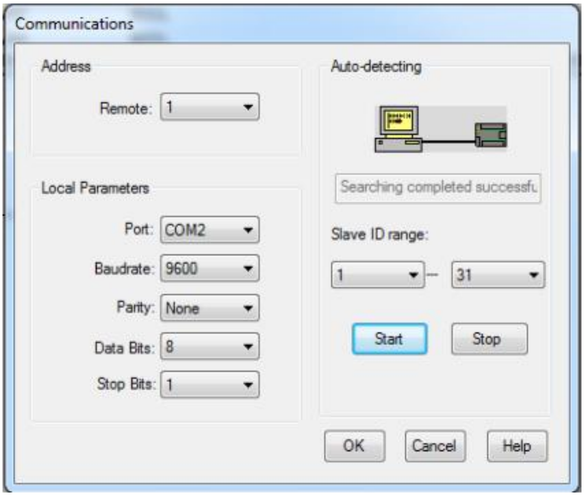


Figure 2-13 The "Communications " Dialog Box

- Select the station number of the target PLC in the [**Remote**] list box; Select a COM port used on the computer in the [**Port**] list box; Configure the parameters of the selected COM port (including [**Baudrate**], [**Parity**], [**Data Bits**] and [**Stop Bits**]) according to those of the CPU's port, and then click [**OK**] button to save and apply them.

If you don't know the communication parameters of the CPU's port, how to acquire them?

There are two ways:

- Select a [**Port**] used on the computer, then click [**Search**] button to make KincoBuilder search for the parameters of the online CPU module automatically. It shall take several seconds to several minutes to complete. If the search completes successfully, KincoBuilder will automatically configure the appropriate parameters for the computer.
- Turn off the power supply for the CPU module; Place its operation switch at STOP position; Then turn the power supply on, and now the CPU's port will use the default serial communication parameters: Station number, 1; Baudrate, 9600; None parity check; 8 data bits; 1 stop bit. You can configure the

computer's serial COM port according to these parameters. *Notice: Do not change the switch's position until you have modified the CPU's communication parameters.*

- After you have configured the communication parameters of the computer's COM port, you are ready to program the Kinco-K5 PLC.

2.6 How to modify the CPU's communication parameters

After you have connected a CPU module with the computer, you can modify its communication parameters at will using KincoBuilder.

- First, open the "Hardware" window by using one of the following ways:
  - Double-click the [**Hardware**] node in the **Manager** window;
  - Right-click the [**Hardware**] node and then select the [**Open**…] command on the pop-up menu.

The upper part of the hardware window shows a detailed list of the PLC modules in table form, and we call it Configuration Table. The Configuration Table represents the real configuration; you arrange your modules in the Configuration Table just as you do in a real control system.

The lower part of the hardware window shows all the parameters of the selected module in the Configuration Table, and we call it Parameters Window.

- Select the CPU module in the Configuration Table, and then select the [**Communication Ports**] tab in the Parameters Window. Now, you can modify the communication parameters here, as shown in the following figure.

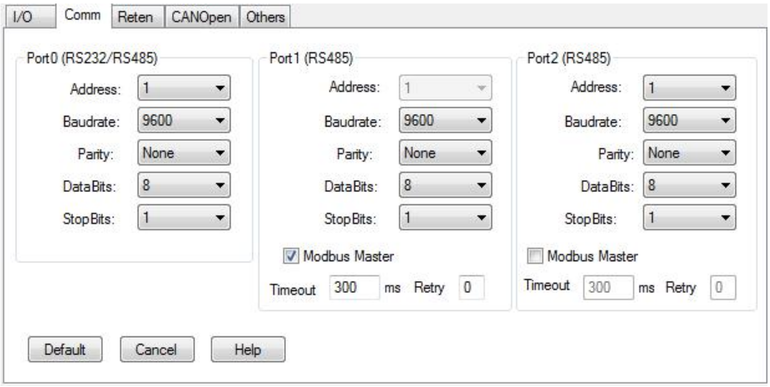


Figure 2-8 Communication Parameters

- After you have modified the parameters, you must download them into the CPU module. *Notice: The configuration parameters won't take effect unless they are downloaded.*

2.7 Example: Common Steps to Create a Project

In order to help the beginners to understand the Kinco-K5 quickly, in the following we'll use a simple example to introduce some common steps for creating and debugging a project step by step. Please refer to the related sections to know a specific function in detail in the following chapters.

Assume that we shall create the following project:

- Project: named "Example";
- Hardware: a Kinco-K506-24AT CPU module;
- Control logic: Toggle Q0.0---Q0.7 in turn and cyclically.

  For better structure, we use two POUs: a subroutine named "Demo" to realize the control logic; the Main Program named "Main" in which "Demo" is invoked.
- Firstly, launch KincoBuilder.
- If necessary, modify the defaults used in KincoBuilder by using the following way:

  Select the [**Tools**]>[**Options**…] menu command

The "Options" dialog box appears, in which you can configure some defaults, e.g. the default "Programming language", etc. These defaults will be saved automatically; and so you just need configure them once before the next modification.

Default programming language is [LD Ladder Diagram].

- Create a new project by using one of the following ways:

  Select the [**File**]>[**New project...**] menu command

  Click the icon in the toolbar

The "New Project…" dialog box appears. You just need to enter the project name and assign its directory, and then click [**Save**], the new project shall be created.

For this example, let's select "D:\temp" as the project directory, and name the project as "Example".

- Modify the hardware configuration. You can configure the hardware at any time. However, because the hardware configuration is necessary for a project, you are recommended to complete it at first.

When a new project has been created, KincoBuilder will automatically add a default CPU assigned in the "Options" dialog box.

You can open the "Hardware" window by using one of the following ways:

- Double-click the [**Hardware**] node in the **Manager** window;
- Right-click the [**Hardware**] node, and then select the [**Open**…] command on the pop-up menu.

Please refer to 2.6 How to modify the CPU's communication parameters for detailed steps.

For this example, a Kinco-K506-24AT module with the default parameters is used.

- Initializing data

You may initialize the data at any time. You may assign initial values to BYTE, WORD, DWORD, INT, DINT and REAL variables in V area. Before CPU is turned power on and enters into the main loop, the initial data will be processed and the initial values assigned by the user will be valued corresponding addresses.

NOTE: Any memory areas that permanently saved by orders as "initialize data" or "data maintain" will be recovered or valued after CPU enters into the main loop. They will follow a sequence: recover the memory as per defined in "data maintain", initialize value of areas as per defined in "initialize data", recover permanently saved data as per defined by users.

- Create the example programs.

KincoBuilder provides IL and LD programming languages. You can select the [**Project**]>[**IL**] or [**Project**]>[**LD**] menu command to change the current POU's language at will.

For this example, a main program named "Main" and a subroutine named "Demo" shall be written in LD language.

◆ Main Program

When creating a new project, KincoBuilder will automatically create an empty main program named "MAIN" at the same time.

◆ Create a new subroutine by using one of the following ways:

- Select the [**Project**]>[**New Subroutine**] menu command
- Click the icon  on the toolbar
- Right-click the [**PROGRAM**] node in the **Manager** window, and then select the [**New Subroutine**] command on the pop-up menu.

Then a new subroutine is created, and its default name is "SBR_0". Now you can enter the following instructions, as shown in Figure 2-9.

After you have finished entering the instructions, you can rename this subroutine by using the following way: Close this subroutine window; Right-click the "(SBR00) SBR_0" node in the **Manager** window, then select [**Rename**] command on the pop-up menu to modify the name to "Demo", or select [**Properties**…] command and make modification in the "Property" dialog box.

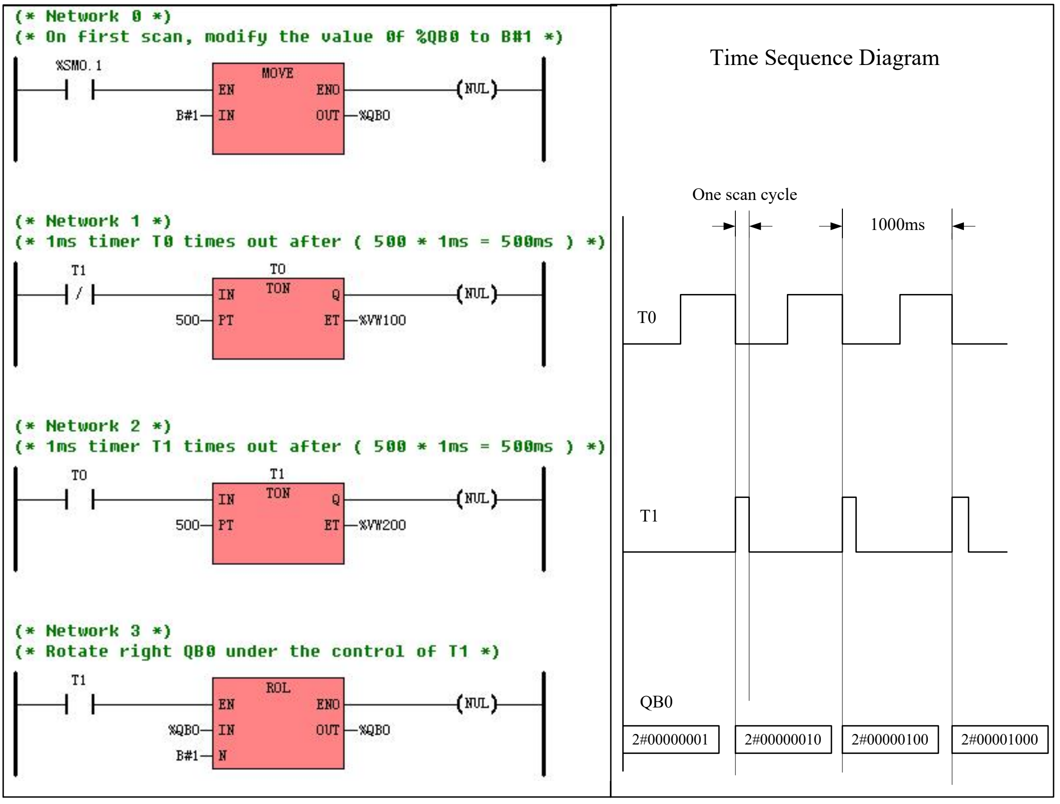


Figure 2-9 the Subroutine “Demo”

- Modify the main program.

Now we have finished the subroutine “Demo”, and we need to return to the main program to add the following instructions, as shown in the following figure 2-10.

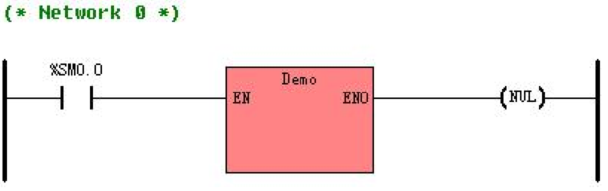


Figure 2-10 the Main Program

➢ Compile the project. After you have finished the whole project, you need to compile it. When compiling a project, KincoBuilder shall save it automatically at first to ensure it is the latest. You can start the compilation by using one of the following ways:

- ➢ Select the [**PLC**]>[**Compile All**] menu command
- ➢ Click the icon  on the toolbar
- ➢ Use the shortcut key **F7**

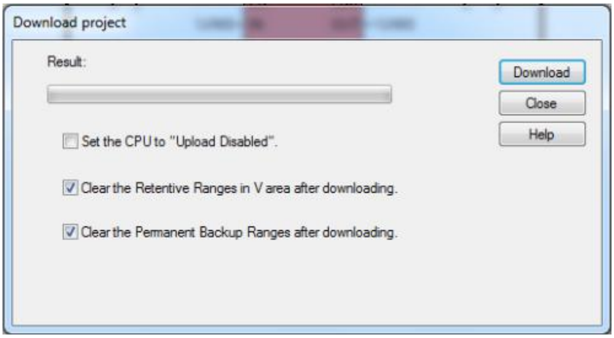
The "Compile" tab in the Output Window keeps a list of the latest compiling messages. To find the source code corresponding to an error, you can double-click on an error message in the "Compile" Window. You have to make modifications according to the error messages until the project is compiled successfully.

➢ Now, it is time to download the project. Notice: if necessary, you can modify the communication parameters of the computer's serial port in the [**Communications**] dialog box.

NOTE: You may refer to 2.5 How to connect the computer with the Kinco-K5 to find the communication parameters.

You can download the project by using one of the following ways:

- ➢ Select [**PLC**]>[**Download…**] menu command
- ➢ Click the icon  on the toolbar
- ➢ Use the shortcut key **F8**
- ➢ "Download User Project" dialogue



◆ [**Upload is prohibited**]

If this item is clicked, CPU will prohibit any one to upload this project after this download.

- **[Clear the data maintaining area in V area after download]**

  If this item is clicked, data in V area and C area will be cleared;

  If not clicked, data in V area and C area will remain unchanged.

- [Clear the Permanent Backup Ranges after downloading]

  If the option is checked, then after download, all the data in Permanent Backup Ranges will be cleared.

  If not check this option, then after download all the data in Permanent Backup Ranges will remain unchanged.

When finish setting, you may click [Start] button to download the project in the PLC and turn CPU to "RUN" to check the project.

If the CPU module is in RUN mode, a dialog box prompts you to place it in STOP mode. Click **Yes** to place it in STOP mode.

After the project has been downloaded, the CPU module goes to RUN mode, and the status LEDs for Q0.0---Q0.7 shall turn on and off in turn and cyclically.

Now, you have completed your first Kinco-K5 project.

- You can monitor the programs online by selecting the [**Debug**] > [**Monitor**] menu command or click the icon  on the toolbar, and then KincoBuilder shows the values of all the variables used in the program.

To stop the CPU module, place it in STOP mode by placing the operation switch at STOP position or by selecting the [**Debug**]>[**Stop**] menu command.

- Debug

You may use the online monitoring and Force functions to debug

- Online monitoring

Online monitoring contains two modes:

- Monitor in the Variable Status Table. You can input any variable to monitor;
- Monitor in the program. You can observe how the program is running. The program is not allowed to be edited.

Online monitoring can only be effective after opening the Variable Status Table, LD or IL. Please be noted that online monitoring is a check command. Any time if you would like to quit online status, you can repeat the online monitoring command.

You may use any command to enter into online monitoring status as follows:

- [**Debug**] → [**Online monitoring**];
- Single click the icon  in the toolbar;
- Shortcut key **F6**.

- Force

You may use the Force to edit the variables value in I area, Q area, M area, V area, AI area or AQ area, among which variables in I area, Q area, M area and V area can be edited by bit, byte, word or double word while variables in AI area and AQ area can be edited by word.

K5 allows users to use the Force to edit maximum 32 variables. Immediate command does not allow to execute the Force.

You may execute the Force via means as follows:

- Via Variable Status Table. You may detect the variables and input the value for Force via Variable Status Table and proceed with the menu commands (or you can right-click and find menu command [**Force**], [**All Force**] and etc.)
- Enter into the status of online monitoring and execute the Force.

On/off Variable: Right-click the Contact and the Coil, execute command [**force to 0**], [**force to 1**] or [**force ...**];

Non On/off Variable: Right-click the variable, execute command [**force ...**].

At mean time, a variable may have the possible values: values assigned by the user due to external input signal (I, AI) or user program command (Q, AQ, M, V). Therefore followings rules will be effective:

- As for variables in M area and V area, the Force value will have the same priority with the command: the

Force will be executed but will only be effective once in one scanning circle and the command will be effective afterwards;

- As for variables in I area and AI area, the Force value will override that of external input signal. If a Force value is assigned, it will be effective in prior;
- As for variables in Q area and AQ area, the value of external input signal will override in the processing; but that of Force will override in the output tasks in the scanning circle.

You may use the menu command of [**Cancel Force**] to cancel the Force of any variable, or use [**All Cancel**] to cancel the Force of all variables.

When CPU is rebooted, the Force status of all variables will be canceled.

Chapter III Concepts for Programming

This chapter will detailedly introduce the fundamentals for programming Kinco-K5 PLC using KincoBuilder, and also some basic concepts of IEC61131-3 standard that are helpful for you to use any type of IEC61131-3 software. The purpose of this chapter is to help you to start primary programming and practice to achieve a level of “know what and know why”.

At the first reading, you are not recommended to pay it an in-depth understanding of every section but to practice while reading and this will be helpful to easy understanding of this manual.

3.1 POU (Program Orgnization Unit)

The blocks from which programs and projects are built are called Program Organisation Units (POUs) in IEC61131-3. As the name implies, POUs are the smallest, independent software units containing the program code. The following three POU types are defined in IEC61131-3:

- **Program**

  Keyword: **PROGRAM**

  This type of POU represents the “main program”, and can be executed on controllers. *Programs* form run-time programs by associating with a *TASK* within the configuration.

  Program can have both input and output parameters.

- **Function**

  Keyword: **FUNCTION**

  Functions have both input parameters and a function value as return value. The *Function* always yields the same result as its function value if it is called with the same input parameters.

- **Function Block**

  Keyword: **FUNCTION_BLOCK**

  Function Block is called FB for short in the following sections of this manual.

FB can be assigned input/output parameters and has static variables, and the static variables can memorize the previous status. An FB will yield results that also depend on the status of the static variables if it is called with the same input parameters.

A user project consists of POUs that are either provided by the manufacturer or created by the user. POUs can call each other with or without parameters, and this facilitates the reuse of software units as well as the modularization of the user project. But recursive calls are forbidden, IEC 61131-3 clearly prescribes that POUs cannot call themselves either directly or indirectly

3.2 Data Types

Data types define the number of bits per data element, range of values and its default initial value. All the variables in the user program must be identified by a data type.

A group of elementary data types is defined in IEC61131-3, and as a result, the implications and usage of these data types are open and uniform for PLC programming.

The elementary data types that Kinco-K5 supports at present are shown in the following table.

Keyword	Description	Size in Bits	Range of Values	Default Initial Value
BOOL	Boolean	1	true, false	false
BYTE	Bit string of length 8	8	0 ~ 255	0
WORD	Bit string of length 16	16	0 ~ 65,535	0
DWORD	Bit string of length 32	32	0 ~ 4,294,967,295	0
INT	Signed integer	16	$-2^{15} \sim (2^{15}-1)$	0
DINT	Signed Double integer	32	$-2^{31} \sim (2^{31}-1)$	0
REAL	Floating-point number, ANSI/IEEE 754--1985 standard format	32	$1.18*10^{-38} \sim 3.40*10^{38}$, 0 $-3.40*10^{38} \sim -1.18*10^{-38}$	0.0

Table 3-1 Elementary Data Types that the Kinco-K5 supports

Types of real numbers in K5 will follow the ANSI/IEEE 754-1985, which is described as FLOAT in C Language.

- **Round-up difference/error of the REAL data**

The binary system of real number is not precise. A REAL data will occupy a space of 4 byte and will present valid numbers with digits of maximum 7 digits. Numbers that are longer than this length will be rounded-up. Valid numbers are data counted from the first number that is not 0 till the last number.

- **Facts about “0.0”**

Due to the round-up difference/error, “0.0” cannot be precisely shown in K5. Any real number that is in the range of [-0.000001, 0.000001] will be regarded as “0.0”.

- **Comparison of real numbers**

When using the comparison commands (GT, GE, EQ, NE, LT, LE), please be noted that two real numbers may not be precisely compared with. As long as the two real number be in the range of [-0.000001, 0.000001] will K5 regards these two number are in equality and vice versa.

3.3 Identifiers

An *identifier* is a string of letters, digits, and underline characters that shall begin with a letter or underline character. (IEC61131-3)

3.3.1 How to define an identifier

You must comply with the following principles while difining an identifier:

- It should begin with a letter or underline character and be followed with some digits, letters or underline characters.
- Identifiers are not case-sensitive. For example, the identifiers abc, ABC and aBC shall be the same.
- The maximum length of the identifier is only restricted by each programming system.

  In KincoBuilder, the maximum length of the identifier is 16-character.
- *Keywords* cannot be used as user-defined identifiers. *Keywords* are standard identifiers, and reserved for programming languages of IEC 61131-3.

3.3.2 Use of Identifiers

The language elements that can use identifiers in KincoBuilder are as follows:

- Program name, function name and the FB instance name
- Variable name
- Label, etc.

3.4 Constant

A *constant* is a lexical unit that directly represents a value in a program. Use constants to represent numeric, character string or time values that cannot be modified. Constants are characterized by having a value and a data type. The features and examples of the constants that Kinco-K5 supports at present are shown in the following table.

Data Type	Format(1)	Range of value	Example
BOOL	true, false	true, false	false
BYTE	**B#**digits	B#0 ~ B#255	B#129
	B#2#binary digits		B#2#10010110
	B#8#octal digits		B#8#173
	B#16#hex digits		B#16#3E
WORD	**W#**digits	W#0 ~ W#65535	W#39675
	2#binary digits		2#100110011
	W#2#binary digits		W#2#110011
	8#octal digits		8#7432
	W#8#octal digits		8#174732
	16#hex digits		16#6A7D
	W#16#hex digits		W#16#9BFE
DWORD	**DW#**digits	DW#0 ~ DW#4294967295	DW#547321
	DW#2#binary digits		DW#2#10111
	DW#8#octal digits		DW#8#76543
	DW#16#hex digits		DW#16#FF7D
INT	Digits	-32768 ~ 32767	12345
	I#digits		I#-2345
	I#2#binary digits (2)		I#2#1111110
	I#8#octal digits (2)		I#8#16732
	I#16#hex digits(2)		I#16#7FFF
DINT	**DI#**digits	DI#-2147483647 ~ DI#2147483647	DI#8976540
	DI#2#binary digits(2)		DI#2#101111

	DI#8#octal digits(2)		DI#8#126732
	DI#16#hex digits (2)		DI#16#2A7FF
REAL	Digits with decimal point	$1.18*10^{-38} \sim 3.40*10^{38}$, 0 $-3.40*10^{38} \sim -1.18*10^{-38}$	1.0, -243.456
	xEy		-2.3E-23

Table 3-2 Constants

Notice:

- ***The descriptor is not case-sensitive, e.g. the constants W#234 and w#234 shall be the same.***
- ***The binary, octal and hex representations of INT and DINT constants all adopt standard Two's Complement Representation, and the MSB is the sign bit: a negative number if MSB is 1, a positive number if MSB is 0. For example, I#16#FFFF = -1, I#16#7FFF = 32767, I#16#8000 = -32768, etc.***

3.5 Variables

In contrast to *constants*, *variables* provide a means of identifying data objects whose contents may change,e.g., Data associated with the inputs, outputs, or memory of the PLC. (IEC61131-3)

Variables are used to initialize, memorize and process data objects. A variable must be declared to be a fixed data type. The storage location of a variable, i.e. the data object associated with a variable, can be defined manually by the user, or be allocated automatically by the programming system.

3.5.1 Declaration

A variable must be declared before it is used. Variables can be declared out of a POU and used globally; also, they can be declared as interface parameters or local variables of a POU. Variables are divided into different *variable types* for declaration purposes.

The standard variable types supported by Kinco-K5 are described in the following table. In the table, "Internal" indicates whether the variable can be read or written to within the POU in which it is decalred, and "External" indicates whether the variable can be visible and can be read or written to within the calling POU.

Variable Type	External	Internal	Description
VAR	---	Read/Write	Local variables. They can only be accessed within their own POU.
VAR_INPUT	Write	Read	Input variables of the calling interface, i.e. formal input parameters. They can be written to within the calling POU, but can only be read within their own POU.
VAR_OUTPUT	Read	Read/Write	Output variables, which act as the return values of their own POU. They are read-only within the calling POU, but can be read and written to within their own POU.
VAR_IN_OUT	Read/Write	Read/Write	Input/output variables of the calling interface, i.e. formal input/output parameters. They have the combined features of VAR_INPUT and

			VAR_OUTPUT.
VAR_GLOBAL	Read/Write	Read/Write	Global variables. They can be read and written to within all POUs.

Table 3-3 Variable Types

3.5.2 Declaring Variables in KincoBuilder

Each type of variables shall be declared within the respective table, and thus it is convenient for you to enter the data. Moreover, KincoBuilder can strictly check your inputs.

Global variables are declared within the Global Variable Table, and other variables are declared within the Variable Table of the respective POU. Each POU has its own separate Variable Table.

If you use the same name for a variable at the local and global level, the local use takes precedence within its POU.

3.5.3 Checking Variables

While programming, KincoBuilder shall check the usage of each variable to verify whether it is accessed using the proper data type or variable type. For example, when a REAL value is assigned to a WORD variable or a VAR_INPUT variable is modified in its POU, KincoBuilder will warn you and prompt for modification.

Because the characteristic of a variable depends on its variable type and data type, the strict checking can assist you in avoiding those errors resulting from improper use of variables.

3.6 How to Access PLC Memory

The Kinco-K5 stores information in different memory units. To be convenient for the users, the Kinco-K5 provides two addressing methods to access the memory units:

- Direct Addressing
- Indirect addressing, i.e. pointer.

3.6.1 Memory Types and Characteristics

The memory of the Kinco-K5 PLC is divided into several different areas for different usage purposes, and each memory area has its own characteristics. The details are shown in the following table.

I	
Description	DI (Digital Input) Image Area. The Kinco-K5 reads all the physical DI channels at the beginning of each scan cycle and writes these values to I area.
Access Mode	Can be accessed by bit, by byte, by word and by double word
Access Right	Read only
Others	Can be forced, and cannot be retentive
Q	
Description	DO (Digital Output) Image Area. At the end of each scan cycle, the Kinco-K5 writes the values stored in Q area to the physical DO channels.
Access Mode	Can be accessed by bit, by byte, by word and by double word
Access Right	Read/write
Others	Can be forced, and cannot be retentive
AI	
Description	AI (Analog Input) Image Area. The Kinco-K5 samples all the AI channels at the beginning of each scan cycle, and converts the analog input values (such as current or voltage) into 16-bit digital values and writes these values to AI area.

Access Mode	Can be accessed by word (the data type is INT)
Access Right	Read only
Others	Can be forced, and cannot be retentive
AQ	
Description	AO (Analog Output) Image Area. At the end of each scan cycle, The Kinco-K5 converts the 16-bit digital values stored in AQ area into field signal values and writes to AO channels.
Access Mode	Can be accessed by word (the data type is INT)
Access Right	Read/write
Others	Can be forced, and cannot be retentive
HC	
Description	High-speed Counter Area. Used to store the current counting value of the high-speed counters.
Access Mode	Can be accessed by double word (the data type is DINT)
Access Right	Read only
Others	Cannot be forced, and cannot be retentive
V	
Description	Variable Area. It's relatively large and can be used to store a large quantity of data.
Access Mode	Can be accessed by bit, by byte, by word and by double word
Access Right	Read/write
Others	Can be forced, and can be retentive
M	
Description	Internal Memory Area. It can be used to store the internal status or other data. Compared with V area, M area can be accessed faster and more propitious to bit operation.
Access Mode	Can be accessed by bit, by byte, by word and by double word
Access Right	Read/write
Others	Can be forced, and can be retentive
SM	

Description	System Memory Area. System data are stored here. You can read some SM addresses to evaluate the current system status, and you can modify some addresses to control some system functions.
Access Mode	Can be accessed by bit, by byte, by word and by double word
Access Right	Read/write
Others	Cannot be forced and cannot be retentive
L	
Description	Local Variable Area. KincoBuilder shall assign memory locations in L area for all the local variables and input/output variables automatically. **You are not recommended to access L area directly.**
Access Mode	Can be accessed by bit, by byte, by word and by double word
Access Right	Read/write
Others	Cannot be forced and cannot be retentive

Table 3-4 Memory Types and Characteristics

3.6.2 Direct Addressing

Direct addressing means that variables can be assigned to the memory units to directly access them.

- Directly represented variable

  According to IEC61131-3, direct representation of a single-element variable is provided by a special symbol formed by the concatenation of the percent sign "%", a memory area identifier and a data size designation, and one or more unsigned integers, separated by periods. For example, %QB7 refers to output byte location 7.

  'Directly represented variable' corresponds to 'Direct address' in traditional PLC systems.

- Symbolic variable

  You can assign a symbolic name to a 'Directly represented variable' to identify it conveniently. Identifier shall be used for symbolic representation of variables.

  In KincoBuilder, you can declare symbolic variables within the Global Variable Table and the Variable Table of the respective POU. Please refer to the corresponding sections for more information.

3.6.2.1 Directly represented variable

Direct address representation for each memory area is shown in the following table, wherein either *x* or *y* represents a decimal number.

➢ **I Area**

Bit Addressing	Format	**%I***x.y*
	Description	*x*: byte address of the variable *y*: bit number, i.e. bit of byte. Its range is 0 ~ 7.
	Data type	BOOL
	Example	%I0.0 %I0.7 %I5.6
Byte Addressing	Format	**%IB***x*
	Description	*x*: byte address of the variable
	Data type	BYTE
	Example	%IB0 %IB1 %IB10
Word Addressing	Format	**%IW***x*
	Description	*x*: starting byte address of the variable. Since the size of WORD is 2 bytes, x must be an even number.
	Data type	WORD, INT
	Example	%IW0 %IW2 %IW12
Double word Addressing	Format	**%ID***x*
	Description	*x*: starting byte address of the variable. Since the size of DWORD is 4 bytes, *x* must be an even number.
	Data type	DWORD, DINT
	Example	%ID0 %ID12

➢ **Q Area**

Bit	Format	**%Q***x.y*

Addressing	Description	*x*: byte address of the variable *y*: bit number, i.e. bit of byte. Its range is 0 ~ 7.
	Data type	BOOL
	Example	%Q0.0 %Q0.7 %Q5.6
Byte Addressing	Format	**%QB***x*
	Description	*x*: byte address of the variable
	Data type	BYTE
	Example	%QB0 %QB1 %QB10
Word Addressing	Format	**%QW***x*
	Description	*x*: starting byte address of the variable. Since the size of WORD is 2 bytes, *x* must be an even number.
	Data type	WORD, INT
	Example	%QW0 %QW2 %QW12
Double word Addressing	Format	**%QD**x
	Description	x: starting byte address of the variable. Since the size of DWORD is 4 bytes, *x* must be an even number.
	Data type	DWORD, DINT
	Example	%QD0 %QD4 %QD12

➢ **AI Area**

Word Addressing	Format	**%AIW***x*
	Description	*x*: starting byte address of the variable. Since the size of INT is 2 bytes, *x* must be an even number.
	Data type	INT
	Example	%AIW0 %AIW2 %AIW12

➢ **AQ Area**

Word Addressing	Format	**%AQW***x*
	Description	*x*: starting byte address of the variable. Since the size of INT is 2 bytes, *x* must be an even number.
	Data type	INT
	Example	%AQW0 %AQW2 %AQW12

- **M Area**

Bit Addressing	Format	**%M***x.y*
	Description	*x*: byte address of the variable *y*: bit number, i.e. bit of byte. Its range is 0 ~ 7.
	Data type	BOOL
	Example	%M0.0 %M0.7 %M5.6
Byte Addressing	Format	**%MB***x*
	Description	*x*: byte address of the variable
	Data type	BYTE
	Example	%MB0 %MB1 %MB10
Word Addressing	Format	**%MW***x*
	Description	*x*: starting byte address of the variable. Since the size of WORD is 2 bytes, *x* must be an even number.
	Data type	WORD, INT
	Example	%MW0 %MW2 %MW12
Double word Addressing	Format	**%MD***x*
	Description	*x*: starting byte address of the variable. Since the size of DWORD is 4 bytes, *x* must be an even number.
	Data type	DWORD, DINT
	Example	%MD0 %MD4 %MD12

- **V Area**

Bit Addressing	Format	**%V***x.y*
	Description	*x*: byte address of the variable *y*: bit number, i.e. bit of byte. Its range is 0 ~ 7.
	Data type	BOOL
	Example	%V0.0 %V0.7 %V5.6
Byte Addressing	Format	**%VB***x*
	Description	*x*: byte address of the variable
	Data type	BYTE
	Example	%VB0 %VB1 %VB10
Word	Format	**%VW***x*

Addressing	Description	*x*: starting byte address of the variable. Since the size of WORD is 2 bytes, *x* must be an even number.
	Data type	WORD, INT
	Example	%VW0 %VW2 %VW12
Double word Addressing	Format	**%VD***x*/**%VR***x*
	Description	*x*: starting byte address of the variable. Since the size of DWORD is 4 bytes, *x* must be an even number.
	Data type	DWORD, DINT（%VDx）; REAL（%VRx）
	Example	%VD0, %VR4; REAL:%VR0, %VR4

➢ **SM Area**

Bit Addressing	Format	**%SM***x.y*
	Description	*x*: byte address of the variable *y*: bit number, i.e. bit of byte. Its range is 0 ~ 7.
	Data type	BOOL
	Example	%SM0.0 %SM0.7 %SM5.6
Byte Addressing	Format	**%SMB***x*
	Description	*x*: byte address of the variable
	Data type	BYTE
	Example	%SMB0 %SMB1 %SMB10
Word Addressing	Format	**%SMW***x*
	Description	*x*: starting byte address of the variable. Since the size of WORD is 2 bytes, *x* must be an even number.
	Data type	WORD, INT
	Example	%SMW0 %SMW2 %SMW12
Double word Addressing	Format	**%SMD***x*
	Description	*x*: starting byte address of the variable. Since the size of DWORD is 4 bytes, *x* must be an even number.
	Data type	DWORD, DINT
	Example	%SMD0 %SMD4 %SMD12

➢ **L Area (Notice: You are not recommended to access L area directly.)**

Bit Addressing	Format	**%L**$x.y$
	Description	x: byte address of the variable y: bit number, i.e. bit of byte. Its range is 0 ~ 7.
	Data type	BOOL
	Example	%L0.0 %L0.7 %L5.6
Byte Addressing	Format	**%LB**x
	Description	x: byte address of the variable
	Data type	BYTE
	Example	%LB0 %LB1 %LB10
Word Addressing	Format	**%LW**x
	Description	x: starting byte address of the variable. Since the size of WORD is 2 bytes, x must be an even number.
	Data type	WORD, INT
	Example	%LW0 %LW2 %LW12
Double word Addressing	Format	**%LD**x
	Description	x: starting byte address of the variable. Since the size of DWORD is 4 bytes, x must be an even number.
	Data type	DWORD, DINT, REAL
	Example	%LD0 %LD4 %LD12

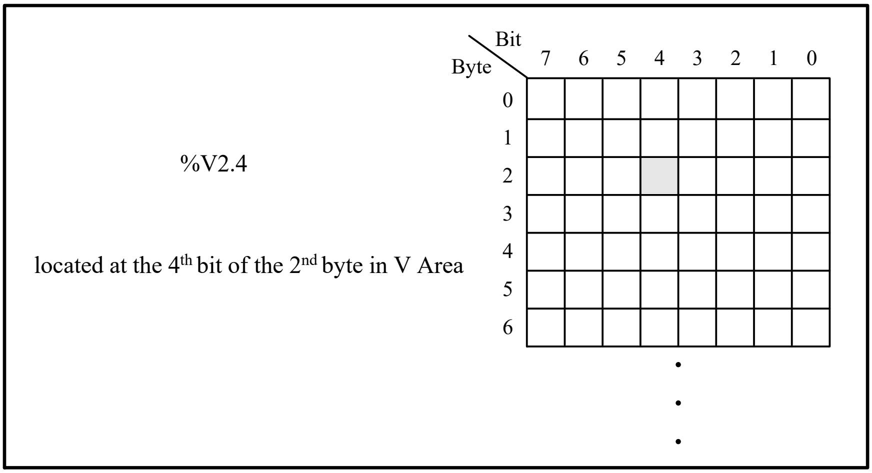
- **HC Area**

Double word Addressing	Format	**%HC**x
	Description	x: the high-speed counter number
	Data type	DINT
	Example	%HC0 %HC1

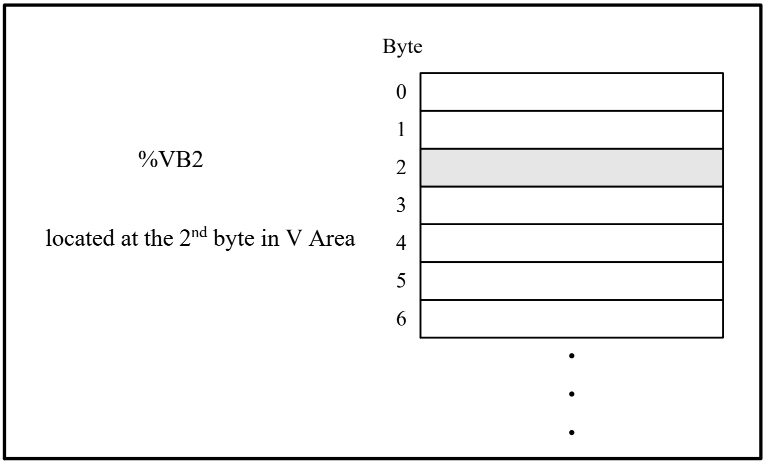
3.6.2.2 Mapping between Direct Address and PLC Memory Location

Each valid direct address corresponds to a PLC memory location, and the mapping relation between them is shown in the following diagram taking V area as an example.

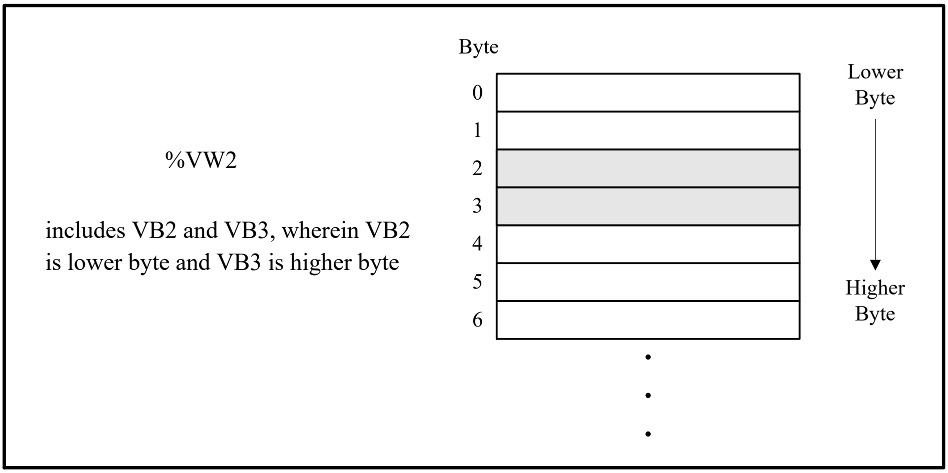
- **Bit Addressing**



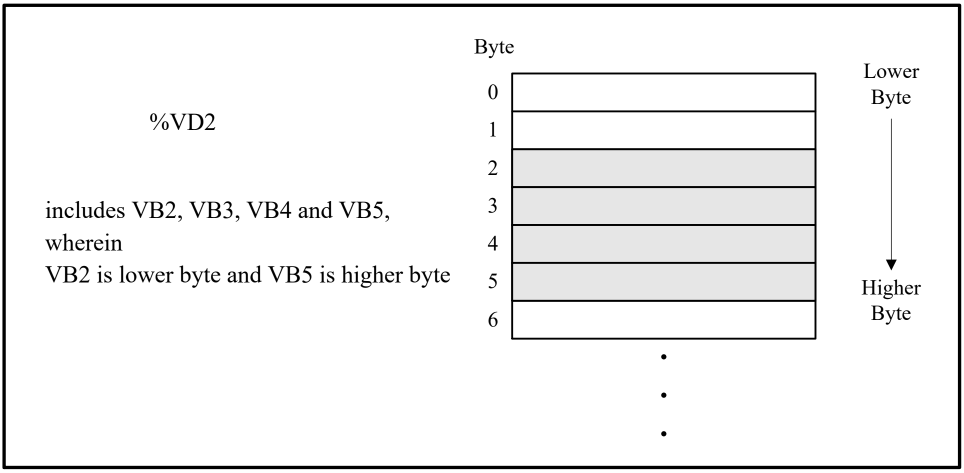
- **Byte Addressing**



- **Word Addressing**



➢ **Double word Addressing**



3.6.3 Indirect Addressing

A pointer is a double word variable which stores the physical address of a memory unit. Indirect addressing uses a pointer to access the data in the corresponding memory.

The Kinco-K5 allows pointers to access the V area (except an individual bit) only. In addition, only the 'Directly represented variable' in the V area can be used as pointer.

3.6.3.1 Creating a pointer

To indirectly access the data in a memory unit, you have to create a pointer to that unit firstly. The address operator '&' can be used, e.g., &VB100 stands for the physical address of VB100.

You can create a pointer using the following way: entering the address operator (&) in front of a directly represented variable to get its physical address, and then write the physical address into another directly represented variable as a pointer using the MOVE instruction.

For example:

```
(* Create a pointer (VD204) which points to VW2. i.e., the physical address of VW2 is stored in VD204. *)
MOVE    &VW2, %VD204
```

3.6.3.2 Access data using a pointer

'*' is the pointer operator. Entering a '*' in front of a pointer represents the direct address variable to which this pointer points. While using a pointer as an operand of an instruction, pleae pay attention to the data types of the instruction's operands.

For example:

```
LD       %SM0.0
MOVE     &VB0, %VD200      (*Create a pointer (VD200) which points to VW2. *)
MOVE     *VD200, %VB10     (* Assign the value of VB0 to VB10. The pointer VD200 points to VB0, *)
                           (* so *VD200 represents VB0. *)
```

3.6.3.3 Modifying the value of a pointer

A pointer is a 32-bit variable, and so it's value can be modified with such instructions as ADD and SUB, etc. Whenever a pointer's value is increased / reduced by 1, the direct address to which it points will be increased / reduced by 1 byte correspondingly. So when you modify a pointer's value, you must pay attention to the data type of the variable pointed to.

- If a pointer points to a BYTE variable, you can modify the pointer's value by any double integer number.
- If a pointer points to a WORD or INT variable, you can modify the pointer's value by a multiple of 2.
- If a pointer points to a DWORD, DINT or REAL variable, you can modify the pointer's value by a multiple of 4.

3.6.3.4 Notice for using the pointers

- The validity of a pointer is guarantee by the user program. The pointer is very flexible, so you need to be very careful when using it. If a pointer points to an illegal address, it may lead to unexpected results.
- The Kinco-K5 only supports single-level pointer and address, multiple-level pointers and addresses are illegal. For example, the following instruction is illegal:

```
MOVE    &VB4, *VD44
```

3.6.3.5 Example

```
(* Network 0 *)
LD       %SM0.0
MOVE     &VW0, %VD200      (*Create a pointer (VD200) which points to VW0. *)
MOVE     *VD200, %VW50     (* Assign the value of VW0 to VW50. The pointer VD200 points to VW0, *)
                           (* so *VD200 represents VW0. *)
ADD      DI#2, %VD200      (* The pointer's value increases by 2 bits, so VD200 points to VW2 now.*)
MOVE     *VD200, %VW52     (* Assign the value of VW2 to VW52 *)
```

3.6.4 Memory Address Ranges

The Kinco-K5 provides several types of CPU module. The memory address ranges of different types of CPU may be different from each other, and the addresses beyond the respective range are illegal. In your program, you must ensure that all the memory addresses that you enter are valid for the CPU. The detailed descriptions are given in the following table.

		CPU504	CPU504EX	CPU506, CPU506EA, CPU508
I	Size	1	5	32
	Bit address	%I0.0 --- %I0.7	%I0.0 --- %I4.7	%I0.0 --- %I31.7
	Byte address	%IB0, IB1	%IB0 --- %IB4	%IB0 --- %IB31
	Word address	%IW0	%IW0 --- %IW2	%IW0 ---% IW30
	Double-word address	———	%ID0	%ID0 --- %ID28
Q	Size	1	5	32
	Bit address	%Q0.0 --- %Q0.7	%Q0.0 --- %Q4.7	%Q31.0 --- %Q31.7
	Byte address	%QB0	%QB0 --- %QB4	%QB0 --- %QB31
	Word address	———	%QW0 --- %QW2	%QW0 --- %QW30
	Double-word address	———	%QD0	%QD0 --- %QD28
AI	Size	0	16	64
	Word address	———	%AIW0 --- %AIW14	%AIW0 --- %AIW62
AQ	Size	0	16	64
	Word address	———	%AQW0 -- %AQW14	%AQW0 -- %AQW62
HC	Size	8		
	Word address	%HC0,%HC1		
V	Size	4096		
	Bit address	%V0.0 ---%V4095.7		
	Byte address	%VB0 --- %VB4095		
	Word address	%VW0 --- %VW4094		
	Double-word address	%VD0 --- %VD4092 %VR0 --- %VR4092		
M	REAL address	1024		

	Size	%M0.0 --- %M1023.7
	Bit address	%MB0 --- %MB1023
	Byte address	%MW0 --- %MW1022
	Word address	%MD0 --- %MD1020
SM	Double-word address	300
	Size	%SM0.0 --- %SM299.7
	Bit address	%SMB0 --- %SMB299
	Byte address	%SMW0 --- %SMW298
	Word address	%SMD0 --- %SMD296
L	Double-word address	272
	Size	%L0.0 --- %L271.7
	Bit address	%LB0 --- %LB271
	Byte address	%LW0 --- %LW270
	Word address	%LD0 --- %LD268

Table 3-5 CPU Memory Ranges

3.6.5 Function Block and Function Block Instance

3.6.5.1 Standard Function Blocks in IEC61131-3

- Timers: TP --- Pulse timer; TON --- On-delay timer; TOF --- Off-delay timer
- Counters: CTU --- Up-counter; CTD --- Down-counter; CTUD --- Up-Down counter
- Bistable elements: SR --- Set dominant; RS --- Ret dominant
- Edge detection: R_TRIG --- Rising edge detector; F_TRIG --- Falling edge detector

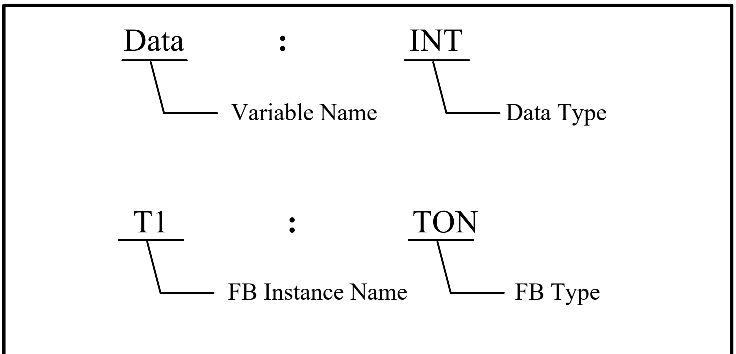
3.6.5.2 Instances of Function Blocks

"Instantiation of FBs" is a very important concept in IEC61131-3.

Instantiation means that the programer declares and creates a variable by specifying its name and data type. After instantiation, the variable can be accessed in the program.

FB also needs to be instantiated as a variable does. After instantiation, a FB (as an instance) can be used in the POU in which it is declared.

As shown in the following graph, only T1 can be called and accessed.



Data is an instance of *INT* type, and *T1* is an instance of *TON*.

3.6.5.3 FB Instance Memory Areas

A fixed memory area is allocated for each type of FB to store its instances in the Kinco-K5 PLC, and the details are shown in the following table.

T	
Description	Timer Memory Area, where instances of TON, TOF and TP can be allocated. It's used to store the status bits and current values of all the timer instances.
Access mode	Directly access the status bit and current value of a timer instance
Access right	Read only
Others	Cannot be retentive, and cannot be forced

C	
Description	Counter Memory Area, where the instances of CTU, CTD and CTUD can be allocated. It's used to store the status bits and current values of all the counter instances.
Access mode	Directly access the status bit and current value of a counter instance
Access right	Read-only
Others	Can be retentive, and cannot be forced
RS	
Description	RS the trigger Area, where instances of RS can be allocated. It's used for storing the status bits for all the RS instances.
Access Mode	Directly access the status of the RS instances
Access Rights	Read-only
Others	Cannot be retentive, and cannot be forced
SR	
Description	SR the trigger Area, where instances of SR can be allocated. It's used for storing the status for all the SR instances.
Access Mode	Directly access the status bit of the SR instances
Access Rights	Read-only
Others	Cannot be retentive, and cannot be forced

Table 3-6 FB Instance Memory Areas

3.6.6 Using FB Instances

A FB instance must be declared before it is used.

For the convenience of users, KincoBuilder complies with the following rules: the representation of FB instances accords with the traditional PLC, e.g. T0, C3; you just need to call the valid FB instances of the desired types in your program, and KincoBuilder will generate the declarations automatically in the Global Variable Table.

- **T**

Format	**T***x*
Description	*x*: a decimal digit, indicating the timer number.

Data type	BOOL --- status bit of the timer INT --- current value of the timer **T***x* is used to access both of the two variables. KincoBuilder will identify access to either the status bit or the current value according to the instruction used: instructions with BOOL operands access the status bit, but instructions with INT operands access the current value.
Example	T0 T5 T20

- **C**

Format	**C***x*
Description	*x*: a decimal digit, indicating the counter number.
Data type	BOOL --- status bit of the counter INT --- current counting value of the counter **C***x* is used to access both of the two variables. KincoBuilder will identify access to either the status bit or the current value according to the instruction used: instructions with BOOL operands access the status bit, but instructions with INT operands access the current value.
Example	C0 C5 C20

- **RS**

Format	**RS***x*
Description	*x*: a decimal digit, indicating the RS Bistable number.
Data Types	BOOL --- the status of the RS Bistable
Example	RS0, RS5, RS10

- **SR**

Format	**SR***x*
Description	*x*: a decimal digit, indicating the SR Bistable number.
Data Types	BOOL --- the status of the SR Bistable
Example	SR0, SR5, SR10

3.6.7 FB Instances Memory Ranges

The size of the memory area that the PLC can allocate to a type of FB instances is limited by the resource of the hardware; therefore, each type of Kinco-K5 CPU allocates a different memory range for the FB instances. The detailed descriptions are given in the following table.

T	Amount	256
	Range	T0 --- T255
	Resolution	T0 --- T3:1ms T4 --- T19:10ms T20 --- T255:100ms
	Max timing	32767* Resolution
C	Amount	256
	Range	C0 --- C255
	Max counting value	32767
RS	Amount	32
	Range	RS0 --- RS31
SR	Amount	32
	Range	SR0 --- SR31

Table 3-7 FB Instances Memory Ranges

Chapter IV How to Use KincoBuilder … Basic Functions

This chapter describes the components of KincoBuilder detailedly, including their functions and operating steps. Based on the basic concepts in the previous chapters, this chapter can help you get a further and comprehensive understanding of KincoBuilder.

LD editor and IL editor may involve IEC61131-3 grammar, which will be introduced in the next chapter.

4.1 Configuring General Software Options

You need to configure some general options for KincoBuilder, e.g. the default programming language and the default CPU type for new projects. KincoBuilder will save your configuration automatically, so you just need configure them once before the next modification

Select the [**Tools**]>[**Options**…] menu command, and then the following dialogue box will popup:

① **General** Tab

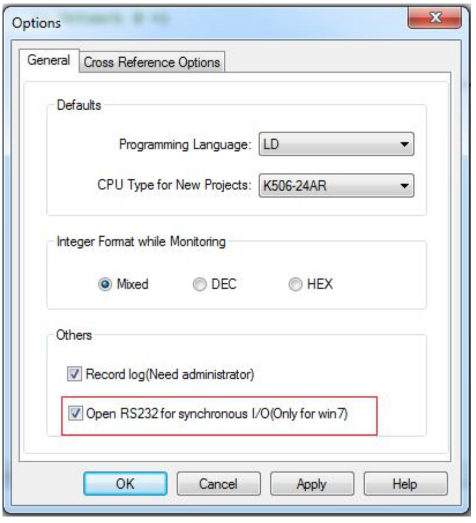


Figure 4-1 The “Options” Dialog Box

➢ **Defaults**

- **Programming Language**:

  Choose the default programming language for new programs, IL or LD.

- **CPU Type for New Projects:**

  Choose the CPU type that new projects always default to use.

➢ **Integer Format While Monitoring**

Choose the display format for the integer values while monitoring.

Mixed: The INT and DINT values are displayed in decimal format;

In addition, the BYTE, WORD and DWORD values are displayed in hexadecimal format.

DEC: All the integer values are displayed in decimal format.

HEX: All the integer values are displayed in hexadecimal format.

➢ **Others**

- **Record log**:

  If this is checked, KincoBuilder will create a sub-directory named "KincoPlcLog" in its installation directory.

  Kincobuilder will create a log file for each time, and it only retain the day's files.

  These log files is helpful for us to track and solve bugs of Kincobuilder.

- **Open RS232 for synchronous I/O**:

  Sometime Kincobuilder maybe fail to communicate with PLC while using some USB to RS232 convertors.

  This problem is caused by the compatibility of the convertor's driver.

  Checking this checkbox maybe helpful, and in most cases it can solve this problem.

② 【Cross Reference Options】

After compilation, all the used parameters and the locations will be displayed in the Cross Reference table.

All the used parameters will be displayed by default in Kincobuilder.

In this page, user could select [Memory Type] and [Data Type] to be displayed in the Cross Reference table. As defined in the above picture, only bit registers of M area will be displayed in the Cross Reference table.

4.2 About Docking Windows

In KincoBuilder, Workspace/Instructions/HW Catalog/Information Output windows are designed as floating windows. These floating windows have two display modes: floating mode and dock mode. In floating mode, a window can appear anywhere on your screen. In dock mode, a window is fixed to a dock along any of the four borders of the main KincoBuilder window.

- ➢ To change a dock window to a floating window

•Double-click in the window border.

• Point to the title bar and drag the window out of its dock area.

- ➢ To dock a floating window

•Double-click the window title bar to return the window to its previous docked location.

• Point to the title bar and drag the window to a dock area.

- ➢ To switch a docking window to auto-hide mode

• Click the icon  located on the top-right corner of the window.

In auto-hide mode, it shall hide automatically and shrink into an icon and stay at the border of the main KincoBuilder window; Point to this icon for a moment, the window shall appear.

- ➢ To cancel the auto-hide mode of a docking window

• Click the icon  to return the window to its previous docked location.

4.3 Configuring Hardware

In a project, you are recommended to finish configuring hardware at first. When a new project has been created, a default CPU assigned in the "Options" dialog box shall be added automatically and you can modify it at will. KincoBuilder provides you with a complete, flexible and convenient hardware configuration environment where you can configure all the parameters for each PLC module. The "Hardware" window is shown as Figure 4-2. We can see that this window is composed of two parts:

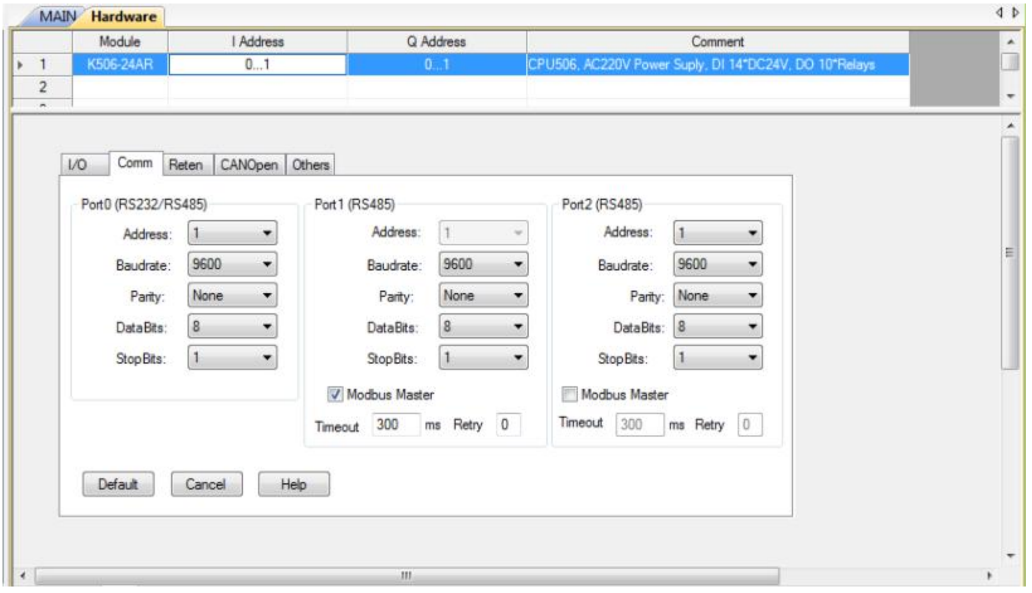


Figure 4-2 the Hardware Window

- **The Configuration Table**

The upper part of the hardware window shows a detailed list of the PLC modules in table form, and we call it Configuration Table. The Configuration Table represents the real configuration: you arrange your modules in the Configuration Table just as you do in a real control system.

- **The Parameters Window**

The lower part of the hardware window shows all the parameters of the selected module in the Configuration

Table, and we call it Parameters Window.

4.3.1 How to open the Hardware window

You can open the "Hardware" window by using one of the following ways:

- Double-click the [**Hardware]** node in the **Manager** window.
- Right-click the [**Hardware**] node, and then select the [**Open**] command on the pop-up menu.

4.3.2 Copy and paste the hardware configuration in different projects

In Kincobuilder, users are allowed to copy and paste [**Hardware Configuration**] in different projects. The [**Hardware Configuration**] refers to configuration of of CANOpen, communication port, etc. and will not copy the information of CPU, which means it can be executed between CPUs. All pending projects must be opened by KincoBuilder. You may use the copy and paste function the same time with that of LD or IL.

This function will be helpful if you would like to transplant the configuration of CANOpen of old projects.

You may use this function as follows:

- Click [**Copy Hardware Configuration**], [**Paste Hardware Configuration**] in the [**Edit**] menu;
- Right-click [**PLC Hardware Configuration**] in the [**Project Manager**] tree and execute [**Copy Hardware Configuration**] and [**Paste Hardware Configuration**]

4.3.3 Add/Remove Modules

- **Add a module**

You can add a module using the following steps:

- In the Configuration Table, click a row to place the focus on it. If there exists a module in this row, it must be removed before adding a new module.
- In the PLC Catalog Window, double-click a module to add it to the row with the current focus in the

Configuration Table.

Row 1 can only be added into with a CPU module, and other rows can only be added into with the expansion modules. There shall not be any null rows between each two modules. If a null row exists, KincoBuilder will not allow continuing to add modules after it, and an error message-box will popup when saving or compiling the project.

- **Remove a module**

You can remove a module by using the following ways:

- Click the module to be removed in the Configuration Table, then use **Del** key to remove it.
- Right-click the module to be removed, and then select the [**Remove**] command on the pop-up menu.

4.3.4 Configuring Module Parameters

Once you have arranged your modules in the Configuration Table, you can continue to assign their parameters. KincoBuilder allows you define all of the parameters of a module.

In the Configuration Table, click a PLC module to place the focus on it, and then the Parameters Window of this module shall appear below. You can assign a module's parameters in its Parameters Window. Of course, you can use **Up** and **Down** arrow key to move the focus in the Configuration Table

On the right hand of the Parameters Window, there are two public buttons: 【**Default**】 and【**Cancel**】.

- 【**Default**】: If you click this button, KincoBuilder will assign default parameters for the current module.
- 【**Cancel**】: If you click this button, the original configuration of the current module will be restored.

Notice: The addresses of the modules in the same memory area (I, Q, AI or AQ) cannot overlap!

4.3.4.1 Parameters of the CPU

① **【I/O Configuration】** tab

Here you can assign the I/O parameters of the CPU module, as shown in the following figure.

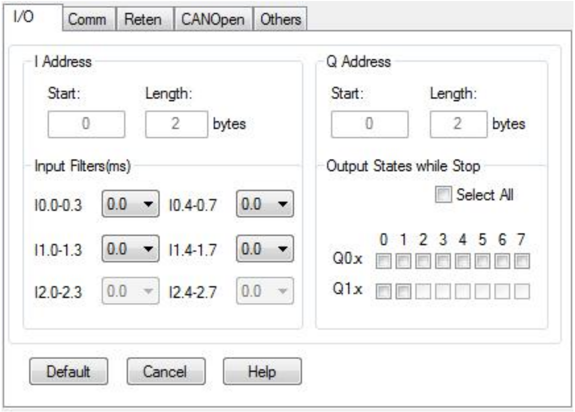


Figure 4-3 I/O Parameters of the CPU

- **Input:** Here, you can configure the DI channels on the CPU body.
- **I Address:** the start byte address of the DI channels in I area. It is fixed to be 0.
- **Input Filters:** Select an input filter (ms) that defines a delay time for DI channels. This delay is helpful to filter the input noise and enhance the anti-interference capacity of the control system. When an input state changes, it won't be accepted as valid unless it remains for the duration of the filter time.
- **Output:** Here, you can configure the DO channels on the CPU body.
- **Q Address:** the start byte address of the DO channels in Q area. It is fixed to be 0.
- **Output States while STOP:** Set the digital outputs in a known state while the CPU stops. If the checkbox for an output is checked, the output shall be set to ON (1) while the CPU stops. The default state of a output while the CPU stops is OFF (0). This function is very significant for safety interlock requirements after a RUN-to-STOP transition.

② **【Communication Ports】** tab

Here you can assign the serial communication parameters for Port0, Port1 and Port2 on the CPU module.

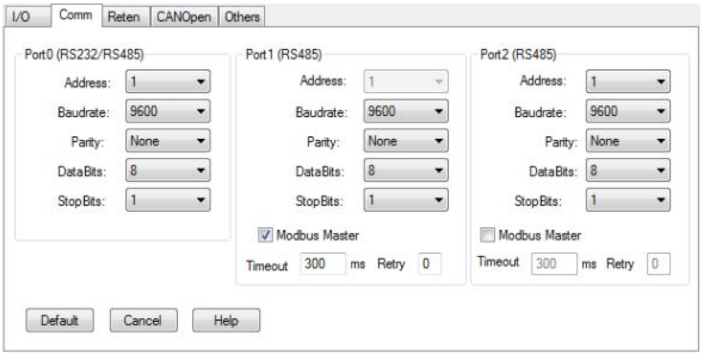


Figure 4-4 Serial Communication Parameters

- **Port0**

- **Address:** Choose the desired station address of Port0. This address also acts as a Modbus RTU slave number, and it is must be exclusive in the network.
- **Baudrate:** Select the desired baud rate. (1200, 2400, 4800, 9600, 19200, 38400, 57600or115200bps)
- **Parity:** Select the desired parity scheme. (No parity, Odd, or Even)
- **DataBits:** Select the number of bits in the bytes transmitted and received. (8)
- **StopBits:** Select the number of stop bits. (1)

- **Port1 and Port2**

Port1 and Port2 are RS485 ports.

- **Modbus Master:** If the checkbox is checked, Port1 will work as a Modbus RTU master.
- **Timeout:** Enter a timeout value for this Modbus master.
- **Retry:** Enter the value of retry times. When the master receives a wrong frame from a slave, it will retry to communicate with the slave for '**Retry'** times.
- **Baudrate:** Select the desired baud rate. (1200, 2400, 4800, 9600, 19200or38400bps)
- **Parity:** Select the desired parity scheme. (No parity, Odd, or Even)
- **DataBits:** Select the number of bits in the bytes transmitted and received. (8)
- **StopBits:** Select the number of stop bits. (1)

When the master station sends out a command, it will report communication errors under the following conditions:

- A communication timeout error will be reported if there is no response received from slave in the defined time.
- If fault response received by master station, then it will try resend commands again. User set the retry times. If master station still does not receive correct response for last time retry, master station will wait for the set timeout time then report a communication timeout error.

③ 【Retentive Ranges】 tab

Here you can define four retentive ranges to select the ranges of the RAM you want to retain on power loss. If the CPU loses power, the instantaneous data in the RAM will be maintained by internal battery, and only the data in the retentive ranges will be left unchanged at next power on.

NOTE: The memory area of "Initial Data", "Data Maintain" and "Data Backup" should be placed to avoid overlap. The data should be recovered after CPU powered on. The sequence is: recover the memory data defined in "Data Maintain", assign initial value to the memory are of "Initial Data" and recover the data permanently saved by commands.

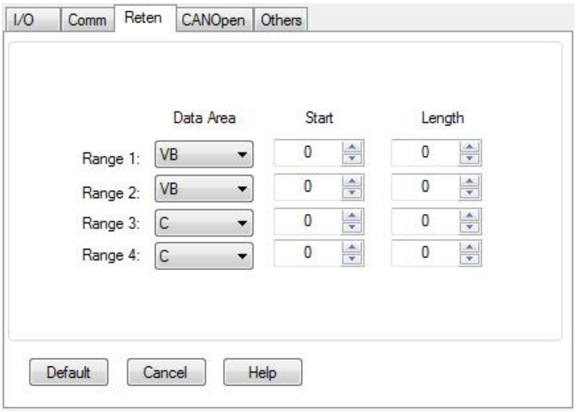


Figure 4-5 Retentive Ranges

There are 4 separate Retentive areas configurable in all.

• **Data area**

Select the memory area for retentive Range 1. (V area or Counter area)

For counters, only the current count values can be retentive.

• **Start**

Assign the start byte address.

• **Length**

Assign the length, unit: byte.

As shown in Figure 4-5, the data stored in Range 1 (%VB0 to %VB9), Range 2 (%VB100 to %VB199), Range 3 (C0 to C9) and Range 4 (C20 to C49) will be retentive on power loss.

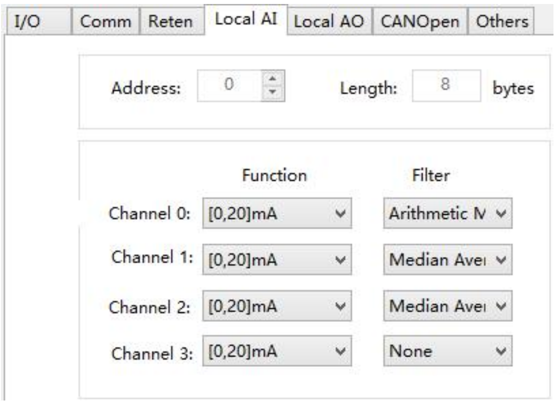
④ **【Local AI/AO】** tab

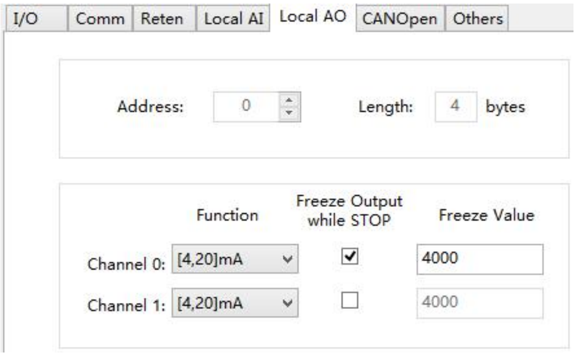
K506EA-30AT integrates 4 AI channels. The channels are mapped to AIW0, AIW2, AIW4, AIW6 respectively. Sampling conversion speed of each channel is about 30times per second.

K506EA also integrates 2 AO channels. The channels are mapped to AQW0, AQW2 respectively.

Sampling conversion speed of each channel is about 30times per second.

For these integrated AI/AO, users have to set functions and filter for each channel in [Hardware]-[Local AI]/[Local AO] tab as follows:





⑤【CANOpen】 tab

See Appendix F.

⑥ 【Others】 tab

1. If not check "Permanent backup VB3648-4095", the K5 PLCs will permanent backup 255 bytes (VB3648-3902) by default which is the same with K3 PLC.

User could check "Permanent backup VB3648-4095" according to the program.

2.Backup the project files.

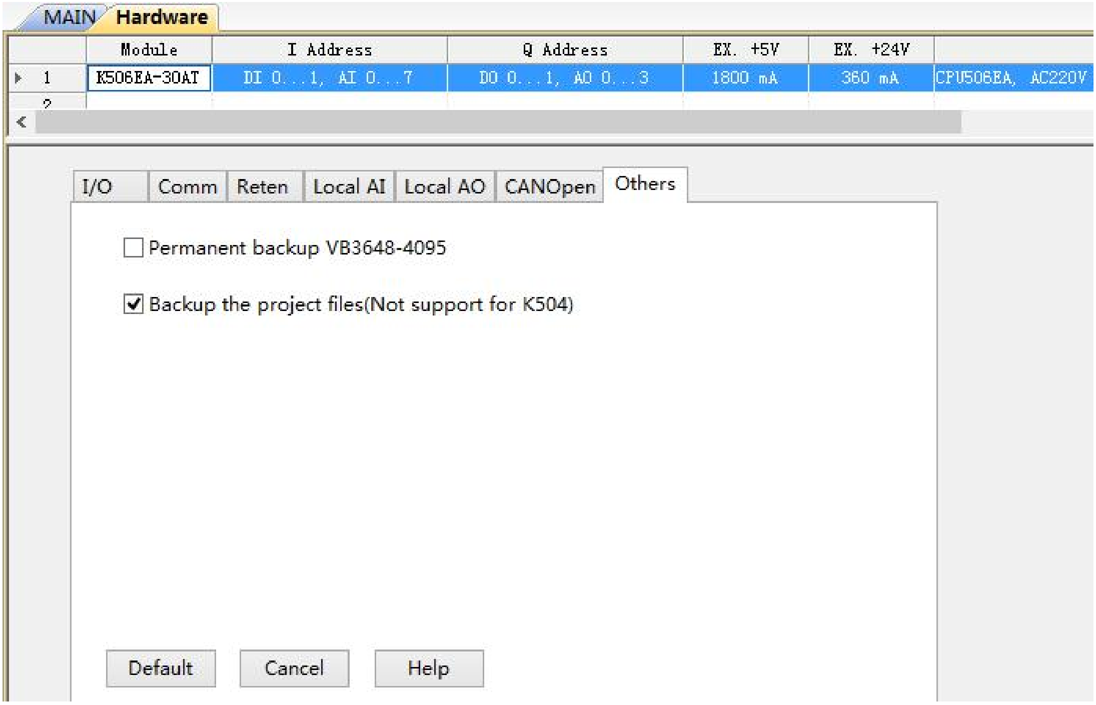
When users new create a project, [Backup the project files(Not support for K504)] is checked by default. By this function, the project programmed by Kincobuilder will be embedded in the OBJ file in ZIP format. When user uploads project, the project will be extracted from the ZIP file.

•Comparing with K3 upload function, notes parameter identifier, program name subroutine name will be saved.

• Backup the project files will occupy EEPROM memories. If the project is too big to be compressed in EEPROM, PLC will ignore this option. The upload function is the same with K3 by default.

• To check this option, it will increase the time for download.

• If user does not need to upload PLC project, just for debugging project, then users could uncheck this option.



4.3.4.2 Parameters of the DI Module

You can set the parameters of a DI module as follows:

Figure 4-6 Parameters of the DI Module

➢ **Address**

• **Start**

Enter the start byte address of the address range of this module in I area. The addresses for this module's channels are based on this start address.

• **Length**

Assign the length. This value is fixed, and it depends on the number of this module's DI channels.

As shown in Figure 4-6, the module has 8 DI channels, and its start address is %IB2, so the addresses of its channels are %I2.0 to %I2.7.

4.3.4.3 Parameters of the DO Module

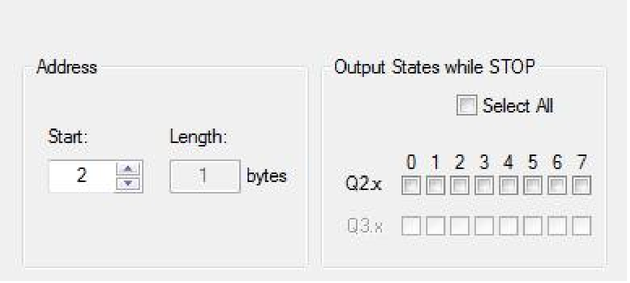


Figure 4-7 Parameters of the DO Module

➢ **Address**

• **Start**

Enter the start byte address of the address range of this module in Q area. The addresses for this module's channels are based on this start address.

• **Length**

Assign the length. This value is fixed, and it depends on the number of this module's DO channels.

As shown in Figure 4-7, the module has 16 DO channels, and its start address is %QB2, so the addresses of its channels are %Q2.0 to %Q3.7.

➢ **Output States while STOP**

Here you can set the digital outputs in a known state while the CPU stops. If the checkbox for an output is checked, the output shall be set to ON (1) while the CPU stops. The default state of the output is 0 while the CPU is in STOP.

4.3.4.4 Parameters of the AI Module

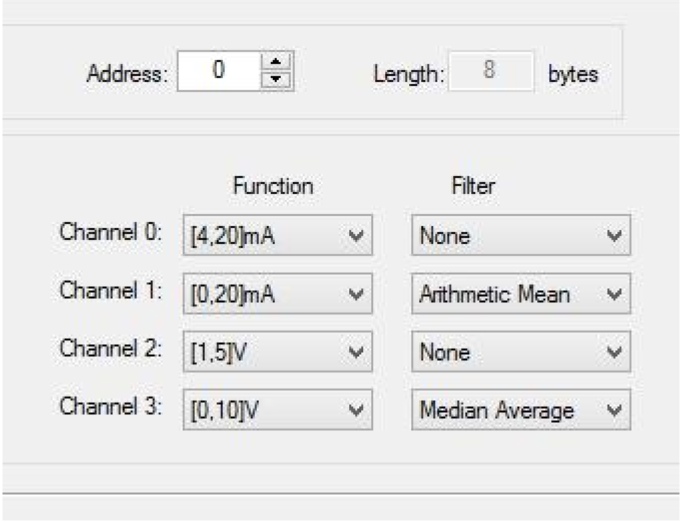


Figure 4-8 Parameters of the AI Module

- **Address**

• Address

Enter the start byte address (address of the first channel) of this module in AI area; the addresses for the other channels are based on this start address, each address occupies two bytes. This numerical value must be even.

• Length

Assign the length. This value is fixed, and it depends on the number of this module's AI channels.

As shown in Figure 4-8, the module has 4 AI channels, and its start address is %AIW0, so the addresses of the other channels are %AIW2, %AIW4 and %AIW6.

- Inputs

• Function

Select a measurement type for a channel, e.g. 4-20mA, 1-5V, etc.

Please refer to 6.1.4 Internal Presentation Format of the Measured Values of Signals in "Hardware Manual" for the representation of the measured value.

• Filter

Select a software filter for a channel. As for the analogue signal with rapid changes, a filter can be helpful to stabilize the measured value.

Notice: If the control system requires responding to an AI signal quickly, the software filter of the corresponding channel should be disabled.

You can assign one of the following filters for a channel:

None --- The software filter is disabled.

Arithmetic Mean --- The filtered value is the arithmetic mean value of a number of samples of the input.

Median Average --- The filtered value is the sliding mean value of a number of samples of the input.

4.3.4.5 Parameters of the AO Module

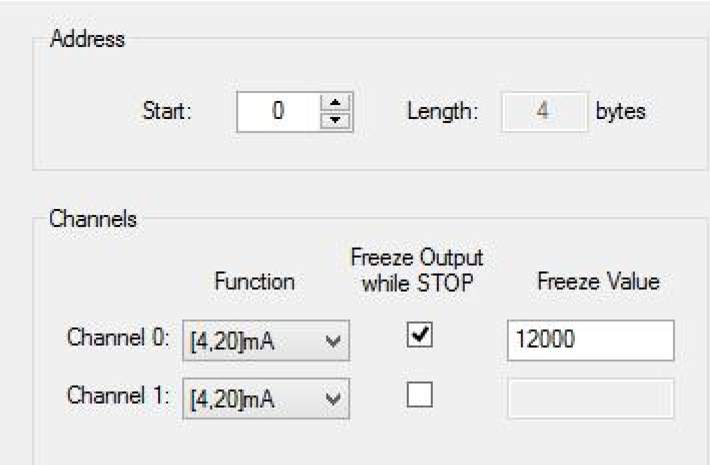


Figure 4-9 Parameters of the AO Module

➢ **Address**

• Address

Enter the start address (address of the first channel) of this module in AQ area; the addresses for the other channels are based on this start address, each address occupies two bytes. This numerical value must be even.

• **Length**

Assign the length. This value is fixed, and it depends on the number of this module's AO channels.

As shown in Figure 4-9, the module has 2 AQ channels, and its start address is %AQW0, so the address of another channel is %AQW2.

➢ **Outputs**

• **Function**

Select a type of output signal for a channel, e.g. 4-20mA, 1-5V, etc.

Please refer to 7.1.4 Internal Presentation Format of Signal Value in "Hardware Manual" for the representation of the output value.

• **Freeze Output while STOP**

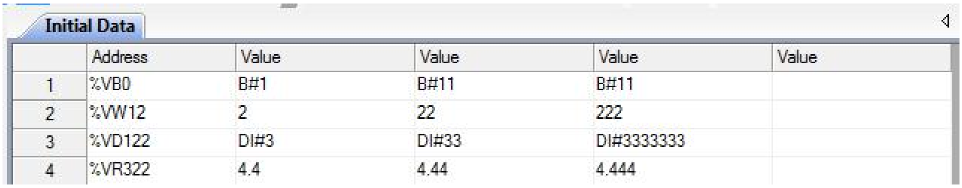
Select whether to set the analog output to a known value (**Freeze Value**) while the CPU stops. If the checkbox for an output is checked, the output shall keep at the freeze value while the CPU stops.

• **Freeze Value**

Here you can enter a value which the analog output shall keep at while the CPU stops.

4.4 The Initial Data Table

In the Initial Data Table, you can assign initial numerical values for BYTE, WORD, DWORD, INT, DINT and REAL variables in V area. The CPU module processes the Initial Data once at power on and then starts the scan cycle. The Initial Data Table is as Figure 4-10.



Initial Data

	Address	Value	Value	Value	Value
1	%VB0	B#1	B#11	B#11	
2	%VW12	2	22	222	
3	%VD122	DI#3	DI#33	DI#3333333	
4	%VR322	4.4	4.44	4.444	

Figure 4-10 the Initial Data Table

NOTE: The memory area of “Initial Data”, “Data Maintain” and “Data Backup” should be placed to avoid overlap. The data should be recovered after CPU powered on. The sequence is: recover the memory data defined in “Data Maintain”, assign initial value to the memory are of “Initial Data” and recover the data permanently saved by commands.

4.4.1 Opening the Initial Data Table

- Double-click the [**Initial Data**] node in the **Manager** window.
- Right-click the [**Initial Data**] node, and then select the [**Open**] command on the pop-up menu.

4.4.2 Editing a Cell

Click on a cell to make it change to the editing mode, and now you can type the desired data. Besides, you can use the **UP**, **DOWN**, **LEFT** and **RIGHT** arrow keys to move the focus from one cell to another, and the cell that gets the focus shall change to the editing mode.

When a cell loses focus, its contents are confirmed. Besides, you can use the **ENTER** key to confirm your work and move the focus to the next cell.

The illegal data shall turn red.

4.4.3 Making Initial Data Assignments

The table has 5 columns: an **Address** column and 4 **Value** columns.

- Enter a direct variable, i.e. a direct address in the **Address** column.
- Enter numerical values in the **Value** columns. You can enter one value or multiple values. If you enter multiple values, KincoBuilder shall make an implicit address assignment.

As shown in Figure 4-10, Row 1 indicates that B#1 is assigned to %VB0, B#11 is assigned %VB1 and B#11 is assigned %VB2; Row 2 indicates that 2, 22 and 222 are assigned to %VW12, %VW14 and %VW16respectively; Row 3 indicates that DI#3, DI#33 and DI#3333333 are assigned to %VD122, %VD126 and %VD130 respectively.

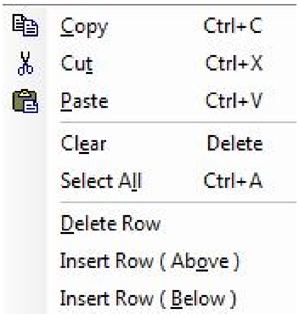
4.4.4 Editing the Initial Data Table

- Sorting

Click the **Address** column header to sort the table.

- The Pop-up Menu

Right-click on any cell in the table, the following menu will popup:



• **Delete Row**: Delete the row in which the focus is located.

• **Insert Row (Above)**: Insert a new blank row above the row in which the focus is located.

• **Insert Row (Below)**: Insert a new blank row below the row in which the focus is located.

Please pay attention when using the paste command: it will not work between different types of table' neither between different rows.

4.5 The Global Variable Table

The Global Variable Table is composed of two parts: the **Global Variable** tab and the **FB Instance** tab.

- The **Global Variable** tab

It can be used to define the Global Variable, which accesses PLC memory address.

The Global Variable in the program can replace PLC memory address to ensure the readability of the program. Each memory address can be assigned one symbolic variable name; similarly, one symbolic variable name will have one corresponding memory address only.

Please refer to 3.3.1 How to define an identifier to see the defining rule;

Please refer to 3.5 Variables to see more information about the global variables.

You can declare global symbolic variables here, as shown in Figure 4-11.

In this manual, "the Global Variable Table" usually indicates this tab.

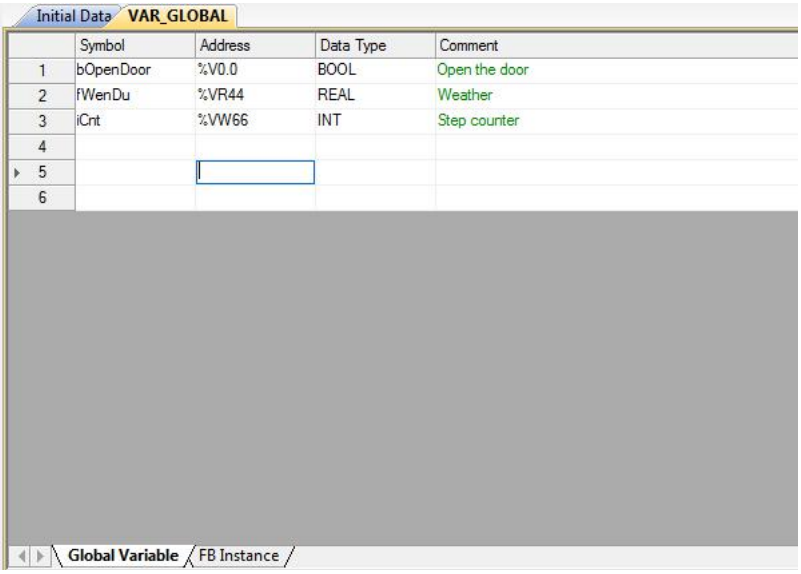


Figure 4-11 the Global Variable tab

➢ The **FB Instance** tab

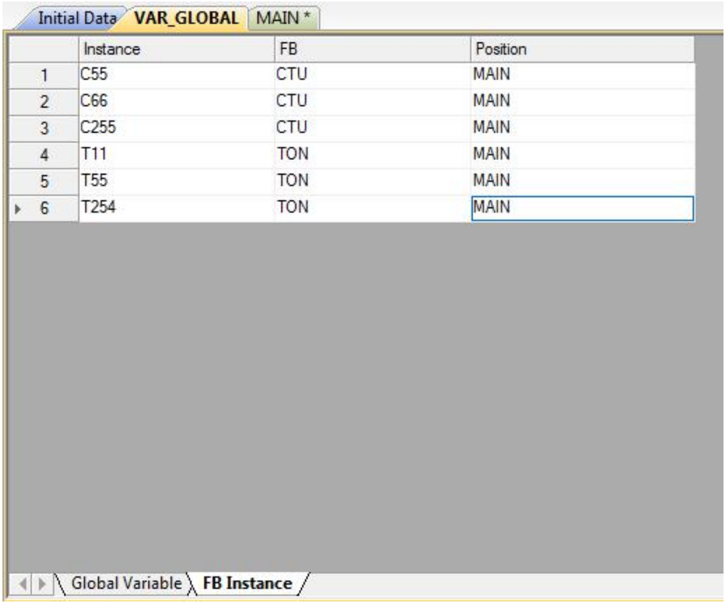


Figure 4-12 the FB Instance tab

As mentioned in 3.6.6 Using of FB Instances, the FB instances are declared by KincoBuilder automatically to facilitate the users. So all the information here is only for reference and you cannot modify them.

4.5.1 Opening the Global Variable Table

There are three ways to open the Global Variable Table:

➢ Double-click the [**Global Variable**] node in the **Manager** window.

➢ Right-click the [**Global Variable**] node, and then select the [**Open**] command on the pop-up menu.

➢ Select the [**Project**]→[**Global Variable**] menu command.

4.5.2 Declaring the Global Variables

The table has 4 columns: **Symbol**, **Address**, **Data Type** and **Comment**.

- Open the Global Variable Table window and select the **Global Variable** tab.
- Enter the symbol name in the **Symbol** column and confirm it.
- Enter the direct address in the **Address** column and confirm it.
- Choose a data type from the drop list in the **Data Type** column.
- (Optional) Enter a **Comment**.

If you declare a global variable in the Global Variable Table, you can use it in any POU, and a direct address is equivalent to its symbolic name in the user program.

Please refer to 3.5 Variables for more information about the global variable.

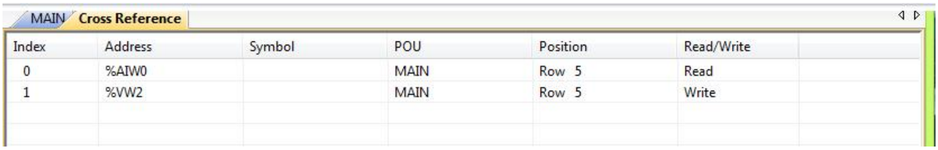
You can operate the Global Variable Table just as the Initial Data Table. Please refer to 4.4 The Initial Data Table for more information.

4.6 The Cross Reference Table

The Cross Reference Table shows all the variables used in the project, and identifies the POU, network or line location, and how to access the operands (read or write to). The Cross Reference Table is helpful when you want to know if a symbolic name or an address is already in use, and where it is used.

Information in the Cross Reference Table only be generated after the first compilation, and will refresh automatically after each compilation.

The Cross Reference Table is as the following figure:



Index	Address	Symbol	POU	Position	Read/Write
0	%AIW0		MAIN	Row 5	Read
1	%VW2		MAIN	Row 5	Write

Figure 4-13 the Cross Reference Table

- **Address** Display all the memory addresses used in the project.
- **Symbol** Display the global symbolic name of the **Address**.
- **POU** Indicate the POU where the **Address** is used.
- **Position** Indicate the line or network where the **Address** is used.
- **Read/Write** Indicate whether the **Address** is read or written to here.

As shown in Figure 4-13, the first row in the table indicates that **%AIW0** is used once in **Network 0** of the **Main** program, and it is read this time.

Double-click on a row in the Cross Reference Table, and you shall go to the corresponding part of your program.

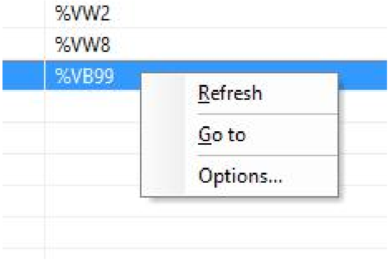
4.6.1 Opening the Cross Reference Table

- Select the [**Project**]→[**Cross Reference**] menu command.
- Click the icon in the toolbar.

➢ Use the **Alt+C** shortcut key.

4.6.2 The Pop-up Menu

Right-click on any row in the table, the following menu shall popup.



• **Refresh**: Refresh the table and display the latest cross-reference information.

• **Go to**: Go to the corresponding part of your program.

• Parameter locating

Double click on one row to enter the POU and locate on the specified parameter.

• **Filter**： Enter [Tools]-[Options]-[Cross Reference Options], then user could select “Memory Type” and “Data Type” to be displayed.

4.7 The Status Chart

You can use the Status Chart to monitor and force any direct variable used in the project after you have downloaded the project to the PLC. The Status Chart is shown as Figure 4-14.

- Memory Monitor Chart

Can be used to detect any memory address of PLC;

This function is available on K3 and K5 PLC; on K5 all memories are available while on K3 only I, Q, AI, AQ, M, V areas.

The Monitor Chart is shown as follows:

- The Status Chart

Initial Data | VAR_GLOBAL | MAIN * | Status Chart

	Address	Number	Format	Value 1	Value 2	Value 3
1	%V0.0	3	DEC	FALSE	FALSE	FALSE
2						
3	%MB6	7	DEC	B#0	B#0	B#0
4	%MB9			B#0	B#0	B#0
5	%MB12			B#0		
6						
7	%VR44	9	DEC	0	0	0
8	%VR56			0	0	0
9	%VR68			0	0	0
10						
11	%SMW66	5	DEC	0	0	0
12	%SMW72			0	0	
13						
14						
15						
16						
17						
18						

Figure 4-14 the Status Chart

You may find in the chart:

[**Memory Address**]: Input the initial address of the memory area to be detected;

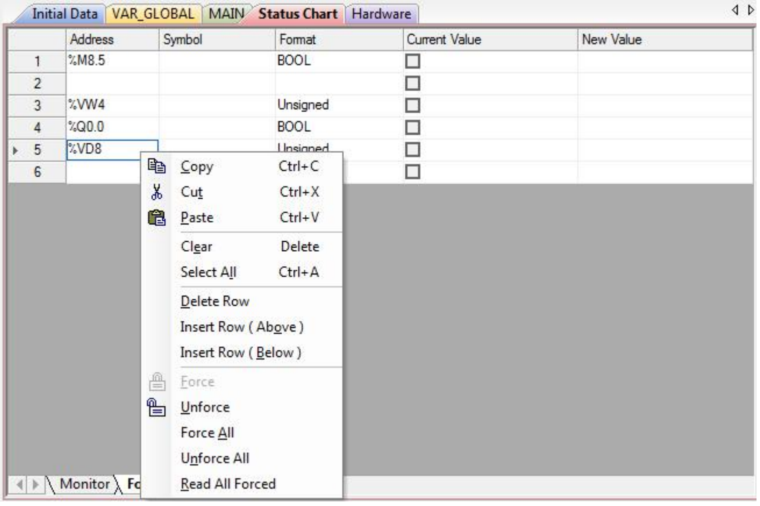
[**Monitor Length**]: Input the total number of data to be detected from the memory addresses. Maximum number is 150.

For each row maximum number of data shown is 3. If more than 3, data will be separate into different rows.

[**Display Format**]: Select the display format, including decimal and hexadecimal system.

[**Memory Value**]: Show the monitoring memory value.

If the monitoring is bit memory, only the TRUE or FALSE will be shown.



- **Address** Enter the initial address to be monitored and forced.
- **Symbol** Display the global symbolic name of the **Address**.
- **Format** Choose a display format for the current value and new value. (BOOL; REAL; Signed, Unsigned, Hexadecimal or Binary)
- **Current value** Display current values of the **Address** from the PLC.
- **New Value** Enter the value to be forced for the **Address** when monitoring

You can open a Status Chart to edit it, but no status information is displayed in the **Current Value** column unless you select the [**Monitor**] command from the [**Debug**] menu or toolbar.

In order to be efficient, KincoBuilder only allows monitoring and forcing the variables used in the project. If you enter the variables that are not used, the **Current Value** and **New Value** won't take effect.

4.7.1 Opening the Status Chart

- Double-click the [**Status Chart**] node in the **Manager** window.
- Right-click the [**Status Chart**] node, and then select the [**Open**] on the pop-up menu.
- Select the [**Debug**] →[**Status Chart**] menu command.

4.7.2 Monitoring the Variable Value

You may monitor the variable value by Status Chart as follows:

- Input the memory address to be monitored in [Address]
- Enter into online monitoring status via following means:

  Execute **[Debug]→[Online Monitor]** command;

  Click the icon  on the toolbar;

  Use shortkey **F6**
- [**Display Format**] of the monitor value can be changed at any time.

4.7.3 The Force Function

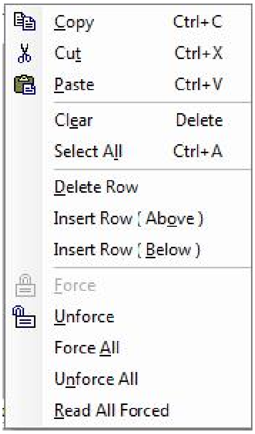
You can use the Force Function to edit the variable value in I area, Q area, M area, V area, AI are, AQ area, among which variables in I area, Q area, M area and V area can be forced by bit, byte, word or double byte; variables in AI area and AQ area can be forced by word. When CPU is rebooted, all force status will be canceled.

K5 allows maximum 32 variables. Immediate commands cannot be forced.

In at certain time of the scanning period, one variable may have following possibilities: exterior input signal (I, AI) or user program result (Q, AQ, M, V). Variable valuing principles are as follows:

- Variables in M area and V area, force value has the same priority of the program execution result.
- Variables in I and AI area, force value is prior to exterior signal input value.
- Variables in Q and AQ area, program execution result will overwhelm.

4.7.4 Right-click Menu



- **Force**: Input [Force Value] the direct memory (address) of PLC.
- **Cancel Force**: Cancel the Force status of single being clicked.
- **Force All**: Input all forced value of [Force Values] to the corresponding direct memories (address) of PLC.
- **All Cancel Force**: Cancel all the Force status.
- **Read All Forced**: Read all forced variables and show them in the Variable Status Table.

4.7.5 Force and Cancel Force

You may force or cancel force a variable in the Variable Status Table as follows:

- Input the direct memory address to be forced in [**Address**];
- Select the [**Display Format**] of the value and you may verify it at any time (**optional**);
- Input the force value. You may input a round number in decimal and Kincobuilder will adjust it accordingly;
- You may force a variable as follows:
- Right-click the row and execute [**Force**] command;
- Click the row and click icon  in the tool bar;
- Click the row and execute [**Debug**] → [**Force**] command;

- You may cancel forcing a direct [**Address**] in a row as follows:
- Right-click the row and execute [**Cancel Force**] command;
- Click the row and click the icon  in the toolbar
- Click the row and execute [**Debug**] → [**Cancel Force**]

The edition of Variable Status Table is the same as Initial Data, please refer to that part.

4.8 Password Protection

The Kinco-K5 provides password protection for you to encrypt the CPU for restricting access to specific functions. A password is a string of letters, digits, and underline characters, and it is case-sensitive. The length of a password is 8-14 characters.

If a CPU is encrypted, the password will be required to enter when you try to access the restricted functions. Here, if a correct password is entered, the CPU will permit the corresponding operation; if a wrong password is entered, the CPU will refuse the corresponding operation. The password is only valid for current operation. If you try to access the restricted functions again, then you have to enter the password again.

K5 limits the number of password input times. When you enter a wrong password for limited number of times, you must restart the PLC to continue the operation that needs a password.

If you set the PLC protection level to be “Level 3: Minimum access” or enable [Upload Disabled] choice when downloading project, the user program will be encrypted and saved in cipher text in the PLC.

4.8.1 Protection Privileges

The Kinco-K5 provides the following 3 protection privileges:

- **Level 1:** Full access. No restriction to access all the functions. This is the default level.
- **Level 2**: Partial access. Password is required while downloading.
- **Level 3:** Minimum access. Password is required while downloading and uploading.

4.8.2 How to change the password and the protection level

Select [**PLC**] →[**Password**…] menu command to open the 'Password' window. See the following figure:

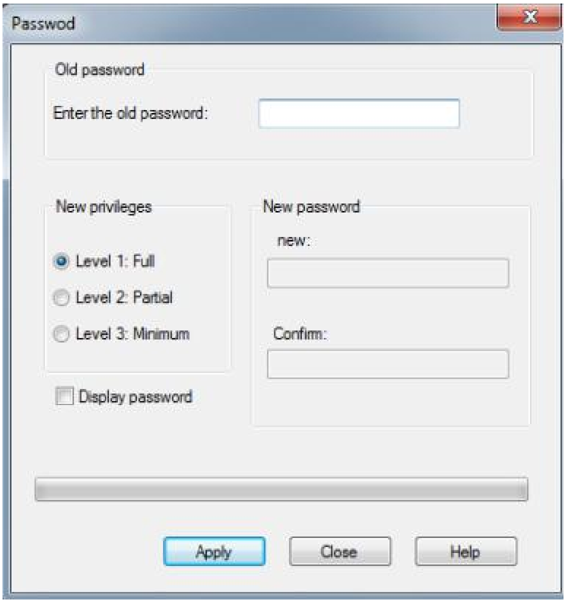


Figure 4-15 the 'Password' Window

- **Old password**

If the connected CPU has been set with password protection, then the original old passwords has to be entered here for verification. If no password protection has ever been set, then just leave the edit box empty.

- **New Privileges**

Here, you can set the new protection levels and passwords for the connected CPU.

- **New Privileges**: You can choose any one from level 1, level 2, and level 3.
- **New password:** You can enter a new password here.
- **Confirm:** You need to enter the new password again here.

After finishing the settings above, you can click on the [**Apply**] button to write the new settings into the connected CPU, and then the new settings will be efficient.

4.8.3 How to recover from a lost password

If you forget the password, you have to clear the memory of the CPU for continuing to use it. Select [**PLC**] → [**Clear**…] menu command to clear the memory of the CPU.

After clearing, all the data in the CPU, including the user program, the configuration data, and the password, will be lost, and the CPU is restored to the factory-set defaults, except for the RTC. Here, the communication parameters are the following: the station number 1, the baudrate is 9600, no parity, data 8 bits, stop 1 bit.

Chapter V How to Use KincoBuilder … Programming

KincoBuilder presently supports IL and LD programming languages, and so two editors are provided for programming: the IL editor and the LD editor. This chapter will detailedly describes the two editors and meanwhile represents the relevant syntaxes and rules of IL and LD languages.

IEC61131-3 defines three textual languages and three graphical languages. The textual languages include: Instruction List (IL), Structured Text (ST) and Sequential Function Chart (SFC, textual version); and the graphical languages include: Ladder Diagram (LD), Function Block Diagram (FBD) and Sequential Function Chart (SFC, graphical version).

KincoBuilder presently provides two editors for programming: the IL editor and the LD editor. You can write a POU in IL or LD language, i.e. you can write a POU with the IL or LD editor. With some restrictions, a POU written in a program editor can be viewed and modified in another program editor. You just select the [**Project**]→[**IL**] or [**Project**]→[**LD**] menu command to switch the editor for the current POU.

5.1 Programming in IL

5.1.1 Overview

IL is a low level language that is very similar with the assembly language, and it is based on similar instruction list languages from well-known PLC manufacturers around the world.
IL is close to a machine code, and so it is an efficient language. IL is very appropriate for experienced programrs. Sometimes you can use IL to solve the problems that you cannot solve easily using LD.

5.1.2 Rules

5.1.2.1 Instructions

IL is a line-oriented language. An IL program consists of a sequence of instructions. Each instruction shall begin on a new line and contains an operator. Operands are optional, and they are separated by commas or spaces. A comment can be entered at the end of the line using parentheses and asterisks. Blank lines are allowable in an instruction list.

The following figure shows the typical format of an IL statement:

```
label:
Operator    Operands                (* Comment *)
```

Figure 5-1 The Typical Format of an IL Statement

- **label**

Optional. Jump is used to jump to a line of the IL program. In this case, a label in front of the destination line is used. The name format of a label is identical with that of an identifier.

- **Operator**

PLC instruction.

- **Operands**

Please refer to instructions set for the detailed descriptions.

- **Comment**

Optional, Only one comment is allowable in a line; nesting is not permitted.

The following is an example:

```
(* NETWORK 0 *)
begin:              (* a label, used at jump *)
LD      %I1.0
TP      T2, 168     (* if %I1.0 is true, the timer T2 is started. T2 is an instance of TP. *)
```

5.1.2.2 Current Result

IL provides a universal accumulator called the "Current Result (CR)", and the current result of logical operation is stored in the CR. The CR will be refreshed after the execution of each statement, and it may act as the execution condition or one of the operands for the next statement.

All the operators in KincoBuilder can be grouped according to their influence on the CR as shown in the following table. Please refer to the instruction set for further details.

Group	Influence on the CR	Examples
C	Create the CR	LD, LDN
P	Set the CR to be the result of operation	Bit logic, Compare instructions, etc.
U	Leave the CR unchanged	ST, R, S, JMP, JMPCN, JMPC, etc.

Table 5-1 The Operator Groups

IEC61131-3 does not define the above groups. As a result, these groups in different programming systems may be different.

5.1.2.3 Network

In KincoBuilder, a POU is composed of the following parts:

- POU type and POU name
- Variable declaration part
- Code part containing the instructions

Network can be taken as the basic code segment; the code part of the POU is composed of several networks. Networks make it easier to view an IL program. A typical network includes:

- Network label
- Network comment.
- Instructions

5.1.3 The IL Editor in KincoBuilder

When a new program in IL language is being established, the IL editor will be ready for programming; if an IL program is opening, the IL editor will also be ready. The IL editor is shown as follows.

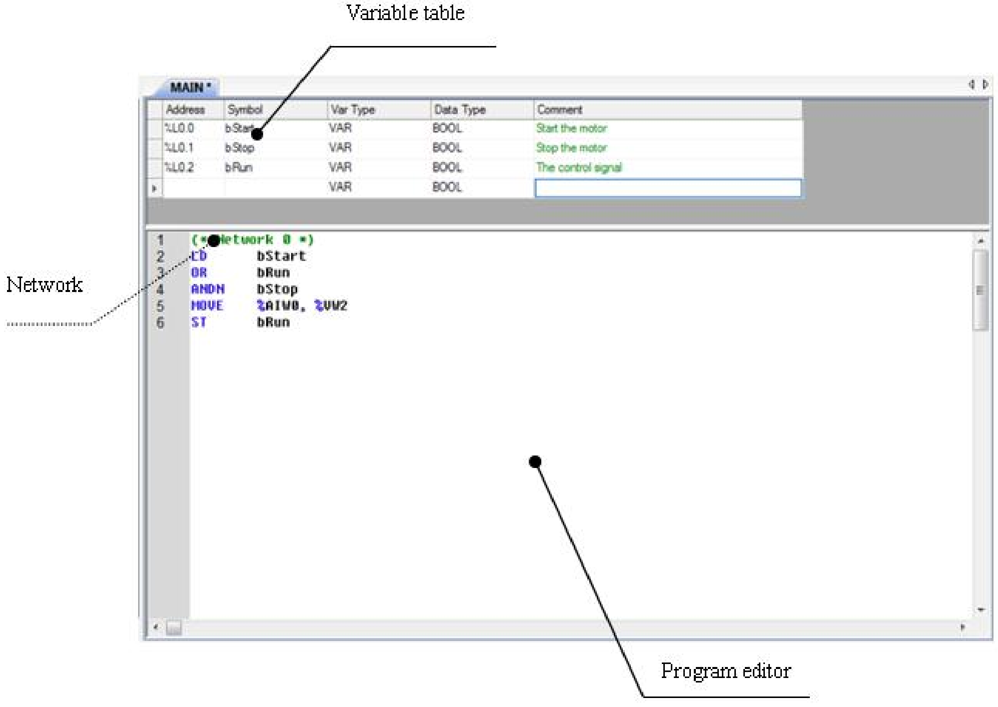


Figure 5-2 the IL Editor

The IL editor is composed of two parts:

• The Variable Table: you can declare the local variables and input/output parameters of the POU here.

• The Program Editor: you can edit your control program here.

5.1.3.1 Adding a Network

Use one of the following ways to add a network:

- Use **Ctrl+Q** shortcut key

- Right-click the Program Editor and select the [**Insert Network**] on the pop-up menu.

5.1.3.2 Allowable Instructions Format in a Network

- There can be only one statement label in a network. For example:

```
(* NETWORK 0 *)
MRun:      (* There can be only one statement label *)
```

- A network can contain some statements.

In 5.2.2.2 Current Result , we divide all the instructions three groups (“C”, “P” and “U”).

The network must begin with one of the instructions in group “C”, and end with one of the instructions in group “P” or “U”. For example:

```
(* NETWORK 0 *)
LD   %M3.5   (*Begin with LD instruction *)
… …          (*you can enter other instructions *)
ST   %Q2.3   (*End with the allowable instruction *)
```

- A network can contain some statement labels and some statements.

The network must begin with a label or one of the instructions in group “C”, and end with one of the instructions in group “P” or “U”. For example:

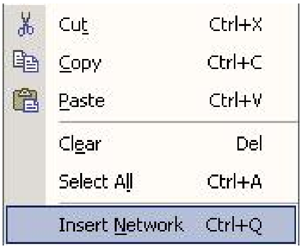
```
(* NETWORK 0 *)
MRun:
LD    %M3.5   (*Begin with LD instruction *)
… …           (*You can enter other instructions*)
ST    %Q2.3   (*End with the allowable instruction *)
```

5.1.3.3 Other Operations

The IL editor can automatically format the statements. It can also check the statements automatically, and a red question mark before a line indicates that there is something wrong with this line.

The IL editor is similar with a text editor and supports common keyboard operations.
All commands in the 【**Edit**】 menu are applicable in the IL editor.

Right-click on the Program Editor, the following menu will popup:



- Input IL statements

  IL program editing area is similar with a text editor, where users could input statements and edit program directly. And it supports basic keyboard operations, such as Delete, Backspace, and moving cursor by UP/DOWN/LEFT/RIGHT arrows.

  IL editor could format input statements automatically, displaying key words in blue, displaying notes in green.

  If user moves cursor to other rows, IL editor will check syntax of the previous row. A red (?) will display at the beginning of the row. Only rows are checked correct could be formatted displayed.

- Check/Delete/Copy/Cut/Paste

  In the IL editor, users could use all the commands in [Edit] menu, including Check All, Copy, Cut, Paste and so on. Also user could use right click menu.

Execute [Check All] command will check all the text in the editing area. Drag cursor or use UP/DOWN/Left/Right arrow and press SHIFT button to check the passing text. The checked area displays with balck background and text is displayed in highlight state.

Delete checked contents by the **Delete** button or by [**Delete**] command.

Use shortcut key Ctrl+C or execute [**Copy**] command to copy the checked contents to clipboard of Windows. The copied contents could be pasted in any text editor, such as Window notebook, Word document.

The Cut operation is equivalent to Copy and Delete the checked contents. Execute [**Cut**] commands or use shortcut key Ctrl+X to Cut checked contents to Windows clipboard.

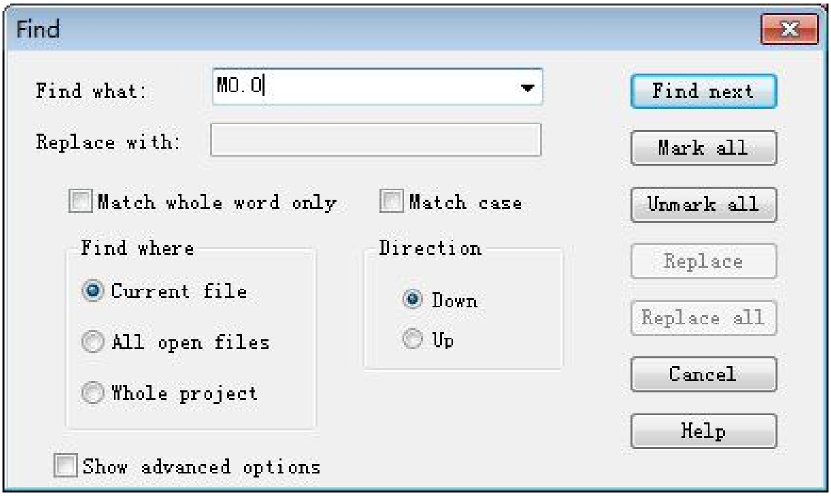
After Copy or Cut operation finished, move cursor to the target location paste, then execute [**Paste**] command or use shortcut key Ctrl+V to paste the contents of clipboard to the current cursor location.

- Find/Replace

IL Editor supports the standard Find and Replace instruction

- Find

Use Ctrl+F or click the menu **Edit>>Find...**, the Find window will be popped up.

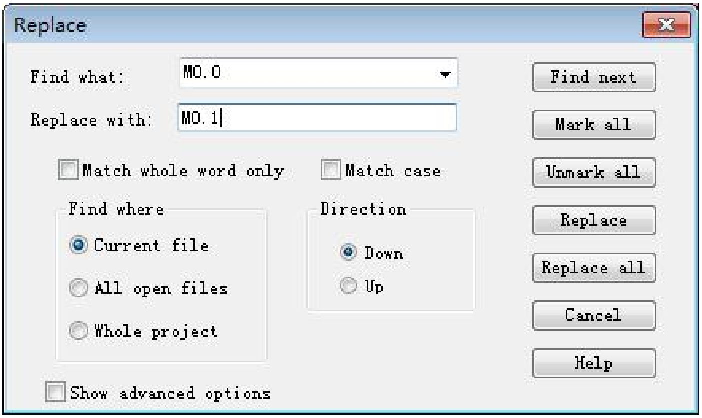


Input char you want to find in the **Find what** box, then click **Find next** to search the program, the found content will be selected in blue highlighted rectangle.

Other options in this window are the same as standard Windows OS.

- Replace

Use Ctrl+R or click the menu **Edit>>Replace**, the Replace window will be popped up:



Input char which needs to be replaced in the **Find what** box and input target char in the **Replace with** box, then click **Replace** button, the editor will find next char needs to be replaced and replace it with target char. If you click the **Replace all** button, the editor will find all the char need to be replaced and replace them all with target char.

Other options in this window are the same as standard Windows OS.

5.1.3.4 Online Monitoring

After the **【Debug】**>**【Monitor】** menu command is selected, the IL editor will change to the online monitoring mode. In this mode, you are not allowed to edit the program.

In the online monitoring mode, the original Program Editor area is divided into two columns by a vertical line in the middle, with the right column displaying the program and left column displaying the corresponding variables. When moving the cursor onto the vertical line, it will turn into ⟺ . Then drag the line to the left or right to change the sizes of the columns.

5.1.3.5 Example

```
(* NETWORK 0 *)
LDN     %M0.0
TON     T0, 1000        (*Start T0 with the output of T1, timing: 1000*1ms *)
ST      %M0.1
LD      %M0.1
TON     T1, 1000        (*Start T1 with the output of T0, timing: 1000*1ms *)
ST      %M0.0

LD      %M0.1
ST      %Q0.0           (* Output square wave with 2s period at %Q0.0 *)
```

5.1.4 Converting IL Program to LD Program

You can select the 【Project】>【LD】 menu command to change the editor to the LD editor; at the same time, the current IL program shall be converted to LD format.

Not all IL programs can be converted to LD format; the successful conversion must satisfy the following conditions:

- There is no error in the source IL program.
- The source IL program must be strictly in line with the following rules:
- Each network must begin with one of the instructions in group “C”; or there must be only one statement label in a network.
- The instruction which the network begins with must be used only once in the network.
- Each network must end with one of the instructions in group “P” or “U”.

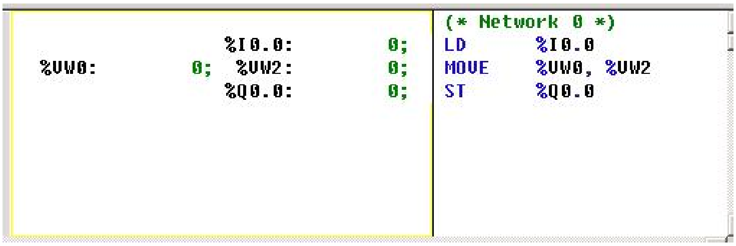
5.1.5 Debug and Monitor the Program

5.1.5.1 Online Monitor IL

You may enter Online Monitor Status with the IL editor by any means below:

- Execute 【**Debug**】 → 【**Online Monitor**】 commands;
- Click icon  in the tool bar;
- Shortcut key **F6**.

In the Online Monitor Status, the edition area will be divided into two columns; the right column is the program and left is corresponding variables. The columns are separated by a line, which can be dragged to change the space of each column.



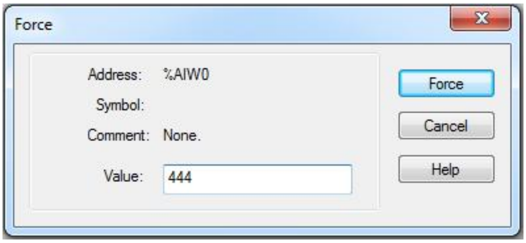
NOTE: The program cannot be edited when in the Online Monitor Status.

5.1.5.2 Force Specific Variables

You may find detailed description in 4.7. 3 The Force Function.

When online monitoring IL, you may execute force or cancel force to specific variables in IL editor; right-click any variable and the menu will pop out (if a Non On/Off Variable is right-clicked, commands 【**Force to be TRUE**】 and 【**Force to be FALSE**】 will be invalid):

- **Force to be TRUE:** Force the value of the variable (On/Off Variable) to be 1 (TRUE)
- **Force to be FALSE:** Force the value of the variable (On/Off Variable) to be 0 (FALSE)
- **Force to be …:** If you select this command, a dialogue will pop out



You can input the value into the 【**Force Value**】 box and click 【**Force**】. You may refer to 3.4 Constant.

- **Unforce:** unforce the variable.
- **Unforce All:** unforce all the variables in the CPU.

5.2 Programming in LD

Some definitions are from IEC 61131-3 standard.

5.2.1 Overview

LD (Ladder Diagram) is one of the most frequently used graphical languages in PLC programming. LD language is based on the traditional relay ladder logic. In addition, the IEC LD language allows the use of user defined function blocks and functions and so can be used in a hierarchical design. LD allows you to program by means of standardized graphic symbols, so it is easy to learn and use. LD shows great advantages in handling Boolean logic. The following is a simple program segment in LD.

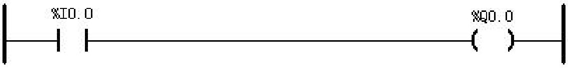
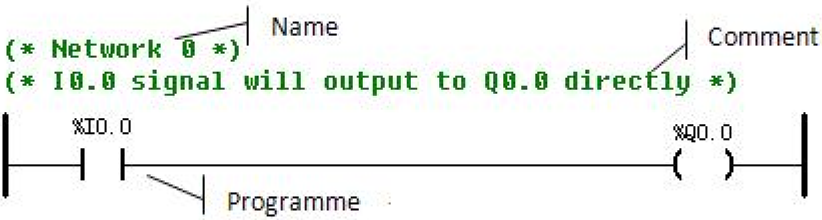


Figure 5-3 A Sample in LD

5.2.2 Network

When you write a program in LD, you can use standardized graphic symbols and arrange them to construct a network of logic. LD network shall be delimited on the left by a vertical line known as the *left power rail*, and on the right by a vertical line known as the *right power rail*. The state of the left rail shall be considered ON all along. No state is defined for the right rail.



5.2.3 Standardized graphic symbols

- **Link**

Horizontal link and vertical link are used in LD, corresponding to serial connection and parallel connection respectively. The link state may be ON or OFF, corresponding to the Boolean values 1 or 0 respectively. The term *link state* shall be synonymous with the term *power flow*.

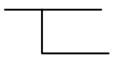
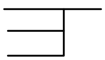
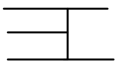
Symbol	Name	Description
	Horizontal link	A horizontal link element shall be indicated by a horizontal line. It transmits the state of the element on its immediate left to the element on its immediate right.
	Vertical link (With attached horizontal links)	The vertical link element shall consist of a vertical line intersecting with one or more horizontal link elements on each side. The vertical link state shall represent the inclusive OR of the ON states of the horizontal links on its left side, that is, the vertical link state shall be: - OFF if the states of all the attached horizontal links to its left are OFF; - ON if the state of one or more of the attached horizontal links to its left is ON. The state of the vertical link shall be copied to all of the attached horizontal links on its right.
		
		

Table 5-2 Link elements

- **Contact**

A *contact* is an element which imparts a state to the horizontal link on its right side which is equal to the Boolean AND of the state of the horizontal link at its left side with an appropriate function of an associated Boolean variable. A contact does not modify the value of the associated Boolean variable.

Symbol	Name	Description

*** ─┤ ├─	Normally open contact	The state of the left link is copied to the right link if the state of the associated Boolean variable (indicated by "***") is ON. Otherwise, the state of the right link is OFF.
*** ─┤/├─	Normally closed contact	The state of the left link is copied to the right link if the state of the associated Boolean variable is OFF. Otherwise, the state of the right link is OFF.

Table 5-3 Contacts

➢ Coil

A *coil* writes the state of the left link into the associated Boolean variable.

Symbol	**Name**	**Description**
*** ─( )─	Coil	The state of the left link is copied to the associated Boolean variable and to the right link.
*** ─(/)─	Negated coil	The inverse of the state of the left link is copied to the associated Boolean variable, that is, if the state of the left link is OFF, then the state of the associated variable is ON, and vice versa.
*** ─(S)─	SET (latch) coil	The associated Boolean variable is set to the ON state when the left link is in the ON state, and remains set until reset by a RESET coil.
*** ─(R)─	RESET (unlatch) coil	The associated Boolean variable is reset to the OFF state when the left link is in the ON state, and remains reset until set by a SET coil.

Table 5-4 Coils

➢ Execution control elements

Transfer of program control in the LD language shall be represented by the graphical elements shown in the following table.

Symbol	Name	Description
├── (1)——**<RETURN>**	Conditional Return	Program execution shall be transferred back to the invoking entry when the horizontal link state to its left is 1 (TRUE), and shall continue in the normal fashion when the Boolean input is 0 (FALSE).
├─>> Label	Unconditional Jump	Program execution shall be transferred to the designated network label unconditionally.
├── (1) ──>> Label	Conditional Jump	Program execution shall be transferred to the designated network label when the horizontal link state to its left is 1 (TRUE), and shall continue in the normal fashion when the Boolean input is 0 (FALSE).

Table 5-5 Execution control elements

Notice: (1) indicates that here is the graphical code whose result is Boolean.

- Functions and function blocks

A function or a function block shall be represented with a rectangular block, and its actual variable connections can be shown by writing the appropriate variable outside the block adjacent to the formal variable name on the inside. At least one Boolean input and one Boolean output shall be shown on each block to allow for power flow through the block.

The function shall have a Boolean input named *EN* and a Boolean output named *ENO*. *EN* is used to control the execution of this function. If *EN* is true, the function will be executed and *ENO* will be set as true. If *EN* is false, the function will not be executed and *ENO* is to be set as false.

Figure 5-4 Functions and Function Blocks

5.2.4 The LD Editor in KincoBuilder

When a new program in LD language is being established, the LD editor will be ready for programming; if an LD program is opening, the LD editor will also be ready. The LD editor is shown as follows.

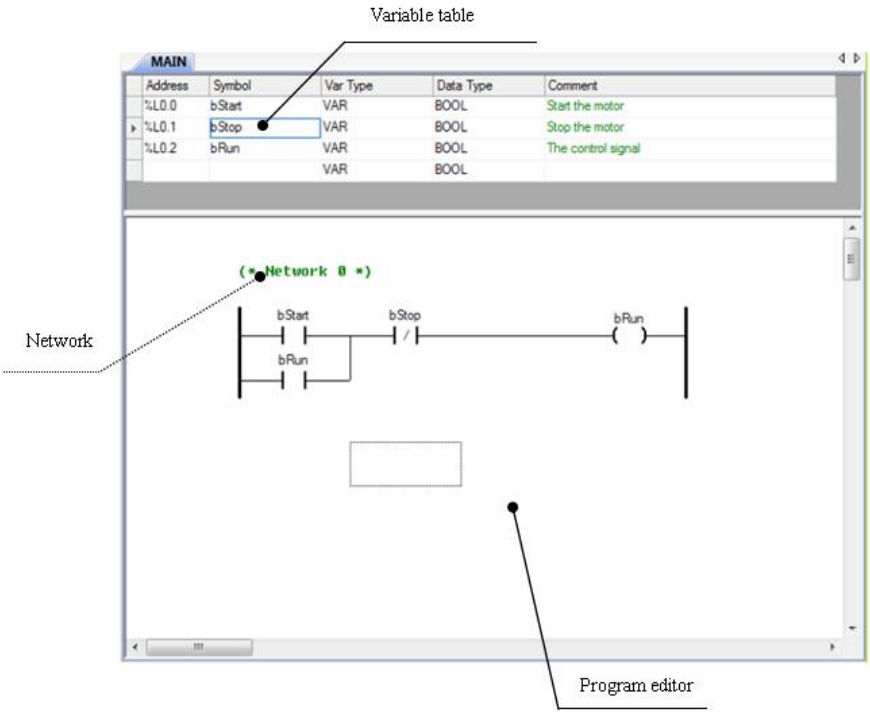


Figure 5-5 the LD Editor

One POU contains of two parts: parameters/variable parts and program parts. So there are two areas in the editor:

- Variable declaration area: Declare the input/output parameters and local variables in this POU. Supports right click menu.
- Program edit area: programming in this area, user can input different LD instructions and components in this area.

5.2.4.1 LD Program Limits

Max. 200 networks are allowed in a LD program.

You can regard the Program Editor window as a canvas divided into cells. The maximum numbers of the elements horizontally in a network are as follows: if there are only coils and contacts, up to 35 contacts and 1 coil; if only with functions/function blocks, up to 12 blocks, 1 coil and 1 contact. In addition, in a network, the branches shall not exceed 16 in a parallel connection.

Parallel connection of two or more independent functions/function blocks is forbidden.

5.2.4.2 Common Operations

The LD editor supports common mouse operations:

- Click an element, then it shall be selected and the focus moves on it (a rectangular frame appears on the element);
- Double-lick an element, then its property dialog box shall pop up, and there you can modify the element's properties;
- Right-click an element, then the context menu shall pop up, and you can select the menu command to execute the corresponding function.

In addition, the LD editor supports keyboard operations:

- Use **UP**, **DOWN**, **LEFT** and **RIGHT** arrow keys to move the focus.
- Press **ENTER** key to select the element's parameter area for entering.
- Press **Del** key to delete the element on which the focus is located.
- There is a shortcut key corresponding to each menu command.

5.2.4.3 LD Programming Steps

The following description will focus on mouse operations.

- Use one of the following ways to add a network:
- Select the [**LD**]>[**Network**] menu command
- Click the icon  on the toolbar
- Use the shortcut key **Ctrl+W**
- Right-click any element, and select the [**Network**] command on the pop-up menu

The network just added is as follows.

Figure 5-6 A New Network

Double-click the network label to open the comment dialog box, and you can enter some comments here to give a description for this network.

- When you add an instruction, its variables are initially denoted by red question marks (????). These question marks indicate that the variable is undefined, and you must define it before compiling the program.

When you click a variable, a box appears to indicate the variable area, and you can enter the desired variable or constant in this box. You can also press **ENTER** key to select the variable area for the element on which the focus is located. The LD Editor shall automatically format the direct address after you enter it, so you need not enter the percent mark if you enter a direct address.

In addition, you can double-click a contact or coil element to open its property dialog box to modify its type and parameters. The following figure shows a contact property dialog box.

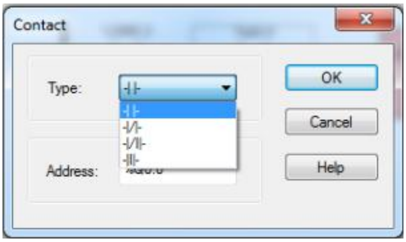
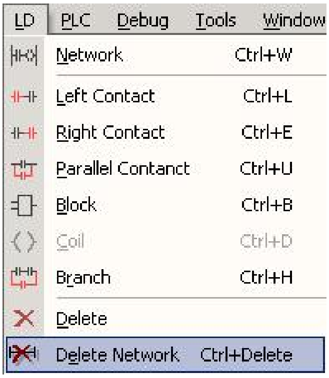


Figure 5-7 A Contact Property Dialog Box

➢ Click an element and select it as the reference, then continue to add other elements using one of the following ways:

➢ Use the [**LD**] menu commands or shortcut keys:



Left Contact: Add a contact on the left of the reference element.

Right Contact: Add a contact on the right of the reference element.

Parallel Contact: Add a contact parallel to the reference contact.

Block: Add a serial block (Function/FB/Subroutine).

Coil: Add a coil parallel with the reference coil.

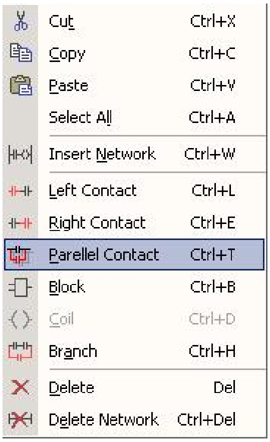
Branch: Draw a branch parallel to other elements.

Delete: Delete the selected element.

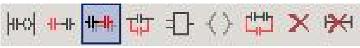
Delete Network: Delete the network where the selected element is located.

➢ Use the context menu commands:

Right-click an element, then the following context menu pops up. Please refer to the above descriptions.



- Use the toolbar buttons:



Click the appropriate toolbar button to add a corresponding element.

- Double-click from the LD Instructions tree:

In the LD Instructions tree, expand the tree, find the desired instruction, and double-click on it, then the instruction shall appear in the LD Editor.

Assume that a “MOVE” block is added. Then the network is as follows:

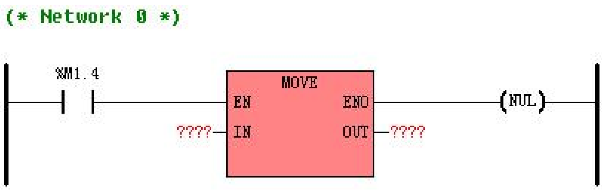


Figure 5-8 Adding other Elements

- Continue to use the mouse or the **ENTER** key to select the variable area to modify the variables of the new elements. In addition, you can double-click on the block elements in the program to open the parameters dialog box to modify the block’s properties.

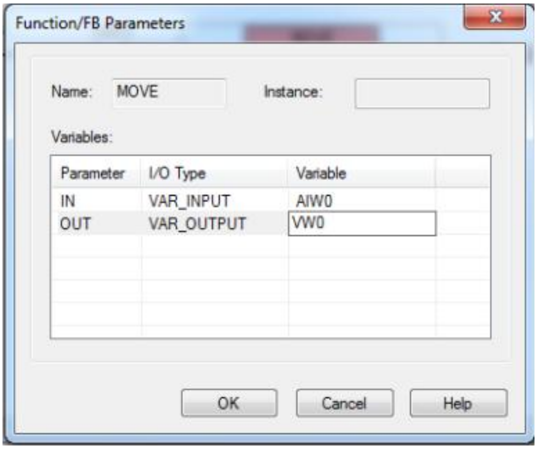


Figure 5-9 The Block Parameters Dialog Box

You can double-click any variable in the [**Variable**] list to modify it, and then press **Enter** key to confirm the typing. In addition, you can also use **Up** or **Down** arrow keys to select a variable, and press **Enter** key to begin editing, then press **ENTER** key to confirm the typing.

KincoBuilder will strictly check the syntax of your typing, wrong variable shall be denied.

The modified network is shown as follows:

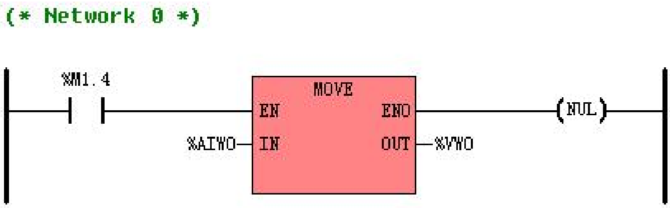


Figure 5-10 The Modified Network

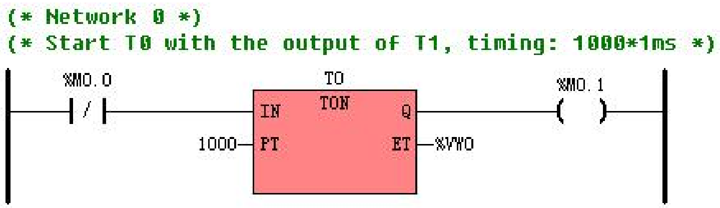
➢ After this network is complete, continue to add and modify new networks until this POU is finished. When adding a new network, if the current network label is selected as the reference, then the new network shall be added above the current network; otherwise, the new network shall be added below the current network. Here the current network means the network where the selected element is located.

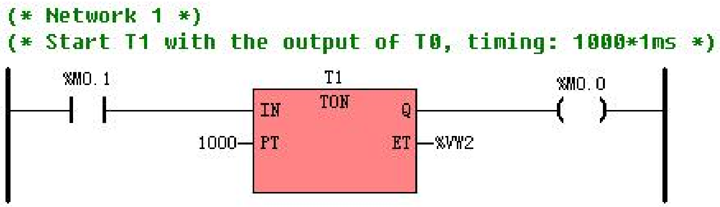
5.2.4.4 Online Monitoring

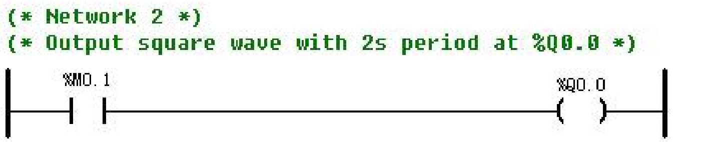
After the [**Debug**]>[**Monitor**] menu command is selected, the LD editor will change to the online monitoring mode.

In this mode, all the PLC data status is displayed in the LD Editor window, and you are not allowed to edit the program.

5.2.4.5 Example







5.2.5 Monitoring and Debugging the Program

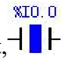
5.2.5.1 Online Monitor of LD Program

You can enter into the online monitor status if LD editor is opened.

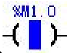
- **[Debug]→[Online Monitor]**
- Click the icon .
- Shortcut key **F6**.

In online monitor status variables are shown as:

- 

Contacts disconnect, 

Contacts connect
- 

Coils disconnect, 

Coils connect
- Non ON/OFF variables will be shown at the right side.

Example:

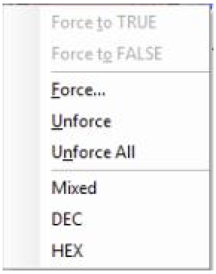
NOTE: Online monitor status does not allow any edition to the program.

NOTE: Yellow lock is the force value

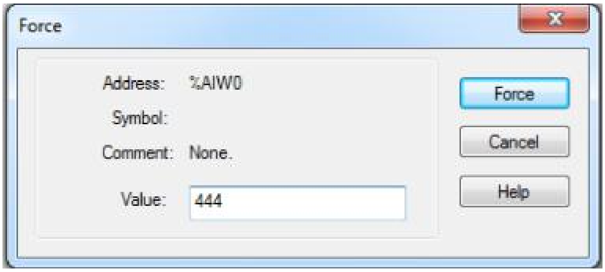
5.2.5.2 Force Specific Variables

You may find detailed description in 4.7.3 The Force Function.

When online monitoring IL, you may execute force or cancel force to specific variables in IL editor; right-click any variable and the menu will pop out (if a Non On/Off Variable is right-clicked, commands [**Force to be TRUE**] and [**Force to be FALSE**] will be invalid):



- **Force to be TRUE:** Force the value of the variable (On/Off Variable) to be 1 (TRUE)
- **Force to be FALSE:** Force the value of the variable (On/Off Variable) to be 0 (FALSE)
- **Force to be …:** If you select this command, a dialogue will pop out



You can input the value into the [**Force Value**] box and click [**Force**]. You may refer to 3.4 Constant.

- **Unforce:** unforce the variable.
- **Unforce All:** unforce all the variables in the CPU.

Chapter VI Kinco-K Instruction Set

Kinco-K5 instruction set accords with IEC 61131-3 standard for programming, the basic instructions and most of the standard functions/function blocks are provided. In addition, some non-standard instructions are available to satisfy different users and actual application requirements.

6.1 Summary

In this chapter, detailed introduction and specific application examples of all instructions shall be given. Instructions for LD and IL are to be described.

For LD, *EN* and *ENO* operands are not described in the following sections, because both of them are the same for all the instructions. *EN* and *ENO* are both connected with power flow. *EN* (Enable) is a BOOL input for most of the blocks, and power flow must be valid at this input for the block to be executed. *ENO* (Enable Out) is a BOOL output for most of the blocks; if the block gets the power flow at the *EN* input and the block is executed right, then the *ENO* is set to be “1” and passes power flow to the next element, otherwise power flow shall be terminated here.

For IL, as mentioned in 5.1.2.2 Current Result in the software manual, the CR will be refreshed after the execution of each statement, and it may act as the execution condition or one of the operands for the next statement. This is described detailedly, and the abbreviations of the operator groups are used in this chapter.

6.2 Bit Logic Instructions

6.2.1 Standard Contact

➢ **Description**

	Name	Usage	Group	
LD	Normally open contact	*bit* —| |—		☑ K5 ☑ K2
	Normally closed contact	*bit* —|/|—		
IL	LD	LD *bit*	C	
	AND	AND *bit*	P	
	OR	OR *bit*		
	LDN	LDN *bit*	C	
	ANDN	ANDN *bit*	P	
	ORN	ORN *bit*		

Operand	Input/Output	Data Type	Acceptable Memory Areas
bit	Input	BOOL	I, Q, V, M, SM, L, T, C, RS, SR, constant

➢ **LD**

When the *bit* is equal to 1, the Normally Open contact is closed (on) and then power flow is passed to the next element.

When the *bit* is equal to 0, the Normally Closed contact is closed (on) and then power flow is passed to the next element.

➢ **IL**

The Normally Open contacts are represented by the *LD*, *AND*, and *OR* instructions.

The *LD* instruction loads the *bit* and sets the CR equal to the result.

The *AND* instruction is used to AND the *bit* with the CR, and set the CR equal to the operation result.

The *OR* instruction is used to OR the *bit* with the CR, and set the CR equal to the operation result.

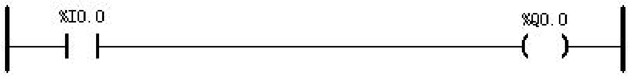
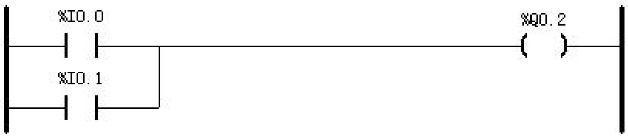
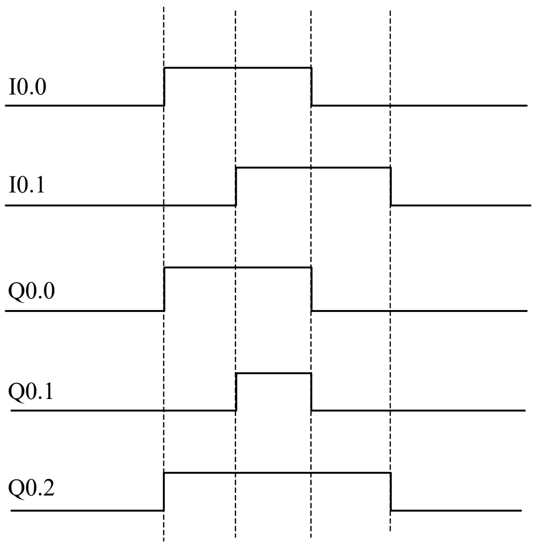
The Normally Closed contacts are represented by the *LDN*, *ANDN*, and *ORN* instructions.

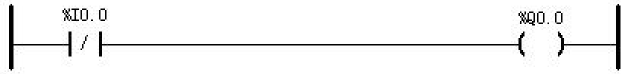
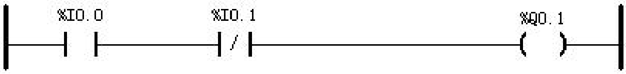
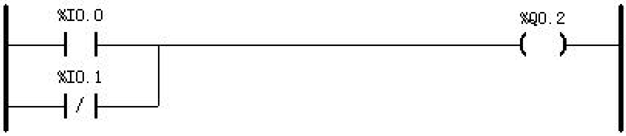
The *LDN* instruction loads the logical NOT of the *bit* value and sets the CR equal to the operation result.

The *ANDN* instruction is used to AND the logical NOT of the *bit* value with the CR, and set the CR equal to the operation result.

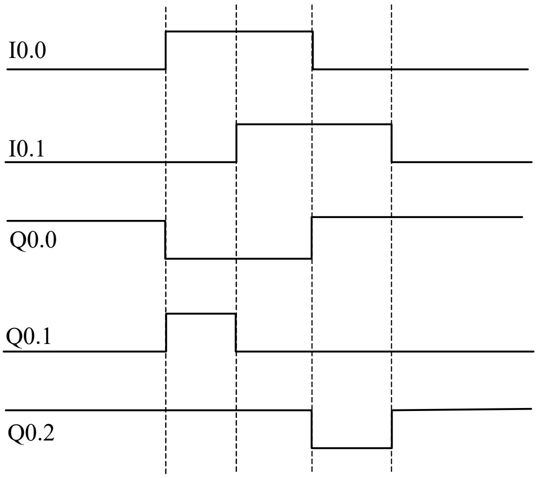
The *ORN* instruction is used to OR the logical NOT of the *bit* value with the CR, and set the CR equal to the operation result.

➢ Examples

LD	IL
	LD %I0.0 ST %Q0.0
	LD %I0.0 AND %I0.1 ST %Q0.1
	LD %I0.0 OR %I0.1 ST %Q0.2
Time Sequence Diagram	
	

LD	IL
	LDN %I0.0 ST %Q0.0
	LD %I0.0 ANDN %I0.1 ST %Q0.1
	LD %I0.0 ORN %I0.1 ST %Q0.2

Time Sequence Diagram



6.2.2 Immediate Contact

- **Description**

	Name	Usage	Group	
LD	Normally open immediate contact	*bit* —| I |—		☑ K5 ☑ K2
	Normally closed immediate contact	*bit* —| /I |—		
IL	LDI	LDI *bit*	C	
	ANDI	ANDI *bit*	P	
	ORI	ORI *bit*		
	LDNI	LDNI *bit*	C	
	ANDNI	ANDNI *bit*	P	
	ORNI	ORNI *bit*		

Operand	Input/Output	Data Type	Acceptable Memory Areas
bit	Input	BOOL	I (CPU body)

When the immediate instruction is executed, it obtains the physical value of the input channel immediately, but the corresponding input image register is not updated.

The immediate instructions can only be used for the DI channels on the CPU body, and are not influenced by the input filter time configured in the [**Hardware**].

In contrary to a standard contanct, an immediate contact does not rely on the scan cycle to update and so it can respond to the input signal more quickly.

- **LD**

When the physical input value (*bit*) is equal to 1, the Normally Open Immediate contact is closed (on) and then power flow is passed to the next element.

When the physical input value (*bit*) is equal to 0, the Normally Closed Immediate contact is closed (on) and then power flow is passed to the next element.

- **IL**

The Normally Open Immediate contacts are represented by the *LDI*, *ANDI*, and *ORI* instructions.

The *LDI* instruction loads the the physical input value (*bit*) and sets the CR equal to the result.

The *ANDI* instruction is used to AND the physical input value (*bit*) with the CR, and set the CR equal to the operation result.

The *ORI* instruction is used to OR the physical input value (*bit*) with the CR, and set the CR equal to the operation result.

The Normally Closed Immediate contacts are represented by the *LDNI*, *ANDNI*, and *ORNI* instructions.

The *LDNI* instruction loads the logical NOT of the physical input value (*bit*) and sets the CR equal to the operation result.

The *ANDNI* instruction is used to AND the logical NOT of the physical input value (*bit*) with the CR, and set the CR equal to the operation result.

The *ORNI* instruction is used to OR the logical NOT of the physical input value (*bit*) with the CR, and set the CR equal to the operation result.

6.2.3 Coil

➢ **Description**

	Name	Usage	Group	
LD	Set Coil	*bit* —( )—		☑ K5 ☑ K2
	Reset Coil	*bit* —(/)—		
	Null coil	—(NUL)—		
IL	ST	ST *bit*	U	
	STN	STN *bit*		

Operand	Input/Output	Data Type	Acceptable Memory Areas
bit	Output	BOOL	Q, V, M, SM, L

➢ **LD**

The Coil instruction writes the power flow to the output image register for the *bit*.

The Negated Coil instruction writes the inverse of the power flow to the output image register for the *bit*.

The function of the Reset Coil is: if the power flow is 1, the output image register for the *bit* is set equal to 0, otherwise the register remains unchanged.

The function of the Set Coil is: if the power flow is 1, the output image register for the *bit* is set equal to 1, otherwise the register remains unchanged.

The function of the Null Coil is to indicate the end of a network, so this instruction is only to facilitate you in programming, but doesn't execute any particular operation.

➢ **IL**

The coils are represented by the *ST*, *STN, R* and *S* instructions.

The *ST* instruction writes the CR to the output image register for the *bit*.

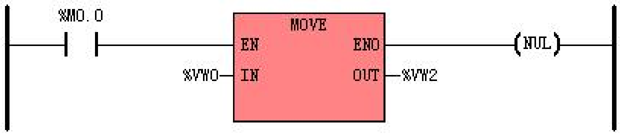
The *STN* instruction writes the inverse of the CR to the output image register for the *bit*.

The function of the *R* instruction is: if the CR is equal to 1, the output image register for the *bit* is set equal to 0, otherwise the register remains unchanged.

The function of the *S* instruction is: if the CR is equal to 1, the output image register for the *bit* is set equal to 1, otherwise the register remains unchanged.

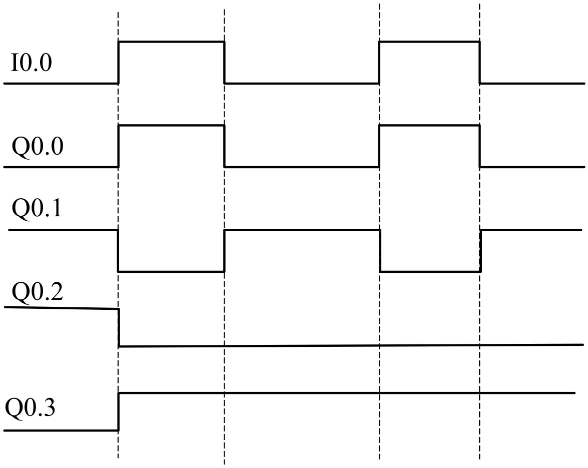
ST, *STN, R* and *S* instructions don't influence the CR.

➢ **Examples**

LD	IL
	LD %I0.0 ST %Q0.0 STN %Q0.1 R %Q0.2 S %Q0.3
	LD %M0.0 MOVE %VW0, %VW2

Time Sequence Diagram

Assume that the values of Q0.1 and Q0.2 are 1 and 0 respectively before these statements are executed.



6.2.4 Immediate Coil

- **Description**

	Name	Usage	Group	
LD	Set Immediate Coil	*bit* —(I)—		☑ K5 ☑ K2
IL	STI	STI *bit*	U	

Operand	Input/Output	Data Type	Acceptable Memory Areas
bit	Output	BOOL	Q (CPU body)

These immediate instructions can only be used for the DO channels on the CPU body.

- **LD**

When the Immediate Coil instruction is executed, it immediately writes the power flow to both the physical output (*bit*) and the corresponding output image register.

When the Reset Immediate Coil instruction is executed, if the power flow is 1, both the physical output (*bit*) and the corresponding output image register are set equal to 0 immediately, otherwise they remain unchanged.

When the Set Immediate Coil instruction is executed, if the power flow is 1, both the physical output (*bit*) and the corresponding output image register are set equal to 1 immediately, otherwise they remain unchanged.

- **IL**

The immediate coils are represented by the *STI*, *RI* and *SI* instructions.

When the *STI* instruction is executed, it immediately writes the CR to both the physical output (*bit*) and the corresponding output image register.

When the *RI* instruction is executed, if the CR is equal to 1, both the physical output (*bit*) and the corresponding output image register are set equal to 0 immediately, otherwise they remain unchanged.

When the *SI* instruction is executed, if the CR is equal to 1, both the physical output (*bit*) and the corresponding output image register are set equal to 1 immediately, otherwise they remain unchanged.

STI, *RI* and *SI* instructions don't influence the CR.

6.2.5 Set And Reset Coil

- **Description**

	Name	Usage	Group	
LD	Reset	*bit* —(R)—		☑ K5 ☑ K2
	Set	*bit* —(S)—		
IL	Reset	R *bit*	U	
	Set	S *bit*		

Operand	Input/Output	Data Type	Acceptable Memory Areas
bit	Output	BOOL	Q, V, M, SM, L

- **LD**

The function of the Reset Coil is: if the power flow is 1, the output image register for the bit is set equal to 0, otherwise the register remains unchanged.

The function of the Set Coil is: if the power flow is 1, the output image register for the bit is set equal to 1, otherwise the register remains unchanged.

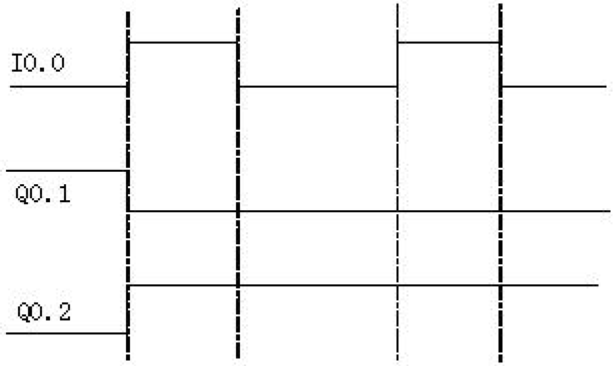
- **IL**

The function of the R instruction is: if the CR is equal to 1, the output image register for the bit is set equal to 0, otherwise the register remains unchanged.

The function of the S instruction is: if the CR is equal to 1, the output image register for the bit is set equal to 1, otherwise the register remains unchanged.

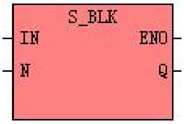
R and S instructions don't influence the CR.

➢ **Examples**

<table>
<tr><th>LD</th><th>IL</th></tr>
<tr><td>
</td><td>LD %I0.0
R %Q0.1
S %Q0.2</td></tr>
<tr><td colspan="2">Time Sequence Diagram</td></tr>
<tr><td colspan="2">Assume that the values of Q0.1 and Q0.2 are 1 and 0 respectively before these statements are excuted.

</td></tr>
</table>

6.2.6 Block Set and Reset Coil

➢ **Description**

<table>
<tr><th></th><th>Name</th><th>Usage</th><th>Group</th><th rowspan="5">☑ K5
☑ K2</th></tr>
<tr><td rowspan="2">LD</td><td>Block Reset Coil</td><td></td><td rowspan="2"></td></tr>
<tr><td>Block Set Coil</td><td></td></tr>
<tr><td rowspan="2">IL</td><td>R_BLK</td><td>R_BLK *N,Q*</td><td rowspan="2">U</td></tr>
<tr><td>S_BLK</td><td>S_BLK *N,Q*</td></tr>
</table>

Operand	Input/Output	Data Type	Acceptable Memory Areas
IN	Input	BOOL	Power flow
N	Input	INT	L, M, V, constant
Q	Output	BOOL	Q, V, M, SM, L

➢ **LD**

The function of the R_BLK is: if the *IN* is 1, it will set *N* consecutive bits that begin with *Q* all equal to 0, otherwise remains these bits unchanged.

The function of the S_BLK is: if the *IN* is 1, it will set *N* consecutive bits that begin with *Q* all equal to 1, otherwise remains these bits unchanged.

➢ **IL**

The function of the R_BLK is: if the CR is 1, it will set *N* consecutive bits that begin with *Q* all equal to 0, otherwise remains these bits unchanged.

The function of the S_BLK is: if the CR is 1, it will set *N* consecutive bits that begin with *Q* all equal to 1, otherwise remains these bits unchanged.

R_BLK and S_BLK will not affect the CR value.

The max amount of *N* is 1024.

***Q* is the starting address of a memory block with variable length. Please be noted that the memory block must be in the legal memory area, otherwise the consequences may be terrible.**

6.2.7 Set And Reset Immediate Coil

- **Description**

	Name	Usage	Group	
LD	Reset Immediate Coil	*bit* —(RI)—		☑ K5 ☑ K2
	Set Immediate Coil	*bit* —(SI)—		
IL	RI	RI *bit*	U	
	SI	SI *bit*		

Operands	Input/Output	Data Type	Acceptable Memory Areas
bit	Output	BOOL	Q（CPU body）

These immediate instructions can only be used for the DO channels on the CPU body.

- **LD**

When the Reset Immediate Coil instruction is executed, if the power flow is 1, both the physical output (bit) and the corresponding output image register are set equal to 0 immediately, otherwise they remain unchanged.

When the Set Immediate Coil instruction is executed, if the power flow is 1, both the physical output (bit) and the corresponding output image register are set equal to 1 immediately, otherwise they remain unchanged.

- **IL**

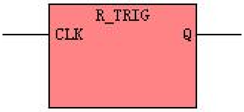
When the RI instruction is executed, if the CR is equal to 1, both the physical output (bit) and the corresponding output image register are set equal to 0 immediately, otherwise they remain unchanged.

When the SI instruction is executed, if the CR is equal to 1, both the physical output (bit) and the corresponding output image register are set equal to 1 immediately, otherwise they remain unchanged.

RI and SI instructions don't influence the CR.

6.2.8 Edge detection

➢ **Description**

	Name	Usage	Group	
LD	Rising edge detector			☑ K5 ☑ K2
	Falling edge detector			
IL	R_TRIG	R_TRIG	P	
	F_TRIG	F_TRIG		

Operands	Input/Output	Data Type	Acceptable Memory Areas
CLK (LD)	Input	BOOL	Power flow
Q (LD)	Output	BOOL	Power flow

➢ **LD**

The function of the *R_TRIG* instruction is to detect the rising edge of the *CLK* input: following a 0-to-1 transition of the *CLK* input, the *Q* output is set to 1 for one scan cycle and then returns to 0.

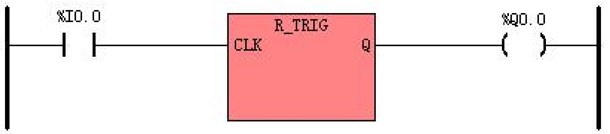
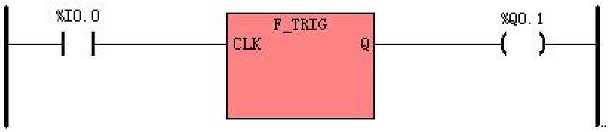
The function of the *F_TRIG* instruction is to detect the falling edge of the *CLK* input: following a 1-to-0 transition of the *CLK* input, the *Q* output is set to 1 for one scan cycle and then returns to 0.

➢ **IL**

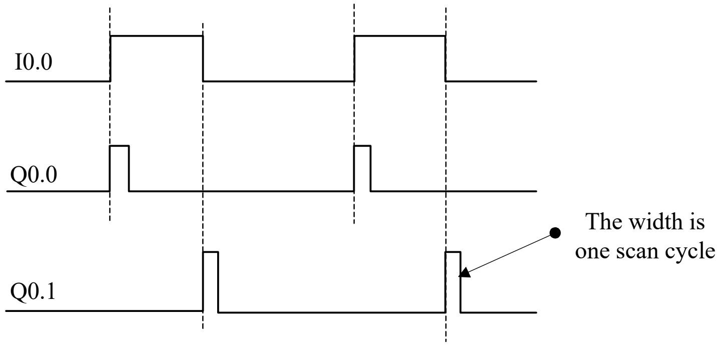
The function of the *R_TRIG* instruction is to detect the rising edge of the CR: following a 0-to-1 transition of the CR, the *Q* output is set to 1 for one scan cycle and then returns to 0.

The function of the *F_TRIG* instruction is to detect the falling edge of the CR: following a 1-to-0 transition of the CR, the *Q* output is set to 1 for one scan cycle and then returns to 0.

➢ **Examples**

LD	**IL**
	LD %I0.0 R_TRIG ST %Q0.0
	LD %I0.0 F_TRIG ST %Q0.1

Time Sequence Diagram



6.2.9 NCR (NOT)

➢ **Description**

	Name	Usage	Group	
LD	NCR			☑ K5 ☑ K2
IL	NCR	NCR	P	

Parameter	Input/Output	Data Type	Acceptable Memory Areas
IN	Input	BOOL	Power flow
Q	Output	BOOL	Power flow

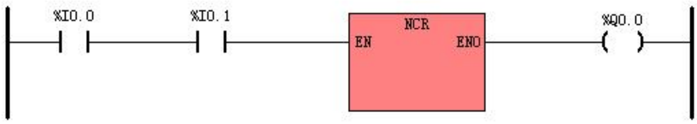
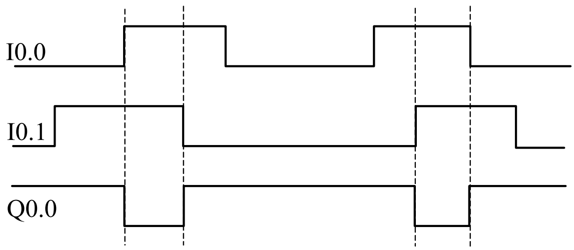
➢ **LD**

The NCR instruction changes the state of the power flow from 1 to 0 or from 0 to 1.

➢ **IL**

The NCR instruction changes the CR from 1 to 0 or from 0 to 1.

- **Examples**

<table>
<tr><th>LD</th><th>IL</th></tr>
<tr><td>
</td><td>LD %I0.0
AND %I0.1
NCR
ST %Q0.0</td></tr>
<tr><th colspan="2">Time Sequence Diagram</th></tr>
<tr><td colspan="2">
</td></tr>
</table>

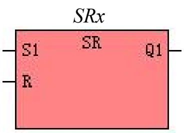
6.2.10 Bistable elements

The Bistable element is one of the function blocks defined in the IEC61131-3 standard, totally in two types, i.e. the Set Dominant Bistable (SR) and the Reset Dominant Bistable (RS).

Please refer to 3.6.5 Function Block and Function Block Instance for more detailed information.

6.2.10.1 SR (Set Dominant Bistable)

- **Description**

	Name	Usage	Group	
LD	SR			☑ K5 ☑ K2
IL	SR	LD *S1* SR *SRx*, *R*	P	

Parameter	Input/Output	Data Type	Acceptable Memory Areas
SRx	-	SR instance	SR
S1	Input	BOOL	Power flow
R	Input	BOOL	I, Q, V, M, SM, L, T, C, RS, SR
Q1	Output	BOOL	Power flow

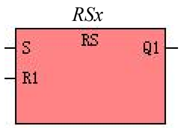
The Set Dominant Bistable (*SR*) is a bistable element where the set input dominates. If the set (*S1*) and reset (*R*) inputs are both 1, both the output *Q1* and the status value of *SRx* will be 1.

The following is a Truth Table for the *SR* Instruction:

S1	*R*	*Q1*, *SRx*
0	0	Previous value
0	1	0
1	0	1
1	1	1

6.2.10.2 RS (Reset Dominant Bistable)

- **Description**

	Name	Usage	Group	
LD	RS			☑ K5 ☑ K2
IL	RS	LD *S* RS *RSx*, *R1*	P	

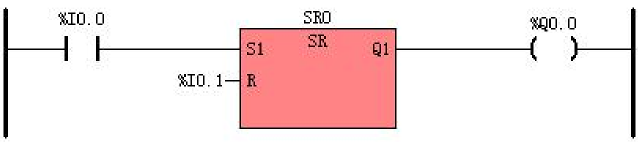
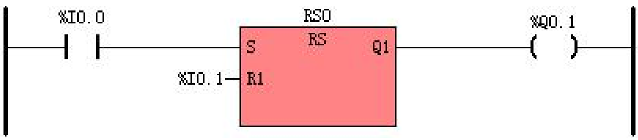
Parameter	Input/Output	Data Type	Acceptable Memory Areas
RSx	-	RS instance	RS
S	Input	BOOL	Power flow
R1	Input	BOOL	I, Q, V, M, SM, L, T, C, RS, SR
Q1	Output	BOOL	Power flow

The Reset Dominant Bistable (*RS*) is a bistable element where the reset input dominates. If the set (*S*) and reset (*R1*) inputs are both 1, both the output *Q1* and the status value of *RSx* will be 0.

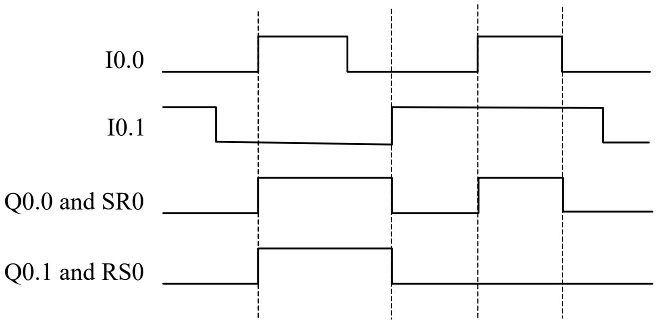
The following is a Truth Table for the *RS* Instruction:

R1	*S*	*Q1, SRx*
0	0	Previous value
0	1	1
1	0	0
1	1	0

6.2.10.3 Examples

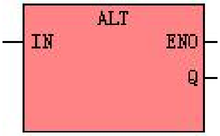
LD	IL
(* Network 0 *) 	(* Network 0 *) LD %I0.0 SR SR0, %I0.1 ST %Q0.0
(* Network 1 *) 	(* Network 1 *) LD %I0.0 RS RS0, %I0.1 ST %Q0.1

Time Sequence Diagram



6.2.11 ALT (Alternate)

- **Description**

	Name	Usage	Group	
LD	ALT			☑ K5 ☑ K2
IL	ALT	ALT *Q*	U	

Parameter	Input/Output	Data Type	Acceptable Memory Areas
IN （LD）	Input	BOOL	Power flow
Q	Output	BOOL	Q, V, M, SM, L

- **LD**

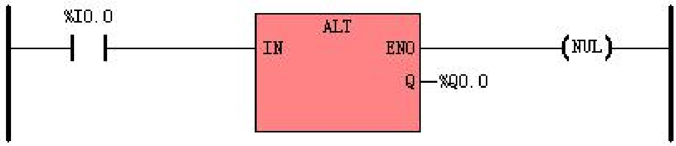
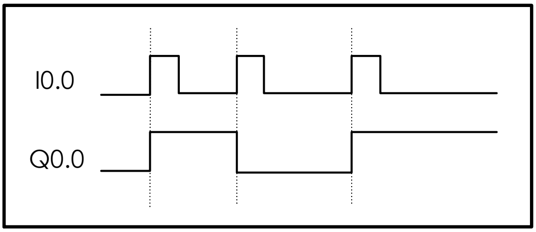
The ALT instruction changes the value of *Q* from 1 to 0 or from 0 to 1 on the rising edge of the *IN* input.

- **IL**

The ALT instruction changes the value of *Q* from 1 to 0 or from 0 to 1 on the rising edge of the CR.

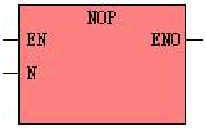
This instruction does not influence the CR.

➢ **Examples**

LD	IL
	LD %I0.0 ALT %Q0.0
Time Sequence Diagram	
	

6.2.12 NOP (No Operation)

➢ **Description**

	Name	**Usage**	**Group**	
LD	Dummy			☑ K5 ☑ K2
IL	Dummy	NOP *N*	U	

Parameter	**Input/Output**	**Data Type**	**Acceptable Memory Areas**
N	Input	INT	Constant (Positive)

The NOP instruction does nothing and has no effect on the user program execution. The program Execution continues with the next instruction.

The NOP instruction is typically used to generate delays in the program execution. The operand *N* is a positive integer constant.

Check the following testing data for K5:

Build a new empty project, call 12 NOP instructions in this project. In each NOP instruction, set the input parameters N to 32767, then download the project to PLC, the scan time of plc is 37ms.

That is to say, the execution time of 393204 NOP instructions is 37ms, which equals to 37000us or 37000000ns.

Then the execution time of 10000 NOP instructions is 37ms, which equals to 941us or 940987ns.

So the average execution time of 1 NOP instruction is 94ns, but the actual execution time of 1 NOP instruction is larger than 94us because of instruction call and one NOP instruction is not very meaningful actually.

6.2.13 Bracket Modifier

- **Description**

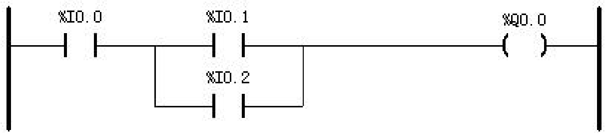
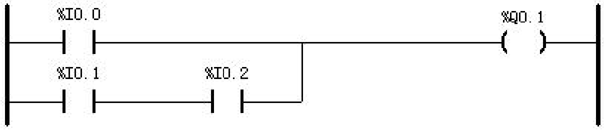
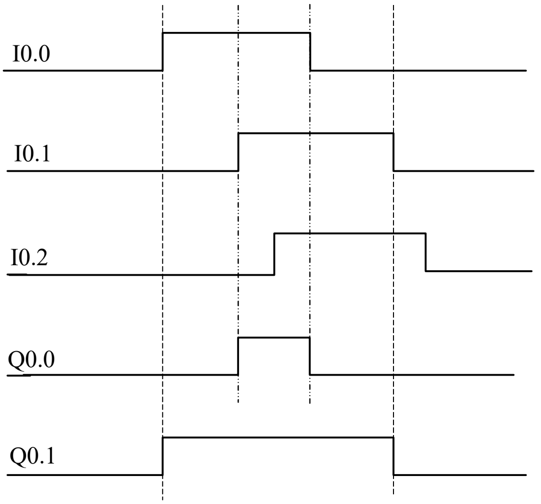
	Name	Usage	Group	
IL	AND(	AND(	U	☑ K5 ☑ K2
	OR(	OR(		
	)	)	P	

The Bracket modifier is only represented in IL. LD, ST and so on can take complicated expressions as operands, but IL only provides simple expressions. Therefore, the IEC61131-3 standard defines bracket modifier for IL to deal with some complicated expressions. Either "*AND(*" or "*OR(*" is paired with "*)*".

In an IL program, before executing the statements between "*AND(*" and "*)*", the CR is temporarily stored at first; then the statements in the brackets are executed, and the execution result is ANDed with the temporarily stored CR, and finally the CR is set equal to the operation result.

Similarly, before executing the statements between "*OR(*" and "*)*", the CR is temporarily stored at first; then the statements in the brackets are executed, and the execution result is ORed with the temporarily stored CR, and finally the CR is set equal to the operation result.

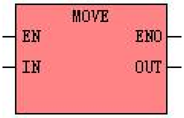
➢ **Examples**

<table>
<tr><th>LD</th><th>IL</th></tr>
<tr><td>
</td><td>LD %I0.0
AND(
LD %I0.1
OR %I0.2
)
ST %Q0.0</td></tr>
<tr><td>
</td><td>LD %I0.0
OR(
LD %I0.1
AND %I0.2
)
ST %Q0.1</td></tr>
<tr><th colspan="2">Timing Diagram</th></tr>
<tr><td colspan="2">
</td></tr>
</table>

6.3 Move Instructions

6.3.1 MOVE

➢ **Description**

	Name	**Usage**	**Group**	
LD	MOVE			☑ K5 ☑ K2
IL	MOVE	MOVE IN, OUT	U	

Operands	**Input/Output**	**Data Type**	**Acceptable Memory Areas**
IN	Input	BYTE, WORD, DWORD, INT, DINT, REAL	I, Q, M, V, L, SM, AI, AQ, T, C, HC, constant, pointer
OUT	Output	BYTE, WORD, DWORD, INT, DINT, REAL	Q, M, V, L, SM, AQ, pointer

The MOVE instruction moves the value of *IN* to the address *OUT*. This instruction executes an assignment operation, and the *IN* and *OUT* must be of the same data type.

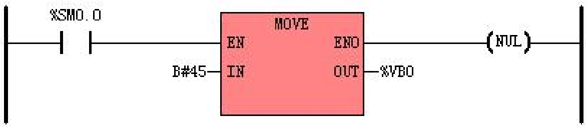
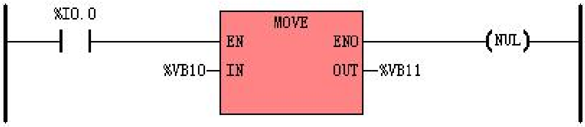
➢ **LD**

If *EN* is 1, this instruction is executed..

➢ **IL**

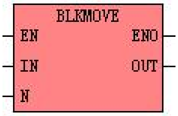
If the CR is 1, this instruction is executed, and it doesn't influence the CR.

➢ **Examples**

LD		%SM0.0 is always ON, therefore the MOVE is always executed: B#45 is assigned to %VB0.
		If %I0.0 is 0, the MOVE is not executed. If %I0.0 is 1, the value of %VB10 is assigned to %VB11.
IL	LD %SM0.0 (* The CR is created with %SM0.0 *) MOVE B#45, %VB0 (* B#45 is assigned to %VB0 *)	
	LD %I0.0 (* The CR is created with %I0.0 *) MOVE %VB10, %VB11 (* If the CR is 1, the value of %VB10 is assigned to %VB11. *) (*Otherwise, this statement is not executed, %VB11 remains unchanged *)	

6.3.2 BLKMOVE (Block Move)

➢ **Description**

	Name	Usage	Group	
LD	BLKMOVE			☑ K5 ☑ K2
IL	BLKMOVE	BLKMOVE *IN*, *OUT*,*N*	U	

Operands	Input/Output	Data Type	Acceptable Memory Areas
IN	Input	BYTE, WORD, DWORD, INT, DINT, REAL	I, Q, M, V, L, SM, AI, AQ, T, C, HC
N	Input	BYTE	I, Q, M, V, L, SM, constant
OUT	Output	BYTE, WORD, DWORD, INT, DINT, REAL	Q, M, V, L, SM, AQ

The *IN* and *OUT* must be of the same data type.

The BLKMOVE instruction moves the *N* number of variables from the successive range that begins with the address *IN* to the successive range that begins with the address *OUT*.

➢ **LD**

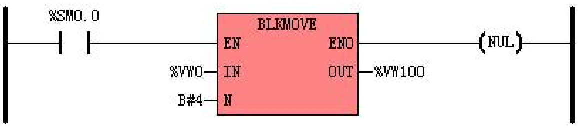
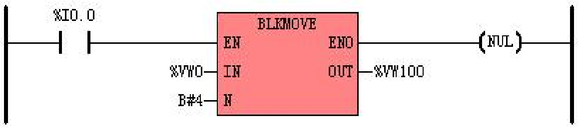
If *EN* is 1, this instruction is executed.

➢ **IL**

If the CR is 1, this instruction is executed, and it does not influence the CR.

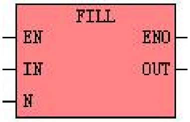
Note: the IN, OUT parameter is memory block whose length is changeable. The whole block cannot be in the illegal area, or there will be unpredictable result.

➢ **Examples**

<table>
<tr><td rowspan="2">LD</td><td>
</td><td>%SM0.0 is always ON, therefore the BLKMOVE is always executed: the data in %VW0 - %VW6 are moved into %VW100 - %VW106.</td></tr>
<tr><td>
</td><td>If %I0.0 is 1, the data in %VW0 - %VW6 are moved into %VW100 - %VW106. Otherwise, the BLKMOVE is not executed.</td></tr>
<tr><td rowspan="2">IL</td><td colspan="2">LD %SM0.0 (* The CR is created with the% SM0.0 *)
BLKMOVE %VW0, %VW100, B#4 (* The data in VW0 - VW6 are moved into %VW100 - %VW106 *)</td></tr>
<tr><td colspan="2">LD %I0.0 (* The CR is created with %I0.0 *)
BLKMOVE %VW0, %VW100, B#4 (* If the CR is 0, this statement isn't executed *)
(* If the CR is 1, the data in %VW0 - %VW6 are moved into %VW100 - %VW106 *)</td></tr>
<tr><td>RESULT</td><td colspan="2">The following is an example:
<table><tr><td>VW0</td><td>VW2</td><td>VW4</td><td>VW6</td></tr><tr><td>0</td><td>10</td><td>20</td><td>30</td></tr></table><table><tr><td>VW100</td><td>VW102</td><td>VW104</td><td>VW106</td></tr><tr><td>0</td><td>10</td><td>20</td><td>30</td></tr></table></td></tr>
</table>

6.3.3 FILL (Memory Fill)

- **Description**

	Name	Usage	Group	
LD	FILL			☑ K5 ☑ K2
IL	FILL	FILL *IN*, *OUT*, *N*	U	

Operands	Input/Output	Data Type	Acceptable Memory Areas
IN	Input	BYTE	Constant
N	Input	BYTE	constant
OUT	Output	BYTE	M, V, L

The FILL instruction sets the *N* number of successive variables, beginning with the address *OUT*, to the specified constant *IN*.

- **LD**

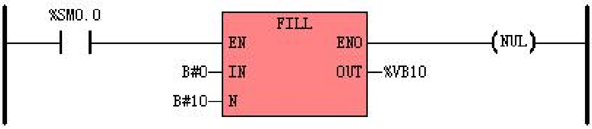
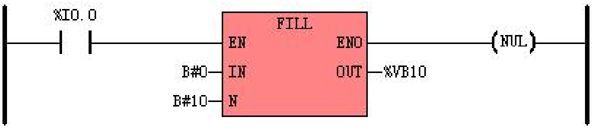
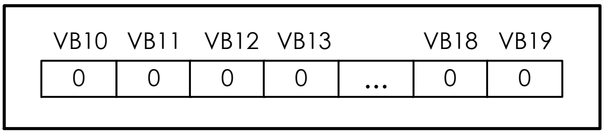
If *EN* is 1, this instruction is executed.

- **IL**

If the CR is 1, this instruction is executed, and it does not influence the CR.

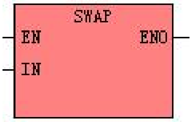
⚠ **Note: the OUT parameter is memory block whose length is changeable. The whole block cannot be in the illegal area, or there will be unpredictable result.**

➢ **Examples**

LD		%SM0.0 is always ON, therefore the FILL is always executed: 10 variables from %VB10 to %VB19 are all set to B#0.
		If %I0.0 is 0, the FILL is not executed. If %I0.0 is 1, 10 variables from %VB10 to %VB19 are all set to B#0.
IL	LD %SM0.0 (* The CR is created with %SM0.0 *) FILL B#0, %VB10, B#10 (* 10 variables from %VB10 to %VB19 are all set to B#0 *)	
	LD %I0.0 (* The CR is created with %I0.0 *) FILL B#0, %VB10, B#10 (* If the CR is 1, 10 variables from %VB10 to %VB19 are all set to B#0 *) (* If the CR is 0, this statement is not executed *)	
RESULT		

6.3.4 SWAP

- **Description**

	Name	Usage	Group	
LD	SWAP			☑ K5 ☑ K2
IL	SWAP	SWAP *IN*	U	

Operands	Input/Output	Data Type	Acceptable Memory Areas
IN	Input/Output	WORD, DWORD	Q, M, V, L, SM

The SWAP instruction exchanges the most significant byte with the least significant byte of the word (*IN*), or exchanges the most significant word with the least significant word of the double word (*IN*).

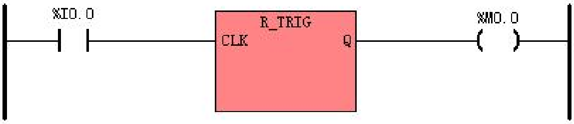
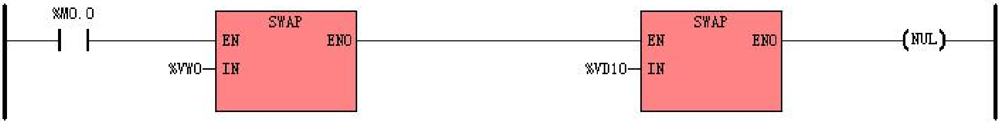
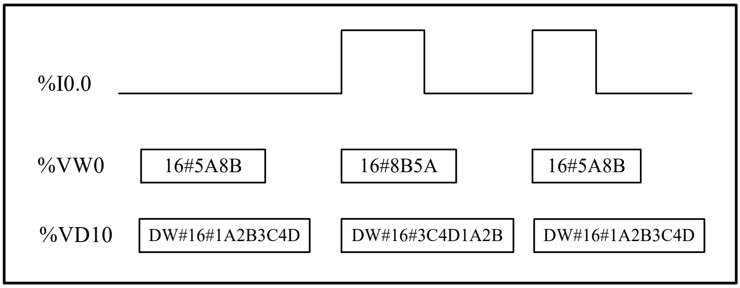
- **LD**

If *EN* is 1,this instruction is executed.

- **IL**

If the CR is 1, this instruction is executed, and it does not influence the CR.

- **Examples**

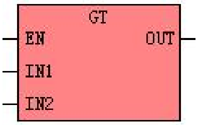
LD	(* Network 0 *) (* On the rising edge of %I0.0, the following program exchanges the most significant byte with the least significant byte of %VW0 and exchanges the most significant word with the least significant word of %VD10. *)  (* Network 1 *) 
IL	(* Network 0 *) LD %I0.0 R_TRIG (* On the rising edge of %I0.0, *) SWAP %VW0 (* the most significant byte with the least significant byte of %VW0 are exchanged, *) SWAP %VD10 (* and the most significant word with the least significant word of %VD10 are exchanged. *)
Result	Assume that the initial value of %VW0 is W#16#5A8B and the initial value of %VD10 is DW#16#1A2B3C4D. 

6.4 Compare Instructions

For all the compare instructions, BYTE comparisons are unsigned. INT, DINT and REAL comparisons are signed.

6.4.1 GT (Greater Than)

- **Description**

	Name	Usage	Group	
LD	GT			☑ K5 ☑ K2
IL	GT	GT *IN1*, *IN2*	P	

Operands	Input/Output	Data Type	Acceptable Memory Areas
IN1	Input	BYTE, INT, DINT, REAL	I, Q, M, V, L, SM, AI, AQ, T, C, HC, constant, pointer
IN2	Input	BYTE, INT, DINT, REAL	I, Q, M, V, L, SM, AI, AQ, T, C, HC, constant, pointer
OUT (LD)	Output	BOOL	Power flow

Note: if the input parameter is real, check the accuracy of real data in 3.2 Data Format/3.4 constant.

The *IN1* and *IN2* must be of the same data type.

- **LD**

If *EN* is 1, this instruction compares *IN1* greater than *IN2* and the Boolean result is assigned to *OUT*;

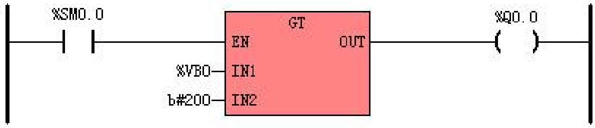
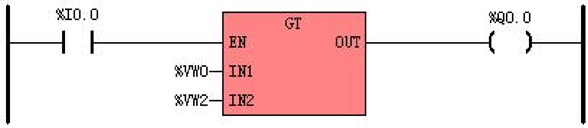
If *EN* is 0, this instruction is not executed, and *OUT* is set equal to 0.

- **IL**

If CR is 1, this instruction compares *IN1* greater than *IN2* and the Boolean result is assigned to CR;

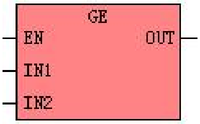
If CR is 0, this instruction is not executed, and CR remains 0.

- **Examples**

LD		SM0.0 is always ON, therefore *GT* is always executed: if the value of VB0 is greater than B#200, Q0.0 is set equal to 1, otherwise Q0.0 is set equal to 0.
		If I0.0 is 1: if the value of VW0 is greater than that of VW2, Q0.0 is set to be 1, otherwise Q0.0 is set to be 0. If I0.0 is 0: *GT* is not executed, and Q0.0 is set to be 0.
IL	LD %SM0.0 (* CR is created with SM0.0 *) GT %VB0, B#200 (* If VB0 is greater than B#200, CR is set to be 1, otherwise CR is set to be 0 *) ST %Q0.0 (* Q0.0 is set equal to CR *)	
	LD %I0.0 (* CR is created with I0.0 *) GT %VW0, %VW2 (* If CR is 1: if VW0 is greater than VW2, CR is set to be 1, otherwise CR is set to be 0 *) (* If CR is 0: GT is not executed, CR remains 0 *) ST %Q0.0 (* Q0.0 is set equal to CR *)	

6.4.2 GE (Greater than or Equal to)

- **Description**

	Name	Usage	Group	
LD	GE			☑ K5 ☑ K2
IL	GE	GE *IN1*, *IN2*	P	

Operands	Input/Output	Data Type	Acceptable Memory Areas
IN1	Input	BYTE, INT, DINT, REAL	I, Q, M, V, L, SM, AI, AQ, T, C, HC, constant, pointer
IN2	Input	BYTE, INT, DINT, REAL	I, Q, M, V, L, SM, AI, AQ, T, C, HC, constant, pointer
OUT (LD)	Output	BOOL	Power flow

⚠**Note: if the input parameter is real, check the accuracy of real data in 3.2 Data Format/3.4 constant.**

The *IN1* and *IN2* must be of the same data type.

- **LD**

If *EN* is 1, this instruction compares *IN1* greater than or equal to *IN2* and the Boolean result is assigned to *OUT*;

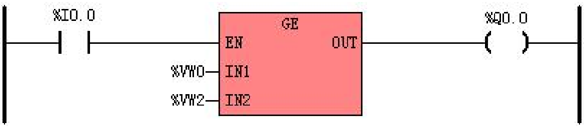
If *EN* is 0, this instruction is not executed, and *OUT* is set equal to 0.

- **IL**

If CR is 1, this instruction compares *IN1* greater than or equal to *IN2* and the Boolean result is assigned to CR;

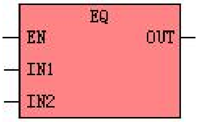
If CR is 0, this instruction is not executed, and CR remains 0.

- **Examples**

<table>
<tr><td rowspan="2">LD</td><td>
</td><td>SM0.0 is always ON, therefore GE is always executed: if VB0 is greater than or equal to B#200, Q0.0 is set equal to 1, otherwise Q0.0 is set equal to 0.</td></tr>
<tr><td>
</td><td>If I0.0 is 1: if VW0 is greater than or equal to VW2, Q0.0 is set to be 1, otherwise Q0.0 is set to be 0.
If I0.0 is 0: GE is not executed, and Q0.0 is set to be 0.</td></tr>
<tr><td rowspan="2">IL</td><td colspan="2">LD %SM0.0 (* CR is created with SM0.0 *)
GE %VB0, B#200 (* If VB0 is greater than or equal to B#200, CR is set to be 1, otherwise CR is set to be 0 *)
ST %Q0.0 (* Q0.0 is set equal to CR *)</td></tr>
<tr><td colspan="2">LD %I0.0 (* CR is created with I0.0 *)
GE %VW0, %VW2 (* If CR is 1: if VW0 is greater than or equal to VW2, CR is set to be 1, *)
(* otherwise CR is set to be 0; If CR is 0: GE is not executed, CR remains 0 *)
ST %Q0.0 (* Q0.0 is set equal to CR *)</td></tr>
</table>

6.4.3 EQ (Equal to)

➢ **Description**

	Name	**Usage**	**Group**	
LD	EQ			☑ K5 ☑ K2
IL	EQ	EQ IN1, IN2	P	

Operands	**Input/Output**	**Data Type**	**Acceptable Memory Areas**
IN1	Input	BYTE, INT, DINT, REAL	I, Q, M, V, L, SM, AI, AQ, T, C, HC, constant, pointer
IN2	Input	BYTE, INT, DINT, REAL	I, Q, M, V, L, SM, AI, AQ, T, C, HC, constant, pointer
OUT (LD)	Output	BOOL	Power flow

Note: if the input parameter is real, check the accuracy of real data in **3.2 Data Format/3.4 constant.**

The *IN1* and *IN2* must be of the same data type.

➢ **LD**

If *EN* is 1, this instruction compares *IN1* equal to *IN2* and the Boolean result is assigned to *OUT*;

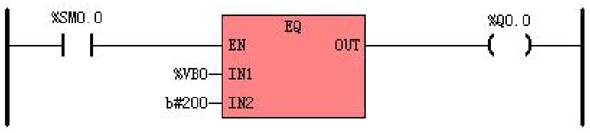
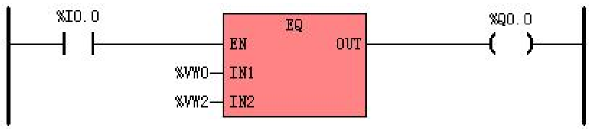
If *EN* is 0, this instruction is not executed, and *OUT* is set equal to 0.

➢ **IL**

If CR is 1, this instruction compares *IN1* equal to *IN2* and the Boolean result is assigned to CR;

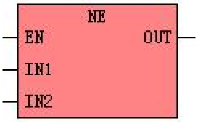
If CR is 0, this instruction is not executed, and CR remains 0.

➢ **Examples**

LD		SM0.0 is always ON, therefore *EQ* is always executed: if the value of VB0 is equal to B#200, Q0.0 is set equal to 1, otherwise Q0.0 is set equal to 0.
		If I0.0 is 1: if the value of VW0 is equal to that of VW2, Q0.0 is set to be 1, otherwise Q0.0 is set to be 0. If I0.0 is 0: *EQ* is not executed, and Q0.0 is set to be 0.
IL	LD %SM0.0 (* CR is created with SM0.0 *) EQ %VB0, B#200 (* If VB0 is equal to B#200, CR is set to be 1, otherwise CR is set to be 0 *) ST %Q0.0 (* Q0.0 is set equal to CR *)	
	LD %I0.0 (* CR is created with I0.0 *) EQ %VW0, %VW2 (* If CR is 1: if VW0 is equal to VW2, CR is set to be 1, otherwise CR is set to be 0 *) (* If CR is 0: EQ is not executed, CR remains 0 *) ST %Q0.0 (* Q0.0 is set equal to CR *)	

6.4.4 NE (Not Equal to)

- **Description**

	Name	Usage	Group	
LD	NE			☑ K5 ☑ K2
IL	NE	NE IN1, IN2	P	

Operands	Input/Output	Data Type	Acceptable Memory Areas
IN1	Input	BYTE, INT, DINT, REAL	I, Q, M, V, L, SM, AI, AQ, T, C, HC, constant, pointer
IN2	Input	BYTE, INT, DINT, REAL	I, Q, M, V, L, SM, AI, AQ, T, C, HC, constant, pointer
OUT (LD)	Output	BOOL	Power flow

Note: if the input parameter is real, check the accuracy of real data in 3.2 Data Format/3.4 constant.

The *IN1* and *IN2* must be of the same data type.

- **LD**

If *EN* is 1, this instruction compares *IN1* not equal to *IN2* and the Boolean result is assigned to *OUT*;

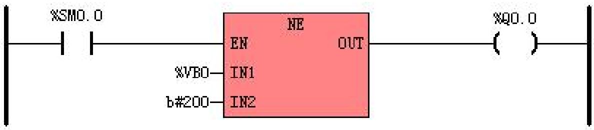
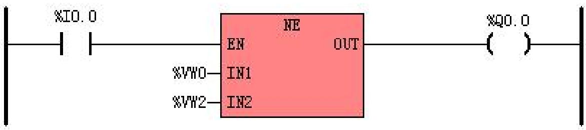
If *EN* is 0, this instruction is not executed, and *OUT* is set equal to 0.

- **IL**

If CR is 1, this instruction compares *IN1* not equal to *IN2* and the Boolean result is assigned to CR;

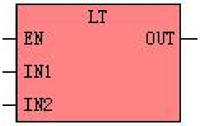
If CR is 0, this instruction is not executed, and CR remains 0.

- **Examples**

<table>
<tr><td rowspan="2">LD</td><td>
</td><td>SM0.0 is always ON, therefore NE is always executed: if the value of VB0 is not equal to B#200, Q0.0 is set equal to 1, otherwise Q0.0 is set equal to 0.</td></tr>
<tr><td>
</td><td>If I0.0 is 1: if the value of VW0 is not equal to that of VW2, Q0.0 is set to be 1, otherwise Q0.0 is set to be 0.
If I0.0 is 0: NE is not executed, and Q0.0 is set to be 0.</td></tr>
<tr><td rowspan="2">IL</td><td colspan="2">LD %SM0.0 (* CR is created with SM0.0 *)
NE %VB0, B#200 (* If VB0 is not equal to B#200, CR is set to be 1, otherwise CR is set to be 0 *)
ST %Q0.0 (* Q0.0 is set equal to CR *)</td></tr>
<tr><td colspan="2">LD %I0.0 (* CR is created with I0.0 *)
NE %VW0, %VW2 (* If CR is 1: if VW0 is not equal to VW2, CR is set to be 1, otherwise CR is set to be 0 *)
(* If CR is 0: NE is not executed, CR remains 0 *)
ST %Q0.0 (* Q0.0 is set equal to CR *)</td></tr>
</table>

6.4.5 LT (Less than)

➢ **Description**

	Name	Usage	Group	
LD	LT			☑ K5 ☑ K2
IL	LT	LT IN1, IN2	P	

Operands	Input/Output	Data Type	Acceptable Memory Areas
IN1	Input	BYTE, INT, DINT, REAL	I, Q, M, V, L, SM, AI, AQ, T, C, HC, constant, pointer
IN2	Input	BYTE, INT, DINT, REAL	I, Q, M, V, L, SM, AI, AQ, T, C, HC, constant, pointer
OUT (LD)	Output	BOOL	Power flow

Note: if the input parameter is real, check the accuracy of real data in 3.2 Data Format/3.4 constant.

The *IN1* and *IN2* must be of the same data type.

➢ **LD**

If *EN* is 1, this instruction compares *IN1* less than *IN2* and the Boolean result is assigned to *OUT*;

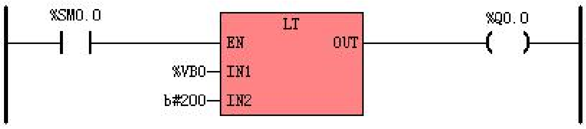
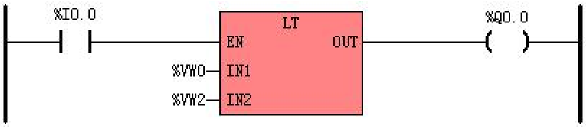
If *EN* is 0, this instruction is not executed, and *OUT* is set equal to 0.

➢ **IL**

If CR is 1, this instruction compares *IN1* less than *IN2* and the Boolean result is assigned to CR;

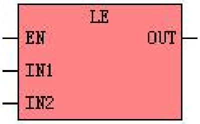
If CR is 0, this instruction is not executed, and CR remains 0.

- **Examples**

<table>
<tr><td rowspan="2">LD</td><td>
</td><td>SM0.0 is always ON, therefore LT is always executed: if the value of VB0 is less than B#200, Q0.0 is set equal to 1, otherwise Q0.0 is set equal to 0.</td></tr>
<tr><td>
</td><td>If I0.0 is 1: if the value of VW0 is less than that of VW2, Q0.0 is set to be 1, otherwise Q0.0 is set to be 0.
If I0.0 is 0: LT is not executed, and Q0.0 is set to be 0.</td></tr>
<tr><td rowspan="2">IL</td><td colspan="2">LD %SM0.0 (* CR is created with SM0.0 *)
LT %VB0, B#200 (* If VB0 is less than B#200, CR is set to be 1, otherwise CR is set to be 0 *)
ST %Q0.0 (* Q0.0 is set equal to CR *)</td></tr>
<tr><td colspan="2">LD %I0.0 (* CR is created with I0.0 *)
LT %VW0, %VW2 (* If CR is 1: if VW0 is less than VW2, CR is set to be 1, otherwise CR is set to be 0 *)
(* If CR is 0: LT is not executed, CR remains 0 *)
ST %Q0.0 (* Q0.0 is set equal to CR *)</td></tr>
</table>

6.4.6 LE (Less than or Equal to)

- **Description**

	Name	Usage	Group	
LD	LE			☑ K5 ☑ K2
IL	LE	LE IN1, IN2	P	

Operands	Input/Output	Data Type	Acceptable Memory Areas
IN1	Input	BYTE, INT, DINT, REAL	I, Q, M, V, L, SM, AI, AQ, T, C, HC, constant, pointer
IN2	Input	BYTE, INT, DINT, REAL	I, Q, M, V, L, SM, AI, AQ, T, C, HC, constant, pointer
OUT (LD)	Output	BOOL	Power flow

Note: if the input parameter is real, check the accuracy of real data in 3.2 Data Format/3.4 constant.

The *IN1* and *IN2* must be of the same data type.

- **LD**

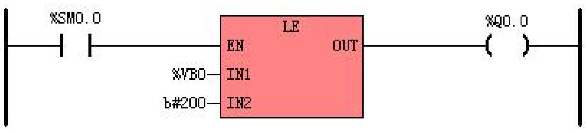
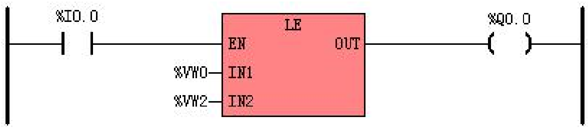
If *EN* is 1, this instruction compares *IN1* less than or equal to *IN2* and the Boolean result is assigned to *OUT*;

If *EN* is 0, this instruction is not executed, and *OUT* is set equal to 0.

- **IL**

If CR is 1, this instruction compares *IN1* less than or equal to *IN2* and the Boolean result is assigned to CR; If CR is 0, this instruction is not executed, and CR remains 0.

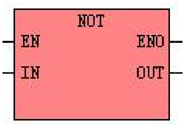
- **Examples**

LD		SM0.0 is always ON, therefore *LE* is always executed: if VB0 is less than or equal to B#200, Q0.0 is set equal to 1, otherwise Q0.0 is set equal to 0.
		If I0.0 is 1: if VW0 is less than or equal to VW2, Q0.0 is set to be 1, otherwise Q0.0 is set to be 0. If I0.0 is 0: *LE* is not executed, and Q0.0 is set to be 0.
IL	LD %SM0.0 (* CR is created with SM0.0 *) LE %VB0, B#200 (* If VB0 is less than or equal to B#200, CR is set to be 1, otherwise CR is set to be 0 *) ST %Q0.0 (* Q0.0 is set equal to CR *)	
	LD %I0.0 (* CR is created with I0.0 *) LE %VW0, %VW2 (* If CR is 1: if VW0 is less than or equal to VW2, CR is set to be 1, *) (* otherwise CR is set to be 0; If CR is 0: LE is not executed, CR remains 0 *) ST %Q0.0 (* Q0.0 is set equal to CR *)	

6.5 Logical Operations

6.5.1 NOT

➢ **Description**

	Name	Usage	Group	
LD	NOT			☑ K5 ☑ K2
IL	NOT	NOT *OUT*	U	

Operands	Input/Output	Data Type	Acceptable Memory Areas
IN	Input	BYTE, WORD, DWORD	I, Q, M, V, L, SM, constant, pointer
OUT	Output	BYTE, WORD, DWORD	Q, M, V, L, SM, pointer

➢ **LD**

The *IN* and *OUT* must be of the same data type.

If *EN* is 1, this instruction inverts each bit of *IN* and assigns the result to *OUT*.

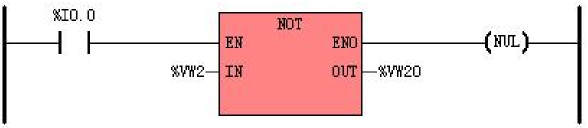
If *EN* is 0, this instruction is not executed.

➢ **IL**

If CR is 1, this instruction inverts each bit of *OUT* and still stores the result in *OUT*. It does not influence CR;

If CR is 0, this instruction is not executed.

➢ **Examples**

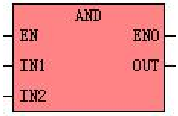
<table>
<tr><td>LD</td><td>
</td><td>If I0.0 is 0: NOT is not executed.
If I0.0 is 1: NOT inverts each bit of VW2 and assigns the result to VW20.</td></tr>
<tr><td>IL</td><td colspan="2">LD %I0.0 (* CR is created with I0.0 *)
NOT %VW20 (* If CR is 1: NOT inverts each bit of VW20 and still stores the result in VW20 *)
(* If CR is 0: NOT instruction is not executed *)</td></tr>
<tr><td>Result</td><td colspan="2">For the LD example, if NOT instruction is executed, the result will be as the following:

Address VW2
Value W#16#5555

Address VW20
Value W#16#AAAA</td></tr>
</table>

6.5.2 AND

➢ **Description**

	Name	Usage	Group	
LD	AND			☑ K5 ☑ K2
IL	AND	AND IN1, OUT	U	

Parameter	Input/Output	Data Type	Acceptable Memory Areas
IN1	Input	BYTE, WORD, DWORD	I, Q, M, V, L, SM, constant, pointer
IN2	Input	BYTE, WORD, DWORD	I, Q, M, V, L, SM, constant, pointer
OUT	Output	BYTE, WORD, DWORD	Q, M, V, L, SM, pointer

➢ **LD**

The *IN1, IN2* and *OUT* must be of the same data type.

If *EN* is 1, this instruction ANDs the corresponding bits of *IN1* and *IN2* and assigns the result to *OUT*.

If *EN* is 0, this instruction is not executed.

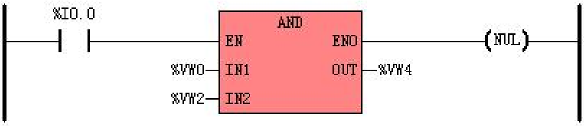
➢ **IL**

The *IN* and *OUT* must be of the same data type.

If CR is 1, this instruction ANDs the corresponding bits of *IN* and *OUT* and assigns the result to *OUT*, and it does not influence CR.

If CR is 0, this instruction is not executed.

- **Examples**

LD		If I0.0 is 0: *AND* is not executed. If I0.0 is 1: The *AND* instruction ANDs the corresponding bits of VW0 and VW2, and assigns the result to VW4.
IL	LD %I0.0 (* CR is created with I0.0 *) AND %VW0, %VW2 (* If CR is 1: The *AND* instruction ANDs the corresponding bits of VW0 and VW2, *) (* and still stores the result in VW2 *) (* If CR is 0: The *AND* instruction is not executed *)	
Result	For the LD example, if *AND* instruction is executed, the result will be as the following: Address: VW0 — Value: W#16#129B; Address: VW2 — Value: W#16#960F Address: VW4 — Value: W#16#120B	

6.5.3 ANDN

- **Description**

	Name	Usage	Group	
LD	ANDN			☑ K5 ☑ K2
IL	ANDN	ANDN *IN1, OUT*	U	

Parameter	Input/Output	Data Type	Acceptable Memory Areas
IN1	Input	BYTE, WORD, DWORD	I, Q, M, V, L, SM, constant, pointer
IN2	Input	BYTE, WORD, DWORD	I, Q, M, V, L, SM, constant, pointer
OUT	Output	BYTE, WORD, DWORD	Q, M, V, L, SM, pointer

- **LD**

The *IN1, IN2* and *OUT* must be of the same data type.

If *EN* is 1, this instruction ANDs the corresponding bits of *IN1* and *IN2*, then inverts each bit of the result, and assigns the final result to *OUT*. If *EN* is 0, this instruction is not executed.

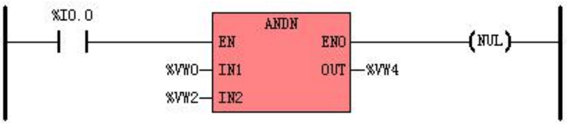
- **IL**

The *IN* and *OUT* must be of the same data type.

If CR is 1, this instruction ANDs the corresponding bits of *IN* and *OUT*, then inverts each bit of the result, and assigns the final result to *OUT*. It does not influence CR.

If CR is 0, this instruction is not executed.

- **Examples**

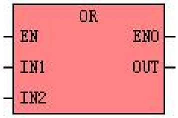
<table>
<tr>
<td>LD</td>
<td>
</td>
<td>If I0.0 is 0: ANDN is not executed.
If I0.0 is 1: The ANDN instruction ANDs the corresponding bits of VW0 and VW2, then inverts each bit of the result, and assigns the final result to VW4.</td>
</tr>
<tr>
<td>IL</td>
<td colspan="2">LD %I0.0 (* CR is created with I0.0 *)
ANDN %VW0, %VW2 (* If CR is 1: The ANDN instruction ANDs the corresponding bits of VW0 and VW2, *)
(* then inverts each bit of the result, and still stores the final result in VW2 *)
(* If CR is 0: The ANDN instruction is not executed *)</td>
</tr>
<tr>
<td>Result</td>
<td colspan="2">For the LD example, if ANDN instruction is executed, the result will be as the following:

<table>
<tr><td>Address</td><td>VW0</td><td>VW2</td></tr>
<tr><td>Value</td><td>W#16#129B</td><td>W#16#960F</td></tr>
</table>

<table>
<tr><td>Address</td><td>VW4</td></tr>
<tr><td>Value</td><td>W#16#EDF4</td></tr>
</table>
</td>
</tr>
</table>

6.5.4 OR

➢ **Description**

	Name	Usage	Group	
LD	OR			☑ K5 ☑ K2
IL	OR	OR IN1, OUT	U	

Parameter	Input/Output	Data Type	Acceptable Memory Areas
IN1	Input	BYTE, WORD, DWORD	I, Q, M, V, L, SM, constant, pointer
IN2	Input	BYTE, WORD, DWORD	I, Q, M, V, L, SM, constant, pointer
OUT	Output	BYTE, WORD, DWORD	Q, M, V, L, SM, pointer

➢ **LD**

The *IN1, IN2* and *OUT* must be of the same data type.

If *EN* is 1, this instruction ORs the corresponding bits of *IN1* and *IN2* and assigns the result to *OUT*.

If *EN* is 0, this instruction is not executed.

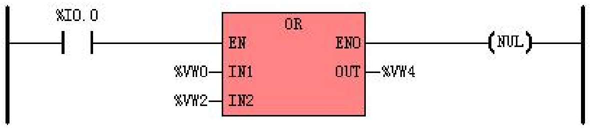
➢ **IL**

The *IN* and *OUT* must be of the same data type.

If CR is 1, this instruction ORs the corresponding bits of *IN* and *OUT* and assigns the result to *OUT*, and it does not influence CR.

If CR is 0, this instruction is not executed.

➢ **Examples**

LD		If I0.0 is 0: *OR* is not executed. If I0.0 is 1: The *OR* instruction ORs the corresponding bits of VW0 and VW2, and assigns the result to VW4.
IL	LD %I0.0 (* CR is created with I0.0 *) OR %VW0, %VW2 (* If CR is 1: The *OR* instruction ORs the corresponding bits of VW0 and VW2, *) (* and still stores the result in VW2 *) (* If CR is 0: The *OR* instruction is not executed *)	
Result	For the LD example, if *OR* instruction is executed, the result will be as the following: Address: VW0 — Value: W#16#5555; Address: VW2 — Value: W#16#AAAA Address: VW4 — Value: W#16#FFFF	

6.5.5 ORN

➢ **Description**

	Name	Usage	Group	
LD	ORN			☑ K5 ☑ K2
IL	ORN	ORN *IN1, OUT*	U	

Parameter	Input/Output	Data Type	Acceptable Memory Areas
IN1	Input	BYTE, WORD, DWORD	I, Q, M, V, L, SM, constant, pointer
IN2	Input	BYTE, WORD, DWORD	I, Q, M, V, L, SM, constant, pointer
OUT	Output	BYTE, WORD, DWORD	Q, M, V, L, SM, pointer

➢ **LD**

The *IN1, IN2* and *OUT* must be of the same data type.

If *EN* is 1, this instruction ORs the corresponding bits of *IN1* and *IN2*, then inverts each bit of the result, and assigns the final result to *OUT*. If *EN* is 0, this instruction is not executed.

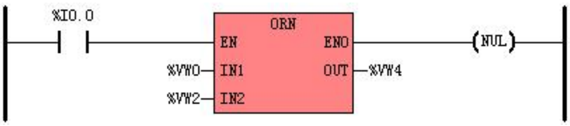
➢ **IL**

The *IN* and *OUT* must be of the same data type.

If CR is 1, this instruction ORs the corresponding bits of *IN* and *OUT*, then inverts each bit of the result, and assigns the final result to *OUT*. It does not influence CR.

If CR is 0, this instruction is not executed.

➢ **Examples**

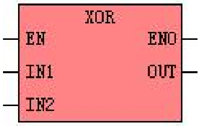
<table>
<tr><td>LD</td><td>
</td><td>If I0.0 is 0: ORN is not executed.
If I0.0 is 1: The ORN instruction ORs the corresponding bits of VW0 and VW2, then inverts each bit of the result, and assigns the final result to VW4.</td></tr>
<tr><td>IL</td><td colspan="2">LD %I0.0 (* CR is created with I0.0 *)
ORN %VW0, %VW2 (* If CR is 1: The ORN instruction ORs the corresponding bits of VW0 and VW2, *)
(* then inverts each bit of the result, and still stores the final result in VW2 *)
(* If CR is 0: The ORN instruction is not executed *)</td></tr>
<tr><td>Result</td><td colspan="2">For the LD example, if ORN instruction is executed, the result will be as the following:

Address: VW0 — Value: W#16#129B; Address: VW2 — Value: W#16#960F

Address: VW4 — Value: W#16#6960</td></tr>
</table>

6.5.6 XOR (Exclusive OR)

➢ **Description**

	Name	Usage	Group	
LD	XOR			☑ K5 ☑ K2
IL	XOR	XOR IN1, OUT	U	

Parameter	Input/Output	Data Type	Acceptable Memory Areas
IN1	Input	BYTE, WORD, DWORD	I, Q, M, V, L, SM, constant, pointer
IN2	Input	BYTE, WORD, DWORD	I, Q, M, V, L, SM, constant, pointer
OUT	Output	BYTE, WORD, DWORD	Q, M, V, L, SM, pointer

➢ **LD**

The *IN1, IN2* and *OUT* must be of the same data type.

If *EN* is 1, this instruction XORs the corresponding bits of *IN1* and *IN2* and assigns the result to *OUT*.

If *EN* is 0, this instruction is not executed.

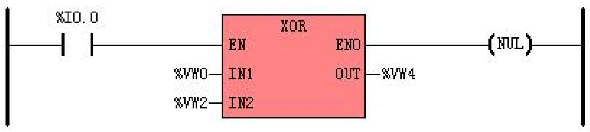
➢ **IL**

The *IN* and *OUT* must be of the same data type.

If CR is 1, this instruction XORs the corresponding bits of *IN* and *OUT* and assigns the result to *OUT*, and it does not influence CR.

If CR is 0, this instruction is not executed.

➢ **Examples**

<table>
<tr><td>LD</td><td>
</td><td>If I0.0 is 0: XOR is not executed.
If I0.0 is 1: The XOR instruction XORs the corresponding bits of VW0 and VW2, and assigns the result to VW4.</td></tr>
<tr><td>IL</td><td colspan="2">LD   %I0.0   (* CR is created with I0.0 *)
XOR   %VW0, %VW2   (* If CR is 1: The XOR instruction XORs the corresponding bits of VW0 and VW2, *)
(* and still stores the result in VW2 *)
(* If CR is 0: The XOR instruction is not executed *)</td></tr>
<tr><td>Result</td><td colspan="2">For the LD example, if XOR instruction is executed, the result will be as the following:

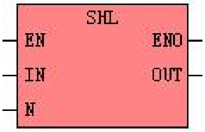
Address: VW0 — Value: W#16#9514; Address: VW2 — Value: W#16#B9A1

Address: VW4 — Value: W#16#2CB5</td></tr>
</table>

6.6 Shift/Rotate Instructions

6.6.1 SHL (Shift left)

➢ **Description**

	Name	**Usage**	**Group**	
LD	SHL			☑ K5 ☑ K2
IL	SHL	SHL *OUT, N*	U	

Operands	**Input/Output**	**Data Type**	**Acceptable Memory Areas**
IN	Input	BYTE, WORD, DWORD	I, Q, M, V, L, SM, constant, pointer
N	Input	BYTE	I, Q, M, V, L, SM, constant, pointer
OUT	Output	BYTE, WORD, DWORD	Q, M, V, L, SM, pointer

➢ **LD**

The *IN* and *OUT* must be of the same data type.

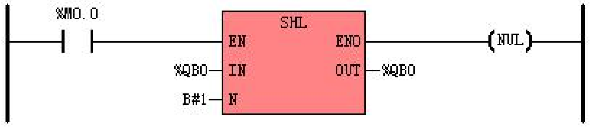
If *EN* is 1, this instruction shifts the value of *IN* to the left by *N* bits, and each bit is filled with a zero while it is shifted left. The result is assigned to *OUT*. If *EN* is 0, this instruction is not executed.

➢ **IL**

If CR is 1, this instruction shifts the value of *OUT* to the left by *N* bits, and each bit is filled with a zero while it is shifted left. The result is still stored in *OUT*. It does not influence CR.

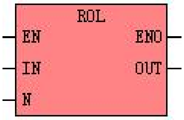
If CR is 0, this instruction is not executed.

- **Examples**

LD		If M0.0 is 0: *SHL* isn't executed. If M0.0 is 1: *SHL* shifts QB0 to the left by 1 bit, and the result is still assigned to QB0.
IL	LD %M0.0 (* CR is created with M0.0 *) SHL %QB0, B#1 (* If CR is 1: *SHL* shifts QB0 to the left by 1 bit, and the result is still stored in QB0 *) (* If CR is 0: *SHL* instruction is not executed *)	
Result	For the LD example, if *SHL* instruction is executed, the result will be as the following: QB0 B#2#10000001 After 1st shift: QB0 B#2#00000010 After 2nd shift: B#2#00000100 After 3rd shift: B#2#00001000 After 4th shift: B#2#00010000	

6.6.2 ROL (Rotate left)

➢ **Description**

	Name	Usage	Group	
LD	ROL			☑ K5 ☑ K2
IL	ROL	ROL *OUT, N*	U	

Operands	Input/Output	Data Type	Acceptable Memory Areas
IN	Input	BYTE, WORD, DWORD	I, Q, M, V, L, SM, constant, pointer
N	Input	BYTE	I, Q, M, V, L, SM, constant, pointer
OUT	Output	BYTE, WORD, DWORD	Q, M, V, L, SM, pointer

➢ **LD**

The *IN* and *OUT* must be of the same data type.

If *EN* is 1, this instruction rotates the value of *IN* to the left by *N* bits, and the MSB is rotated to the LSB. The result is assigned to *OUT*. If *EN* is 0, this instruction is not executed.

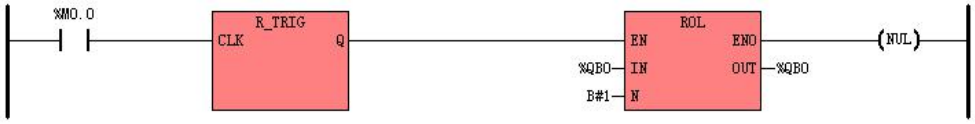
➢ **IL**

If CR is 1, this instruction rotates the value of *OUT* to the left by *N* bits, and the MSB is rotated to the LSB. The result is still stored in *OUT*. It does not influence CR.

If CR is 0, this instruction is not executed.

- **Examples**

LD



If M0.0 is 0: *ROL* isn't executed.

If M0.0 is 1: *ROL* rotates QB0 to the left by 1 bit, and the MSB is rotated to the LSB. The result is still assigned to QB0.

IL

```
LD      %M0.0           (* CR is created with M0.0 *)
ROL     %QB0, B#1       (* If CR is 1: ROL rotates QB0 to the left by 1 bit, and the result is still stored in QB0 *)
                        (* If CR is 0: ROL instruction is not executed *)
```

Result

For the LD example, if *ROL* instruction is executed, the result will be as the following:

QB0 B#2#10100001

	After 1st shift	After 2nd shift	After 3rd shift	After 4th shift
QB0	B#2#01000011	B#2#10000110	B#2#00001101	B#2#00011010

6.6.3 SHR (Shift right)

➢ **Description**

	Name	Usage	Group	
LD	SHR			☑ K5 ☑ K2
IL	SHR	SHR *OUT, N*	U	

Operands	Input/Output	Data Type	Acceptable Memory Areas
IN	Input	BYTE, WORD, DWORD	I, Q, M, V, L, SM, constant, pointer
N	Input	BYTE	I, Q, M, V, L, SM, constant, pointer
OUT	Output	BYTE, WORD, DWORD	Q, M, V, L, SM, pointer

➢ **LD**

The *IN* and *OUT* must be of the same data type.

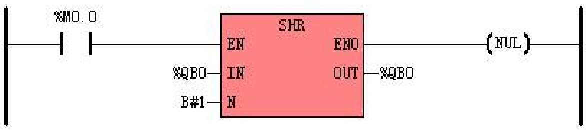
If *EN* is 1, this instruction shifts the value of *IN* to the right by *N* bits, and each bit is filled with a zero while it is shifted right. The result is assigned to *OUT*. If *EN* is 0, this instruction is not executed.

➢ **IL**

If CR is 1, this instruction shifts the value of *OUT* to the right by *N* bits, and each bit is filled with a zero while it is shifted right. The result is still stored in *OUT*. It does not influence CR.

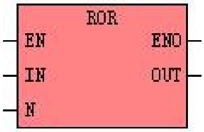
If CR is 0, this instruction is not executed.

- **Examples**

LD		If M0.0 is 0: *SHR* isn't executed. If M0.0 is 1: *SHR* shifts QB0 to the right by 1 bit, and the result is still assigned to QB0.
IL	LD %M0.0 (* CR is created with M0.0 *) SHR %QB0, B#1 (* If CR is 1: *SHR* shifts QB0 to the right by 1 bit, and the result is still stored in QB0 *) (* If CR is 0: *SHR* instruction is not executed *)	
Result	For the LD example, if *SHR* instruction is executed, the result will be as the following: QB0 B#2#10000001 After 1st shift: QB0 B#2#01000000 After 2nd shift: B#2#00100000 After 3rd shift: B#2#00010000 After 4th shift: B#2#00001000	

6.6.4 ROR (Rotate right)

- **Description**

	Name	Usage	Group	
LD	ROR			☑ K5 ☑ K2
IL	ROR	ROR *OUT, N*	U	

Operands	Input/Output	Data Type	Acceptable Memory Areas
IN	Input	BYTE, WORD, DWORD	I, Q, M, V, L, SM, constant, pointer
N	Input	BYTE	I, Q, M, V, L, SM, constant, pointer
OUT	Output	BYTE, WORD, DWORD	Q, M, V, L, SM, pointer

- **LD**

The *IN* and *OUT* must be of the same data type.

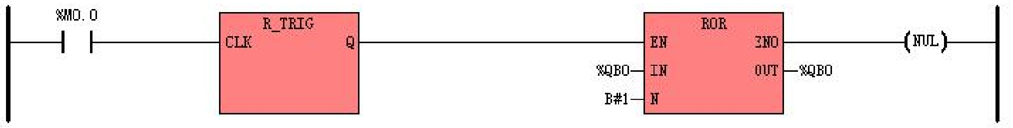
If *EN* is 1, this instruction rotates the value of *IN* to the right by *N* bits, and the LSB is rotated to the MSB. The result is assigned to *OUT*. If *EN* is 0, this instruction is not executed.

- **IL**

If CR is 1, this instruction rotates the value of *OUT* to the right by *N* bits, and the LSB is rotated to the MSB. The result is still stored in *OUT*. It does not influence CR.

If CR is 0, this instruction is not executed.

➢ **Examples**

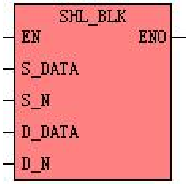
<table>
<tr><td>LD</td><td>
</td></tr>
<tr><td></td><td>If M0.0 is 0: ROR isn’t executed.
If M0.0 is 1: ROR rotates QB0 to the right by 1 bit, and the LSB is rotated to the MSB. The result is still assigned to QB0.</td></tr>
<tr><td>IL</td><td>LD %M0.0 (* CR is created with M0.0 *)
ROL %QB0, B#1 (* If CR is 1: ROR rotates QB0 to the right by 1 bit, and the result is still stored in QB0 *)
(* If CR is 0: ROR instruction is not executed *)</td></tr>
<tr><td>Result</td><td>For the LD example, if ROR instruction is executed, the result will be as the following:

QB0 B#2#10100001

After 1st shift: QB0 B#2#11010000
After 2nd shift: B#2#01101000
After 3rd shift: B#2#00110100
After 4th shift: B#2#00011010</td></tr>
</table>

6.6.5 SHL_BLK (Bit String Shift Left)

➢ **Description**

	Name	Usage	Group	
LD	SHL_BLK			☑ K5 ☑ K2
IL	SHL_BLK	SHL_BLK S_DATA, S_N, D_DATA, D_N	U	

Operands	Input/Output	Data Type	Acceptable Memory Areas
S_DATA	Input	BOOL	I, Q, M, V, L
S_N	Input	INT	I, Q, V, M, L, SM, T, C, AI, AQ, Constant, Pointer
D_DATA	Input/Output	BOOL	Q, M, V, L
D_N	Input	INT	I, Q, V, M, L, SM, T, C, AI, AQ, Constant, Pointer

Note: the maximum of S_N, D_N is 1024, if the input value is larger than 1024, the software considers it as 1024. If the S_N is larger than D_N , the software considers S_N equals D_N. The S_N and D_N must be larger than 0。

Note: the S_DATA, D_DATA parameter is memory block whose length is changeable. The whole block cannot be in the illegal area, or there will be unpredictable result.

This instruction shifts the number *D_N* of continuous bits, beginning with *D_DATA*, to the left by *S_N* bits. Meanwhile, the number *S_N* of continuous bits, beginning with *S_DATA,* are filled into the right most bits of *D_DATA*.

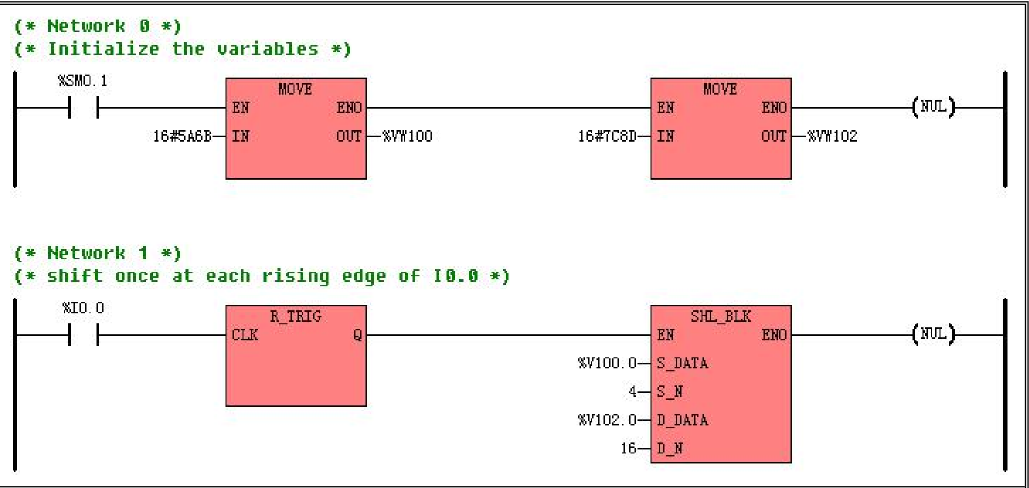
- **LD**

If *EN* is 1, this instruction is executed.

- **IL**

If CR is 1, this instruction is executed, and it does not influence CR.

- **Examples**

LD	

IL	(* Network 0 *)
	(*Initialize the variables*)
	LD %SM0.1
	MOVE 16#5A6B, %VW100
	MOVE 16#7C8D, %VW102
	(* Network 1 *)
	(*shift once at each rising edge of I0.0*)
	LD %I0.0
	R_TRIG
	SHL_BLK %V100.0, 4, %V102.0, 16

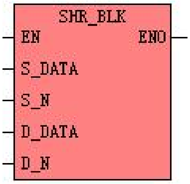
Result

The result is shown as the following:

	VW102 (V103.7 … V102.0)				VW100 (V101.7 … V100.0)			
Initial value	0111	1100	1000	1101	0101	1010	0110	1011
After the 1st execution	1100	1000	1101	1011				
After the 2nd execution	1000	1101	1011	1011				
After the 3rd execution	1101	1011	1011	1011				

6.6.6 SHR_BLK (Bit String Shift Right)

➢ **Description**

	Name	Usage	Group	
LD	SHR_BLK			☑ K5 ☑ K2
IL	SHR_BLK	SHR_BLK S_DATA, S_N, D_DATA, D_N	U	

Operands	Input/Output	Data Type	Acceptable Memory Areas
S_DATA	Input	BOOL	I, Q, M, V, L
S_N	Input	INT	I, Q, V, M, L, SM, T, C, AI, AQ, Constant, Pointer
D_DATA	Input/Output	BOOL	Q, M, V, L
D_N	Input	INT	I, Q, V, M, L, SM, T, C, AI, AQ, Constant, Pointer

Note: the maximum of S_N, D_N is 1024, if the input value is larger than 1024, the software considers it as 1024. If the S_N is larger than D_N , the software considers S_N equals D_N. The S_N and D_N must be larger than 0。

Note: the S_DATA, D_DATA parameter is memory block whose length is changeable. The whole block cannot be in the illegal area, or there will be unpredictable result.

This instruction shifts the number *D_N* of continuous bits, beginning with *D_DATA*, to the right by *S_N* bits. Meanwhile, the number *S_N* of continuous bits, beginning with *S_DATA,* are filled into the left most bits of *D_DATA*.

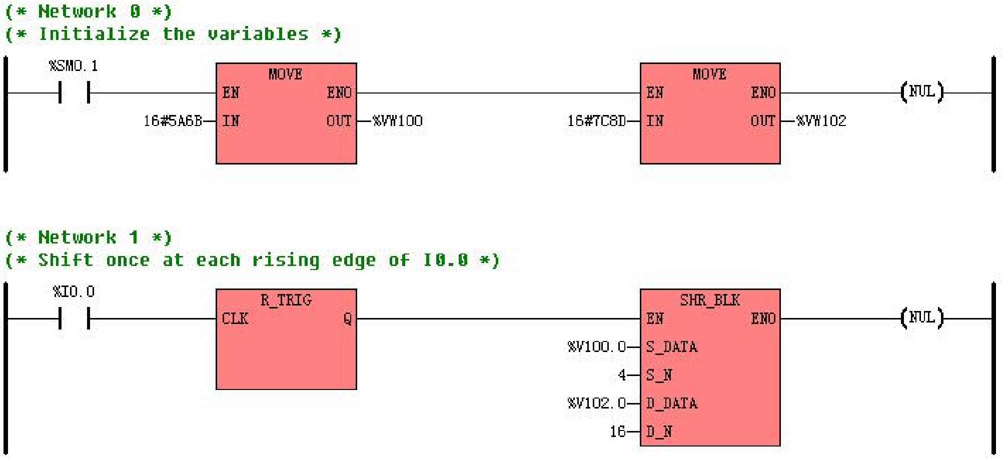
- **LD**

If *EN* is 1, this instruction is executed.

- **IL**

If CR is 1, this instruction is executed, and it does not influence CR.

- **Examples**

LD	

IL	(* Network 0 *)
	(*Initialize the variables*)
	LD %SM0.1
	MOVE 16#5A6B, %VW100
	MOVE 16#7C8D, %VW102
	(* Network 1 *)
	(*Shift once at each rising edge of I0.0*)
	LD %I0.0
	R_TRIG
	SHR_BLK %V100.0, 4, %V102.0, 16

Result

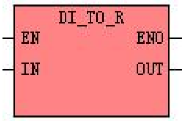
The result is shown as the following:

	VW102				VW100			
	V103.7			V102.0	V101.7			V100.0
Initial value	0111	1100	1000	1101	0101	1010	0110	1011
After the 1st execution	1011	0111	1100	1000				
After the 2nd execution	1011	1011	0111	1100				
After the 3rd execution	1011	1011	1011	0111				

6.7 Convert Instructions

6.7.1 DI_TO_R (DINT To REAL)

➢ **Description**

<table>
<tr><th></th><th>Name</th><th>Usage</th><th>Group</th><td rowspan="3">☑ K5
☑ K2</td></tr>
<tr><td>LD</td><td>DI_TO_R</td><td>
</td><td></td></tr>
<tr><td>IL</td><td>DI_TO_R</td><td>DI_TO_R IN, OUT</td><td>U</td></tr>
</table>

Operands	Input/Output	Data Type	Acceptable Memory Areas
IN	Input	DINT	I, Q, M, V, L, SM, HC, Constant
OUT	Output	REAL	V, L

This instruction converts a DINT value (*IN*) to a REAL value and assigns the result to *OUT*.

➢ **LD**

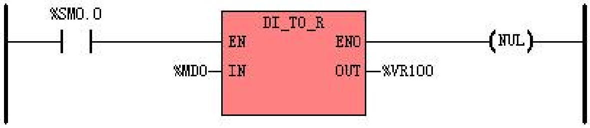
If *EN* is 1, this instruction is executed.

➢ **IL**

If CR is 1, this instruction is not executed, and it does not influence CR.

➢ **Examples**

LD



SM0.0 is always ON, therefore *DI_TO_R* is always executed: The value of MD0 is converted to a REAL value that is assigned to VR100.

IL

```
LD        %SM0.0           (* CR is created SM0.0 *)
DI_TO_R   %MD0, %VR100     (* The value of MD0 is converted to a REAL value that is assigned to VR100 *)
```

Result

The result is shown as the following:

MD0	VR100
DI#123	123.0
DI#-9876	-9876.0

6.7.2 R_TO_DI (REAL To DINT)

➢ **Description**

	Name	Usage	Group	
LD	R_TO_DI			☑ K5 ☑ K2
IL	R_TO_DI	R_TO_DI *IN, OUT*	U	

Operands	Input/Output	Data Type	Acceptable Memory Areas
IN	Input	REAL	V, L, constant
OUT	Output	DINT	M, V, L, SM

This instruction converts a REAL value (*IN*) to a DINT value and assigns the result to *OUT*. During the conversion, the decimal fraction is cut off.

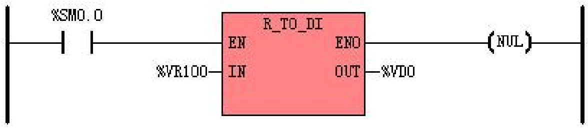
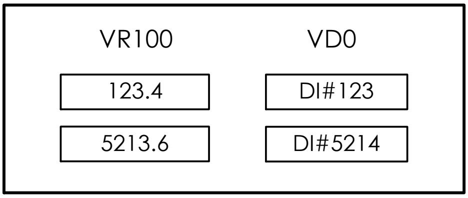
➢ **LD**

If *EN* is 1, this instruction is executed.

➢ **IL**

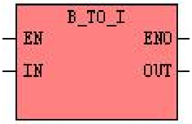
If CR is 1, this instruction is executed, and it does not influence CR.

➢ **Examples**

<table>
<tr><td>LD</td><td>
</td><td>SM0.0 is always ON, therefore R_TO_DI is always executed: The value of VD4000 is converted to a DINT value that is assigned to VD0.</td></tr>
<tr><td>IL</td><td colspan="2">LD %SM0.0 (* CR is created SM0.0 *)
R_TO_DI %VD4000, %VD0 (* The value of VD4000 is converted to a DINT value that is assigned to VD0 *)</td></tr>
<tr><td>Result</td><td colspan="2">The result is shown as the following:

</td></tr>
</table>

6.7.3 B_TO_I (BYTE To INT)

- **Description**

	Name	Usage	Group	
LD	B_TO_I			☑ K5 ☑ K2
IL	B_TO_I	B_TO_I *IN, OUT*	U	

Operands	Input/Output	Data Type	Acceptable Memory Areas
IN	Input	BYTE	I, Q, M, V, L, SM, Constant
OUT	Output	INT	Q, M, V, L, SM, AQ

This instruction converts the input byte *IN* to an integer value and assigns the result to *OUT*.

- **LD**

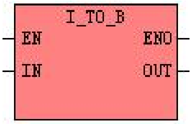
If *EN* is 1, this instruction is executed.

- **IL**

If CR is 1, this instruction is executed, and it does not influence CR.

6.7.4 I_TO_B (INT To BYTE)

- **Description**

	Name	Usage	Group	
LD	I_TO_B			☑ K5 ☑ K2
IL	I_TO_B	I_TO_B *IN, OUT*	U	

Operands	Input/Output	Data Type	Acceptable Memory Areas
IN	Input	INT	I, Q, M, V, L, SM, AI, AQ, T, C, Constant
OUT	Output	BYTE	Q, M, V, L, SM

Note: If the input parameter exceeds the range of output data format, there will be an error. The output value will be calculated by force format transformation with C language rule.

This instruction assigns the least byte of the input *IN* to the *OUT*.

The range of byte is from B#0 to B#255, if the value of IN exceeds this range, the result will be lower byte value of IN parameter; K5 CPU will also recode the overflow error.

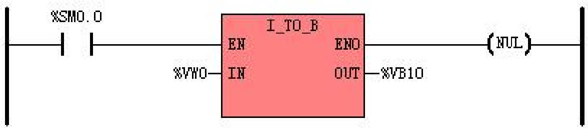
- **LD**

If *EN* is 1, this instruction is executed.

- **IL**

If CR is 1, this instruction is executed, and it does not influence CR.

- **Examples**

LD		SM0.0 is always 1, so I_TO_B is always be executed: assigns VB0 (the least byte of VW0) to VB10.
IL	LD %SM0.0 I_TO_B %VW0, %VB10	
Result	The result is shown as the following:	

VW0	VB10
24	B#24
255	B#255
I#16#FFFD	B#16#FD

6.7.5 DI_TO_I (DINT To INT)

➢ **Description**

	Name	Usage	Group	
LD	DI_TO_I			☑ K5 ☑ K2
IL	DI_TO_I	DI_TO_I *IN, OUT*	U	

Operands	Input/Output	Data Type	Acceptable Memory Areas
IN	Input	DINT	I, Q, M, V, L, SM, HC, Constant
OUT	Output	INT	Q, M, V, L, SM, AQ

Note: If the input parameter exceeds the range of output data format, there will be an error. The output value will be calculated by force format transformation with C language rule

This instruction assigns the least word of the input *IN* to the *OUT*.

The range of integer value is from -32768 to 32767, if the value of IN exceeds this range, the result will be lower word value of IN parameter; K5 CPU will also recode the overflow error.

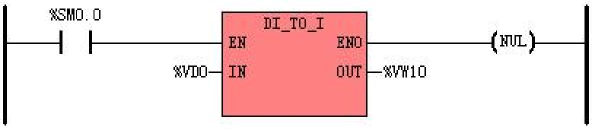
➢ **LD**

If *EN* is 1, this instruction is executed.

➢ **IL**

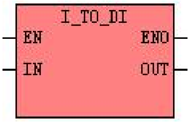
If CR is 1, this instruction is executed, and it does not influence CR.

➢ **Examples**

<table>
<tr><td>LD</td><td>
</td><td>SM0.0 is always 1, so DI_TO_I is always executed: assigns VW0 (the least word of VD0) to VW10.</td></tr>
<tr><td>IL</td><td colspan="2">LD %SM0.0
DI_TO_I %VD0, %VW10</td></tr>
<tr><td>Result</td><td colspan="2">The result is shown as the following:
<table>
<tr><th>VD0</th><th>VW10</th></tr>
<tr><td>DI#12345</td><td>12345</td></tr>
<tr><td>DI#-234</td><td>-234</td></tr>
<tr><td>DI#16#7A8B9C1D</td><td>I#16#9C1D</td></tr>
</table></td></tr>
</table>

6.7.6 I_TO_DI (INT To DINT)

- **Description**

	Name	Usage	Group	
LD	I_TO_DI			☑ K5 ☑ K2
IL	I_TO_DI	I_TO_DI *IN, OUT*	U	

Operands	Input/Output	Data Type	Acceptable Memory Areas
IN	Input	INT	I, Q, M, V, L, SM, AI, AQ, T, C, Constant
OUT	Output	DINT	Q, M, V, L, SM

This instruction converts the input integer *IN* to a DINT value and assigns the result to *OUT*.

- **LD**

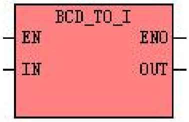
If *EN* is 1, this instruction is executed.

- **IL**

If CR is 1, this instruction is executed, and it does not influence CR.

6.7.7 BCD_TO_I (BCD To INT)

➢ **Description**

	Name	Usage	Group	
LD	BCD_TO_I			☑ K5 ☑ K2
IL	BCD _TO_I	BCD _TO_I *IN, OUT*	U	

Operands	Input/Output	Data Type	Acceptable Memory Areas
IN	Input	WORD	I, Q, M, V, L, SM, Constant
OUT	Output	INT	Q, M, V, L, SM, AQ

This instruction converts the input Binary-Coded Decimal value (*IN*) to an integer value and assigns the result to the *OUT*.

Note: The 8421 codes are adopted for the BCD code. The valid range of *IN* is 0 to 9999 BCD.

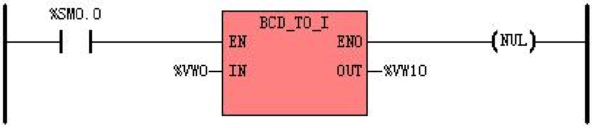
➢ **LD**

If *EN* is 1, this instruction is executed.

➢ **IL**

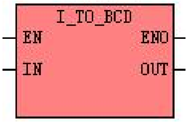
If CR is 1, this instruction is executed, and it does not influence CR.

- **Examples**

<table>
<tr><td>LD</td><td>
</td><td>SM0.0 is always 1, so BCD_TO_I is always be executed: converts VW0 from BCD to an integer and assigns it to VW10.</td></tr>
<tr><td>IL</td><td colspan="2">LD %SM0.0
BCD_TO_I %VW0, %VW10</td></tr>
<tr><td>Result</td><td colspan="2">The result is shown as the following:
<table><tr><th>VW0</th><th>VW10</th></tr><tr><td>16#99</td><td>99</td></tr><tr><td>16#4567</td><td>4567</td></tr><tr><td>16#9999</td><td>9999</td></tr></table></td></tr>
</table>

6.7.8 I_TO_BCD (INT To BCD)

➢ **Description**

	Name	Usage	Group	
LD	I_TO_BCD			☑ K5 ☑ K2
IL	I_TO_BCD	I _TO_BCD *IN, OUT*	U	

Operands	Input/Output	Data Type	Acceptable Memory Areas
IN	Input	INT	I, Q, M, V, L, SM, AI, AQ, T, C, Constant
OUT	Output	WORD	Q, M, V, L, SM

Note: If the Input parameter of I_TO_BCD exceeds the range, there will be an error. If the input is smaller than minimum value, plc considers it as minimum value, if the input is larger than maximum value; plc considers it as maximum value.

Note: BCD use 8421 code, the available range of input is from 0 to 9999.If the IN is smaller than 0, the result is 0, if IN is larger than 9999, the transform result is 9999 BCD. K5 CPU will also recode the overflow error

This instruction converts the input integer value (*IN*) to a Binary-Coded Decimal value and assigns the result to the *OUT*.

Note: The 8421 codes are adopted for the BCD code. The valid range of *IN* is 0 to 9999.

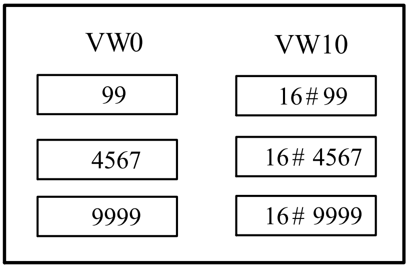
➢ **LD**

If *EN* is 1, this instruction is executed.

- **IL**

If CR is 1, this instruction is executed, and it does not influence CR.

- **Examples**

LD		SM0.0 is always 1, so I_TO_ BCD is always be executed: converts VW0 to a BCD value and assigns it to VW10.
IL	LD %SM0.0 I_TO_ BCD %VW0, %VW10	
Result	The result is shown as the following: 	

6.7.9 I_TO_A (INT To ASCII)

➢ **Description**

	Name	Usage	Group	
LD	I_TO_A			☑ K5 ☑ K2
IL	I_TO_A	I_TO_A IN, OUT, FMT	U	

Operands	Input/Output	Data Type	Acceptable Memory Areas
IN	Input	INT	I, Q, M, V, L, SM, AI, AQ, T, C, Constant
FMT	Input	BYTE	I, Q, M, V, L, SM
OUT	Output	BYTE	Q, M, V, L, SM

⚠**Note: the OUT parameter is memory block whose length is changeable. The whole block cannot be in the illegal area, or there will be unpredictable result。**

This instruction converts an integer value (*IN*) to an ASCII string, then formats the string according to *FMT* and put the result into the Output Buffer beginning with *OUT*. The conversion result of a positive value does not include any sign, and the conversion result of a negative value begins with a leading minus sign (-).

The *OUT* defines the starting address of the Output Buffer, which occupies a memory range of 8 successive bytes. In the buffer, the strings are right alignment, and the free bytes are filled with spaces (whose ASCII is 32).

The *FMT* is used to format the string, and the rules are shown in the figure below:

MSB							LSB
7	6	5	4	3	2	1	0
0	0	0	0	c	n	n	n

(1) *nnn* --- This field specifies the number of digits of the decimal part.
Its available rang is 0 to 5. 0 stands for no decimal part.
(2) *c* --- This field specifies the separator between the whole number and the fraction:
0 for a decimal point (whose ASCII is 46), and 1 for a comma(whose ASCII is 44).
(3) The upper 4 bits must be zero.

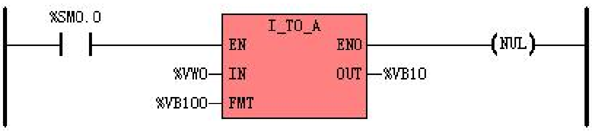
➢ **LD**

If *EN* is 1, this instruction is executed.

➢ **IL**

If CR is 1, this instruction is executed, and it does not influence CR.

➢ **Examples**

LD	 	SM0.0 is always 1, so the instruction I_TO_A is always executed: converts the value of VW0 to a string, and format the string and put the result to a buffer beginning with VB10.
IL	LD %SM0.0 I_TO_A %VW0, %VB10, %VB100	

Result

The result is as the following:

VB100	VW0	Result (VB10 … VB17)							
B#3	12	32	32	32	48	46	48	49	50
		‘ ’	‘ ’	‘ ’	‘0’	‘.’	‘0’	‘1’	‘2’
	-23456	32	45	50	51	46	52	53	54
		‘ ’	‘-’	‘2’	‘3’	‘.’	‘4’	‘5’	‘6’

6.7.10 DI_TO_A (DINT To ASCII)

- **Description**

	Name	Usage	Group	
LD	DI_TO_A			☑ K5 ☑ K2
IL	DI_TO_A	DI_TO_A IN, OUT, FMT	U	

Operands	Input/Output	Data Type	Acceptable Memory Areas
IN	Input	DINT	I, Q, M, V, L, SM, HC, Constants
FMT	Input	BYTE	I, Q, M, V, L, SM
OUT	Output	BYTE	Q, M, V, L, SM

Note: the OUT parameter is memory block whose length is changeable. The whole block cannot be in the illegal area, or there will be unpredictable result。

This instruction converts a DINT value (*IN*) to an ASCII string, then formats the string according to *FMT* and put the result into the Output Buffer beginning with *OUT*. The conversion result of a positive value does not include any sign, and the conversion result of a negative value begins with a leading minus sign (-).

The *OUT* defines the starting address of the Output Buffer, which occupies a memory range of 12 successive bytes. In the buffer, the strings are right alignment, and the free bytes are filled with spaces (whose ASCII is 32).

The *FMT* is used to format the string, and the rules are shown in the figure below:

MSB LSB

7	6	5	4	3	2	1	0
0	0	0	0	c	n	n	n

(1) *nnn* --- This field specifies the number of digits of the decimal part.
Its available rang is 0 to 5. 0 stands for no decimal part.

(2) *c* --- This field specifies the separator between the whole number and the fraction:
0 for a decimal point (whose ASCII is 46), and 1 for a comma(whose ASCII is 44).

(3) The upper 4 bits must be zero.

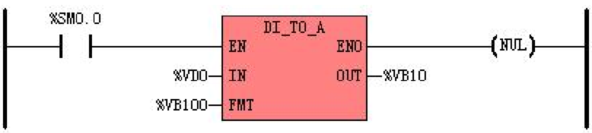
- **LD**

If *EN* is 1, this instruction is executed.

- **IL**

If CR is 1, this instruction is executed, and it does not influence CR.

- **Examples**

LD		SM0.0 is always 1, so the instruction DI_TO_A is always executed: Convert the value of VD0 to a string, and format the string and put it to a buffer beginning with VB10.
IL	LD %SM0.0 DI_TO_A %VD0, %VB10, %VB100	

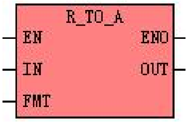
Result

The result is as the following:

VB100	VD0	Result (VB10 … VB21)											
B#3	DI#12	32	32	32	32	32	32	32	48	46	48	49	50
		‘ ’	‘ ’	‘ ’	‘ ’	‘ ’	‘ ’	‘ ’	‘0’	‘.’	‘0’	‘1’	‘2’
	DI#123456	32	32	32	32	45	49	50	51	46	52	53	54
		‘ ’	‘ ’	‘ ’	‘ ’	‘-’	‘1’	‘2’	‘3’	‘.’	‘4’	‘5’	‘6’

6.7.11 R_TO_A (REAL To ASCII)

- **Description**

	Name	Usage	Group	
LD	R_TO_A			☑ K5 ☑ K2
IL	R_TO_A	R_TO_A IN, OUT, FMT	U	

Operands	Input/Output	Data Type	Acceptable Memory Areas
IN	Input	REAL	V, L, Constants
FMT	Input	BYTE	I, Q, M, V, L, SM
OUT	Output	BYTE	Q, M, V, L, SM

Note: the OUT parameter is memory block whose length is changeable. The whole block cannot be in the illegal area, or there will be unpredictable result.

Note: this instruction takes a little long to run, if there are many R_TO_A in operation at the same time, it may trigger the watch dog, user can use WDR instruction to delay the watch dog time.

Note: If the input or output of this instruction exceeds the range, there will be an error. The whole output area will be filled by blank space. The range of input is from -2147480000 to 4294960000.

This instruction converts a REAL value (*IN*) to an ASCII string, then formats the string according to *FMT* and put the result into the Output Buffer beginning with *OUT*. The conversion result of a positive value does not include any sign, and the conversion result of a negative value begins with a leading minus sign (-). If the digits of the decimal part of *IN* is larger than the *nnn* in *FMT*, which specifies the digits of the decimal part in the string, then *IN* is round off before being converted. Otherwise, if it is less than *nnn*, the missing digits of the decimal part are filled with 0 in the string.

The *OUT* defines the starting address of the Output Buffer, whose size is specified in *FMT*. In the buffer, the strings are right alignment, and the free bytes are filled with spaces (whose ASCII is 32).

The *FMT* is used to format the string, and the rules are shown in the figure below:

MSB ... LSB

7	6	5	4	3	2	1	0
s	s	s	s	c	n	n	n

(1) *nnn* --- This field specifies the number of digits of the decimal part.
Its available rang is 0 to 5. 0 stands for no decimal part.

(2) *c* --- This field specifies the separator between the whole number and the fraction:
0 for a decimal point (whose ASCII is 46), and 1 for a comma(whose ASCII is 44).

(3) *ssss* --- This field specifies the size of the buffer.
Its available rang is 3 to 15, and it must be greater than *nnn*.

Note: If the length of the resulting string exceeds the length of the Output Buffer, then the whole buffer will be filled with spaces (whose ASCII is 32).

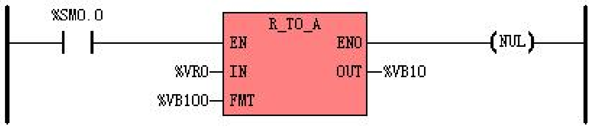
- **LD**

If *EN* is 1, this instruction is executed.

- **IL**

If CR is 1, this instruction is executed, and it does not influence CR.

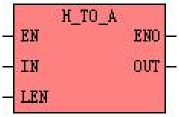
- **Examples**

LD		SM0.0 is always 1, so the instruction DI_TO_A is always executed: Convert the value of VR0 to a string, and format the string and put it to a buffer beginning with VB10.
IL	LD %SM0.0 R_TO_A %VR0, %VB10, %VB100	
Result	The result is as the following:	

VB100	VR0	Result VB10							VB17
B#16#83	123.4	32	49	50	51	46	52	48	48
		‘ ’	‘1’	‘2’	‘3’	‘.’	‘4’	‘0’	‘0’
	-123.4567	45	49	50	51	46	52	53	55
		‘-’	‘1’	‘2’	‘3’	‘.’	‘4’	‘5’	‘7’

6.7.12 H_TO_A (Hexadecimal To ASCII)

➢ **Description**

	Name	Usage	Group	
LD	H_TO_A			☑ K5 ☑ K2
IL	H_TO_A	H_TO_A IN, OUT, LEN	U	

Operands	Input/Output	Data Type	Acceptable Memory Areas
IN	Input	BYTE	I, Q, M, V, L, SM
LEN	Input	BYTE	I, Q, M, V, L, SM, Constants
OUT	Output	BYTE	Q, M, V, L, SM

Note: the IN,OUT parameter is memory block whose length is changeable. The whole block cannot be in the illegal area, or there will be unpredictable result.

This instruction converts the number *LEN* of hexadecimal digits, beginning with *IN*, to an ASCII string, and put the string into the Output Buffer beginning with *OUT*.

Note: Every 4 binary digits makes 1 hexadecimal digit, so every input byte includes 2 hexadecimal digits, and so the size of the Output Buffer occupies is *LEN**2 bytes.

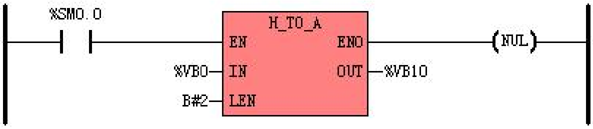
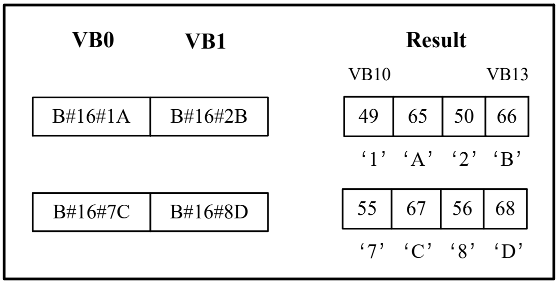
➢ **LD**

If *EN* is 1, this instruction is executed.

➢ **IL**

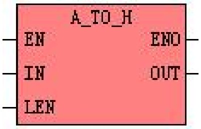
If CR is 1, this instruction is executed, and it does not influence CR.

➢ **Examples**

LD		SM0.0 is always 1, so H_TO_A is always executed: converts 2-bytes hexadecimal digits, beginning with VB0, to a string and put the result into the buffer which occupies 4 continuous bytes beginning with VB10.
IL	LD %SM0.0 H_TO_A %VB0, %VB10, B#2	
Result	The result is as the following: 	

6.7.13 A_TO_H (ASCII to Hexadecimal)

➢ **Description**

	Name	Usage	Group	
LD	A_TO_H			☑ K5 ☑ K2
IL	A_TO_H	A_TO_H IN, OUT, LEN	U	

Operands	Input/Output	Data Type	Acceptable Memory Areas
IN	Input	BYTE	I, Q, M, V, L, SM
LEN	Input	BYTE	I, Q, M, V, L, SM, Constants
OUT	Output	BYTE	Q, M, V, L, SM

Note: the IN,OUT parameter is memory block whose length is changeable. The whole block cannot be in the illegal area, or there will be unpredictable result.

This instruction converts the number *LEN* of ASCII characters, beginning with *IN*, to hexadecimal digits, and put the digits into the Output Buffer beginning with *OUT*. Note:Every 4 binary digits makes 1 hexadecimal digit, so every input byte, which stands for an ASCII character, occupies 4 binary digits of memory space (i.e., a half byte) in the Output Buffer.

The valid ASCII input range is: B#16#30 to B#16#39 (stands for the characters 0 to 9), B#16#41 to B#16#46 (stands for the characters A to F), B#16#61 to B#16#66 (stands for the characters a to f).

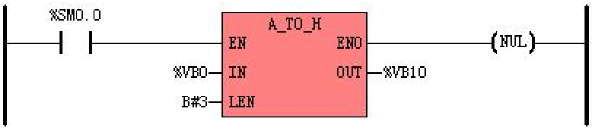
➢ **LD**

If *EN* is 1, this instruction is executed.

- **IL**

If CR is 1, this instruction is executed, and it does not influence CR.

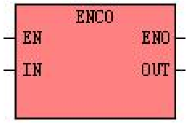
- **Examples**

<table>
<tr><td>LD</td><td>
</td><td>SM0.0 is always 1, so A_TO_H is always executed: converts the 3-bytes ASCII string, beginning with VB0, to hexadecimal digits, and put the result into the Output Buffer beginning with VB100.</td></tr>
<tr><td>IL</td><td colspan="2">LD %SM0.0
A_TO_H %VB0, %VB10, B#3</td></tr>
<tr><td>Result</td><td colspan="2">The result is as the following:

<table>
<tr><th>VB0</th><th>VB1</th><th>VB2</th><th>VB10</th><th>VB11</th></tr>
<tr><td>51
‘3’</td><td>56
‘8’</td><td>54
‘6’</td><td>B#16#38</td><td>B#16#6x</td></tr>
<tr><td>55
‘7’</td><td>65
‘A’</td><td>49
‘1’</td><td>B#16#7A</td><td>B#16#1x</td></tr>
</table>
Note: x stands for this half byte (4 bits) keeps the original value.</td></tr>
</table>

6.7.14 ENCO (Encoding)

- **Description**

	Name	Usage	Group	
LD	ENCO			☑ K5 ☑ K2
IL	ENCO	ENCO IN, OUT	U	

Operands	Input/Output	Data Type	Acceptable Memory Areas
IN	Input	WORD	I, Q, M, V, L, SM, Constant
OUT	Output	BYTE	Q, M, V, L, SM

This instruction checks the input Word *IN* from the least significant bit, and writes the bit number of the first bit equal to 1 into the output byte *OUT*. Note: If the value of *IN* is 0, the result is meaningless.

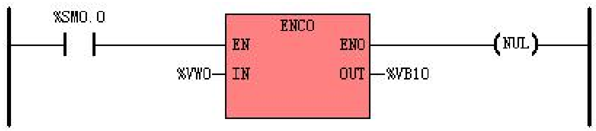
- **LD**

If *EN* is 1, this instruction is executed.

- **IL**

If CR is 1, this instruction is executed, and it does not influence CR.

➢ **Examples**

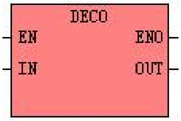
LD		SM0.0 is always 1, so ENCO is always executed: writes the bit number of the first bit equal to 1 into VB10.
IL	LD %SM0.0 ENCO %VW0, %VB10	
Result	The result is as the following:	

VW0 / **VB10**

(MSB) 15			12			9					4				0 (LSB)	VB10
0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	B#9
0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	B#4

6.7.15 DECO (Decoding)

- **Description**

	Name	Usage	Group	
LD	DECO			☑ K5 ☑ K2
IL	DECO	DECO IN, OUT	U	

Operands	Input/Output	Data Type	Acceptable Memory Areas
IN	Input	BYTE	I, Q, M, V, L, SM, Constant
OUT	Output	WORD	Q, M, V, L, SM

This instruction sets the bit in the output word *OUT* that corresponds to the bit number represented by the least significant "nibble" (4 bits) of the input byte *IN*. All other bits in the *OUT* are reset.

- **LD**

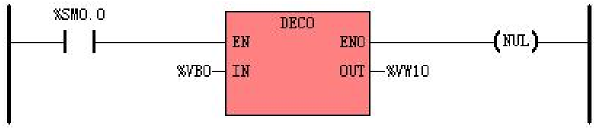
If *EN* is 1, this instruction is executed.

- **IL**

If CR is 1, this instruction is executed, and it does not influence CR.

➢ **Examples**

LD



SM0.0 is always 1, so DECO is always executed: sets the bit in VW10 which corresponds to the bit number represented by the least significant "nibble" of VB0.

IL

```
LD        %SM0.0
DECO      %VB0, %VW10
```

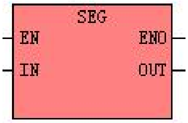
Result

The result is as the following:

VB0	**VW10** (MSB) 15						9					4				0 (LSB)
B#9	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
B#16#D4	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0

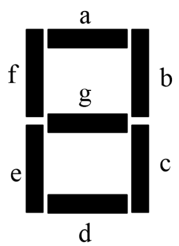
6.7.16 SEG (7-segment Display)

➢ **Description**

	Name	Usage	Group	
LD	SEG			☑ K5 ☑ K2
IL	SEG	SEG IN, OUT	U	

Operands	Input/Output	Data Type	Acceptable Memory Areas
IN	Input	BYTE	I, Q, M, V, L, SM, Constant
OUT	Output	BYTE	Q, M, V, L, SM

This instruction generates a bit pattern of a 7-segment display according to the value represented by the least significant "nibble" (4 bits) of the input byte *IN*, and then put the result into the *OUT*.



IN (LSD)	Display	*OUT* (- g f e d c b a)	*IN* (LSD)	Display	*OUT* (- g f e d c b a)
0	0	0 0 1 1 1 1 1 1	8	8	0 1 1 1 1 1 1 1
1	1	0 0 0 0 0 1 1 0	9	9	0 1 1 0 0 1 1 1
2	2	0 1 0 1 1 0 1 1	A	A	0 1 1 1 0 1 1 1
3	3	0 1 0 0 1 1 1 1	B	B	0 1 1 1 1 1 0 0
4	4	0 1 1 0 0 1 1 0	C	C	0 0 1 1 1 0 0 1
5	5	0 1 1 0 1 1 0 1	D	D	0 1 0 1 1 1 1 0
6	6	0 1 1 1 1 1 0 1	E	E	0 1 1 1 1 0 0 1
7	7	0 0 0 0 0 1 1 1	F	F	0 1 1 1 0 0 0 1

➢ **LD**

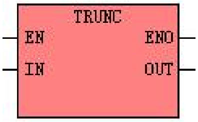
If *EN* is 1, this instruction is executed.

➢ **IL**

If CR is 1, this instruction is executed, and it does not influence CR.

6.7.17 TRUNC (Truncate)

➢ **Description**

	Name	Usage	Group	
LD	TRUNC			☑ K5 ☑ K2
IL	TRUNC	TRUNC *IN, OUT*	U	

Operands	Input/Output	Data Type	Acceptable Memory Areas
IN	Input	REAL	V, L, Constant
OUT	Output	DINT	M, V, L, SM

This instruction converts the REAL value *IN* to a DINT value and assigns the result to the *OUT*. The decimal part of *IN* is truncated off.

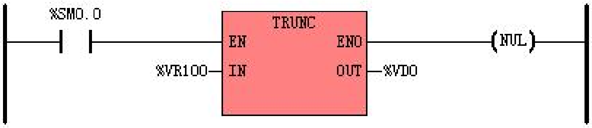
➢ **LD**

If *EN* is 1, this instruction is executed.

➢ **IL**

If CR is 1, this instruction is executed, and it does not influence CR.

➢ **Examples**

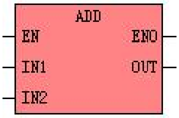
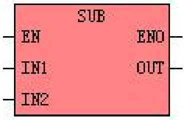
LD		SM0.0 is always 1, so TRUNC is always executed: truncates off the fraction of VR100, then converts the result to a DINT value and assigns it to VD0.
IL	LD %SM0.0 TRUNC %VR100, %VD0	
Result	The result is as the following:	

VR100	VD0
123.4	DI#123
5213.6	DI#5213

6.8 Numeric Instructions

6.8.1 ADD and SUB

➢ **Description**

<table>
<tr><th></th><th>Name</th><th>Usage</th><th>Group</th><th rowspan="5">☑ K5
☑ K2</th></tr>
<tr><td rowspan="2">LD</td><td>ADD</td><td></td><td rowspan="2"></td></tr>
<tr><td>SUB</td><td></td></tr>
<tr><td rowspan="2">IL</td><td>ADD</td><td>ADD IN1, OUT</td><td rowspan="2">U</td></tr>
<tr><td>SUB</td><td>SUB IN1, OUT</td></tr>
</table>

Operands	Input/Output	Data Type	Acceptable Memory Areas
IN1	Input	INT, DINT, REAL	I, Q, AI, AQ, M, V, L, SM, T, C, HC, constant, Pointer
IN2	Input	INT, DINT, REAL	I, Q, AI, AQ, M, V, L, SM, T, C, HC, constant, Pointer
OUT	Output	INT, DINT, REAL	Q, AQ, M, V, L, SM, Pointer

➢ **LD**

The *IN1*, *IN2* and *OUT* must be of the same data type.

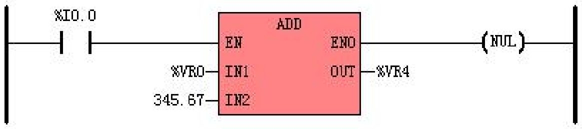
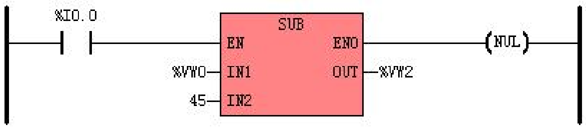
If *EN* is 1, the role that the *ADD* instruction plays is: *OUT=IN1+IN2*, and the role that the *SUB* instruction plays is: *OUT=IN1-IN2*.

➢ **IL**

The *IN1* and *OUT* must be of the same data type.

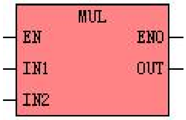
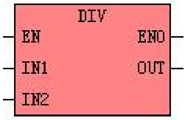
If CR is 1, the role that the *ADD* instruction plays is: *OUT=OUT+IN1*, and the role that the *SUB* instruction plays is: *OUT=OUT - IN1*. The *ADD* and *SUB* instructions won't influence CR.

- **Examples**

LD		If I0.0 is 0: *ADD* isn't executed. If I0.0 is 1: The instruction adds VR0 and 345.67, and assigns the result to VR4.
		If I0.0 is 0: *SUB* isn't executed. If I0.0 is 1: The instruction subtracts 45 from VW0, and assigns the result to VW2.
IL	LD %I0.0 ADD 345.67, %VR4	(* CR is created with I0.0 *) (* If CR is 1: VR4 = VR0 +345.67 *) (* If CR is 0: the instruction isn't executed *)
	LD %I0.0 SUB 45, %VW2	(* CR is created with I0.0 *) (* If CR is 1: VW2 = VW0 - 45 *) (* If CR is 0: the instruction isn't executed *)

6.8.2 MUL and DIV

➢ **Description**

	Name	Usage	Group	
LD	MUL			☑ K5 ☑ K2
	DIV			
IL	MUL	MUL IN1, OUT	U	
	DIV	DIV IN1, OUT		

Operands	Input/Output	Data Type	Acceptable Memory Areas
IN1	Input	INT, DINT, REAL	I, Q, AI, AQ, M, V, L, SM, T, C, HC, constant, Pointer
IN2	Input	INT, DINT, REAL	I, Q, AI, AQ, M, V, L, SM, T, C, HC, constant, Pointer
OUT	Output	INT, DINT, REAL	Q, AQ, M, V, L, SM, Pointer

⚠ **Note: If the divisor is 0, there will be an error, the output keeps the last calculated value, PLC will also recode the "divisor is 0" error.**

➢ **LD**

The *IN1*, *IN2* and *OUT* must be of the same data type.

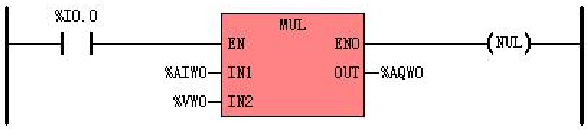
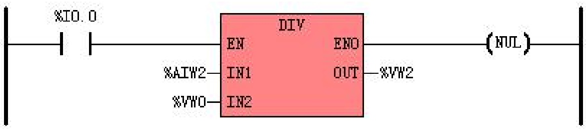
If *EN* is 1, the role that the *MUL* instruction plays is: *OUT=IN1×IN2*, and the role that the *DIV* instruction plays is: *OUT=IN1÷IN2*.

- **IL**

The *IN1* and *OUT* must be of the same data type.

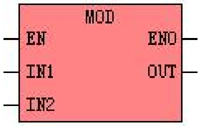
If CR is 1, the role that the *MUL* instruction plays is: *OUT=OUT×IN1*, and the role that the *DIV* instruction plays is: *OUT=OUT ÷ IN1*. The *MUL* and *DIV* instructions won't influence CR.

- **Examples**

LD		If I0.0 is 0: *MUL* isn't executed. If I0.0 is 1: The instruction multiplies AIW0 and VW0, and assigns the result to AQW0.
		If I0.0 is 0: *DIV* isn't executed. If I0.0 is 1: The instruction divides AIW2 by VW0, and assigns the result to VW2.
IL	LD %I0.0 MUL %AIW0, %VW0	(* CR is created with I0.0 *) (* If CR is 1: VW0 = VW0 × AIW0 *) (* If CR is 0: the instruction isn't executed *)
	LD %I0.0 DIV %AIW2, %VW0	(* CR is created with I0.0 *) (* If CR is 1: VW0 = VW0 ÷ AIW2 *) (* If CR is 0: the instruction isn't executed *)

6.8.3 MOD (Modulo-Division)

- **Description**

	Name	Usage	Group	
LD	MOD			☑ K5 ☑ K2
IL	MOD	MOD *IN1*, *OUT*	U	

Operands	Input/Output	Data Type	Acceptable Memory Areas
IN1	Input	BYTE, INT, DINT	I, Q, AI, AQ, M, V, L, SM, T, C, HC, constant, Pointer
IN2	Input	BYTE, INT, DINT	I, Q, AI, AQ, M, V, L, SM, T, C, HC, constant, Pointer
OUT	Output	BYTE, INT, DINT	Q, AQ, M, V, L, SM, Pointer

Note: If the divisor is 0, there will be an error, the output keeps the last calculated value, PLC will also recode the “divisor is 0” error.

- **LD**

The *IN1*, *IN2* and *OUT* must be of the same data type.

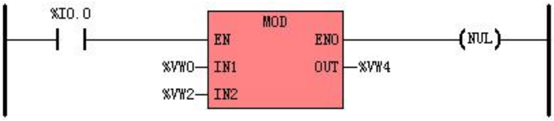
If *EN* is 1, this instruction divides *IN1* by *IN2,* and assigns the remainder to *OUT*.

- **IL**

The *IN1* and *OUT* must be of the same data type.

If CR is 1, this instruction divides *OUT* by *IN1,* and assigns the remainder to *OUT*. It does not influence CR.

➢ **Examples**

<table>
<tr><td>LD</td><td>
</td><td>If I0.0 is 0: MOD is not executed.
If I0.0 is 1: VW0 is divided by VW2, and the remainder is assigned to VW4.</td></tr>
<tr><td>IL</td><td colspan="2">LD %I0.0 (* CR is created with I0.0 *)
MOD %VW0, %VW4 (* If CR is 1: VW4 is divided by VW0, and the remainder is still stored in VW4 *)
(* If CR is 0: this instruction is not executed *)</td></tr>
<tr><td>Result</td><td colspan="2">For the LD example, if MOD instruction is executed, the result is shown as the following:

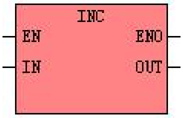
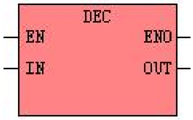
Address: VW0 = 8, VW2 = 3
Address: VW4 = 2</td></tr>
</table>

Address	VW0	VW2
Value	8	3

Address	VW4
Value	2

6.8.4 INC and DEC

➢ **Description**

	Name	Usage	Group	
LD	INC			☑ K5 ☑ K2
	DEC			
IL	INC	INC *OUT*	U	
	DEC	DEC *OUT*		

Operands	Input/Output	Data Type	Acceptable Memory Areas
IN	Input	BYTE, INT, DINT	I, Q, AI, AQ, M, V, L, SM, T, C, HC, constant, Pointer
OUT	Output	BYTE, INT, DINT	Q, AQ, M, V, L, SM, Pointer

➢ **LD**

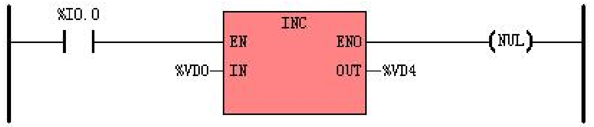
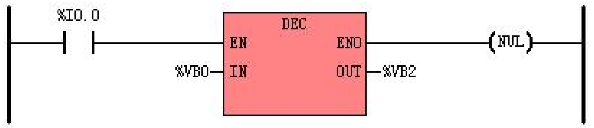
The *IN* and *OUT* must be of the same data type.

If *EN* is 1, the role that the *INC* instruction plays is: *OUT = IN + 1*, and the role that the *DEC* instruction plays: *OUT = IN - 1*.

➢ **IL**

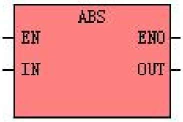
If CR is 1, the role that the *INC* instruction plays is: *OUT=OUT+1*, and the role that the *DEC* instruction plays: *OUT = OUT - 1*. They do not influence CR.

- **Examples**

LD		If I0.0 is 0: *INC* isn't executed. If I0.0 is 1: VD4 = VD0 + DI#1.
		If I0.0 is 0: *DEC* isn't executed. If I0.0 is 1: VB2 = VB0 – B#1.
IL	LD %I0.0 (* CR is created with I0.0 *) INC %VD4 (* If CR is 1: VD4 =VD4 + DI#1 *) (* If CR is 0: this instruction isn't executed *)	
	LD %I0.0 (* CR is created with I0.0 *) DEC %VB2 (* If CR is 1: VB2 = VB2 - B#1 *) (* If CR is 0: this instruction isn't executed *)	

6.8.5 ABS (Absolute Value)

➢ **Description**

	Name	Usage	Group	
LD	ABS			☑ K5 ☑ K2
IL	ABS	ABS IN, OUT	U	

Operands	Input/Output	Data Type	Acceptable Memory Areas
IN	Input	INT, DINT, REAL	I, Q, V, M, L, SM, T, C, AI, AQ, HC, Constant, Pointer
OUT	Output	INT, DINT, REAL	Q, V, M, L, SM, AQ, Pointer

The *IN* and *OUT* must be of the same data type.

This instruction calculates the absolute value of the input *IN*, and assigns the result to *OUT*, as shown in the following formula: *OUT* = |*IN*|.

➢ **LD**

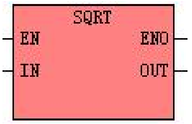
If *EN* is 1, this instruction is executed.

➢ **IL**

If CR is 1, this instruction is executed, and it does not influence CR.

6.8.6 SQRT (Square Root)

➢ **Description**

	Name	Usage	Group	
LD	SQRT			☑ K5 ☑ K2
IL	SQRT	SQRT *IN*, *OUT*	U	

Operands	Input/Output	Data Type	Acceptable Memory Areas
IN	Input	REAL	V, L, Constant, Pointer
OUT	Output	REAL	V, L, Pointer

Note: If the SQRT is minus value, there will be an error; the output keeps the last calculated value. Check the definition of real data 0 in **3.2 Data Format 3.4 Constant.**

This instruction calculates the square root of the input *IN*, and assigns the result to *OUT*, as shown in the following formula: $OUT = \sqrt{IN}$.

Note: If the IN parameter is 0, there will be an error, the output keeps the last calculated value, K5 CPU will also recode the error**.**

➢ **LD**

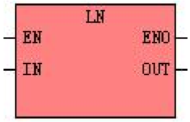
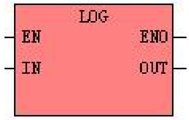
If *EN* is 1, this instruction is executed.

➢ **IL**

If CR is 1, this instruction is executed, and it does not influence CR.

6.8.7 LN (Natural Logarithm), LOG (Common Logarithm)

➢ **Description**

	Name	Usage	Group	
LD	LN			☑ K5 ☑ K2
	LOG			
IL	LN	LN *IN*, *OUT*	U	
	LOG	LOG *IN*, *OUT*		

Operands	Input/Output	Data Type	Acceptable Memory Areas
IN	Input	REAL	V, L, Constant, Pointer
OUT	Output	REAL	V, L, Pointer

Note: If the LN or LOG is 0 or minus value, there will be an error, the output keeps the last calculated value. Check the definition of real data 0 in 3.2 Data Format 3.4 Constant.

The LN instruction calculates the natural logarithm of the input *IN*, and assigns the result to *OUT*, as shown in the following formula: $OUT = \log_e(IN)$.

The LOG instruction calculates the common logarithm of the input *IN*, and assigns the result to *OUT*, as shown in the following formula: $OUT = \log_{10}(IN)$.

Note: If the IN parameter is 0 or negative, there will be an error, the output keeps the last calculated value, K5 CPU will also recode the error**.**

➢ **LD**

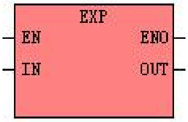
If *EN* is 1, this instruction is executed.

- **IL**

If CR is 1, this instruction is executed, and it does not influence CR.

6.8.8 EXP (Exponent with the base e)

- **Description**

	Name	Usage	Group	
LD	EXP			☑ K5 ☑ K2
IL	EXP	EXP IN, OUT	U	

Operands	Input/Output	Data Type	Acceptable Memory Areas
IN	Input	REAL	V, L, Constant, Pointer
OUT	Output	REAL	V, L, Pointer

This instruction calculates the exponent with the base e of the input *IN*, and assigns the result to *OUT*, as shown in the following formula: $OUT = e^{IN}$.

- **LD**

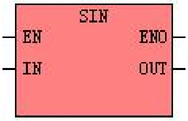
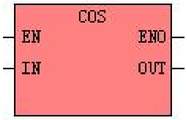
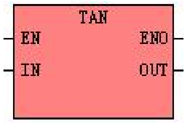
If *EN* is 1, this instruction is executed.

- **IL**

If CR is 1, this instruction is executed, and it does not influence CR.

6.8.9 SIN (sine), COS (cosine), TAN (tangent)

- **Description**

	Name	Usage	Group	
LD	SIN			☑ K5 ☑ K2
	COS			
	TAN			
IL	SIN	SIN IN, OUT	U	
	COS	COS IN, OUT		
	TAN	TAN IN, OUT		

Operands	Input/Output	Data Type	Acceptable Memory Areas
IN	Input	REAL	V, L, Constant, Pointer
OUT	Output	REAL	V, L, Pointer

IN indicates radian value.

The SIN instruction calculates the sine value of the input *IN*, and assigns the result to *OUT*, as shown in the following formula: *OUT* = SIN (*IN*).

The COS instruction calculates the cosine value of the input *IN*, and assigns the result to *OUT*, as shown in the following formula: *OUT* = COS (*IN*).

The TAN instruction calculates the tangent value of the input *IN*, and assigns the result to *OUT*, as shown in the following formula: *OUT* = TAN (*IN*).

- **LD**

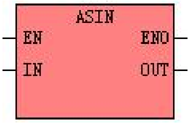
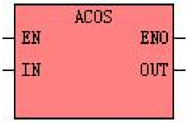
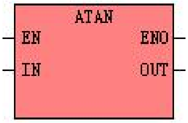
If *EN* is 1, this instruction is executed.

- **IL**

If CR is 1, this instruction is executed, and it does not influence CR.

6.8.10 ASIN (arc-sine), ACOS (arc-cosine), ATAN (arc-tangent)

➢ **Description**

	Name	Usage	Group	
LD	ASIN			☑ K5 ☑ K2
	ACOS			
	ATAN			
IL	ASIN	ASIN IN, OUT	U	
	ACOS	ACOS IN, OUT		
	ATAN	ATAN IN, OUT		

Operands	Input/Output	Data Type	Acceptable Memory Areas
IN	Input	REAL	V, L, Constant, Pointer
OUT	Output	REAL	V, L, Pointer

The ASIN instruction calculates the arc-sine value of the input *IN*, and assigns the result to *OUT*, as shown in the following formula: *OUT* = ARCSIN (*IN*).

The ACOS instruction calculates the arc-cosine value of the input *IN*, and assigns the result to *OUT*, as shown in the following formula: *OUT* = ARCCOS (*IN*).

The ATAN instruction calculates the arc-tangent value of the input *IN*, and assigns the result to *OUT*, as shown in the following formula: *OUT* = ARCTAN (*IN*).

IN indicates radian value.

- **LD**

If *EN* is 1, this instruction is executed.

- **IL**

If CR is 1, this instruction is executed, and it does not influence CR.

6.9 Program Control

In IL, jump instructions and return instructions do not influence CR, so CR shall remain unchanged just after a jump or return instruction is executed, and you need pay more attention when using them.

6.9.1 LBL and JMP Instructions

➢ **Description**

	Name	Usage	Group	
LD	LBL	lbl —(LBL)—		☑ K5 ☑ K2
	JMP	lbl —(JMP)—		
	JMPC	lbl —(JMPC)—		
	JMPCN	lbl —(JMPCN)—		
IL	Label	lbl:	U	
	JMP	JMP *lbl*		
	JMPC	JMPC *lbl*		
	JMPCN	JMPCN *lbl*		

Operand	Description
lbl	Valid identifier

Note: the lbl number in JMP instruction must be available and in the same program as this instruction.

This instruction may take long time to run, it may trigger the watch dog, and user can use WDR instruction to delay the watch dog time. Make sure the condition of JMP is not in endless loop.

- **LD**

The *LBL* instruction is used to define a label at the current position, and the label will function as the destination for the jump instructions. Redefinition of a label identifier is forbidden. This instruction is executed unconditionally, so you need not add any elements on its left. Actually, KincoBuilder will ignore all the elements on its left.

The *JMP* instruction is used to unconditionally transfer program execution to the network label specified by *lbl*.

The *JMPC* instruction is used to transfer program execution to the network label specified by *lbl* when the horizontal link state on its left is true.

The *JMPCN* instruction is used to transfer program execution to the network label specified by *lbl* when the horizontal link state on its left is false.

The jump instruction and its destination label must always exist within the same POU.

- **IL**

The definition format of a label is ***a legal identifier:*** The definition occupies an independent line. Redefinition of a label identifier is forbidden.

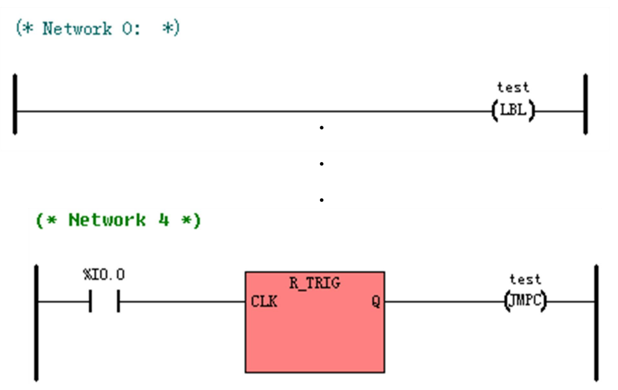
The *JMP* instruction is used to unconditionally transfer program execution to the label specified by *lbl*.

The *JMPC* instruction is used to transfer program execution to the label specified by *lbl* when CR is 1.

The *JMPCN* instruction is used to transfer program execution to the label specified by *lbl* when CR is 0.

The jump instruction and its destination label must always exist within the same POU.

➢ **Examples**

LD	IL
	(* NETWORK 0 *) test: … (* NETWORK 4 *) LD %I0.0 R_TRIG JMPC test

6.9.2 Return Instructions

Notice: Return instructions can only be used in subroutines and interrupt routines.

- **Description**

<table>
<tr><th></th><th>Name</th><th>Usage</th><th>Group</th><th></th></tr>
<tr><td rowspan="2">LD</td><td>RETC</td><td>—(RETC)—</td><td rowspan="2"></td><td rowspan="4">☑ K5
☑ K2</td></tr>
<tr><td>RETCN</td><td>—(RETCN)—</td></tr>
<tr><td rowspan="2">IL</td><td>RETC</td><td>RETC</td><td rowspan="2">U</td></tr>
<tr><td>RETCN</td><td>RETCN</td></tr>
</table>

- **LD**

The *RETC* instruction is used to terminate a subroutine or an interrupt routine and transfer program execution back to the calling entry when the horizontal link state on its left is true.

The *RETCN* instruction is used to terminate a subroutine or an interrupt routine and transfer program execution back to the calling entry when the horizontal link state on its left is false.

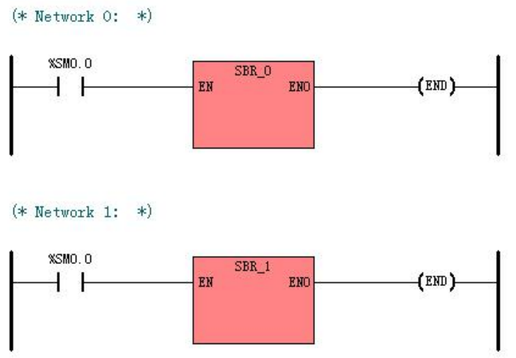
- **IL**

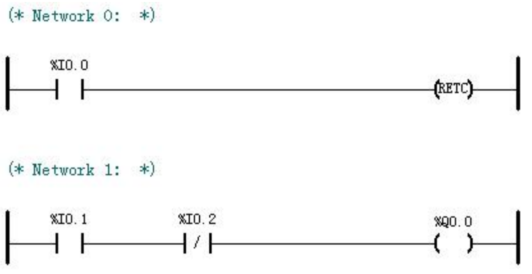
The *RETC* instruction is used to terminate a subroutine or an interrupt routine and transfer program execution back to the calling entry when CR is 1.

The *RETCN* instruction is used to terminate a subroutine or an interrupt routine and transfer program execution back to the calling entry when CR is 0.

Note: the execution of return instruction does not affect the CR value. If it is necessary, user should build new CR value before the return point to avoid the program execution error.

➢ **Examples**

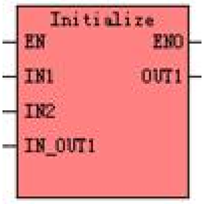
<table>
<tr>
<td>LD</td>
<td>Main program:


Subroutine SBR_0:

</td>
<td>For SBR_0:
If I0.0 is 0, the instructions are executed sequentially.
If I0.0 is 1, program execution is transferred back to the calling entry in the main program, and the KINCO-K5 continues to execute the instructions in Network 1.</td>
</tr>
<tr>
<td>IL</td>
<td colspan="2">Main Program:
LD %SM0.0 (* CR is created with SM0.0 *)
CAL SBR_0 (* Call SBR_0 *)
CAL SBR_1 (* Call SBR_1 *)

SBR_0:
LD %I0.0 (* CR is created I0.0 *)
RETC (* If CR is 1, SBR_0 shall be terminate and program execution is transferred *)
(* back to the calling entry in the main program. *)
LD %I0.1 (* If RETC is not executed, the subsequent instructions are to be executed *)
ANDN %I0.2
ST %Q0.0</td>
</tr>
</table>

6.9.3 CAL (Call a subroutine)

➢ **Description**

	Name	Usage	Group	
LD	CAL			☑ K5 ☑ K2
IL	CAL	CAL subroutine, subroutine 1, subroutine 2, …	U	

This instruction is used for calling and executing a subroutine with the specified *NAME*. The subroutine to be called must exist in the user program already.

You can use a CAL instruction with or without parameters.If a CAL instruction is used with parameters, the data type and the variable type of the actual parameters, must match those of the formal parameters which are defined in the Local Variable Table of the called subroutine. Also, the order of the actual parameters must be the same as that of the the formal parameters.

➢ **LD**

All the names of the subroutines appear in the group [**SBR**] of the [**LD instructions**] tree. Double click on a name, then the corresponding subroutine is added into you program. If *EN* is 1, this subroutine is executed.

➢ **IL**

If CR is 1, the subroutine will be called and executed.

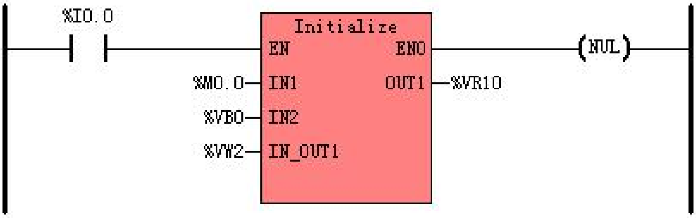
The CAL instruction does not influence CR, but CR may be changed in the subroutine.

➢ **Examples**

LD

Main program:

(* Network 0 *)
(* call the subroutine 'Initialize' *)



The Local Variable Table of the subroutine 'Initialize':

Address	Symbol	Var Type	Data Type	Comment
%L0.0	IN1	VAR_INPUT	BOOL	
%LB16	IN2	VAR_INPUT	BYTE	
%LW22	IN_OUT1	VAR_IN_OUT	INT	
%LD18	OUT1	VAR_OUTPUT	REAL	

In main program:

If I0.0= 0， it jumps the subroutine, and continues to execute following instructions sequentially.

If I0.0=1， it will call and execute subroutine “Initialize”.

IL

Main Program:

(* Network 0 *)

(*call the subroutine 'Initialize'*)

LD %I0.0 (*CR is created with SM0.0 *)

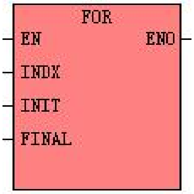
CAL Initialize, %M0.0, %VB0, %VW2, %VR10 (*If CR is 1, Call and execute the Intialize *)

The Local Variable Table of the subroutine 'Initialize':

Address	Symbol	Var Type	Data Type	Comment
%L0.0	IN1	VAR_INPUT	BOOL	
%LB16	IN2	VAR_INPUT	BYTE	
%LW22	IN_OUT1	VAR_IN_OUT	INT	
%LD18	OUT1	VAR_OUTPUT	REAL	

6.9.4 FOR/NEXT (FOR/NEXT Loop)

- **Description**

	Name	Usage	Group	
LD	FOR			☑ K5 ☑ K2
	NEXT			
IL	FOR	FOR INDX, INIT, FINAL	U	
	NEXT	NEXT		

Operands	Input/Output	Data Type	Acceptable Memory Areas
INDX	Input	INT	M, V, L, SM
INIT	Input	INT	M, V, L, SM, T, C, Constant
FINAL	Output	INT	M, V, L, SM, T, C, Constant

⚠ **This instruction may take long time to run, it may trigger the watch dog, and user can use WDR instruction to delay the watch dog time.**

⚠ **Note: the FINAL parameter cannot equal to 32767 and INIT must smaller than or equal to FINAL, for example:**

INIT = 0, FINAL = 0, execute 1 time;

INIT = -1, FINAL = 0, execute 2 times;

INIT = 32766, FINAL = 32766, execute 1 time;

INIT = -32768, FINAL = -32767, execute 2 times;

INIT = 0, FINAL = 32766, execute 32767 times;

INIT = -32768, FINAL = 32766, execute 65535 times;

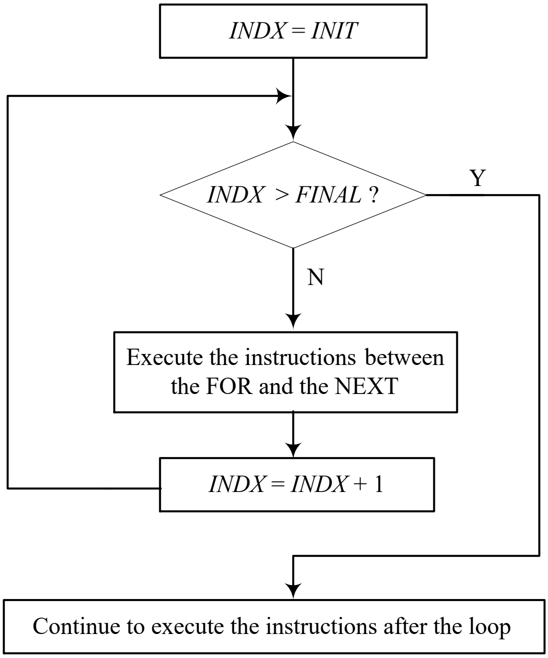
INIT = 3, FINAL = 2, Do not execute; （Error, INIT is larger than FINAL）.

The FOR/NEXT instructions express a loop that is repeated for the specified count. You specify the loop count (*INDX*), the starting value (*INIT*), and the ending value (*FINAL*).

The NEXT instruction marks the end of the loop, and the FOR instruction executes the instructions between the FOR and the NEXT. They must be used in pairs, each FOR instruction requires a NEXT instruction.

If a FOR/NEXT loop exists within another FOR/NEXT loop, it is called a nested loop. You can nest FOR/NEXT loops to a depth of eight.

The execution process of the FOR/NEXT loop is shown in the following figure:



When using the FOR/NEXT instructions, you need to notice the following details:

- The FOR instruction must be the 2nd instruction within a Network.
- The NEXT instruction must monopolize a Network.
- You can change the final value from within the loop itself to change the end condition of the loop.

- A loop, which needs to execute for a long time that exceed the CPU's watchdog time, can leads to the CPU restarting.

- **LD**

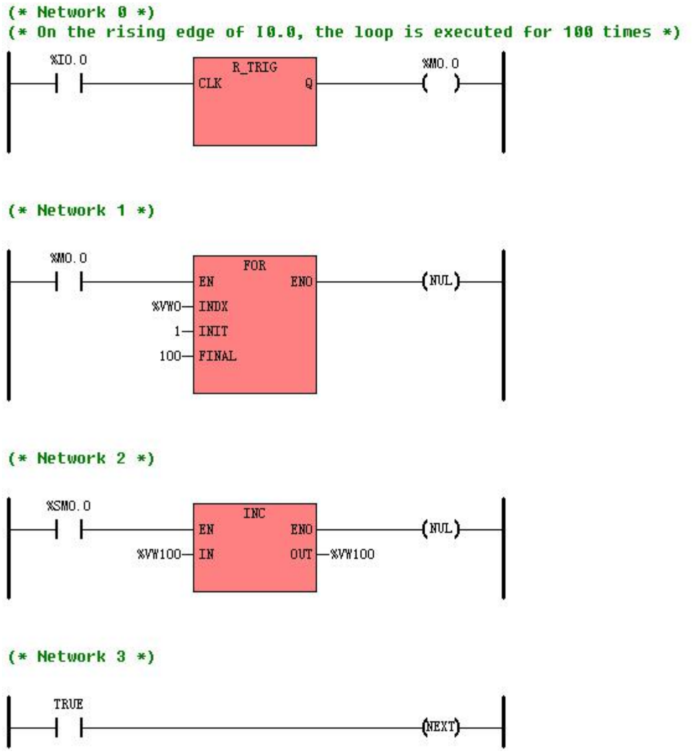
If *EN* is 1, this instruction is executed.

- **IL**

If CR is 1, this instruction is executed, and it does not influence CR.

- **Example**

LD



IL	(* Network 0 *) (*On the rising edge of I0.0, the loop is executed for 100 times*) LD %I0.0 R_TRIG ST %M0.0 (* Network 1 *) LD %M0.0 FOR %VW0, 1, 100 (* Network 2 *) LD %SM0.0 INC %VW100 (* Network 3 *) LD TRUE NEXT

6.9.5 END (Terminate the scan cycle)

- **Description**

	Name	Usage	Group	
LD	END			☑ K5 ☑ K2
IL	END	END	U	

This instruction can only be used in the main program, for terminating the current scan cycle.

At the end of the main program, KincoBuilder automatically calls the END instruction implicitly.

- **LD**

If the horizontal link state on its left is 1, this instruction is executed. Otherwise, this instruction does not take effect.

- **IL**

If CR is 1, this instruction will be executed. Otherwise, this instruction does not take effect.

This instruction does not influence CR.

6.9.6 STOP (Stop the CPU)

➢ **Description**

	Name	Usage	Group	
LD	STOP	—(STOP)—		☑ K5 ☑ K2
IL	STOP	STOP	U	

This instruction terminates the execution of your program and turns the CPU from RUN into STOP mode immediately.

➢ **LD**

If the horizontal link state on its left is 1, this instruction is executed. Otherwise, this instruction does not take effect.

➢ **IL**

If CR is 1, this instruction is executed. Otherwise, this instruction does not take effect.

This instruction does not influence CR.

6.9.7 WDR (Watchdog Reset)

➢ **Description**

	Name	Usage	Group	
LD	WDR	—(WDR)—		☑ K5 ☑ K2
IL	WDR	WDR	U	

This instruction re-triggers the system watchdog timer of the CPU.

Using the WDR instructin can increase the time that the scan cycle is allowed to take without leading to a watchdog error, so the program that needs longer time can be executed successfully. But you should use this instruction carefully, because the following processes are inhibited until the scan cycle is completed:

- ➢ CPU self-diagnosis
- ➢ Read the inputs (sample all the physical input channels and writes these values to the input image areas)
- ➢ Communication
- ➢ Write to the outputs (write the values stored in the output image areas to the physical output channels)
- ➢ Timing for the 10-ms and 100-ms timers

➢ **LD**

If the horizontal link state on its left is 1, this instruction is executed. Otherwise, this instruction does not take effect.

➢ **IL**

If CR is 1, this instruction is executed. Otherwise, this instruction does not take effect.

This instruction does not influence CR.

6.10 Interrupt Instructions

The purpose of using interrupt technique is to increase the execution efficiency of the Kinco-K5 to quickly respond to special internal or external predefined events. The Kinco-K5 supports tens of events each of which is assigned with a unique event number.

6.10.1 How K5 handles Interrupt Routines

An interrupt routine is executed once only on each occurrence of the interrupt event associated with it. Once the last instruction of the interrupt routine has been executed, program execution is transferred back to the main program. You can exit the routine by executing a *RETC* or *RETCN* instruction.
Interrupt technique makes the Kinco-K5 respond to special events quickly, so you should optimize interrupt routines to be short and efficient.

6.10.2 Interrupt Priority and Queue

Different events are on different priority levels. When interrupt events occur, they will queue up according to their priority levels and time sequence: the interrupt events in the same priority group are handled following the principle of "first come, first served"; the events in the higher priority group are handled preferentially. Only one interrupt routine can be executed at one point in time. Once an interrupt routine begins to be executed, it cannot be interrupted by another interrupt routine. Interrupt events that occur while another interrupt routine is being executed are queued up for later handling.

6.10.3 Types of Interrupt Events Supported by the Kinco-K5

The Kinco-K5 supports the following types of interrupt events:

- Communication Port Interrupts

This type of interrupts has the highest priority.

They are used for free-protocol communication mode. The Receive and Transmit interrupts facilitate you to fully control the communication. Please refer to the Transmit and Receive instructions for detailed information.

- I/O Interrupts

This type of interrupts has a medium priority.

These interrupt include rising/falling edge interrupts, HSC interrupts and PTO interrupts.

The rising/falling edge interrupts can only be trapped by the first four DI channels (%I0.0~%I0.3) on the CPU body. Each of them can be used to notify that the signal state has changed and the PLC must respond immediately.

The HSC interrupts occur when the counting value reaches the preset value, the counting direction changes or the counter is reset externally. Each of them allows the PLC respond in real time to high-speed events that cannot be responded immediately at scan speed.

The PTO interrupts occur immediately when outputting the specified number of pulses is completed. A typical application is to control the stepper motor.

- Time Interrupts

This type of interrupts has the lowest priority.

These interrupt include timed interrupts and the timer T2 and T3 interrupts.

The timed interrupts occur periodically (unit: 0.1ms), and they can be used for periodical tasks. **(the period of these interrupts period will not be affected by plc scanning time.)**

The timer interrupt occurs immediately when the current value of T2 or T3 reaches the preset value. It can be used to timely respond to the end of a specified time interval. **(the period of these interrupts period will be affected by plc scanning time.)**

6.10.4 Interrupt Events List

Event No.	Description	Type
34	PORT 2: XMT complete	Communication

33	PORT 2: RCV complete	Port Interrupts
32	PORT 1: XMT complete	
31	PORT 1: RCV complete	
30	PORT 0: XMT complete	
29	PORT 0: RCV complete	
28~27	Reserved	I/O Interrupts
26	I0.0, Falling edge	
25	I0.0, Rising edge	
24	I0.1, Falling edge	
23	I0.1, Rising edge	
22	I0.2, Falling edge	
21	I0.2, Rising edge	
20	I0.3, Falling edge	
19	I0.3, Rising edge	
18	HSC0 CV=PV	
17	HSC0 direction changed	
16	HSC0 external reset	
15	HSC1 CV=PV	
14	HSC1 direction changed	
13	HSC1 external reset	
12~5	Reserved	
4	Timed interrupt 1. Its period is specified in SMD16, unit: 0.1ms.**(Doesn't be affected by scan cycle)**	Time Interrupts
3	Timed interrupt 0. Its period is specified in SMD12, unit: 0.1ms. **(Doesn't be affected by scan cycle)**	
2	Timer T3 ET=PT**(Doesn't be affected by scan cycle)**	
1	Timer T2 ET=PT**(Doesn't be affected by scan cycle)**	

Table 6-1 Interrupt Events

The Event 3 and 4(timed interrupt 1 and 2) are not affected by plc scanning time. But they are affected by higher priority hardware interrupts. The timed time of these two interrupts is normally a little long. So when they are used in velocity or flow measuring application, user can make some

compensation according to actual situation.

he Event 3 and 4(timed interrupt 1 and 2) are affected by plc scanning time, if user needs accurate timing , please use EVNT 3 and 4.

6.10.5 ENI (Enable Interrupt), DISI (Disable Interrupt)

- **Description**

	Name	Usage	Group	
LD	ENI	—(ENI)—		☑ K5 ☑ K2
	DISI	—(DISI)—		
IL	ENI	ENI	U	
	DISI	DISI		

The ENI instruction globally enables processing all attached interrupt events.

The DISI instruction globally inhibits processing all interrupt events.

ENI and DISI just execute once.

All interrupts are enabled being processed by default.

- **LD**

If the horizontal link state on its left is 1, the instruction is executed. Otherwise, the instruction does not take effect.

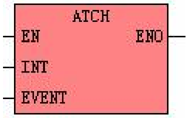
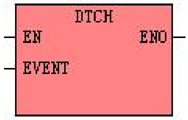
- **IL**

If CR is 1, the instruction is executed. Otherwise, the instruction does not take effect.

The instruction does not influence CR.

6.10.6 ATCH and DTCH Instructions

➢ **Description**

	Name	Usage	Group	
LD	ATCH			☑ K5 ☑ K2
	DTCH			
IL	ATCH	ATCH INT, EVENT	U	
	DTCH	DTCH EVENT		

Operands	Input/Output	Data Type	Description
INT	Input	Identifier	The name of an existing interrupt routine
EVENT	Input	INT	Constant, an interrupt event No.

➢ **LD**

If *EN* is 1, the *ATCH* instruction attaches an interrupt event (specified by the event number *EVENT*) to the interrupt routine (specified by the routine name *INT*) and enables the interrupt event. After this instruction is executed, the interrupt routine shall be invoked automatically on the occurrence of the interrupt event. You can attach several events to one interrupt routine, but one event can only be attached to one interrupt routine.

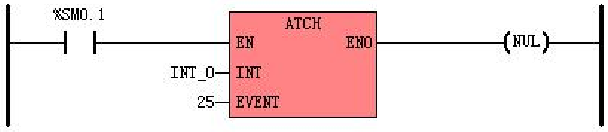
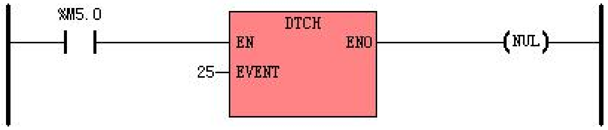
If *EN* is 1, the *DTCH* instruction breaks the attachment between the interrupt event (specified by the event number *EVENT*) and its interrupt routine, and makes the interrupt event return to be disabled.

➢ **IL**

If CR is 1, the *ATCH* instruction attaches an interrupt event (specified by the event number *EVENT*) to the interrupt routine (specified by the routine name *INT*) and enables the interrupt event. This instruction does not influence CR.

If CR is 1, the *DTCH* instruction breaks the attachment between the interrupt event (specified by the event number *EVENT*) and its interrupt routine, and makes the interrupt event return to be disabled. This instruction does not influence CR.

➤ **Examples**

LD	(* Network 0 *) (* On the first scan, No.25 event is enabled and attached to INT_0 routine *)  (* Network 1 *) (* If M5.0 is 1, disable No.25 event *) 
IL	(* NETWORK 0 *) LD %SM0.1 ATCH INT_0, 25 (*On the first scan, No.25 event is enabled and attached to INT_0 routine *) LD %M5.0 (* CR is created with M5.0 *) DTCH 25 (*If CR is 1, disable No.25 event *)

6.11 Clock Instructions

A real-time clock (RTC) is built in the CPU module for real-time clock/calendar indication. The real-time clock/calendar adopts BCD-format coding through second to year, automatically executes leap-year adjustment and uses the super capacitor as backup. At normal temperature, the duration of the super capacitor is 3 years.

6.11.1 Adjusting the RTC online

You should adjust the RTC to the current actual time and date before using it. Before adjustment, the value of the RTC may be random.

Execute the [**PLC**]>[**Time of Day Clock…**] menu command to open the "Time of Day Clock…" dialog to adjust the RTC online, as shown in the following figure.

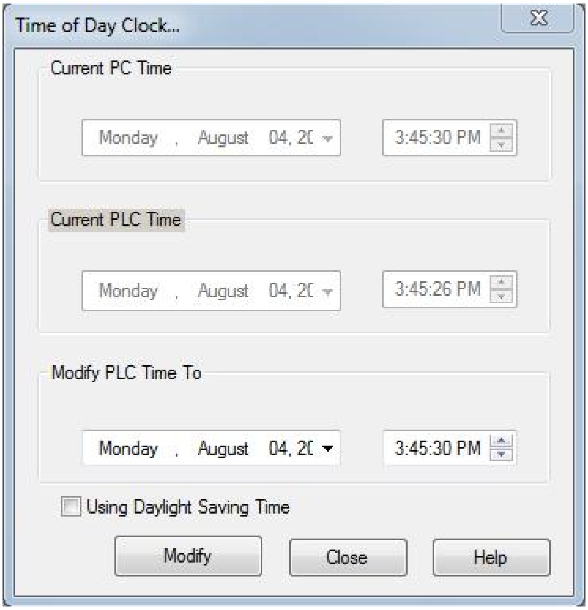


Figure 6-1 Adjusting the RTC

- **Current PC Time**: Indicate the current date and time of the current PC.
- **Current PLC Time**: Indicate the current date and time of the RTC of the online CPU module. Its

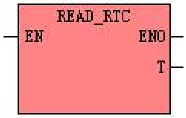
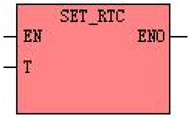
background being green indicates that the CPU module communicates with the PC successfully, and its background being yellow indicates the CPU module fails to communicate with the PC.

- **Modify PLC Time To**: You can enter the desired date and time for the RTC here. Enter them through keyboard, or click the arrowhead at the right end of the relevant box to select the date or adjust the time.
- **Adopt Summer Time**: You may click this item when needed
- **Modify**: Click this button, the date and time you have entered shall be written into the CPU module, and then the RTC shall be adjusted to the desired date and time.

NOTE: If Summer Time is adopted it is required to reboot Kincobuilder to take effect.

6.11.2 READ_RTC and SET_RTC

- **Description**

	Name	Usage	Group	
LD	READ_RTC			☐ CPU504 ☑ CPU504EX ☑ CPU506 ☑ CPU506EA ☑ CPU508 ☑ K2
	SET_RTC			
IL	READ_RTC	READ_RTC *T*	U	
	SET_RTC	SET_RTC *T*		

Operands	Input/Output	Data Type	Acceptable Memory Areas
T	Input (SET_RTC)	BYTE	V
	Output (READ_RTC)		

Note: the T parameter is memory block whose length is changeable. The whole block cannot be in the illegal area, or there will be unpredictable result.

The *READ_RTC* instruction is used to read the current date and time from the RTC and write them to an 8-byte time buffer beginning with address *T*.

The *SET_RTC* instruction is used to write the date and time specified by the 8-byte time buffer beginning with address *T* to the RTC.

The storage format of the date and time in the time buffer is shown in the following table.

Note: All the values are of BCD coding.

V Byte	Meaning	Remark
T	Week	Range: 1~7, thereof 1 represents Monday, 7 represents Sunday.
T+1	Second	Range: 0~59
T+2	Minute	Range: 0~59
T+3	Hour	Range: 0~23
T+4	Day	Range: 1~31
T+5	Month	Range: 1~12
T+6	Year	Range: 0~99
T+7	Century	Fixed as 20

Table 6-2 The Time Buffer

Notice:

- **You are recommended to adjust the RTC correctly using [PLC]>[Time of Day Clock…] menu command before using it.**
- **Because the CPU module won't check the validity of the date and time you have entered and invalid data (e.g. Feb 30) will be accepted. Therefore, you have to ensure the validity of the date/time you have entered.**

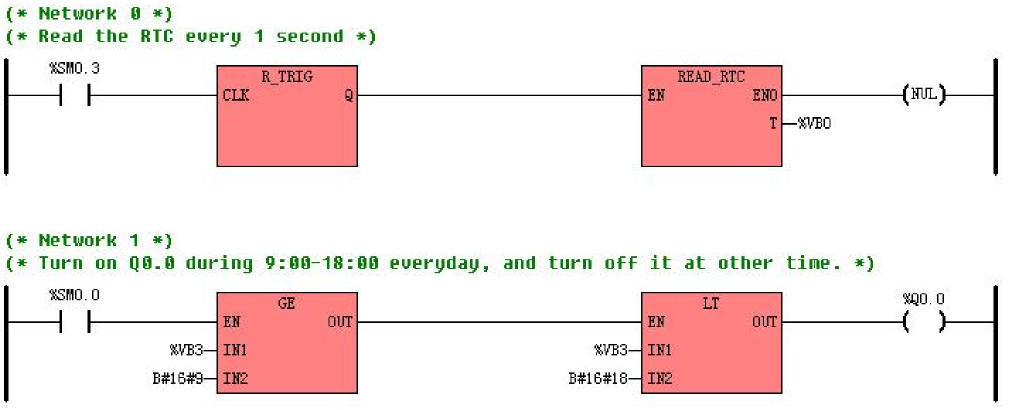
- **LD**

If *EN* is 1, this instruction is executed.

➢ **IL**

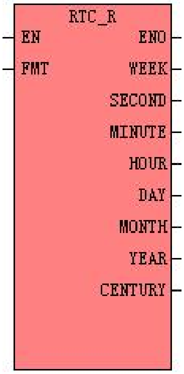
If CR is 1, this instruction is executed, and it does not influence CR.

➢ **Examples**

LD	
IL	(* Network 0 *) (*Read the RTC every 1 second*) LD %SM0.3 R_TRIG READ_RTC %VB0 (* Network 1 *) (*Turn on Q0.0 during 9:00-18:00 everyday, and turn off it at other time.*) LD %SM0.0 GE %VB3, B#16#9 LT %VB3, B#16#18 ST %Q0.0

6.11.3 RTC_R

➢ **Description**

	Name	Usage	Group	
LD	RTC_R			☐ CPU504 ☑ CPU504EX ☑ CPU506 ☑ CPU506EA ☑ CPU508 ☑ K2
IL	RTC_R	RTC_R *FMT, WEEK, SECOND, MINUTE, HOUR, DAY, MONTH, YEAR, CENTURY*	U	

Operands	Input/Output	Data Type	Acceptable Memory Areas
FMT	Input	BYTE	L, M, V, Constants
WRRK	Output	BYTE	L, M, V
SECOND	Output	BYTE	L, M, V
MINUTE	Output	BYTE	L, M, V
HOUR	Output	BYTE	L, M, V
DAY	Output	BYTE	L, M, V
MONTH	Output	BYTE	L, M, V
YEAR	Output	BYTE	L, M, V
CENTURY	Output	BYTE	L, M, V

You may refer to the table below to see the parameters:

Operands	Description
EN	Enable
FMT	Output Format. 0 represents decimal and 1 represents BCD code
WRRK	Week. 1-7 represents Mon to Sun
SECOND	Second, ranging from 0-59
MINUTE	Minute, ranging from 0-59
HOUR	Hour, ranging from 0-23
DAY	Day, ranging from 1-31
MONTH	Month, ranging from 1-12
YEAR	Year, ranging from 0-99
CENTURY	Century, a fixed value of 20

The *RTC_R* instruction is used to read the current date and time from the RTC and write them into the corresponding output parameters.

FMT represents the format of each parameter; 0 represents decimal and 1 represents BCD code.

- **LD**

If EN is 1, this instruction is executed.

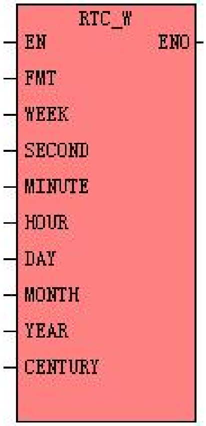
- **IL**

If CR is 1, this instruction is executed.

This instruction will not affect CR value.

6.11.4 RTC_W

- **Description**

	Name	Usage	Group	
LD	RTC_W			□ CPU504 ☑ CPU504EX ☑ CPU506 ☑ CPU506EA ☑ CPU508 ☑ K2
IL	RTC_W	RTC_W *FMT, WEEK, SECOND, MINUTE, HOUR, DAY, MONTH, YEAR, CENTURY*	U	

Operands	Input/Output	Data Type	Acceptable Memory Areas
FMT	Input	BYTE	L, M, V, Constants
WRRK	Input	BYTE	L, M, V , Constants
SECOND	Input	BYTE	L, M, V, Constants
MINUTE	Input	BYTE	L, M, V, Constants
HOUR	Input	BYTE	L, M, V, Constants
DAY	Input	BYTE	L, M, V, Constants
MONTH	Input	BYTE	L, M, V, Constants
YEAR	Input	BYTE	L, M, V, Constants
CENTURY	Input	BYTE	L, M, V, Constants

FMT, WEEK, SECOND, MINUTE, HOUR, DAY, MONTH, YEAR and CENTURY must be constant or memory register at the same time. You may refer to the table below to see the parameters:

Operands	Description
EN	Enable
FMT	Output Format. 0 represents decimal and 1 represents BCD code
WRRK	Week. 1-7 represents Mon to Sun
SECOND	Second, ranging from 0-59
MINUTE	Minute, ranging from 0-59
HOUR	Hour, ranging from 0-23
DAY	Day, ranging from 1-31
MONTH	Month, ranging from 1-12
YEAR	Year, ranging from 0-99
CENTURY	Century, a fixed value of 20

The *RTC_W* instruction is used to write the date and time specified by the corresponding input parameters into the RTC.

the FMT represents the format of each parameter; 0 represents decimal and 1 represents BCD code.

- **LD**

If EN is 1, this instruction is executed.

- **IL**

If CR is 1, this instruction is executed.

This instruction will not affect CR value.

6.12 Communication Instructions

6.12.1 Free-protocol Communication

These instructions are used for free-protocol communication. Free-protocol communication mode allows your program to entirely control the communication ports of the CPU. You can use free-protocol communication mode to implement user-defined communication protocols to communicate with all kinds of intelligent devices. ASCII and binary protocols are both supported.

The CPU module is integrated with 1, 2 or 3 communication ports, each of that serves as a default Modbus RTU slave. After the communication instructions are executed, free-protocol communication mode shall be activated, involving no manual operation.

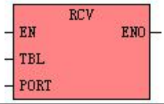
You can configure the communication parameters (such as Baudrate, Parity, etc) of each port in the Hardware Window. Please refer to 4.3.4.1 Parameters of the CPU for detailed information.

The general procedure to execute the Free-protocol Communication programming:

- Set the port communication parameter (including station number, baud rate, even-odd check, etc.) of the communication port of the 【**PLC Hardware Configuration**】. For more detail please refer to 4.3.4.1 Parameters of the CPU.
- Set the free communication control register (see definition in following clauses). NOTE: the control register must be set ready in prior.
- Call XMT and RCV command and program as status register and communication interruption of the free communication.

6.12.2 XMT and RCV

- **Description**

	Name	Usage	Influence	
LD	XMT			☑ K5 ☑ K2
	RCV			
IL	XMT	XMT TBL, PORT	U	
	RCV	RCV TBL, PORT		

Operands	Input/Output	Data Type	Acceptable Memory Areas
TBL	Input	BYTE	I, Q, M, V, L, SM
PORT	Input	INT	Constant (0 to 2)

Note: the TBL parameter is memory block whose length is changeable. The whole block cannot be in the illegal area, or there will be unpredictable result.

The *XMT* instruction is used to transmit the data stored in a data buffer through the communication port specified by *PORT* in free-protocol communication mode. The data buffer begins with address *TBL*, and the first byte specifies the number of bytes to be transmitted, then followed with the effective data. If SM87.1=1, when the CPU has transmitted the last character in the data buffer, there will automatically occur a XMT-complete interrupt event (the event number is 30 for PORT 0, and 32 for PORT 1). If the number of bytes to be transmitted is set to be 0, the *XMT* instruction won't execute any operation, and of course, the interrupt event won't occur.

The *RCV* instruction is used to receive data through the communication port specified by *PORT* in free-protocol communication mode, and the data received shall be stored in a data buffer. The data buffer begins with address

TBL, and the first byte specifies the number of bytes received, then followed with the effective data received. You must specify a Start and and End condition for the *RCV* operation. If SM87.1=1, when the CPU completes receiving (disregarding normal or abnormal completion), there will automatically occur a RCV-complete interrupt event (the event number is 29 for PORT 0, and 31 for PORT 1).

In LD, the *EN* input decides whether to execute the *XMT* and *RCV* instructions. If EN is 1 then XMT and RCV instructions will be executed and vice versa;

In IL, CR decides whether to execute the *XMT* and *RCV* instructions. If CR is 1 then XMT and RCV instructions will be executed and vice versa; they won't influence CR.

- Status Registers and Control Registers in SM area for Free-protocol Communication

Besides XMT and RCV instructions, some status registers and control registers in SM area are provided for free-protocol communication. Your program can read and write to these registers to interpret the communication status and control the communication. The following is the brief summary of status bytes and control words.

- **SMB86 --- Receive Status Register**

Bit (read-only)			Status	Description
PORT 0	PORT 1	PORT 2		
SM86.0	SM186.0	SM286.0	1	A parity error is detected, but receive shall not be terminated.
SM86.1	SM186.1	SM286.1	1	Receive was terminated because of receiving the maximum character number.
SM86.2	SM186.2	SM286.2	1	Receive was terminated because of receiving a character Overtime.
SM86.3	SM186.3	SM286.3	1	Receive was terminated because of System Overtime.
SM86.4	SM186.4	SM286.4	-	Reserved.
SM86.5	SM186.5	SM286.5	1	Receive was terminated because of receiving the user-defined End character.
SM86.6	SM186.6	SM286.6	1	Receive was terminated because of the errors in the parameters or missing the Start or End condition.
SM86.7	SM186.7	SM286.7	1	Receive was terminated because of the user disable command.

- **SMB87 --- Receive Control Register**

Bit			Status	Description
PORT 0	PORT 1	PORT 2		
SM87.0	SM187.0	SM287.0	-	Reserved.
SM87.1	SM187.1	SM287.1	0	Disenable XMT-complete and RCV-complete interrupts.
			1	Enable XMT-complete and RCV-complete interrupts.
SM87.2	SM187.2	SM287.2	0	Ignore SMW92/ SMW192/SMW292.
			1	Terminate receive if the time in SMW92/ SMW192/SMW292 is exceeded while receiving a character.
SM87.3	SM187.3	SM287.3	-	Reserved.
SM87.4	SM187.4	SM287.4	0	Ignore SMW90/ SMW190/ SMW290.
			1	Turn to effective receive if the time interval in SMW90/ SMW190/SMW290 is exceeded.
SM87.5	SM187.5	SM287.5	0	Ignore SMB89/ SMB189/ SMB289.
			1	Enable the user-defined End character in SMB89/ SMB189/ SMB289.
SM87.6	SM187.6	SM287.6	0	Ignore SMB88/ SMB188/ SMB288.
			1	Enable the user-defined Start character in SMB88/SMB188/ SMB288
SM87.7	SM187.7	SM287.7	0	Disenable RCV function. This condition prevails over any other conditions.
			1	Enable RCV function.

- **Other Control Registers**

PORT 0	PORT 1	PORT 2	Description
SMB88	SMB188	SMB288	To store the user-defined receive Start character. After executing the *RCV* instruction, the CPU turns into effective receive state when the Start character is received, and the previously received data will be rejected. CPU takes the Start character as the first effective byte received. SM87.6/ SM187.6/ SM287.6 should be set to be 1 to enable SMB88/

			SMB188/ SMB288.
SMB89	SMB189	SMB289	To store the user-defined receive End character. The CPU will take this character as the last effective byte received. When the character is received, the CPU will immediately terminate receive disregarding any other End conditions. SM87.5/ SM187.5/ SM287.5 should be set to be 1 to enable SMB89/ SMB189/ SMB289.
SMW90	SMW190	SMW290	To store the user-defined receive Ready time (Range: 1~60,000ms). After executing the *RCV* instruction and passing through this time interval, the CPU will automatically turn into effective receive state disregarding whether the Start character is received or not. Thereafter, the data received shall be effective. SM87.4/SM287.4/ SM287.4 should be set to be 1 to enable SMW90/ SMW190/ SMW290.
SMW92	SMW192	SMW292	To store the user-defined receiving a character Overtime (Range: 1~60,000ms). After executing the *RCV* instruction and turning into effective receive state, if no character is received within this time interval, the CPU will terminate receive disregarding any other End condition. SM87.2/SM187.2/SM287.2 should be set to be 1 to enable SMW92/ SMW192/ SMW292.
SMW94	SMW194	SMW294	To store the maximum number of characters to be received (1~255). The CPU will immediately terminate receive as soon as the maximum effective characters are received disregarding any other End conditions. If this value is set to be 0, the *RCV* instruction will return directly.

In free-protocol communication mode, there is a default System Receive Overtime (90 seconds). This overtime value functions as the following: After executing the *RCV* instruction, the CPU will immediately terminate receive if no data is received during this time interval. Besides, when the CPU turns into effective receive state, it will use the value of the receiving a character Overtime defined in SMW92 first, and if no valid value is in SMW92, the value of System Receive Overtime will be used as a substitute.

- Communication Interruption

Kinco-K5 offers variable interruption for free communications. If you would like to know more detail information, please refer to 6.10.1 How the Kinco K5 Handle Interruption Routines.

You may use SM87.1, SM187.1 or SM287.1 to allow or forbid CPU to interrupt communication. The interruption control set to 1 represent an allow routine; CPU will generate an interruption of sending completion when complete send the last word in buffer area; CPU will generate an interruption of receive completion when quit receiving (regardless of normal or abnormal quit).

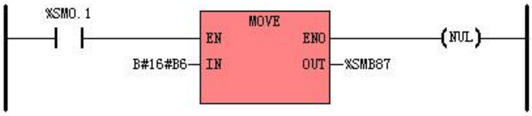
- **Examples**

Examples are given below to illustrate the application of the free-protocol communication mode. In the example, the CPU will receive a character string, taking **RETURN** character as the receive End character; if receive is completed normally, the data received is transmitted back and receive is restarted, if receive is completed abnormally (e.g. because of communication errors, time out, etc), the data received will be ignored and receive will be restarted.

LD

MAIN Program:

(* Network 0 *)
(* The following program is to initialize free-protocol communication.
At first,configure the Start and End conditions of the effective Receive state. *)

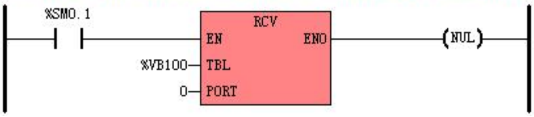


(* Network 1 *)
(* The receive Ready time is set to be 10ms,
The receive End character is set to be RETURN character whose ASCII is 13. *)

(* Network 2 *)
(* The receiving a character Overtime is set to be 500ms,
The maximum number of characters to be received is set to be 100. *)

(* Network 3 *)
(* Attach the RCV-complete event to the EndReceiver routine,
Attach the XMT-complete event to the EndSendroutine *)

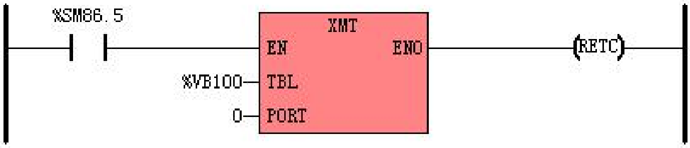
(* Network 4 *)
(* Start the Receive task once on the first scan. *)



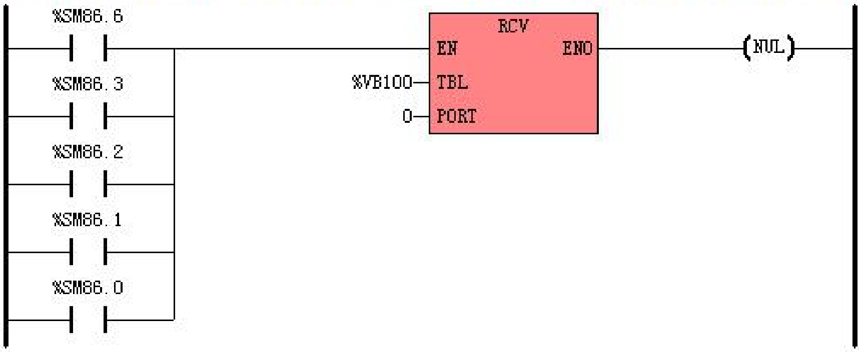
LD

EndReceive (INT00): The RCV-complete interrupt routine

(* Network 0 *)
(* If receiving the receive End character,
then transmit bach the data received and return. *)

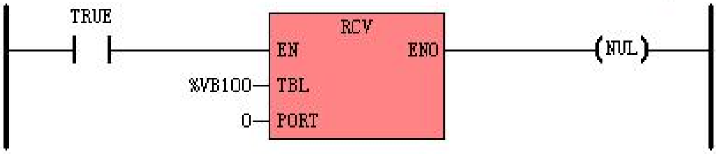


(* Network 1 *)
(* if receive is completed abnormally, then restart receive. *)



EndSend (INT01): XMT-complete interrupt routine

(* Network 0 *)
(* Restart receive after the transmition is completed. *)



IL	**MAIN Program:**
	
	(* Network 0 *)
	(* The following program is to initialize free-protocol communication. *)
	(* At first, configure the Start and End conditions of the effective Receive state. *)
	LD %SM0.1
	MOVE B#16#B6, %SMB87
	
	(* Network 1 *)
	(* The receive Ready time is set to be 10ms, *)
	(* The receive End character is set to be RETURN character whose ASCII is 13. *)
	LD %SM0.1
	MOVE 10, %SMW90
	MOVE B#16#D, %SMB89
	
	(* Network 2 *)
	(* The receiving a character Overtime is set to be 500ms, *)
	(* The maximum number of characters to be received is set to be 100. *)
	LD %SM0.1
	MOVE 500, %SMW92
	MOVE B#100, %SMB94
	
	(* Network 3 *)
	(* Attach the RCV-complete event to the EndReceiver routine, *)
	(* Attach the XMT-complete event to the EndSendroutine *)
	LD %SM0.1
	ATCH EndReceive, 29
	ATCH EndSend, 30
	
	(* Network 4 *)
	(* Start the Receive task once on the first scan. *)
	LD %SM0.1
	RCV %VB100, 0

	EndReive (INT00): The RCV-complete interrupt routine (* Network 0 *) (* If receiving the receive End character, then transmit bach the data received and return. *) LD %SM86.5 XMT %VB100, 0 RETC (* Network 1 *) (* if receive is completed abnormally, then restart receive. *) LD %SM86.6 OR %SM86.3 OR %SM86.2 OR %SM86.1 OR %SM86.0 RCV %VB100, 0
	EndSend (INT01): XMT-complete interrupt routine (* Network 0 *) (* Restart receive after the transmition is completed. *) LD TRUE RCV %VB100, 0

6.12.3 Modbus RTU Master Instructions

The Modbus RTU protocol is widely used in the industrial field. The KINCO-K5 provides the Modbus RTU Master instructions, and you can call them directly to make the KINCO-K5 as a Modbus RTU master.

Note: these instructions are supported by PORT1 and PORT2.

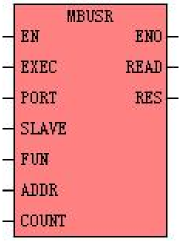
The general steps of the Modbus master programming are described as followings:

- Configure the communication parameters of Port1 in the **Hardware** Window. Please refer to 2.6 How to modify the CPU's communication parameters and 4.3.4.1 Parameters of the CPU for more details.
- Call the instructions MBUSR and MBUSW in the program.

  Please refer to Appendix A 2、Basic Report Format of Modbus RTU Protocal for more details about Modbus RTU.

6.12.3.1 MBUSR (Modbus RTU Master Read)

- **Description**

	Name	Usage	Group	☐ CPU504 ☑ CPU504EX ☑ CPU506 ☑ CPU506EA ☑ CPU508 ☑ K2
LD	MBUSR			
IL	MBUSR	MBUSR *EXEC, PORT, SLAVE, FUN, ADDR, COUNT, READ, RES*	U	

Operands	Input/Output	Data Type	Acceptable Memory Areas
EXEC	Input	BYTE	I, Q, V, M, L, SM, RS, SR
PORT	Input	INT	Constant (0~2)
SLAVE	Input	BYTE	I, Q, M, V, L, SM, Constant
FUN	Input	INT	Constant (MODBUS function code)
ADDR	Input	INT	I, Q, M, V, L, SM, AI, AQ, Constant
COUNT	Input	INT	I, Q, M, V, L, SM, AI, AQ, Constant
READ	Output	BOOL, WORD, INT	Q, M, V, L, SM, AQ
RES	Output	BYTE	Q, M, V, L, SM

The "SLAVE, ADDR, COUNT" should be constants or variables at the same time.

Note: the READ parameter is memory block whose length is changeable. The whole block cannot be in the illegal area, or there will be unpredictable result.

This instruction is used for reading data from a slave. The available function codes include 1 (read DO status), 2 (read DI status), 3 (read AO data) and 4 (Read AI data).

The parameter *PORT* defines the communication port used. The *SLAVE* defines the target slave address, whose available range is **1~255**. The *FUN* defines a valid function code. The *ADDR* defines the starting address of the Modbus register to be read. **The *COUNT* defines the number (Max. 32) of the registers to be read**.

The rising edge of *EXEC* is used for starting the communication. While a MBUSR instruction is executed, it will communicate for one time on the rising edge of *EXEC*: Organize a Modbus RTU message according to the parameters *SLAVE, FUN, ADDR* and *COUNT*, then transmit it and wait for the response of the slave; When receiving the slave's response message, check the CRC, slave number and function code to decide whether the message is correct or not, if correct, the useful data will be written into the buffer beginning with *READ*, otherwise, the received message will be discarded.

The *READ* defines the starting address of a buffer, which stores the received data. The data type of *READ* must match the function code. If the function code is of 1 or 2, the *READ* is of BOOL type; and if the function code is of 3 or 4, the *READ* is of INT or WORD type.

The *RES* stores the communication status and the failure information of the current execution, and it is read-only. It is described in the following figure.

MSB							LSB
7	6	5	4	3	2	1	0

Bit 7 --- Indicates whether the communication has been finished or not: 0 = not finished, 1 = finished.
Bit 6 --- Reserved。
Bit 5 --- Illegal *SLAVE*.
Bit 4 --- Illegal *COUNT*.
Bit 3 --- Illegal *ADDR*.
Bit 2 --- The specified port is busy.
Bit 1 --- Time out
Bit 0 --- The received message is wrong because of CRC error, frame error, etc.

LD

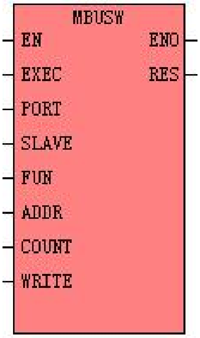
If *EN* is 1, this instruction is executed.

- **IL**

If CR is 1, this instruction is executed, and it does not influence CR.

6.12.3.2 MBUSW (Modbus RTU Master Write)

➢ **Description**

	Name	Usage	Group	
LD	MBUSW			☐ CPU504 ☑ CPU504EX ☑ CPU506 ☑ CPU506EA ☑ CPU508 ☑ K2
IL	MBUSW	MBUSW *EXEC, PORT, SLAVE, FUN, ADDR, COUNT, READ, RES*	U	

Operands	Input/Output	Data Type	Acceptable Memory Areas
EXEC	Input	BYTE	I, Q, V, M, L, SM, RS, SR
PORT	Input	INT	Constant (0~2)
SLAVE	Input	BYTE	I, Q, M, V, L, SM, Constant
FUN	Input	INT	Constant (MODBUS function code)
ADDR	Input	INT	I, Q, M, V, L, SM, AI, AQ, Constant
COUNT	Input	INT	I, Q, M, V, L, SM, AI, AQ, Constant
WRITE	Input	BOOL, WORD, INT	I, Q, RS, SR, V, M, L, SM, T, C, AI, AQ
RES	Output	BYTE	Q, M, V, L, SM

The "SLAVE, ADDR, COUNT" should be constants or variables at the same time.

Note: the WRITE parameter is memory block whose length is changeable. The whole block cannot be in the illegal area, or there will be unpredictable result.

This instruction is used for writing data to a slave. The available function codes include 1 (write to a DO), 2 (write to a DI), 3 (write to an AO) and 4 (write to an AI).

The parameter *PORT* defines the communication port used. The *SLAVE* defines the target slave address, whose available range is 1~31. The *FUN* defines a valid function code. The *ADDR* defines the starting address of the Modbus register to be written into. The *COUNT* defines the number (Max. 32) of the registers.

The *WRITE* defines the starting address of a buffer, which stores the data to be written into the slave. The data type of *WRITE* must match the function code. If the function code is of 5 or 15, the *WRITE* is of BOOL type; and if the function code is of 6 or 16, the *WRITE* is of INT or WORD type.

The rising edge of *EXEC* is used for starting the communication. While a MBUSW instruction is executed, it will communicate for one time on the rising edge of *EXEC*: Organize a Modbus RTU message according to the parameters *SLAVE, FUN, ADDR, COUNT* and *WRITE*, then transmit it and wait for the response of the slave; When receiving the slave's response message, check the CRC, slave number and function code to decide whether the target slave executed the command correctly or not.

The *RES* stores the communication status and the failure information of the current execution, and it is read-only. It is described in the following figure.

MSB ... LSB

7	6	5	4	3	2	1	0

Bit 7 --- Indicates whether the communication has been finished or not: 0 = not finished, 1 = finished.
Bit 6 --- Reserved。
Bit 5 --- Illegal *SLAVE*.
Bit 4 --- Illegal *COUNT*.
Bit 3 --- Illegal *ADDR*.
Bit 2 --- 1 = The specified port is busy.
Bit 1 --- 1 = Time out
Bit 0 --- 1 = The received message is wrong because of CRC error, frame error, etc.

⚠ **NODE, INDEX, SUBINDEX, DATALEN must all be constants or all be variables at the same time.**

- **LD**

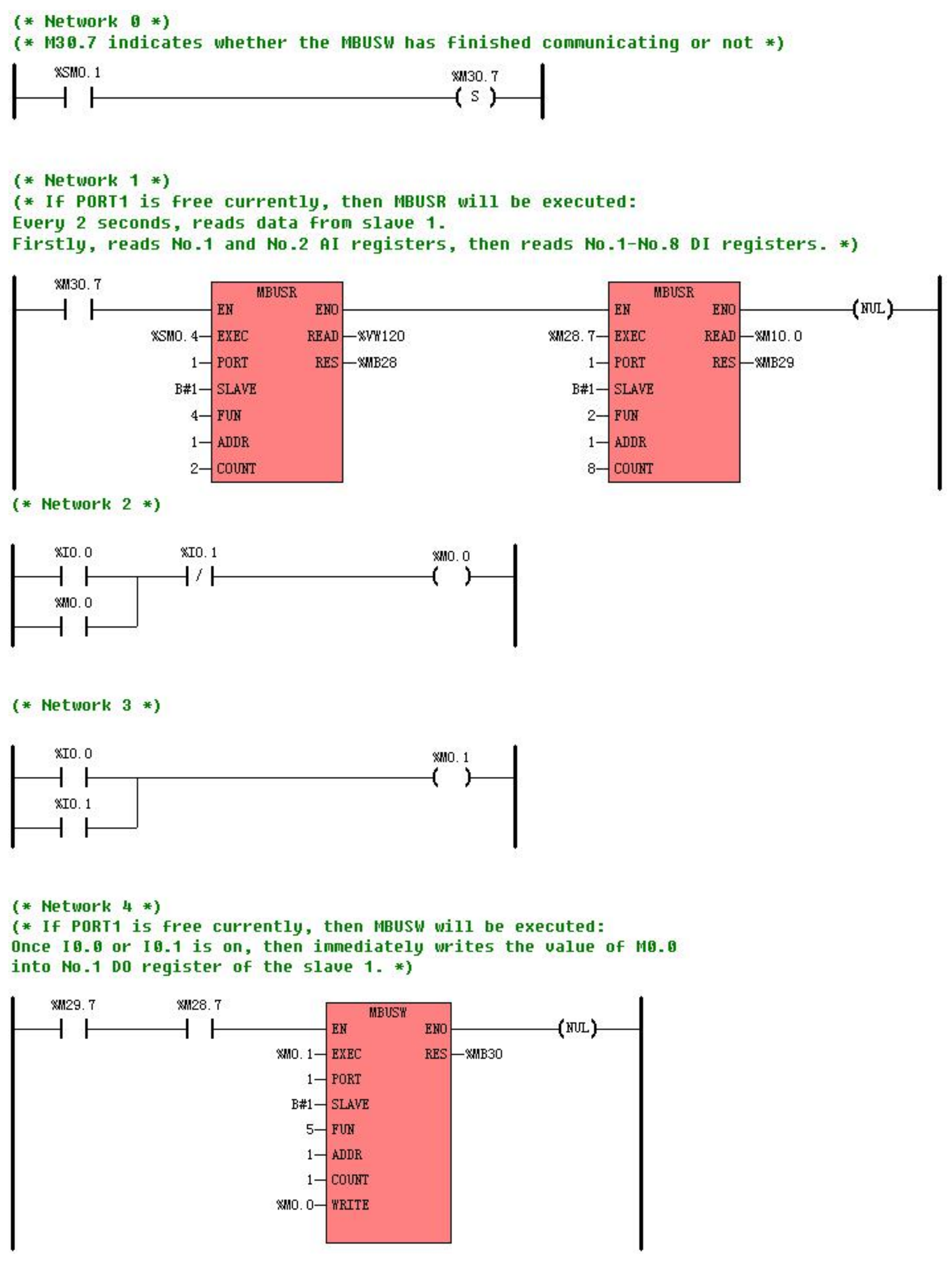
If *EN* is 1, this instruction is executed.

- **IL**

If CR is 1, this instruction is executed, and it does not influence CR.

6.12.3.3 Example for MBUSR and MBUSW

LD



IL	(* Network 0 *) (* M30.7 indicates whether the MBUSW has finished communicating or not*) LD %SM0.1 S %M30.7 (* Network 1 *) (* If PORT1 is free currently, then MBUSR will be executed: *) (* Every 2 seconds, reads data from slave 1. *) (* Firstly, reads No.1 and No.2 AI registers, then reads No.1-No.8 DI registers.*) LD %M30.7 MBUSR %SM0.4, 1, B#1, 4, 1, 2, %VW120, %MB28 MBUSR %M28.7, 1, B#1, 2, 1, 8, %M10.0, %MB29 (* Network 2 *) LD %I0.0 OR %M0.0 ANDN %I0.1 ST %M0.0 (* Network 3 *) LD %I0.0 OR %I0.1 ST %M0.1 (* Network 4 *) (* If PORT1 is free currently, then MBUSW will be executed: *) (* Once I0.0 or I0.1 is on, then immediately writes the value of M0.0 *) (* into No.1 DO register of the slave 1.*) LD %M29.7 AND %M28.7 MBUSW %M0.1, 1, B#1, 5, 1, 1, %M0.0, %MB30

6.12.4 CANOpen and SDO

➢**CANopen Nain Functions**

- Supports NMT management message
  - Supports CANopen predefine connection mode, the total PDO number are 255 TxPDO and 255 RxPDO, each salve can configure 1~8 TxPDO and 1~8 RxPDOl
  - Supports 100 slaves, the slave station number are available from 10~126.
  - Supports Emergency Message, Node Guide and Heartbeat Message.
  - Supports configuring the boot up process of slaves
  - Supports EDS file importing function
  - Use SDO_WRITE and SDO_READ to operation SDO
  - Supports 254 and 255 PDO transmission mode, supports sending the PDO by timed time, it can send 8 PDO data at the same time , and the timed time can be set.
  - Supports various baud rate: 10K/20K/50K/125K/250K/500K/800K/1M;
  - Check the master and salve status by the PLC system register
  - Supports multiple plc network communication by CAN bus
  - Supports slave error handling function, when the error happens, there are three methods optional to handle the error, they are STOP NODE, STOP NETWORD and NO OPERATION.

➢**SDO Instruction：**

SDO is used to transmit the low priority data, the typical application is used to configure/manage the slave device. For example, it is used to change the current loop/velocity loop/position loop parameters, PDO configuration parameters and so on. This kind of data transmission is the same as Modbus, the slave needs to return the data to response master. This transmission is only suitable for setting the parameters, but not suitable for the real time data transmission. When HMI or PLC communicates with servo, they use this method to configure the communication parameters.

➢**SDO data format：**

CAN master send the following upload instruction: 01 40 FF 60 00 00 00 00 00 60, this instruction is to read the target speed (60FF0020) of slave

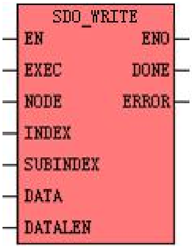
Slave Response： 01 43 FF 60 00 00 20 4E 00 EF

SDO is short for Service Data Object in CANOpen protocol. It accesses data in the dictionary of one device through index and subindex. The visitor is called Client and the one to be visited is called Server. Client's request will surely be responded by Server.

SDO is mainly used to transfer low-priority data among devices. It is suitable for configuration and management to devices but not data transmission for data that requires high real-time performance.

6.12.4.1 SDO_WRITE

- **Description**

	Name	Usage	Group	
LD	SDO_WRITE			☐ CPU504 ☑ CPU504EX ☑ CPU506 ☑ CPU506EA ☑ CPU508 ☑ K2
IL	SDO_WRITE	SDO_WRITE *EXEC, NODE, INDEX, SUBINDEX, DATA, DATALEN, DONE, ERROR*	U	

Operands	Input/Output	Data Type	Acceptable Memory Areas
EXEC	Input	BOOL	I, Q, V, M, L, SM, RS, SR
NODE	Input	BYTE	I, Q, V, M, L, SM, Constant
INDEX	Input	WORD	I, Q, V, M, L, SM, Constant
SUBINDEX	Input	BYTE	I, Q, V, M, L, SM, Constant
DATA	Input	BYTE	I, Q, V, M, L, SM
DATALEN	Input	BYTE	I, Q, V, M, L, SM, Constant
DONE	Output	BOOL	Q, M, V, L, SM
ERROR	Output	DWORD	Q, M, V, L, SM

NODE, INDEX, SUBINDEX, DATALEN should be constants or variables simultaneously.

Note: the DATA parameter is memory block whose length is changeable. The whole block cannot be in the illegal area, or there will be unpredictable result.

Operands	Description
EN	Enable. If EN is 1 then this instruction can be executed.

EXEC	If *EN* is 1, the *EXEC* starts the SDO communication on the rising edge. It is better to ensure the EN is prior to EXEC.
NODEID	ID of the Node to be visited
Index	Index of the object to be visited in the OD
SubIndex	Subindex of the object to be visited in the OD
Data	The starting address of a buffer which stores the data bytes to be sent.
DataLen	Length of the data to be sent. Unit: byte.
DONE	Indicates whether the instruction has finished or not. 0 = not finished; 1 = finished.
ERROR	Error identification. Please see below.

Code	**Description**
0	No errors.
1	The number of all used SDO instructions is out of limitation. At most 72 SDO instructions (SDO_WRITE and SDO_READ) can be called in one project.
2	The Master node is not in Operational mode, so this SDO is not sent.
4	The target node does not exist or stops due to error so this SDO is not sent
6	Command parameter error.
8	The response is time-out. The [SDO time out] value can be set in the [CANOpen]->[Global settings] tab.
9	The length of the SDO response is wrong.
10	The SDO response is wrong.

- **LD**

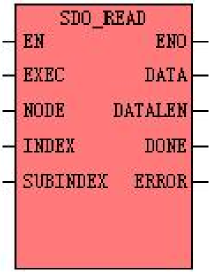
  If EN is 1, the rising edge of *EXEC* will start executing this instruction once.
- **IL**

  If CR is 1, the rising edge of *EXEC* will start executing this instruction once.

  This instruction does not influence CR.

6.12.4.2 SDO_READ

➢ **Description**

	Name	Usage	Group	
LD	SDO_READ			☐ CPU504 ☑ CPU504EX ☑ CPU506 ☑ CPU506EA ☑ CPU508 ☑ K2
IL	SDO_READ	SDO_READ *EXEC, NODE, INDEX, SUBINDEX, DATA, DATALEN, DONE, ERROR*	U	

Operands	Input/Output	Data Type	Acceptable Memory Areas
EXEC	Input	BOOL	I, Q, V, M, L, SM, RS, SR
NODE	Input	BYTE	I, Q, V, M, L, SM, Constant
INDEX	Input	WORD	I, Q, V, M, L, SM, Constant
SUBINDEX	Input	BYTE	I, Q, V, M, L, SM, Constant
DATA	Output	BYTE	I, Q, V, M, L, SM
DATALEN	Output	BYTE	I, Q, V, M, L, SM
DONE	Output	BOOL	Q, M, V, L, SM
ERROR	Output	DWORD	Q, M, V, L, SM

NODE, INDEX, SUBINDEX, DATALEN should be constants or variables simultaneously.

Note: the DATA parameter is memory block whose length is changeable. The whole block cannot be in the illegal area, or there will be unpredictable result.

Operands	Description
EN	Enable. If EN is 1 then this instruction can be executed.
EXEC	If *EN* is 1, the *EXEC* starts the SDO communication on the rising edge. It is better to ensure the EN is prior to EXEC.
NODEID	ID of the Node to be visited
Index	Index of the object to be visited in the OD
SubIndex	Subindex of the object to be visited in the OD
Data	The starting address of a buffer which will store the data bytes to be read.
DataLen	Length of the data to be read. Unit: byte.
DONE	Indicates whether the instruction has finished or not. 0 = not finished; 1 = finished.
ERROR	Error identification. Please see below.

Code	Description
0	No errors.
1	The number of all used SDO instructions is out of limitation. At most 72 SDO instructions (SDO_WRITE and SDO_READ) can be called in one project.
2	The Master node is not in Operational mode, so this SDO is not sent.
4	The target node does not exist or stops due to error so this SDO is not sent
6	Command parameter error.
8	The response is time-out. The [SDO time out] value can be set in the [CANOpen]->[Global settings] tab.
9	The length of the SDO response is wrong.
10	The SDO response is wrong.

- **LD**

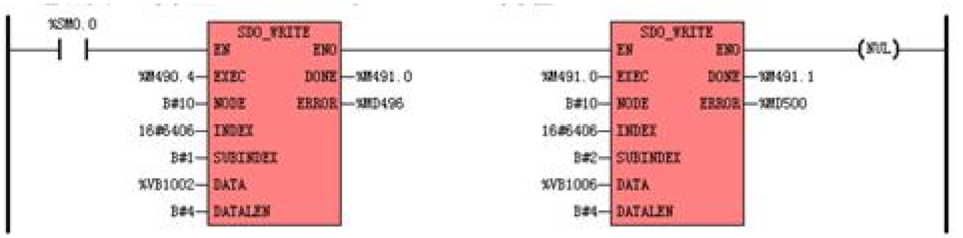
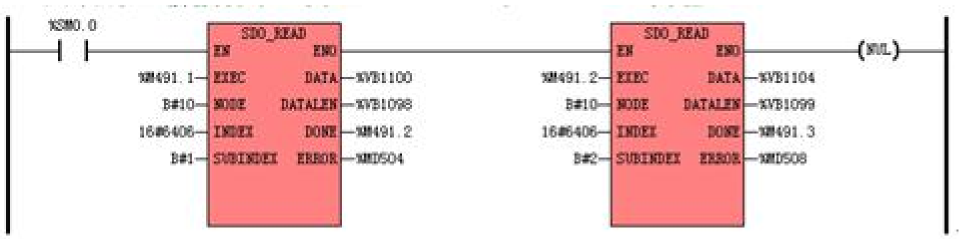
  If EN is 1, the rising edge of *EXEC* will start executing this instruction once.

- **IL**

  If CR is 1, the rising edge of *EXEC* will start executing this instruction once

  This instruction does not influence CR.

6.12.4.3 Example for SDO_WRITE and SDO_READ

LD	(* Network 0 *) (*modify the value of 0x6406sub01 and 0x6406sub02 of node 10.*)  (* Network 1 *) (*read the value of 0x6406sub01 and 0x6406sub02 of node 10 *) 
IL	(* Network 0 *) (*modify the value of 0x6406sub01 and 0x6406sub02 of node 10.*) LD %SM0.0 SDO_WRITE %M490.4, B#10, 16#6406, B#1, %VB1002, B#4, %M491.0, %MD496 SDO_WRITE %M491.0, B#10, 16#6406, B#2, %VB1006, B#4, %M491.1, %MD500 (* Network 1 *) (*read the value of 0x6406sub01 and 0x6406sub02 of node 10 *) LD %SM0.0 SDO_READ %M491.1, B#10, 16#6406, B#1, %VB1100, %VB1098, %M491.2, %MD504 SDO_READ %M491.2, B#10, 16#6406, B#2, %VB1104, %VB1099, %M491.3, %MD508

6.12.5 CAN Communication Command

K5 provide the functions of CANOpen Master and CAN free-protocol communication, and they must work along with a K541 module. The two functions can be used at the same time. Please be noted that when used at the same time the baud rate of all nodes must be the same.

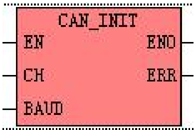
CAN free-protocol function supports CAN2.0A and CAN2.0B, and it only supports data frame but not RTR.

The format of CAN message is as follows:

ID	Data Bytes
11 bits (CAN2.0A, standard frame) or 29 bits (CAN 2.0B, extended frame)	1-8 bytes

6.12.5.1 CAN_INIT

- **Description**

	Name	Usage	Group	☐ CPU504 ☑ CPU504EX ☑ CPU506 ☑ CPU506EA ☑ CPU508
LD	CAN_INIT			
IL	CAN_INIT	CAN_INIT CH, BAUD	U	

Operands	Input/Output	Data Type	Acceptable Memory Areas
EN	Input	BOOL	I, Q, V, M, L, SM
CH	Input	INT	Constant(only can be 2 now)
BAUD	Input	INT	L, M, V, Constant
ERR	Output	BOOL	L, M, V, Constant

Operands	Description
EN	Enable.
CH	The CAN port number. 2 represents K541 module.

BAUD	Baud rate: 8 --- 1000K 7 --- 800K 6 --- 500K 5 --- 250K 4 --- 125K 3 --- 50K 2 --- 20K 1--- 10K
ERR	Error identification.. 1 represents success, and 0 represents error.

This instruction is used to initialize the specified CAN port(CH) and set its baud rate to be the value of BAUD represents.

The rising edge of EN(or CR) will start executing this instruction once.

- LD

The rising edge of EN will start executing this instruction once.

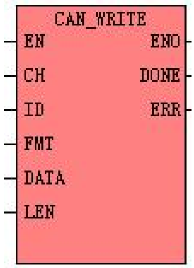
- IL

The rising edge of CR will start executing this instruction once.

This instruction does not influence CR.

6.12.5.2 CAN_WRITE

➢ **Description**

	Name	Usage	Group	
LD	CAN_WRITE			☐ CPU504 ☑ CPU504EX ☑ CPU506 ☑ CPU506EA ☑ CPU508
IL	CAN_WRITE	CAN_WRITE CH,ID,FMT,DATA,LEN,DONE,ERR	U	

Operands	Input/Output	Data Type	Acceptable Memory Areas
CH	Input	INT	Constant(only can be 2 now)
ID	Input	DWORD	L, M, V, Constant
FMT	Input	BYTE	L, M, V, Constant
DATA	Input	BYTE	L, M, V
LEN	Input	BYTE	L, M, V, Constant
DONE	Output	BOOL	L, M, V
ERR	Output	BOOL	L, M, V

Operands	Description
EN	Enable.
CH	The CAN port number. 2 represents K541 module.
ID	CAN ID of the message to be send.
FMT	Frame type. 0 represents standard frame and 1 represents extended frame.
DATA	The starting address of a buffer which stores the data bytes to be sent.
LEN	Length of the data to be sent. Unit: byte.
DONE	Indicates whether the instruction has finished or not. 0 = not finished; 1 = finished.

ERR	Error identification. 0 represents no error, and 1 represents error.

⚠ ***ID, FMT and LEN should be constants or variables simultaneously.***

⚠ **Note: the DATA parameter is memory block whose length is changeable. The whole block cannot be in the illegal area, or there will be unpredictable result.**

This instruction is used to send a CAN message which is specified by ID, FMT (frame type, standard frame or extended frame), DATA (the starting address of a buffer which stores the data) and LEN (the length of the data). The rising edge of EN(or CR) will start executing this instruction once: it generates a CAN message according to the input parameters, and writes this message into the Sending-FIFO, and then K5 will send this message via the certain CAN port (CH) at the right time.

If this instruction successfully writes the message into the FIFO, it will return successfully and set DONE to 1 and ERR to 0. If the FIFO is full, then this instruction fails and set DONE and ERR all to 1.

- LD

  The rising edge of EN will start executing this instruction once.

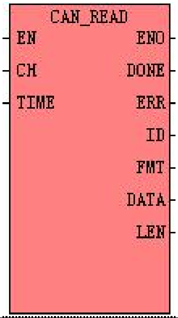
- IL

  The rising edge of CR will start executing this instruction once.

  This instruction does not influence CR.

6.12.5.3 CAN_READ (Receiving one message immediately)

➢ **Description**

	Name	Usage	Group	
LD	CAN_READ			☐ CPU504 ☑ CPU504EX ☑ CPU506 ☑ CPU506EA ☑ CPU508
IL	CAN_READ	CAN_READ CH, TIME, DONE, ERR, FMT, DATA, LEN	U	

Operands	Input/Output	Data Type	Acceptable Memory Areas
CH	Input	INT	Constant(only can be 2 now)
TIME	Input	INT	L, M, V, Constant
DONE	Output	BOOL	L, M, V
ERR	Output	BOOL	L, M, V
ID	Output	DWORD	L, M, V
FMT	Output	BYTE	L, M, V
DATA	Output	BYTE	M, V
LEN	Output	BYTE	L, M, V

Operands	Description
EN	Enable
CH	The CAN port number. 2 represents K541 module.
TIME	Time-out for receiving a message. Unit: ms.
DONE	Indicates whether the instruction has finished or not. 0 = not finished; 1 = finished.
ERR	Error identification. 0 represents success, and 1 represents error.

ID	The CAN ID of the received message.
FMT	Frame type of the received message. 0 represents standard frame and 1 represents extended frame.
DATA	The starting address of a buffer which stores the received data bytes.
LEN	Length of the received data. Unit: byte.

Note: the DATA parameter is memory block whose length is changeable. The whole block cannot be in the illegal area, or there will be unpredictable result.

The rising edge of EN(or CR) will start executing this instruction once: it will immediately monitor the certain CAN port (CH) and receive one message of any type. And if it receive a message within time limitation(TIME), it will analyze this message and save the ID, FMT, DATA and LEN respectively, then quit receiving state and set DONE to 1 and ERR to 0. If it does not receive a message within the time limitation, it will quit receiving state and set DONE and ERR to 1.

Because CAN_READ will receive any message from the certain CAN port, please pay special attention when using it along with other protocols (e.g. CANOpen).

- LD

  The rising edge of EN will start executing this instruction once.

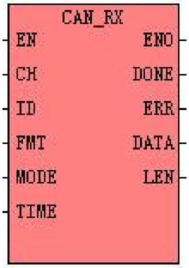
- IL

  The rising edge of CR will start executing this instruction once.

  This instruction does not influence CR.

6.12.5.4 CAN_RX (Receiving the specified message)

➢ **Description**

	Name	Usage	Group	
LD	CAN_RX			☐ CPU504 ☑ CPU504EX ☑ CPU506 ☑ CPU506EA ☑ CPU508
IL	CAN_RX	CAN_RX CH, ID, FMT, MODE, TIME, DONE, ERR, FMT, DATA, LEN	U	

Operands	Input/Output	Data Type	Acceptable Memory Areas
CH	Input	INT	Constant（only can be 2 now）
ID	Input	DWORD	L, M, V, Constant
FMT	Input	INT	L, M, V, Constant
MODE	Input	INT	L, M, V, Constant
TIME	Input	INT	L, M, V, Constant
DONE	Output	BOOL	L, M, V
ERR	Output	BOOL	L, M, V
DATA	Output	BYTE	M, V
LEN	Output	BYTE	L, M, V

Operands	Description
EN	Enable
CH	The CAN port number. 2 represents K541 module.
ID	The CAN ID of the desired message.
FMT	The format of the desired message.

	0 represents standard frame and 1 represents extended frame.
MODE	Receiving mode. 0 represents endless receiving, and 1 represents single receiving
TIME	Time-out for receiving the next message. Unit: ms.
DONE	Indicates whether the instruction has finished or not. 0 = not finished; 1 = finished.
ERR	Error identification. 0 represents success, and 1 represents error.
DATA	The starting address of a buffer which stores the latest received data bytes.
LEN	Length of the latest received data. Unit: byte.

⚠ ***ID, FMT, MODE and LEN should be constants or variables simultaneously.***

⚠ **Note: the DATA parameter is memory block whose length is changeable. The whole block cannot be in the illegal area, or there will be unpredictable result.**

The rising edge of EN(or CR) will start executing this instruction: it will immediately monitor the certain CAN port (CH) and receive the desired message specified by ID and FMT parameter.

If MODE is 1, CAN_RX is in single receiving mode: if it receive one desired message within time limitation(TIME), it will analyze this message and save the DATA and LEN respectively, then quit receiving state and set DONE to 1 and ERR to 0. If it does not receive a desired message within the time limitation, it will quit receiving state and set DONE and ERR to 1.

If MODE is 0, CAN_RX is in endless receiving mode: it will always monitor the certain CAN port and receive all desired message endlessly. After it receives a desired message, it will set ERR to 0. And after one successful receiving, if it doesn't receive another desired message again within time limitation, it will set ERR to 1. DONE is always 0 in this mode.

You can call at most 64 CAN_RX instructions in your project.

- LD

  The rising edge of EN will start executing this instruction.

- IL

The rising edge of CR will start executing this instruction.

This instruction does not influence CR.

6.12.5.5 Examples

<table>
<tr>
<td>LD</td>
<td>
(* Network 0 *)
(* Initialize the K541’s CAN port and set its baud rate *)


(* Network 0 *)
(*Begin to endlessly receive the desired message specified by the ID and frame type. *)

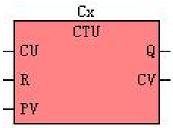
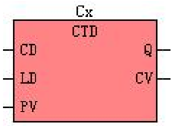

</td>
</tr>
</table>

6.13 Counters

6.13.1 CTU (Up Counter) and CTD (Down Counter)

Counter is one of the function blocks defined in the IEC61131-3 standard, totally in three types i.e. CTU, CTD and CTUD. Please refer to 3.6.5 Function Block and Function Block Instance for more detailed information.

➢ **Description**

	Name	Usage	Group	
LD	CTU			☑ K5 ☑ K2
	CTD			
IL	CTU	CTU Cx, R, PV	P	
	CTD	CTD Cx, LD, PV		

Operands	Input/Output	Data Type	Acceptable Memory Areas
Cx	-	Counter instance	C
CU	Input	BOOL	Power flow
R	Input	BOOL	I, Q, M, V, L, SM, T, C
CD	Input	BOOL	Power flow
LD	Input	BOOL	I, Q, M, V, L, SM, T, C
Q	Output	BOOL	Power flow
CV	Output	INT	Q, M, V, L, SM, AQ

- **LD**

The *CTU* counter counts up on the rising edge of the *CU* input. When the current value *CV* is equal to or greater than the preset value *PV*, both the counter output *Q* and the status bit of *Cx* are set to be 1. *Cx* is reset when the reset input *R* is enabled. When the counter reaches *PV*, it continues counting until it reaches and keeps at the maximum INT value (i.e. 32767).

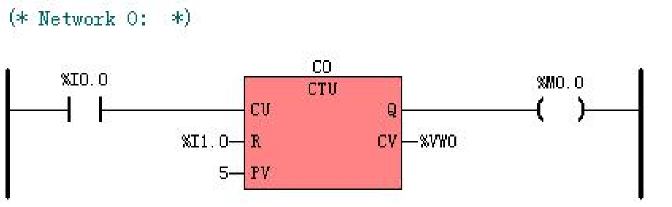
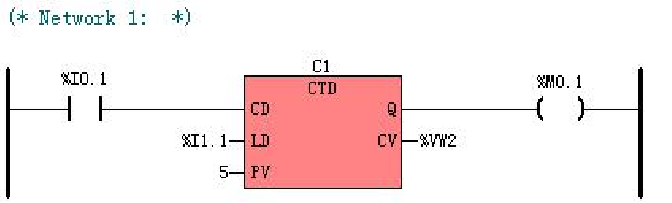
The *CTD* counter counts down on the rising edge of the *CD* input. When the current value *CV* is equal to or greater than the preset value *PV*, both the counter output *Q* and the status bit of *Cx* are set to be 1. *Cx* is reset and *PV* is loaded into *CV* when the load input *LD* is enabled. When the counter reaches *PV*, it continues counting until it reaches and keeps at 0.

- **IL**

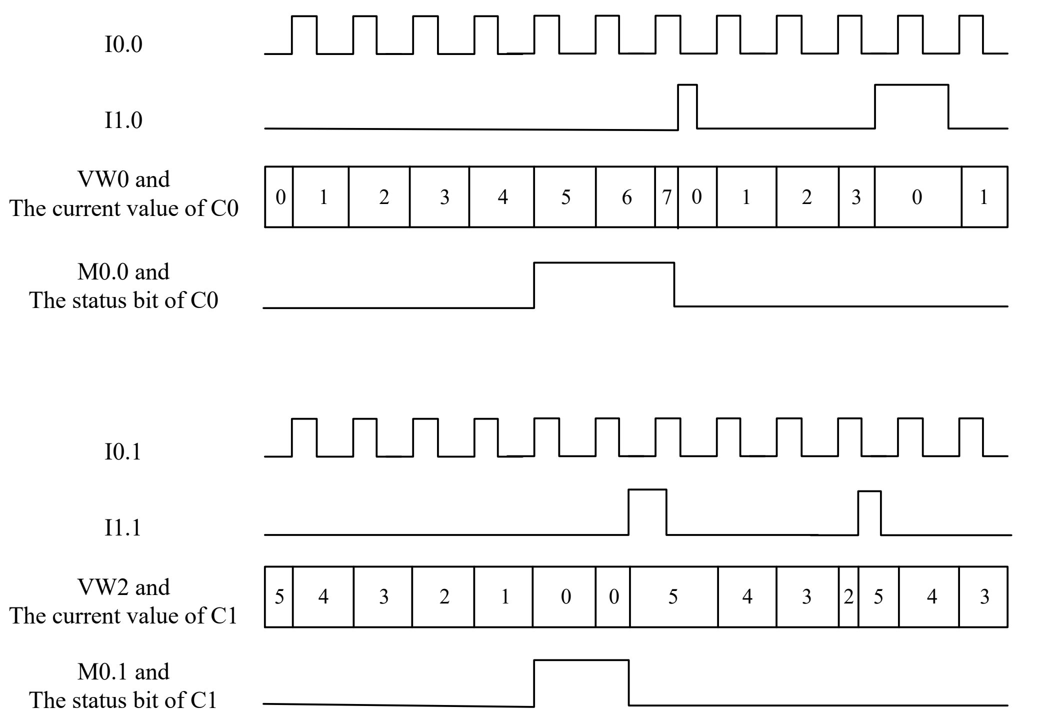
The *CTU* counter counts up on the rising edge of CR. When the current value of *Cx* is equal to or greater than the preset value *PV*, the counter status bit are set to be 1. *Cx* is reset when the reset input *R* is enabled. When the counter reaches *PV*, it continues counting until it reaches and keeps at the maximum INT value (i.e. 32767). After each scan, CR is set to be the status bit value of *Cx*.

The *CTD* counter counts down on the rising edge of CR. When the current value of *Cx* is equal to or greater than the preset value *PV*, the counter status bit are set to be 1.*Cx* is reset and *PV* is loaded into the current value when the load input *LD* is enabled. When the counter reaches *PV*, it continues counting until it reaches and keeps at 0. After each scan, CR is set to be the status bit value of *Cx*.

➢ **Examples**

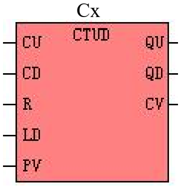
LD	IL
	(* NETWORK 0 *) LD %I0.0 CTU C0, %I1.0, 5 ST %M0.0
	(* NETWORK 1 *) LD %I0.1 CTD C1, %I1.1, 5 ST %M0.1

Time Sequence Diagram



6.13.2 CTUD (Up-Down Counter)

➢ **Description**

	Name	Usage	Group	
LD	CTUD			☑ K5 ☑ K2
IL	CTUD	CTUD Cx, CD, R, LD, PV, QD	P	

Operands	Input/Output	Data Type	Acceptable Memory Areas
Cx	-	Counter instance	C
CU	Input	BOOL	Power flow
CD	Input	BOOL	I, Q, M, V, L, SM, T, C, RS, SR
R	Input	BOOL	I, Q, M, V, L, SM, T, C, RS, SR
LD	Input	BOOL	I, Q, M, V, L, SM, T, C, RS, SR
PV	Input	INT	I, Q, M, V, L, SM, AI, AQ, constant
QU	Output	BOOL	Power flow
QD	Output	BOOL	Q, M, V, L, SM
CV	Output	INT	Q, M, V, L, SM, AQ

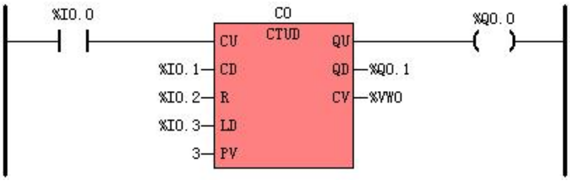
➢ **LD**

The *CTUD* counter counts up on the rising edge of the *CU* input and counts down on the rising edge of the *CD* input, and the current counter value *Cx* is assigned to *CV*. When *CV* is equal to or greater than the preset value *PV*, both *QU* and the status bit of *Cx* are set to 1, otherwise they are set to 0. When *CV* is equal to 0, *QD* is set to 1, otherwise it is set to 0. When the reset input *R* is enabled, *Cx* and *CV* is reset. When the load input *LD* is enabled, *PV* is loaded into *Cx* and *CV*. If *R* and *LD* are 1 at the same time, *R* takes the higher priority.

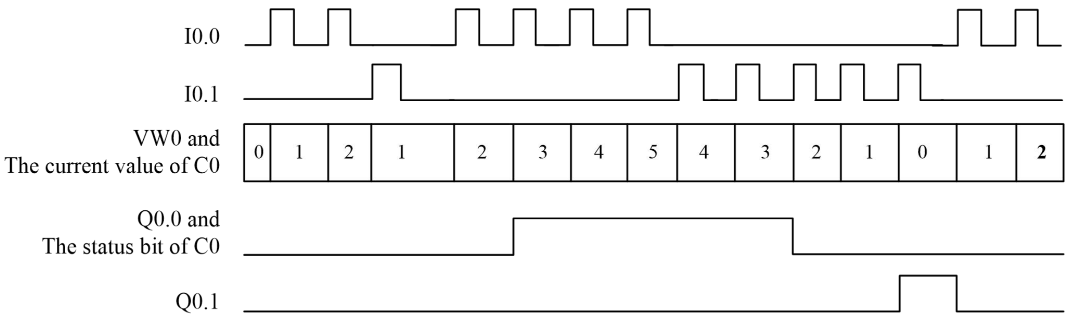
➢ **IL**

The *CTUD* counter counts up on the rising edge of CR and counts down on the rising edge of the *CD* input, and the current counter value *Cx* is assigned to *CV*. When *CV* is equal to or greater than the preset value *PV*, both *QU* and the status bit of *Cx* are set to 1, otherwise they are set to 0. When *CV* is equal to 0, *QD* is set to 1, otherwise it is set to 0. When the reset input *R* is enabled, *Cx* and *CV* is reset. When the load input *LD* is enabled, *PV* is loaded into *Cx* and *CV*. If *R* and *LD* are 1 at the same time, *R* takes the higher priority.
After each scan, CR is set to be the status bit value of *Cx*.

➢ **Example**

LD	IL
	LD %I0.0 CTUD C1, %I0.1, %I0.2, %I0.3, 4 ,%Q0.1 ST %Q0.0

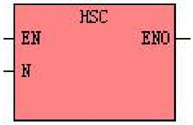
Time Sequence Diagram



6.13.3 High-speed Counter Instructions

High-speed counters count high-speed pulse inputs that cannot be controlled at the CPU scan rate.

➢ **Description**

<table>
<tr><th></th><th>Name</th><th>Usage</th><th>Group</th><th></th></tr>
<tr><td rowspan="2">LD</td><td>HDEF</td><td>
</td><td rowspan="2"></td><td rowspan="4">☑ K5
☑ K2</td></tr>
<tr><td>HSC</td><td>
</td></tr>
<tr><td rowspan="2">IL</td><td>HDEF</td><td>HDEF HSC, MODE</td><td rowspan="2">U</td></tr>
<tr><td>HSC</td><td>HSC *N*</td></tr>
</table>

Operands	Input/Output	Data Type	Description
HSC	Input	INT	Constant (HSC number)
MODE	Input	INT	Constant (0~11, Operations mode)
N	Input	INT	Constant (HSC number)

The *HDEF* (High-speed Counter Definition) instruction is used to define the operation mode (*MODE*) of a high-speed counter (*HSC*). This instruction is suitable for each high-speed counter. A high-speed counter can be configured to be one of the 11 different operation modes. The mode decides the clock input, counting direction, start, and reset properties of the high-speed counter.

The *HSC* (High-Speed Counter) instruction configures and operates the high-speed counter whose number is specified by *N* according to the values of the corresponding SM registers.

Note: Call the HSC to start the high speed counter only once when you needs counting, if you use SM0.0 to call the HSC all the time , the high speed counter will be initialized all the time, so the high speed counter cannot count the pulse probably.

In IL, CR decides whether to execute the *HDEF* and *HSC* instructions. They won't influence CR.

- **LD**

If the EN value is 1 then execute HDEF and HSC and vice versa.

- **IL**

If the CR value is 1 then execute HDEF and HSC and vice versa..

The execution of HDEF and HSC will not affect the CR value.

6.13.3.1 High-speed Counters Supported by the Kinco-K5

Feature	CPU504, CPU504EX, CPU506, CPU506EA, CPU508
High-speed counters	2 counters (HSC0 and HSC1)
Single phase	2 at 60KHz
Two phase	2 at 20KHz.

Before started, the high-speed counter should be assigned an operation mode by HDEF command. All the high-speed counters have the same function in the same operation mode.

Each input of a high-speed counter functions as follows:

6.13.3.2 Operation Modes and Inputs of the High-speed Counters

Input signals of high-speed counter include: clock (input impulse), direction, start and reset.

If the Start input is 0, then Clock input and Reset input will be ignored and current value remains unchanged. If the Start input is 1 and Reset signal is 0, the counter is allowed to count. If the Reset input and Start input are both 1, current value will be cleared. For single-phase high-speed counter controlled by Direction input. If the Direction input is 1, then counter is incremented, otherwise, counter is decremented.

In different operation modes input signals is different. Please see below:

<table>
<tr><th colspan="5">HSC 0</th></tr>
<tr><th>Mode</th><th>Description</th><th>I0.1</th><th>I0.0</th><th>I0.5</th></tr>
<tr><td>0</td><td rowspan="3">Single-phase up/down counter
with internal direction control: SM37.3</td><td rowspan="3">Clock</td><td></td><td></td></tr>
<tr><td>1</td><td>Reset</td><td></td></tr>
<tr><td>2</td><td>Reset</td><td>Start</td></tr>
<tr><td>3</td><td rowspan="2">Single-phase up/down counter
with external direction control</td><td rowspan="2">Clock</td><td></td><td>Direction</td></tr>
<tr><td>4</td><td>Reset</td><td>Direction</td></tr>
<tr><td>6</td><td>Two-phase counter with up/down clock inputs</td><td>Clock Down</td><td>Clock Up</td><td></td></tr>
<tr><td>9</td><td>A/B phase quadrature counter</td><td>Clock A</td><td>Clock B</td><td></td></tr>
</table>

<table>
<tr><th colspan="6">HSC 1</th></tr>
<tr><th>Mode</th><th>Description</th><th>I0.4</th><th>I0.6</th><th>I0.3</th><th>I0.2</th></tr>
<tr><td>0</td><td rowspan="3">Single-phase up/down counter
with internal direction control: SM47.3</td><td></td><td></td><td rowspan="3">Clock</td><td></td></tr>
<tr><td>1</td><td>Reset</td><td></td><td></td></tr>
<tr><td>2</td><td>Reset</td><td>Start</td><td></td></tr>
<tr><td>3</td><td rowspan="3">Single-phase up/down counter
with external direction control</td><td></td><td></td><td rowspan="3">Clock</td><td>Direction</td></tr>
<tr><td>4</td><td>Reset</td><td></td><td>Direction</td></tr>
<tr><td>5</td><td>Reset</td><td>Start</td><td>Direction</td></tr>
<tr><td>6</td><td rowspan="3">Two-phase counter
with up/down clock inputs</td><td></td><td></td><td rowspan="3">Clock Down</td><td rowspan="3">Clock Up</td></tr>
<tr><td>7</td><td>Reset</td><td></td></tr>
<tr><td>8</td><td>Reset</td><td>Start</td></tr>
<tr><td>9</td><td rowspan="3">A/B phase quadrature counter</td><td></td><td></td><td rowspan="3">Clock A</td><td rowspan="3">Clock B</td></tr>
<tr><td>10</td><td>Reset</td><td></td></tr>
<tr><td>11</td><td>Reset</td><td>Start</td></tr>
</table>

6.13.3.3 Time Sequence of High-speed Counter

In order to help you well understand the high-speed counter, the following diagrams shows various time sequences.

- **Reset and Start**

The operations in the following figures are suitable for all modes that use the reset and start inputs.

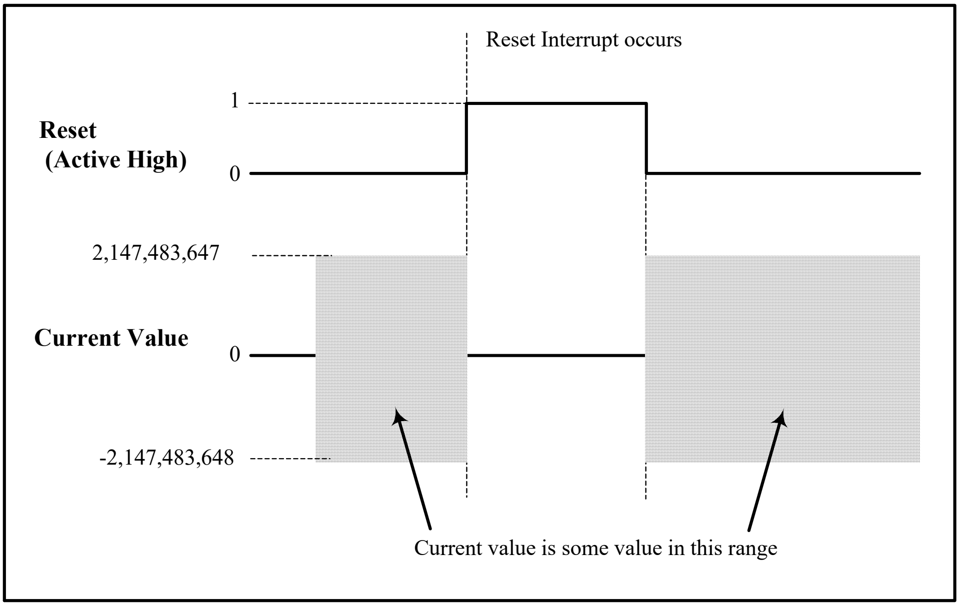


Figure 6-2 Time Sequence with Reset and without Start

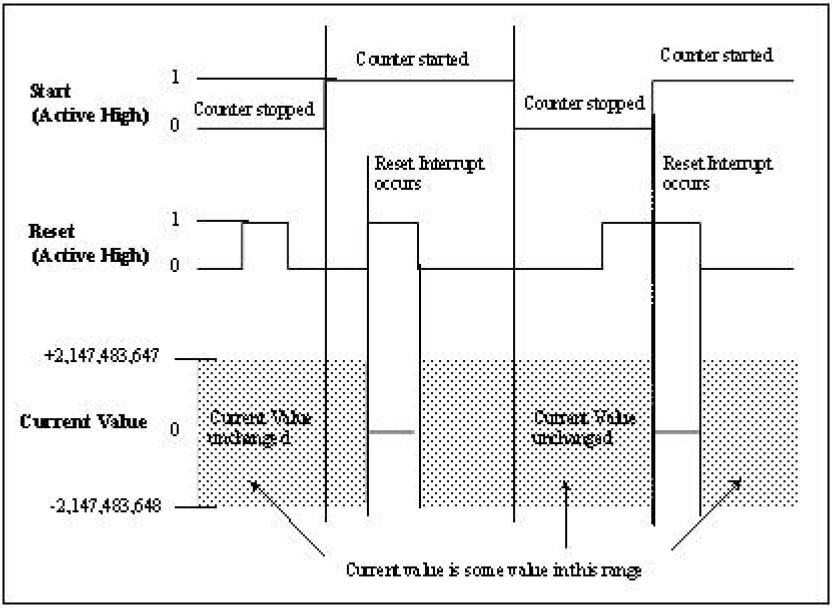


Figure 6-3 Time Sequence with Reset and Start

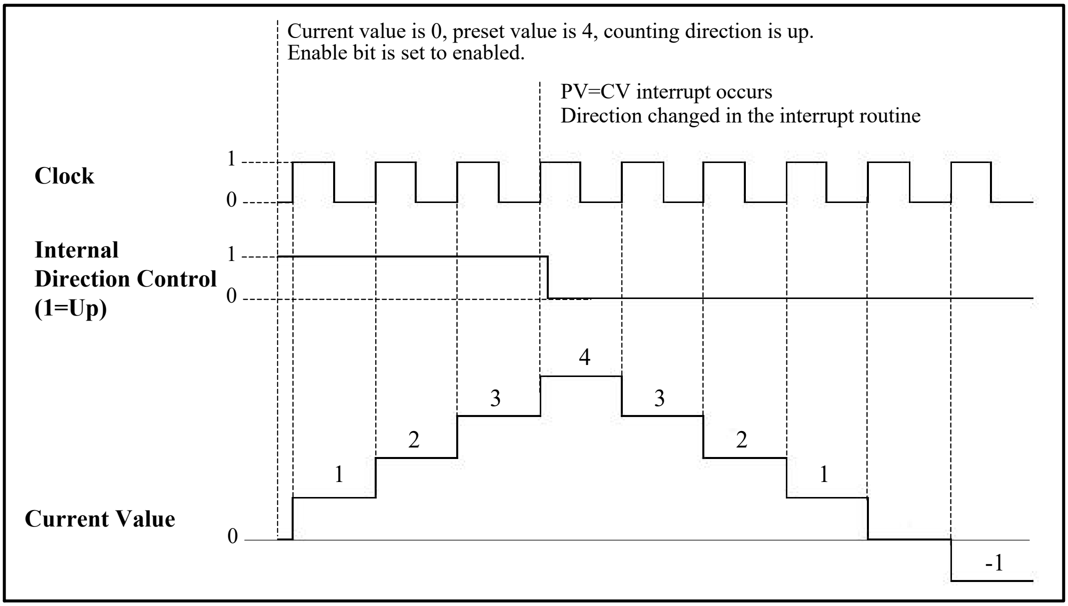


Figure 6-4 Time Sequence of Mode 0, 1 or 2

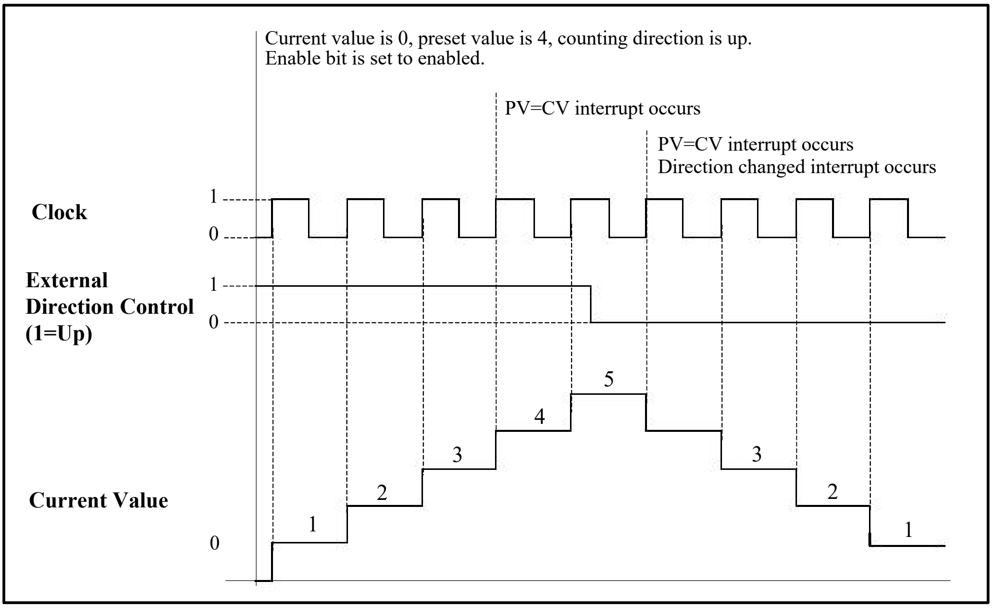


Figure 6-5 Time Sequence of Mode 3, 4 or 5

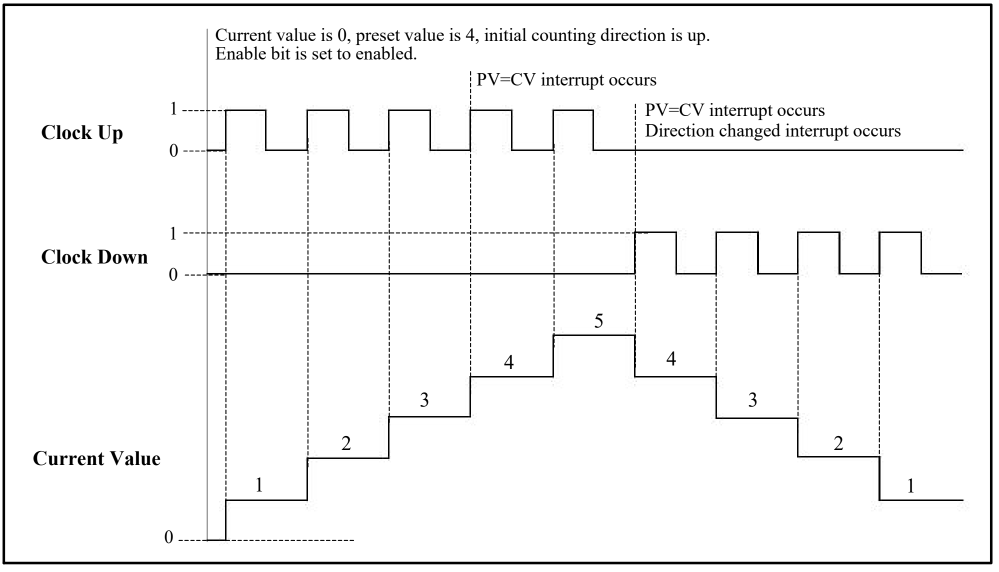


Figure 6-6 Time Sequence of Mode 6, 7 or 8

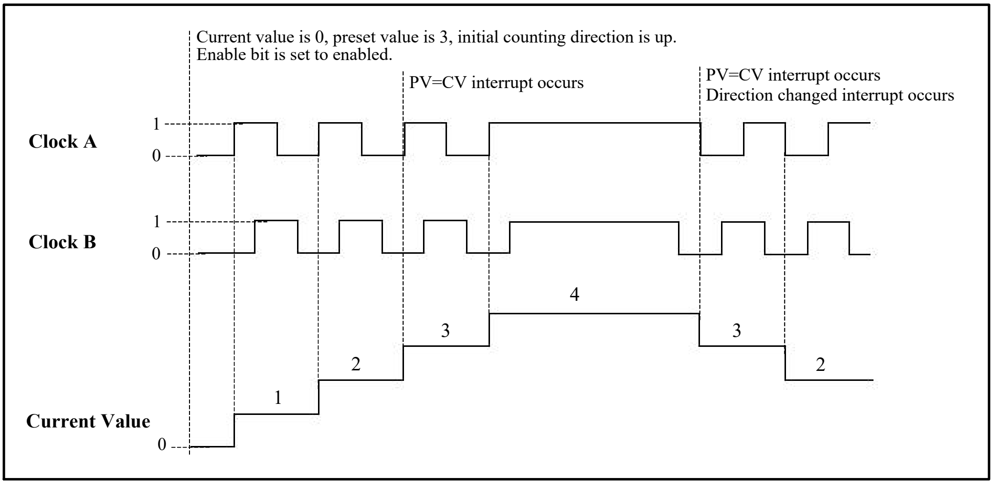


Figure 6-7 Time Sequence of Mode 9, 10 or 11 (Quadrature, 1x rate)

6.13.3.4 Control Byte and Status Byte

- **Control Byte**

In SM area each high-speed counter is assigned control byte to save its configuration data: one control word (8 bit), current value and pre-set (double-integer with 32 bit). Initial value of current assigned. If the current value is written in the high-speed counter, it will start counting from that value. Please see below:

HSC0	HSC1	Description
SM37.0	SM47.0	Effective electrical level of reset signal:0=high;1=low
SM37.1	SM47.1	Effective electrical level to start signal:0=high;1=low
SM37.2	SM47.2	Orthogonal counter rate:0=1x rate;1=4x rate*
SM37.3	SM47.3	Counting direction 0=minus;1=plus
SM37.4	SM47.4	Write counting direction in HSC? 0= NO; 1= Yes
SM37.5	SM47.5	Write new pre-set value in HSC? 0= NO; 1= Yes
SM37.6	SM47.6	Write new current value in HSC? 0= NO; 1= Yes
SM37.7	SM47.7	Allow this high-speed counter? 0=NO; 1= YES
HSC0	HSC1	Description
SMD38	SMD48	Current value

SMD42	SMD52	Pre-set value

Please note that not all the control bits are suitable for all the operation modes. For example: "Counting direction" and "Write the counting direction to the HSC" are only suitable for operation mode 0/1/2(Single-phase up/down counter with internal direction control). If operation modes of counter with external direction control are chosen, then the two bits will be ignored.

The default values of control word, current value and preset value are 0.

Only after the high-speed counter and its mode are defined, can the dynamic parameters of the counter be programed. A control byte is provided for each high-speed counter, and you can operate as follows:

- Enable or disable the HSC
- The counting direction control (limited to mode 0, 1 and 2), or the initial direction of all other modes
- Load the current value
- Load the preset value

The control byte, relevant current value and preset value shall be loaded before executing the *HSC* instruction. The following table describes each of these control bits.

- **Status Byte**

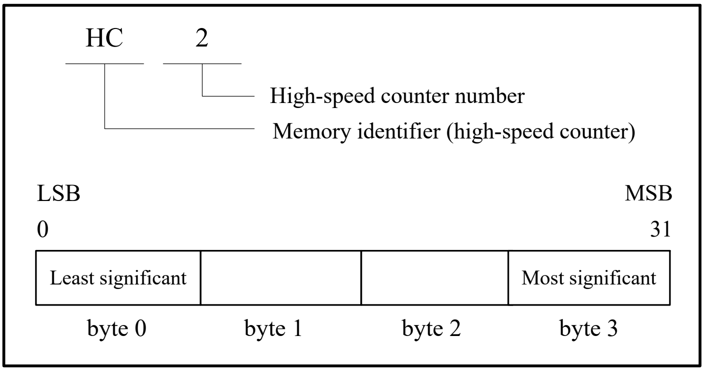
In SM area, each high-speed counter has a status byte, in which some bits indicate the current counting direction and whether the current value is equal to or greater than the preset value. Definition of the status bits for each high-speed counter is shown in the following table.

HSC0	HSC1	Description
SM36.0	SM46.0	Reserved
SM36.1	SM46.1	Reserved
SM36.2	SM46.2	Reserved
SM36.3	SM46.3	Reserved
SM36.4	SM46.4	Reserved
SM36.5	SM46.5	Current counting direction: 0 = Down; 1= Up

SM36.6	SM46.6	Current value equal to preset value: 0 = Not equal; 1 = Equal
SM36.7	SM46.7	Current value greater than preset value: 0 = Not greater than; 1 = Greater than

- **Accessing the Current Value of a High-Speed Counter**

The current counting value of a high-speed counter is read-only and can be represented only as a double integer (32-bit). The current counting value of a high-speed counter is accessed using the memory type (HC) and the counter number; for example, HC0 represents the current value of HSC0, as shown in the following diagram.



Figue 6-8 Accessing the Current Value of a High-Speed Counter

6.13.3.5 Assigning Interrupts

Each mode supports a PV=CV (the current value equal to the preset value) interrupt. The mode that use an external reset input supports an External Reset interrupt. The mode that use an external direction control input supports a Direction Changed interrupt. Each of these interrupt conditions can be enabled or disabled separately. Please refer to 6.10 Types of Interrupt Events Supported by the Kinco-K5 for details.

6.13.3.6 Programming the High-speed Counter

You can program a high-speed count as follows:

- Assign the control byte.
- Assign the current value (i.e. starting value) and the preset value.
- (Optional) Assign the interrupt routines using the *ATCH* instruction.
- Define the counter and its mode using the *HDEF* instruction.

Note: The *HDEF* instruction can only be executed once for each high-speed counter after the CPU enters RUN mode.

- Start the high-speed counter using the *HSC* instruction.

The following is the detailed introduction for the initialization and operation steps taking HSC0 as an example. You are recommended to make a subroutine that contains the *HDEF* instruction and other initialization instructions and call this subroutine in the main program using SM0.1 to reduce the CPU cycle time.

- **Using HSC**

  The following example uses Mode 9. And the other modes take the similar steps.

- In the initialization subroutine, load the desired control status into SMB37.

  For example (1x counting rate), SMB37 = b#16#F0 indicates:
- Enable HSC0
- Write a new current value to HSC0
- Write a new preset value to HSC0
- Set the start input and the reset input to be active high
- Load the desired current value (32-bit) into SMD38. If 0 is loaded, SMD38 is cleared.
- Load the desired preset value (32-bit) into SMD42.
- (Optional) Attach the CV = PV event (event 18) to an interrupt routine to respond in real time to a current-value-equal-to-preset-value event.

- (Optional) Attach the direction-changed event (event 17) to an interrupt routine to respond in real time to a direction-changed event.
- (Optional) Attach the external reset event (event 16) to an interrupt routine to respond in real time to an external reset event
- Execute the *HDEF* instruction with the *HSC* input set to be 0 and the *MODE* input set to 9.
- Execute the *HSC* instruction to cause the CPU to configure HSC0 and start it.

➢ **Change the Counting Direction in Mode 0, 1 and 2:**

The following introduces how to change the direction of HSC0 (Mode 0, 1 and 2).

- Load the desired control status into SMB37:

  SMB37 = b#16#90: Enable the counter,

  Set the new direction to be down-counter
- Execute the HSC instruction to cause the CPU to configure HSC0 and start it.

- Load the new current value (in all the modes)

The following introduces how to change the current value (i.e. starting value) of HSC0.

- Load the desired control status into SMB37:

  SMB37 = b#16#C0 Enable the counter

  Allow writing the new current value to HSC0.
- Load the desired current value into SMD38. If 0 is loaded, SMD38 is cleared.
- Execute the HSC instruction to cause the CPU to configure HSC0 and start it.

➢ **Load the new preset value (in all the modes)**

The following introduces how to change the preset value of HSC0.

- Load the desired control status into SMB37:

  SMB37 = b#16#A0 Enable the counter

Allow writing the new preset value to HSC0.

- Load the desired preset value into SMD42.
- Execute the HSC instruction to cause the CPU to configure HSC0 and start it.

➢ **Disable the High-speed Counter (in all modes)**

The following introduces how to disable HSC0.

- Load the desired control status into SMB37:

  SMB37 = b#16#00 Disable the counter;

- Execute the HSC instruction to cause the CPU to disable the counter.

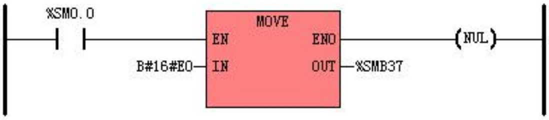
6.13.3.7 Examples

The following example also uses HSC0.

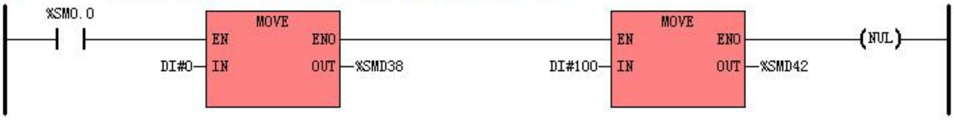
LD

The initialization subroutine: Initialize

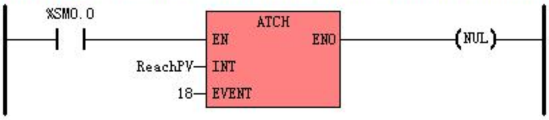
(* Network 0 *)
(* 1x counting rate; Enable HSC0; Allow updating current value and preset value; Set the start input and the reset input to be active high *)



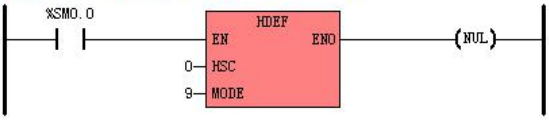
(* Network 1 *)
(* Set the new current value and new preset value *)



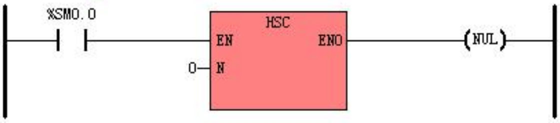
(* Network 2 *)
(* Attach the CV = PV event (event 18) to ReachPV interrupt routine *)



(* Network 3 *)
(* Define HSC0 to be in mode 9 *)



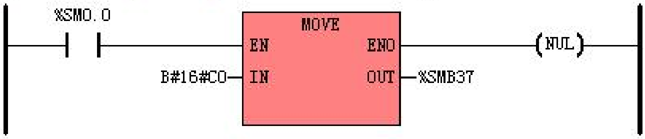
(* Network 4 *)
(* Configure and start HSC0 *)



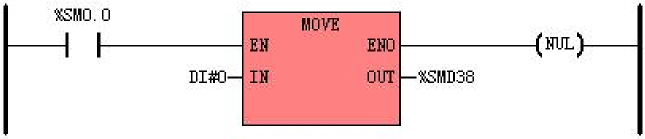
LD

The interrupt routine: ReachPV

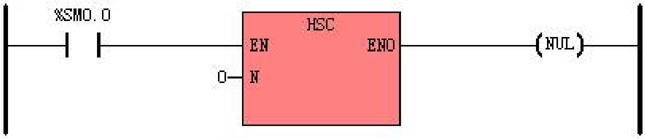
(* Network 0 *)
(* Allow updating current value *)



(* Network 1 *)
(* Set the new current value to be 0 to re-count *)

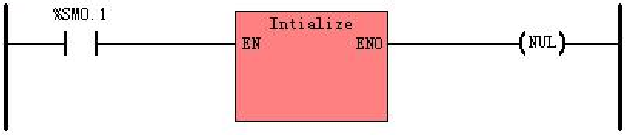


(* Network 2 *)
(* Configure and restart HSC0 *)



Main program:

(* Network 0 *)
(* Call Initialize subroutine *)



IL	**The initialization subroutine: Initialize**
	
	(* Network 0 *)
	(* 1x counting rate; Enable HSC0; Allow updating current value AND preset value; *)
	(* Set the start input and the reset input to be active high *)
	LD %SM0.0
	MOVE B#16#E0, %SMB37
	(* Network 1 *)
	(*Set the new current value and new preset value*)
	LD %SM0.0
	MOVE DI#0, %SMD38
	MOVE DI#100, %SMD42
	(* Network 2 *)
	(*Attach the CV = PV event (event 18) to ReachPV interrupt routine*)
	LD %SM0.0
	ATCH ReachPV, 18
	(* Network 3 *)
	(*Define HSC0 to be in mode 9*)
	LD %SM0.0
	HDEF 0, 9
	(* Network 4 *)
	(*Configure and start HSC0*)
	LD %SM0.0
	HSC 0

IL	**The interrupt routine: ReachPV**
	
	(* Network 0 *)
	(*Allow updating current value*)
	LD %SM0.0
	MOVE B#16#C0, %SMB37
	(* Network 1 *)
	(*Set the new current value to be 0 to re-count*)
	LD %SM0.0
	MOVE DI#0, %SMD38
	(* Network 2 *)
	(*Configure and restart HSC0*)
	LD %SM0.0
	HSC 0
	
	Main program:
	
	(* Network 0 *)
	(*Call Initialize subroutine*)
	LD %SM0.1
	CAL Intialize

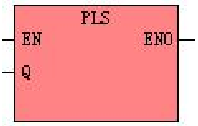
6.13.4 Pulse-Width Modulation (PWM)

Here the high-speed pulse output means the Pulse-Width Modulation (PWM).

K5 provides two PWM impulse generator to output PWM, using tunnel of Q0.0 and Q0.1, called PWM0 and PWM1. The generator and DO image register share the same address Q0.0 and Q0.1. If PWM is started in Q0.0 or Q0.1, the generator will control the output tunnel and forbid the output of general function.When PWM function is forbidden, Q0.0 and Q0.1 will be controlled by DO image register.

The highest output rate of CPU modules is 200kHz.

- **Description**

	Name	Usage	Group	
LD	PLS			☑ K5 ☑ K2
IL	PLS	PLS *Q*	U	

Operands	Input/Output	Data Type	Description
Q	Input	INT	Constant (0 or 1)

The *PLS* instruction is used to load the corresponding configurations of the PTO/PWM specified by *Q* from the specified SM registers and then operate the PTO/PWM generator accordingly.

In LD, the *EN* input decides whether to execute the *PLS* instruction.

In IL, CR value decides whether to execute the *PLS* instructions. It won’t influence CR.

6.13.4.1 Configuring and Controlling the PWM Operation

Each PWM generator is provided with some registers in SM area to store its configurations or indicate its status. The characteristics of a PWM waveform can be changed by modifying the corresponding SM registers and then executing the *PLS* instruction. The following table decribes control registers detaildly.

Q0.0	Q0.1	Description
SM67.0	SM77.0	Whether to update the cycle time: 0 = not update; 1 = update
SM67.1	SM77.1	Whether to update pulse width time: 0 = not update; 1 = update
SM67.2	SM77.2	Reserve
SM67.3	SM77.3	Time base:0 = 1μs; 1 = 1ms
SM67.4	SM77.4	Reserve
SM67.5	SM77.5	Reserve
SM67.6	SM77.6	1 = PWM
SM67.7	SM77.7	Enable: 0 = disable; 1 = enable
SMW68	SMW78	Cycle time value, Range: 2 to 65535
SMW70	SMW80	Pulse width value, Range: 0 to 65535

6.13.4.2 PWM Operations

The fallowing takes PWM0 as an example to introduce how to configure and operate the PWM generator in the user program.

- **Initializing the PWM Output**

Use SM0.1 (the first scan memory bit) to call a subroutine that contains the initialization instructions. Since SM0.1 is used, the subroutine shall be invoked only once, and this reduces scan time and provides a better program structure.

The following steps describes how to configure PWM0 in the initialization subroutine:

- Load the desired control status into SMB67:

  For example, SMB67 = B#16#D3 indicates

  - Enable the PWM function
  - Select PWM operation
  - Select 1μs as the time base
  - Allow updating the pulse width value and cycle time value
  - Setlect synchronousv update method

- Load the cycle time value into SMW68.
- Load the pulse width value into SMW70.
- Execute the *PLS* struction to cause the CPU to configure PWM0 and start it.

- **Changing the Pulse Width for the PWM Output**

The following steps describes how to change PWM output pulse width (assume that SMB67 has been preloaded with B#16#D2 or B#16#DA.):

- Load the desired control status into SMB67

For example, SMB67 = B#16#D2 indicates

  - Enable the PWM function
  - Select PWM operation
  - Select 1μs as the time base
  - Allow updating the pulse width value
  - Setlect synchronousv update method

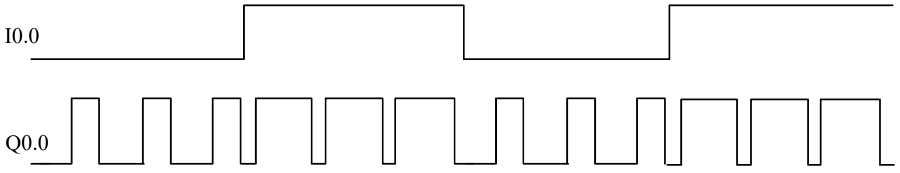
- Load the pulse width value (16-bit) into SMW70.
- Execute the *PLS* struction to cause the CPU to configure PWM and start it.

6.13.4.3 Example

- **PWM**

PWM1 (output through Q0.1) is used in the example.

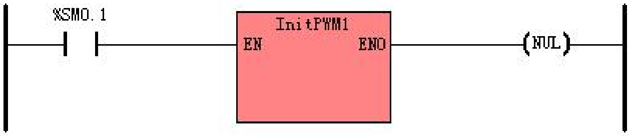
If I0.0 is false, change the pulth width to 40% duty cycle; if I0.0 is true, change the pulth width to 40% duty cycle. The time sequence diagram is shown as follows:



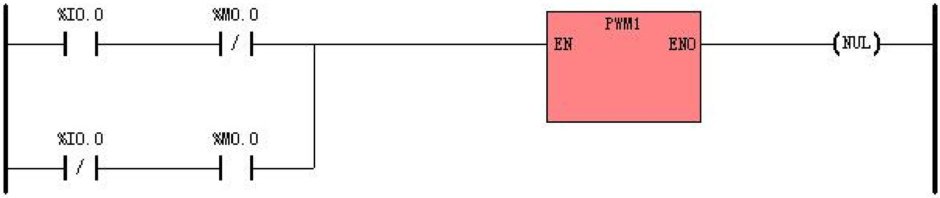
LD

MAIN Program:

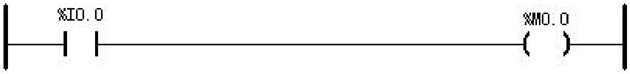
(* Network 0 *)
(* Use SM0.1 to call subroutine InitPWM1 to initialize PWM1 *)



(* Network 1 *)
(* If the status of I0.0 changes,
subroutine PWM1 shall be called to change the pulse width. *)

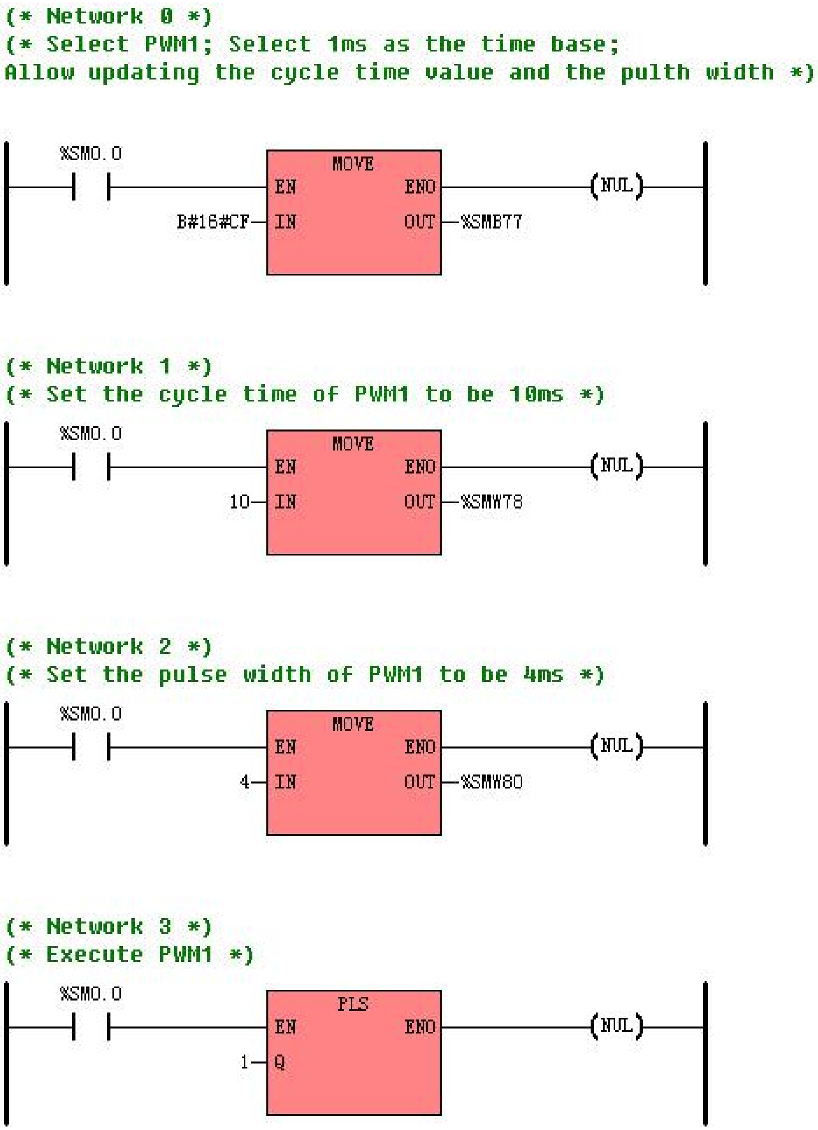


(* Network 2 *)



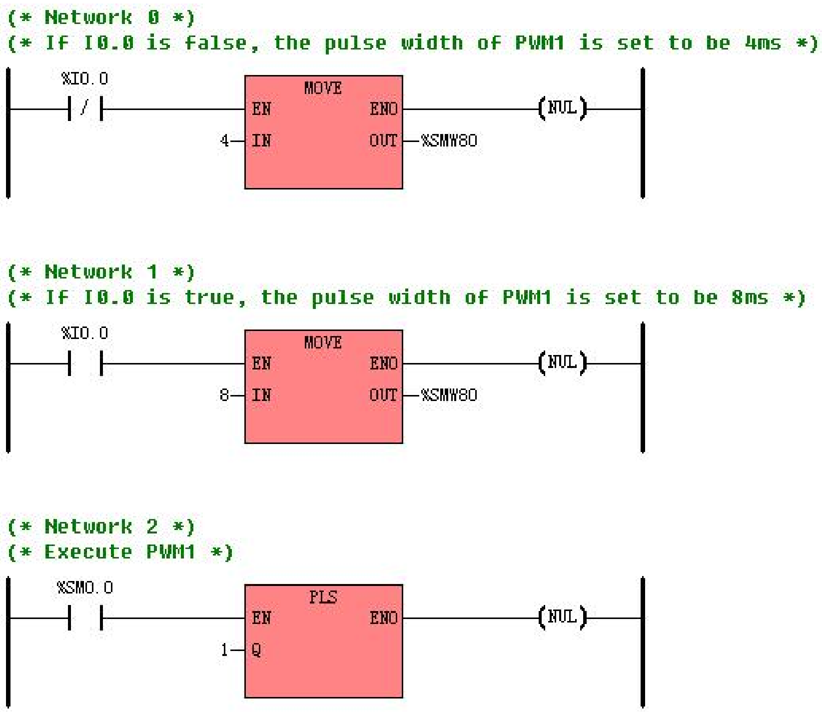
LD

Subroutine *InitPWM1*:



LD

Subroutine ***PWM1*:**



IL	**MAIN Program:** (* Network 0 *) (* Use SM0.1 to call subroutine InitPWM1 to initialize PWM1 *) LD %SM0.1 CAL InitPWM1 (* Network 1 *) (* If the status of I0.0 changes, subroutine PWM1 shall be called to change the pulse width. *) LD %I0.0 ANDN %M0.0 OR(LDN %I0.0 AND %M0.0) CAL PWM1 (* Network 2 *) LD %I0.0 ST %M0.0

<table>
<tr><td rowspan="2">IL</td><td>
Subroutin InitPWM1:
(* Network 0 *)
(*Select PWM1; Select 1ms as the time base; Allow updating the cycle time value and the pulth width*)
LD %SM0.0
MOVE B#16#CF, %SMB77
(* Network 1 *)
(*Set the cycle time of PWM1 to be 10ms*)
LD %SM0.0
MOVE 10, %SMW78
(* Network 2 *)
(*Set the pulse width of PWM1 to be 4ms*)
LD %SM0.0
MOVE 4, %SMW80
(* Network 3 *)
(*Execute PWM1*)
LD %SM0.0
PLS 1
</td></tr>
<tr><td>
Subroutin PWM1:
(* Network 0 *)
(*If I0.0 is false, the pulse width of PWM1 is set to be 4ms*)
LDN %I0.0
MOVE 4, %SMW80
(* Network 1 *)
(*If I0.0 is true, the pulse width of PWM1 is set to be 8ms*)
LD %I0.0
MOVE 8, %SMW80
(* Network 2 *)
(*Execute PWM1*)
LD %SM0.0
PLS 1
</td></tr>
</table>

6.14 Timers

Timer is one of the function blocks defined in the IEC61131-3 standard, totally in three types i.e. TON, TOF and TP. Please refer to 2.6.5 Function Block and Function Block Instance for more detailed information.

6.14.1 The resolution of the timer

There are three resolutions for timers in K5. The timer number determines the resolution.

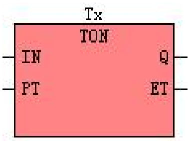
The resolution of the time numbers T0-T3 is 1ms; the resolution of the time numbers T4-T19 is 10ms; the resolution of the time numbers T20-T255 is 100ms

The maxim value of the timer is *32767 × Resolution*. The preset value and the current value of a timer are all multiples of this timer's resolution, for example, a value of 100 on a 10ms timer represents 1000ms.

PLC will update the timing value of the timer only when execute the timer command. It will be influenced by the scan cycle.

6.14.2 TON (On-delay Timer)

- **Description**

	Name	Usage	Group	
LD	TON			☑ K5 ☑ K2
IL	TON	TON Tx, PT	P	

Operands	Input/Output	Data Type	Acceptable Memory Areas
Tx	-	Timer instance	T
IN	Input	BOOL	Power flow
PT	Input	INT	I, AI, AQ, M, V, L, SM, constant
Q	Output	BOOL	Power flow

ET	Output	INT	Q, M, V, L, SM, AQ

Tx is an instance of TON fuction block.

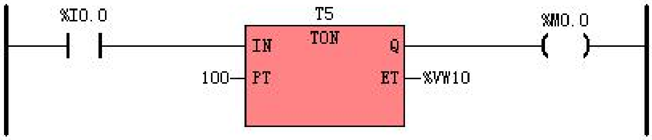
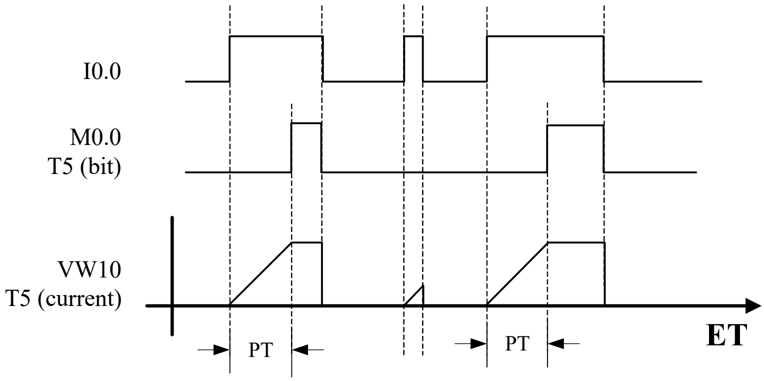
- **LD**

Tx starts to time on the rising edge of the *IN* input. When the elapsed time (i.e. the current value) *ET* is greater than or equal to the preset time *PT*, both the *Q* output and the status bit of *Tx* are set to be TRUE. If the *IN* input turns to FALSE, *Tx* is reset, and both the *Q* output and its status bit value are set to be FALSE, meanwhile its current value is cleared to 0.

- **IL**

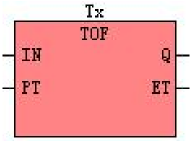
Tx starts to time on the rising edge of CR. When the current value is greater than or equal to the preset value *PT*, the status bit of *Tx* is set to be TRUE. If CR turns to FALSE, *Tx* is reset, and its status bit is set to be FALSE, meanwhile its current value is cleared to 0. After each scan, CR is set to be the status bit value of *Tx*.

➢ **Examples**

<table>
<tr><th>LD</th><th>IL</th></tr>
<tr><td>(* Network 0 *)
(* T5 is an instance of TON,
and its preset time is 1000ms (100*10ms) *)

</td><td>(* NETWORK 0 *)
LD %I0.0
TON T5, 100
ST %M0.0</td></tr>
<tr><th colspan="2">Time Sequence Diagram</th></tr>
<tr><td colspan="2">
</td></tr>
</table>

6.14.3 TOF (Off-delay Timer)

➢ **Description**

	Name	Usage	Group	
LD	TOF			☑ K5 ☑ K2
IL	TOF	TOF Tx, PT	P	

Operands	Input/Output	Data Type	Acceptable Memory Areas
Tx	-	Timer instance	T
IN	Input	BOOL	Power flow
PT	Input	INT	I, AI, AQ, M, V, L, SM, constant
Q	Output	BOOL	Power flow
ET	Output	INT	Q, M, V, L, SM, AQ

Tx is an instance of TOF fuction block.

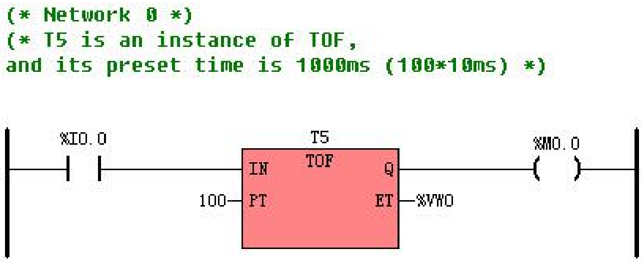
➢ **LD**

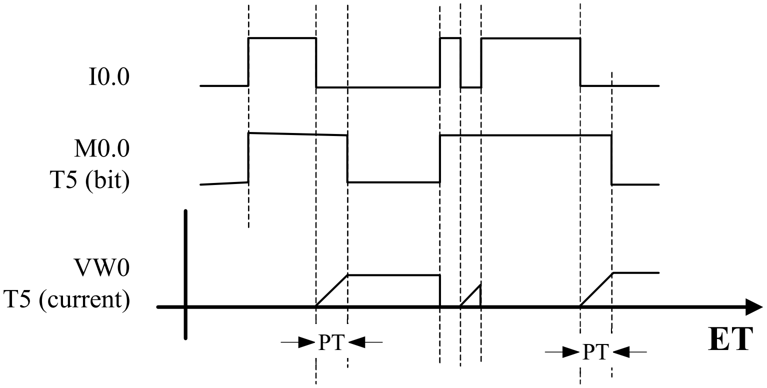
Tx starts to time on the falling edge of the *IN* input. When the elapsed time (i.e. the current value) *ET* is greater than or equal to the preset time *PT*, both the *Q* output and the status bit of *Tx* are set to be FALSE. If the *IN* input turns to TRUE, *Tx* is reset, and both the *Q* output and it status bit are set to be TRUE, meanwhile its current value is cleared to 0.

➢ **IL**

Tx starts to time on the falling edge of CR. When the current value is greater than or equal to the preset value *PT*, the status bit of *Tx* is set to be FALSE. If CR turns to TRUE, *Tx* is reset, and its status bit is set to be TRUE, meanwhile its current value is cleared to 0. After each scan, CR is set to be the status bit value of *Tx*.

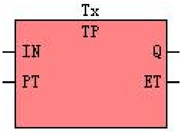
- **Examples**

LD	IL
	(* NETWORK 0 *) LD %I0.0 TOF T5, 100 ST %M0.0

Time Sequence Diagram


6.14.4 TP (Pulse Timer)

➢ **Description**

	Name	Usage	Group	
LD	TP			☑ K5 ☑ K2
IL	TP	TP Tx, PT	P	

Operands	Input/Output	Data Type	Acceptable Memory Areas
Tx	-	Timer instance	T
IN	Input	BOOL	Power flow
PT	Input	INT	I, AI, AQ, M, V, L, SM, constant
Q	Output	BOOL	Power flow
ET	Output	INT	Q, M, V, L, SM, AQ

Tx is an instance of TP fuction block. The *TP* instruction is used to generate a pulse for the preset time.

➢ **LD**

On the rising edge of the *IN* input, *Tx* starts to time, and both the *Q* output and the status bit of *Tx* are set to be TRUE. The *Q* output and the status bit remain TRUE within the preset time *PT*. As soon as the elapsed time (i.e. the current value) *ET* reaches the *PT*, both the *Q* output and the status bit become FALSE.

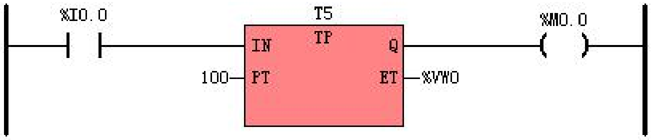
➢ **IL**

On the rising edge of CR, *Tx* starts to time, and the status bit of *Tx* is set to be TRUE. The status bit remains TRUE within the preset time *PT*. As soon as the current value reaches the *PT*, the status bit becomes FALSE. After each scan, CR is set to be the status bit value of *Tx*.

- **Examples**

<table>
<tr><th>LD</th><th>IL</th></tr>
<tr><td>

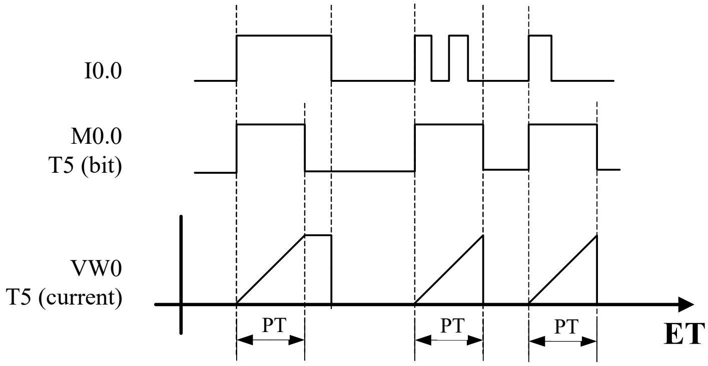
(* Network 0 *)
(* T5 is an instance of TP,
and its preset time is 1000ms (100*10ms) *)



</td><td>

(* NETWORK 0 *)
LD %I0.0
TP T5, 100
ST %M0.0

</td></tr>
<tr><th colspan="2">Time Sequence Diagram</th></tr>
<tr><td colspan="2">



</td></tr>
</table>

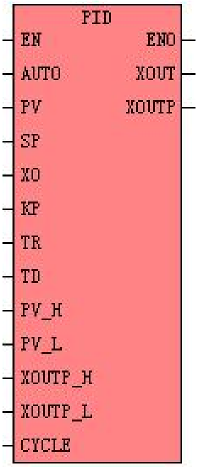
6.15 PID

A PID controller is used to correct the error between the measured process variable and the desired set-point by calculating and then outputting a corrective action that can adjust the process accordingly.

Kinco-K5 provides PID instruction to serve as a digital PID loop controller. You can use it for PID fixed set-point control with continuous input and output, and you can use up to 8 PID loops in one CPU.

6.15.1 PID

➢ **Description**

	Name	Usage	Group	
LD	PID			☑ K5 ☑ K2
IL	PID	PID AUTO, PV, SP, XO, KP, TR, TD, PV_H, PV_L, XOUTP_H, XOUTP_L, CYCLE, XOUT, XOUTP	U	

Operands	IN/OUT	Data Type	Memory Areas	Comment
AUTO	INPUT	BOOL	I, Q, V, M, SM, L, T, C	Manual/Auto. 0=Manual, 1=Auto.
PV	INPUT	INT	AI, V, M, L	Process Variable
SP	INPUT	INT	V	Set-point
XO	INPUT	REAL	V	Manual value, range [0.0, 1.0]
KP	INPUT	REAL	V	Proportionality constant
TR	INPUT	REAL	V	Reset time, which determines the time response of the integrator. (Unit: s)
TD	INPUT	REAL	V	Derivative time, which determines the time response of the derivative unit. (Unit: s)
PV_H	INPUT	INT	V	The upper limit value of *PV*
PV_L	INPUT	INT	V	The lower limit value of *PV*
XOUTP_H	INPUT	INT	V	The upper limit value of *XOUTP*
XOUTP_L	INPUT	INT	V	The lower limit value of *XOUTP*
CYCLE	INPUT	DINT	V	Sampling period. (Unit: ms)
XOUT	OUTPUT	REAL:	V	Manipulated Value, range [0.0, 1.0].
XOUTP	OUTPUT	INT	AQ, V	Manipulated Value Peripheral. This value is the normalizing result of *XOUT*.

This instruction adopts position algorithm, and its input and output are continuous.

- **LD**

If *EN* is 1, this instruction is executed. PLC samples value of PV, calculates and outputs result at intervals of sampling period (CYCLE).

- **IL**

If *EN* is 1, this instruction is executed, and it does not influence CR. PLC samples value of PV, calculates and outputs result at intervals of sampling period (CYCLE).

- **Detailed descriptions for PID instruction**

- **Manual/Auto**

It is possible to switch between a manual and an automatic mode with the help of *Auto* input.

If *Auto* is 0, then the PID is in the manual mode, and now the value of *XO* input shall be directly set as the manipulated value (*XOUT*).

If *Auto* is 1, then the PID is in the automatic mode, and now it shall execute the PID calculations according to the inputs and set the final result as the manipulated value (*XOUT*).

A PID controller should be in the automatic mode while it is performing a process control.

- **Normalizing the PV and SP**

The *PV* and *SP* can be input in the peripheral format (an integer). But PID algorithm needs a floating-point value of 0.0 to 1.0, so normalization is needed.

The Kinco-K5 automatically finishes the normalization according to the *PV*, *SP*, *PV_H* and *PV_L* input. You may assign any linear correlation values of them, but the inputs must be the same dimension.

For example, you want to control the pressure to the expected value 25MPa. A pressure transmitter is used to measure the pressure, and the transformer's measuring range is 0-40MPa and its output range is 4-20mA. The transformer's output is connected to a channel of an AI module, and this channel is configured as the following: the address is AIW0, and the measured type is '4-20mA' whose the measured value is '4000-20000'. Now, you can assign the following values to the PID inputs:

	Actual Parameter	**Comment**
PV	AIW0	AIW0 can be set as *PV* because of their linear relation.
SP	14000	14mA. Because 14mA means the real pressure value 25MPa.
PV_L	4000	The lower limit value of the transformer's output
PV_H	20000	The upper limit value of the transformer's output

- **Manipulated Values**

This PID has two manipulated values: *XOUT* and *XOUTP*.

XOUT is a value between 0.0 and 1.0 (that is between 0.0 and 100.0%).

XOUTP is an integer value with the user-defined peripheral format, and it is the result of normalizing *XOUT* according to the *XOUTP_H* and *XOUTP_L* input:

$$XOUTP = (XOUTP\_H - XOUTP\_L) * XOUT + XOUTP\_L$$

It is convenient for the user to transfer *XOUT_P* to an AO channel. For example, PID results should be sent to a regulating valve via AQW0 of AO module, then the related parameter settings are as follows:

	Actual Parameter	**Comment**
XOUTP	AQW0	AQW0 could be directly taken as PID output for the linear relationship between value of AQW0 and opening of valve.
XOUTP_L	4000	The lower limit value of the AQW0.
XOUTP_H	20000	The upper limit value of the AQW0.

- Proportional term

The proportional term makes a change to the output that is proportional to the current error (E) which is the difference between the set-point (*SP*) and the process variable (*PV*). The proportional response can be adjusted by multiplying the error by the proportional gain (*KP*).

The proportional equation is:

MPn = KP * En = KP * (SPn – PVn)

where: MPn is the output value of the proportional term at sample time n
KP is the proportional gain
SPn is the value of the set-point at sample time n
PVn is the value of the process variable at sample time n

A high proportional gain (*KP*) results in a large change in the output for a given change in the error. If the proportional gain is too high, the system can become unstable. In contrast, a small gain results in a small output response to a large input error, and a less responsive (or sensitive) controller. If the proportional gain is too low, the control action may be too small when responding to system disturbances.

The loop is forward-acting if the *KP* is positive and reverse-acting if the *KP* is negative.

- Integral term

The contribution from the integral term is proportional to both the magnitude of the error and the duration of the error. Summing the instantaneous error over time (integrating the error) gives the accumulated offset that should have been corrected previously. The accumulated error is then divided by the integration time (*TR*) and added to the controller output. The magnitude of the contribution of the integral term to the overall control action is determined by the proportional gain (*KP*), the sampling period (*Ts*), and the integral time (*TR*), which is a time used to control the influence of the integral term in the output calculation. (*TR*). The integral equation is:

MIn = KP * Ts * En / TR = KP * Ts * (SPn – PVn) / TR

where: MIn is the output value of the integral term at sample time n
KP is the proportional gain
TR is the integration time
Ts is the sampling cycle
SPn is the value of the set-point at sample time n
PVn is the value of the process variable at sample time n

The integral term (when added to the proportional term) accelerates the movement of the process towards set-point and eliminates the residual steady-state error that occurs with a proportional only controller. If *TR* is equal to 0, the integral term is canceled.

- Derivative term

The rate of change of the process error is calculated by determining the slope of the error over time (i.e. its first derivative with respect to time) and multiplying this rate of change by the derivative time (*KD*). The derivative term is used to reduce the magnitude of the overshoot produced by the integral component and improve the controller-process stability. However, differentiation of a signal amplifies noise and thus this term is highly sensitive to noise in the error term, and can cause a process to become unstable if the noise and the derivative gain are sufficiently large. The derivative equation is:

MDn = KP * TD / Ts * (En – En-1) = KP * TD / Ts* ((SPn – PVn) - (SPn-1 – PVn-1))

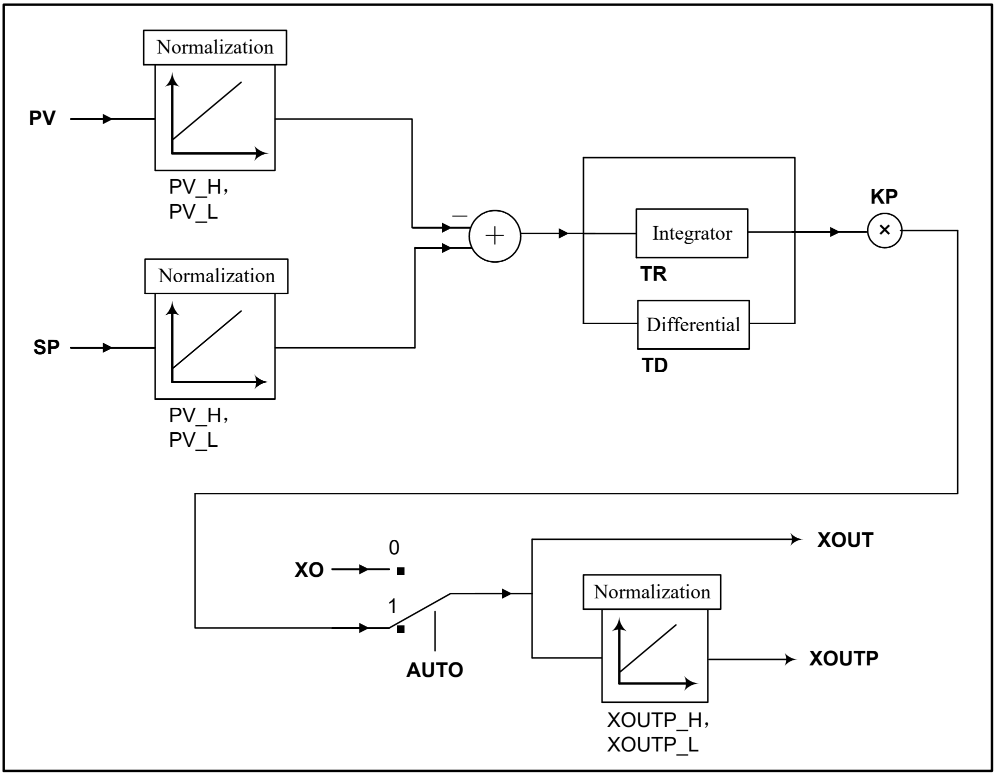
where: MDn is the output value of the derivative term at sample time n
KP is the proportional gain
TD is the derivative time
Ts is the sampling cycle
SPn is the value of the set-point at sample time n

PVn is the value of the process variable at sample time n

SPn-1 is the value of the set-point at sample time n-1

PVn1 is the value of the process variable at sample time n-1

➢ **PID Diagram**

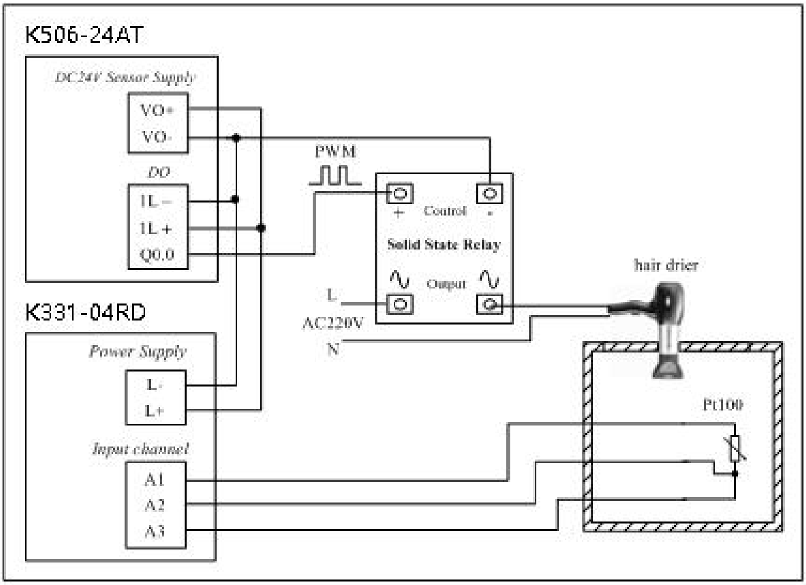


➢ **Example**

Let's establish a simple control system: we try to control the temperature within a box, and we use an electric heater to heat, but rely on natural cooling. We use a Pt100 transducer to measure the temperature, and use a solid state relay to control the power supply of the heater.

We use a K506-24AT and a K531-04RD. The Pt100 is connected to the AIW0 channel of K531-04RD. Q0.0 is connected to the control terminal of the solid state relay. Q0.0 outputs the PWM pulses, and the PID result is used for adjusting the pulse width and then controlling the power time of the heater.

The following is the diagram of this system:



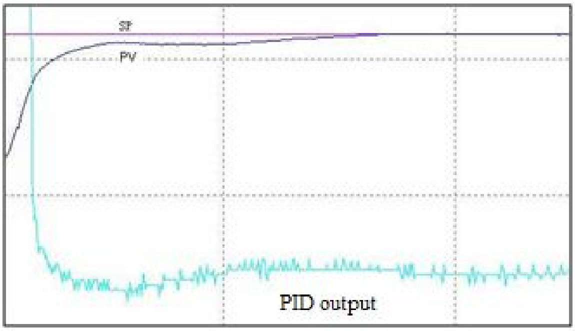
The idea of this example program is as follows:

1) Using a TON timer to generate simple PWM output.

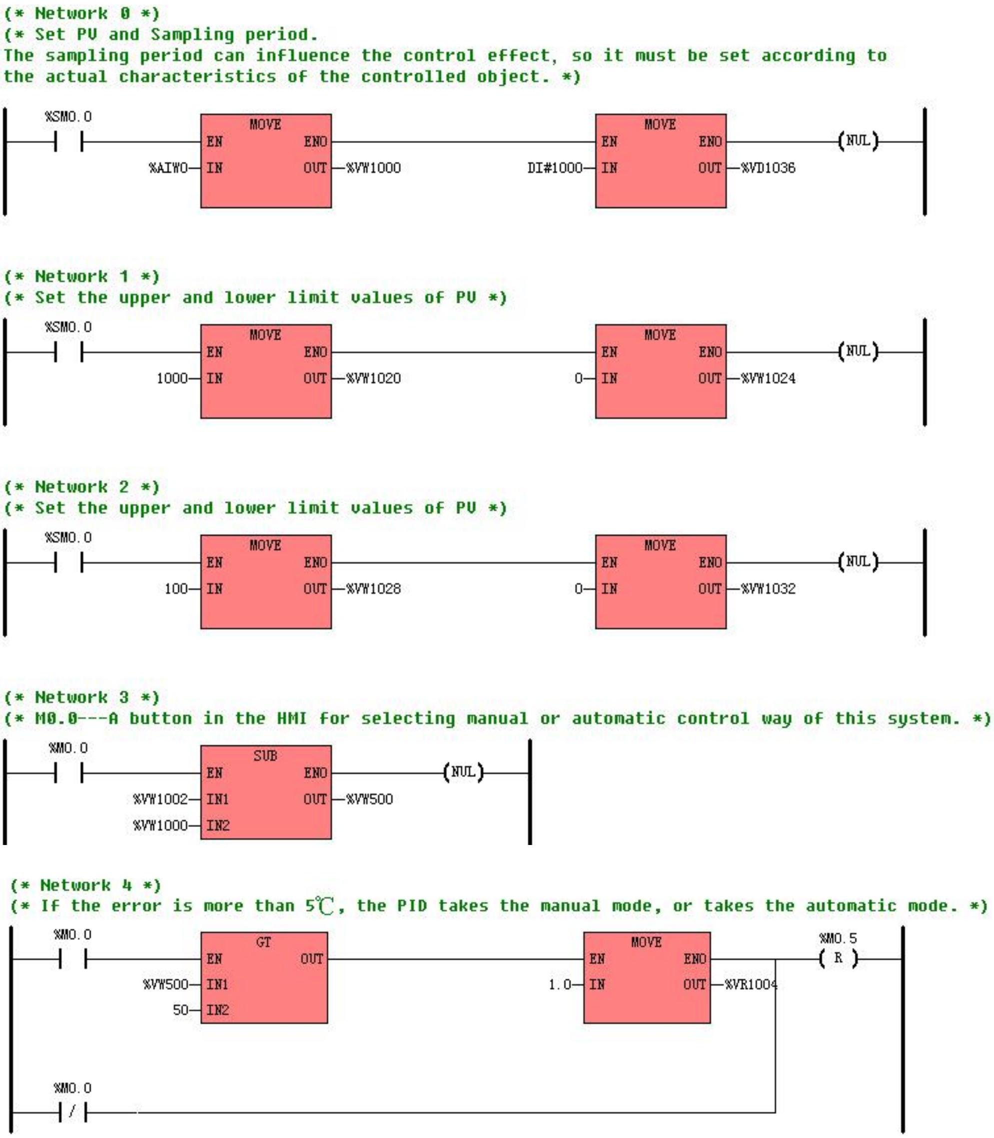
2) To improve the control effect, we take the following way: If the error (SP-PV) is more than 5°C, the PID controller takes the manual mode and its manipulated value is set to be 100%; If the error is less than or equal to 5℃, the PID controller then switch to the automatic mode.

If the error is too large, the automatic mode can lead to excessive overshoot and longer adjustment time because of the accumulation effect of the integral term, so now the PID controller takes the manual way.

The following picture is the result when SP is set to be 50℃.

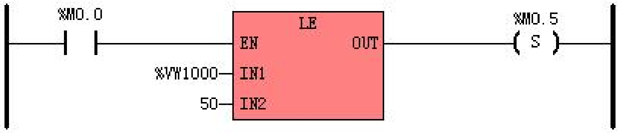


LD

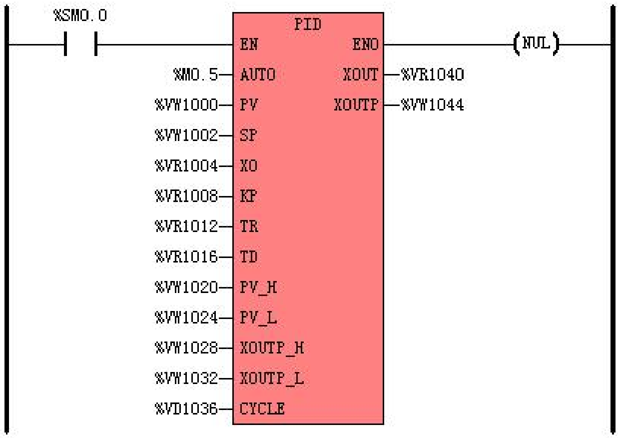

(* Network 0 *)
(* Set PV and Sampling period.
The sampling period can influence the control effect, so it must be set according to
the actual characteristics of the controlled object. *)
%SM0.0
MOVE
EN ENO
%AIW0 IN OUT %VW1000
MOVE
EN ENO
DI#1000 IN OUT %VD1036
(NUL)
(* Network 1 *)
(* Set the upper and lower limit values of PV *)
%SM0.0
MOVE
EN ENO
1000 IN OUT %VW1020
MOVE
EN ENO
0 IN OUT %VW1024
(NUL)
(* Network 2 *)
(* Set the upper and lower limit values of PV *)
%SM0.0
MOVE
EN ENO
100 IN OUT %VW1028
MOVE
EN ENO
0 IN OUT %VW1032
(NUL)
(* Network 3 *)
(* M0.0---A button in the HMI for selecting manual or automatic control way of this system. *)
%M0.0
SUB
EN ENO
%VW1002 IN1 OUT %VW500
%VW1000 IN2
(NUL)
(* Network 4 *)
(* If the error is more than 5℃, the PID takes the manual mode, or takes the automatic mode. *)
%M0.0
GT
EN OUT
%VW500 IN1
50 IN2
MOVE
EN ENO
1.0 IN OUT %VR1004
%M0.5
(R)
%M0.0

LD

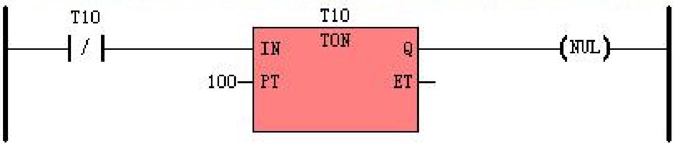
(* Network 5 *)



(* Network 6 *)



(* Network 7 *)
(* Using a timer to generate PWM output whose period is 1s. *)



(* Network 8 *)
(* The output of PID is used for adjusting the pulse width of PWM. *)

IL	(* Network 0 *)
	(*Set PV and Sampling period*)
	(*The sampling period can influence the control effect , so it must be set according to the actual characteristics of the controlled object. *)
	LD %SM0.0
	MOVE %AIW0, %VW1000
	MOVE DI#1000, %VD1036
	(* Network 1 *)
	(*Set the upper and lower limit values of *PV* *)
	LD %SM0.0
	MOVE 1000, %VW1020
	MOVE 0, %VW1024
	(*Set the upper and lower limit values of *XOUT_P**)
	MOVE 100, %VW1028
	MOVE 0, %VW1032
	(* Network 3 *)
	(*M0.0---A button in the HMI for selecting manual or automatic control way of this system.*)
	(*If the user selects the automatic way, the PLC calculates the error and determines PID's mode.*)
	LD %M0.0
	MOVE %VW1002, %VW500
	SUB %VW1000, %VW500
	(* Network 4 *)
	(*If the error is more than 5℃, the PID takes the manual mode, or takes the automatic mode. *)
	LD %M0.0
	GT %VW500, 50
	MOVE 1.0, %VR1004
	ORN %M0.0
	R %M0.5
	(* Network 5 *)
	LD %M0.0
	LE %VW1000, 50
	S %M0.5

IL	(* Network 6 *) LD %SM0.0 PID %M0.5, %VW1000, %VW1002, %VR1004, %VR1008, %VR1012, %VR1016, %VW1020, %VW1024, %VW1028, %VW1032, %VD1036, %VR1040, %VW1044 (* Network 7 *) (*Using a timer to generate PWM output whose period is 1s.*) LDN T10 TON T10, 100 (* Network 8 *) (*The output of PID is used for adjusting the pulse width of PWM.*) LD %SM0.0 GT %VW1044, T10 ST %Q0.0

6.16 Position Control

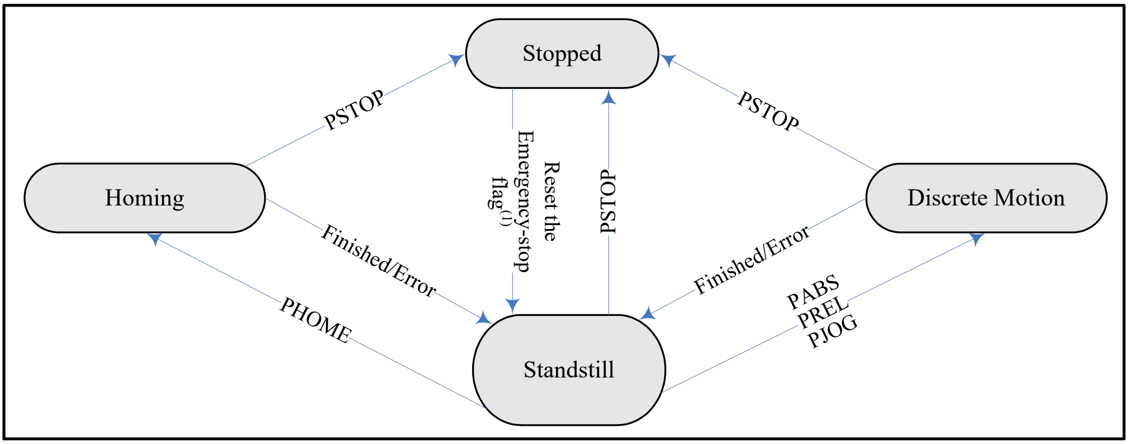
The Kinco-K5 provides 2 high-speed pulse output channels: Q0.0 and Q0.1, and can be used for position control for 2 axes. In 6.13.4 Pulse Width Modulation (PWM), the usage of PWM and the PLS instruction is described detailedly.

The Position Control instructions described in this chapter is another usage of the high-speed pulse output function. Comparing with the PLS instruction, the Position Control instructions are more convenient for the position control applications. Similarly, the frequency of the pulse output is between 20kHz-200kHz.

6.16.1 Model

The following diagram is focused on a single axis, and it normatively defines the behavior of the axis at a high level when the position control instructions are activated. The basic rule is that position commands are always taken sequentially.

The axis is always in one of the defined state (see diagram below). Any position command is a transition that changes the state of the axis and, as a consequence, modifies the way the current position is computed.



- The Emergency-Stop flag is SM201.7/ SM231.7. It will be set to 1 automatically while executing the PSTOP instruction. Please refer to the detailed description in the following section.

6.16.2 The correlative variables

6.16.2.1 The direction output channel

For the Position Control instructions, the Kinco-K5 specifies a direction output channel for each high-speed pulse output channel, and a control bit in the SM area to enable the direction output. Please see the following table.

High-speed Pulse Output Channel	Q0.0	Q0.1
Direction output channel	Q0.2	Q0.3
Direction control bit	SM201.3	SM231.3

The direction output channel is used for providing a direction signal which controls the direction of the electric motors: 0 means rotating forwards, and 1 means rotating backwards.

The direction control bit is used to disable or enable the corresponding direction output channel. The direction control bit has the highest priority. If disabled, no direction signal will be provided while executing a position control instruction and the corresponding direction output channel can be used as a normal DO point.

6.16.2.2 The Status and Control Registers

For the Position Control instructions, the Kinco-K5 specifies a control byte for each high-speed output channel to store its configurations.

A status register is also specified for storing the current value (the number of pulses output, DINT). The current value increases when rotating forwards, and decreases when rotating backwards. The following table describes these registers detailedly. Note: After a position control instruction has finished, the current value will not be cleared automatically, and you can clear it in your program.

The following table describes the control byte and the current value.

Q0.0	Q0.1	Description
SM201.7	SM231.7	Emergency-Stop flag.

		If this bit is 1, no position control instructions can be executed. When executing the PSTOP instruction, this bit is set to 1 automatically, and it must be reset by your program.
SM201.6	SM231.6	Reset the current value or not 1 --- Clear the current value. 0 --- Maintain the current value.
SM201.5~SM201.4	SM231.4~SM231.5	Reserved
SM201.3	SM231.3	Direction control bit. 1 --- Disable the direction output channel. 0 --- Enable the direction output channel.
SM201.0~SM201.2	SM231.0~SM231.2	Reserved
Q0.0	**Q0.1**	**Description**
SMD212	SMD242	The current value

6.16.2.3 The error identification

During the execution of the position control instructions, non-fatal errors may occur, then the CPU will generate error identification, and write it to the *ERRID* parameter of the instruction. The following table describes these error codes and their descriptions.

Error Code	Description
0	No error
1	Acceleration/deceleration time is too short or the initial speed is too low, leading to initial pulse period exceed preset TIME for each segment.
2	The value of *MINF* is larger than the value of *MAXF(200KHz)*.
3	The value of *MINF* is less than the allowed lowest frequency (125Hz).
4	Pulses numbers required for acceleration and deceleration exceed total pulse numbers
5	The value of *MINF* is larger than that of *MAXF*

6.16.3 PHOME (Homing)

➢ **Description**

	Name	Usage	Group	
LD	PHOME			☑ K5 ☑ K2
IL	PHOME	PHOME *AXIS, EXEC, HOME, NHOME, MODE, DIRC, MINF, MAXF, TIME, DONE, ERR, ERRID*	U	

Operands	Input/Output	Data Type	Acceptable Memory Areas
AXIS	Input	INT	Constant (0 or 1)
EXEC	Input	BOOL	I, Q, V, M, L, SM, RS, SR
HOME	Input	BOOL	I, Q, V, M, L, SM, RS, SR
NHOME	Input	BOOL	I, Q, V, M, L, SM, RS, SR
MODE	Input	INT	I, Q, V, M, L, SM, T, C, AI, AQ, Constant
DIRC	Input	INT	I, Q, V, M, L, SM, T, C, AI, AQ, Constant
MINF	Input	WORD	I, Q, M, V, L, SM, Constant
MAXF	Input	DWORD	I, Q, M, V, L, SM, Constant
TIME	Input	WORD	I, Q, M, V, L, SM, Constant
DONE	Output	BOOL	Q, M, V, L, SM
ERR	Output	BOOL	Q, M, V, L, SM
ERRID	Output	BYTE	Q, M, V, L, SM

Note: ***MODE, DIRC, MINF, MAXF, TIME should be constants or variables simultaneously.***

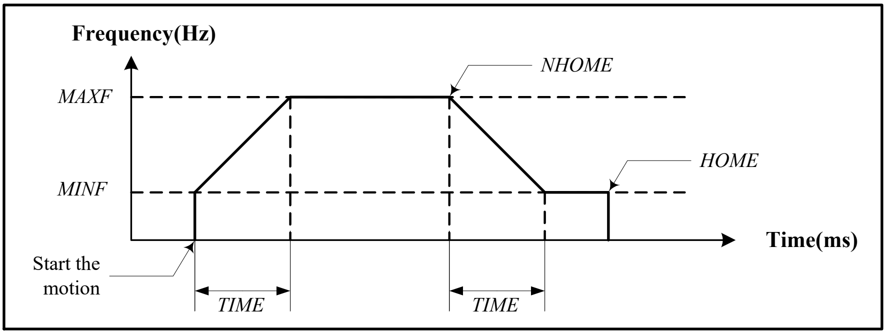
The SMD212 and SMD242 can only be reset (cleared) by SM201.6 and SM231.6. When you use K5 to replace K3, please be aware of this, because the SMD212 and MD242 can be reset (cleared) directly in K3 PLC.

The following table describes all the operands detailedly.

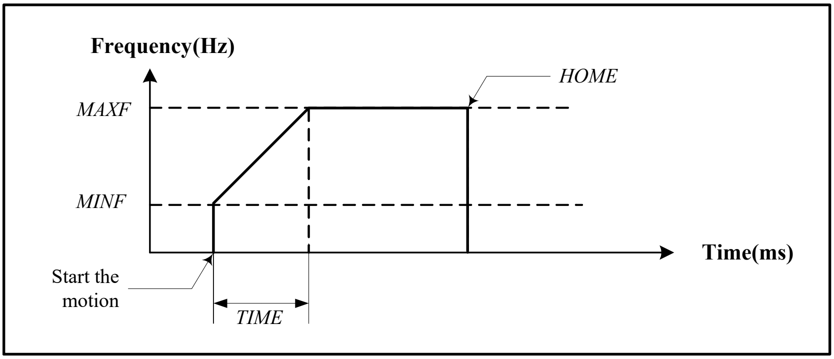
Operands	Description
AXIS	The high-speed output channel, 0 means Q0.0, 1 means Q0.1.
EXEC	If *EN* is 1, the *EXEC* starts the 'search home' motion on the rising edge.
HOME	The home signal from the home sensor
NHOME	The near home signal from the near home sensor
MODE	Specifies the homing mode: 0 means that the home signal and the near home signal are all used; 1 means that only the home signal is used.
DIRC	Specifies the rotating direction of the electric motor: 0 means rotating forwards; 1 means rotating backwards. Please refer to 6.16.2.1 The direction output channel for more information.
MINF	Specifies the initial speed (i.e., the initial frequency) of the pulse train output. Unit: Hz. Note: the value of *MINF* must be equal to or less than 125Hz.
MAXF	Specifies the highest speed (i.e., the highest frequency) of the pulse train output. Unit: Hz. The available range of *MAXF* is 125Hz ~ 200KHz. *MAXF* must be larger than or equal to *MINF*.
TIME	Specifies the acceleration/deceleration time. Unit: ms. In the position control instructions, the acceleration time is the same as the deceleration time. The acceleration time is the time for the speed accelerating from *MINF* to *MAXF*. The deceleration time is the time for the speed decelerating from *MAXF* to *MINF*.
DONE	Indicates that the instruction has finished successfully. 0 = not finished; 1 = finished.
ERR	Indicates that error has occurred during the execution. 0 = no error; 1 = an error has occurred.
ERRID	Error identification.

This instruction controls the *AXIS* to execute the 'search home' sequence using the *HOME* and *NHOME* signals. The *MODE* specifies the homing mode. While executing the 'search home' motion, if the *DIRC* is set to be 0 (rotating forwards), the current value (SMD212/SMD242) increases; if the *DIRC* is set to be 1 (rotating backwards), the current value (SMD212/SMD242) decreases.

- If the *MODE* is 0 (using both the *HOME* and the *NHOME* signals), the PHOME instruction will control the *AXIS* to decelerate as soon as the *NHOME* becomes 1, and to stop as soon as the *HOME* becomes 1. The timing diagram is as followings:



- If the *MODE* is 1 (using the *HOME* signal only), the PHOME instruction will control the *AXIS* to stop as soon as the *HOME* becomes 1. The timing diagram is as followings:



Notice: when the HOME signal becomes 1, the registers (SMD212/SM242) do not clear the current values; they need change the current values in condition.

The SMD212 and SMD242 can only be reset (cleared) by SM201.6 and SM231.6. When you use K5 to replace K3, please be aware of this, because the SMD212 and MD242 can be reset (cleared) directly in K3 PLC.

- **LD**

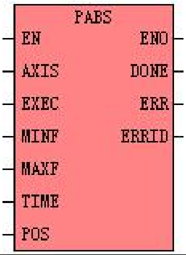
If *EN* is 1, this instruction is executed.

- **IL**

If CR is 1, this instruction is executed, and it does not influence CR.

6.16.4 PABS (Moving Absolutely)

- **Description**

	Name	Usage	Group	
LD	PABS			☑ K5 ☑ K2
IL	PABS	PABS AXIS, EXEC, MINF, MAXF, TIME, POS, DONE, ERR, ERRID	U	

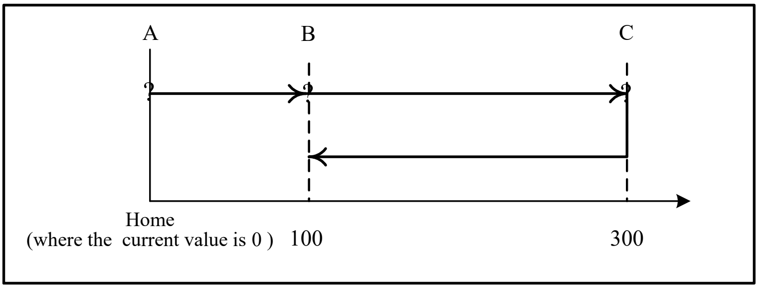
Operands	Input/Output	Data Type	Acceptable Memory Areas
AXIS	Input	INT	Constant (0 or 1)
EXEC	Input	BOOL	I, Q, V, M, L, SM, RS, SR
MINF	Input	WORD	I, Q, M, V, L, SM, Constant

MAXF	Input	DWORD	I, Q, M, V, L, SM, Constant
TIME	Input	WORD	I, Q, M, V, L, SM, Constant
POS	Input	DINT	I, Q, M, V, L, SM, HC, Constant
DONE	Output	BOOL	Q, M, V, L, SM
ERR	Output	BOOL	Q, M, V, L, SM
ERRID	Output	BYTE	Q, M, V, L, SM

Note: ***MINF, MAXF, TIME, POS should be constants or variables simultaneously.***

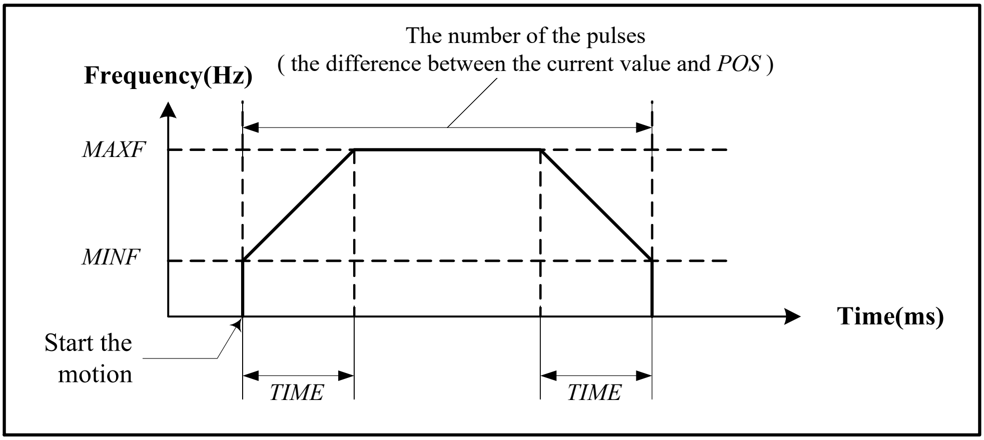
The following table describes all the operands detailedly.

Operands	Description
AXIS	The high-speed output channel, 0 means Q0.0, 1 means Q0.1.
EXEC	If *EN* is 1, the *EXEC* starts the absolute motion on the rising edge.
MINF	Specifies the initial speed (i.e., the initial frequency) of the pulse train output. Unit: Hz. Note: the value of *MINF* must be equal to or less than 125Hz.
MAXF	Specifies the highest speed (i.e., the highest frequency) of the pulse train output. Unit: Hz. The available range of *MAXF* is 125Hz ~ 200KHz. *MAXF* must be larger than or equal to *MINF*.
TIME	Specifies the acceleration/deceleration time. Unit: ms. In the position control instructions, the acceleration time is the same as the deceleration time. The acceleration time is the time for the speed accelerating from *MINF* to *MAXF*. The deceleration time is the time for the speed decelerating from *MAXF* to *MINF*.

POS	Specifies the target value. It is represented with the number of pulses between the home positon, where the current value is 0, and the target position. As shown in the following figure, if the object is moved from A to B, the *POS* should be set as '100'; If it is moved from B to C, the *POS* should be set as '300'; If it is moved from C to B, the *POS* should be set as '100'. 
DONE	Indicates that the instruction has finished successfully. 0 = not finished; 1 = finished.
ERR	Indicates that error has occurred during the execution. 0 = no error; 1 = an error has occurred.
ERRID	Error identification.

If the Direction Control Bit (SM201.3/SM231.3) is set to 0, the PABS instruction will generate the direction output signal at the corresponding direction output channel (Q0.2/Q0.3): If the target value is greater than the current value, it generates a direction output of rotating forwards, then the current value (SMD212/SMD242) increases; If the target value is less than the current value, it generates a direction output of rotating backwards, and then the current value (SMD212/SMD242) decreases.

The timing diagram is as following:



➢ **LD**

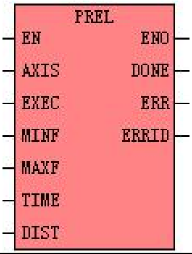
If *EN* is 1, this instruction is executed.

➢ **IL**

If CR is 1, this instruction is executed, and it does not influence CR.

6.16.5 PREL (Moving Relatively)

- **Description**

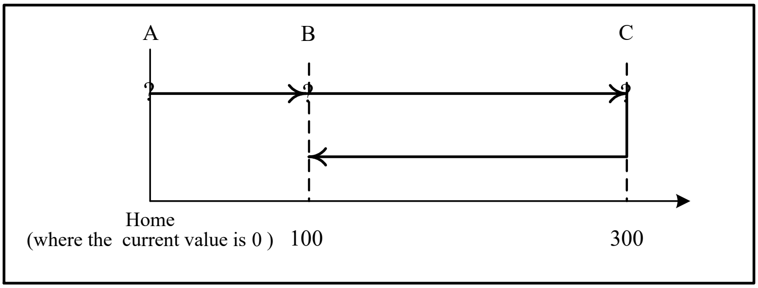
	Name	Usage	Group	
LD	PREL			☑ K5 ☑ K2
IL	PREL	PREL AXIS, EXEC, MINF, MAXF, TIME, DIST, DONE, ERR, ERRID	U	

Operands	Input/Output	Data Type	Acceptable Memory Areas
AXIS	Input	INT	Constant (0 or 1)
EXEC	Input	BOOL	I, Q, V, M, L, SM, RS, SR
MINF	Input	WORD	I, Q, M, V, L, SM, Constant
MAXF	Input	DWORD	I, Q, M, V, L, SM, Constant
TIME	Input	WORD	I, Q, M, V, L, SM, Constant
DIST	Input	DINT	I, Q, M, V, L, SM, HC, Constant
DONE	Output	BOOL	Q, M, V, L, SM
ERR	Output	BOOL	Q, M, V, L, SM
ERRID	Output	BYTE	Q, M, V, L, SM

Note: ***MINF, MAXF, TIME, DIST should be constants or variables simultaneously.***

The following table describes all the operands detailedly.

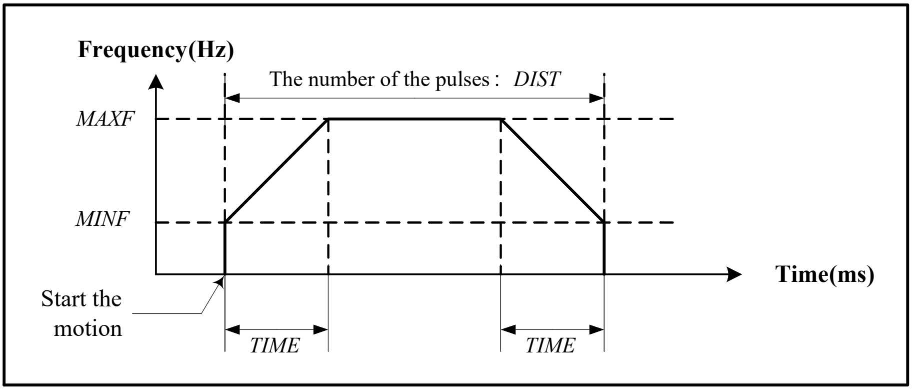
Operands	Description
AXIS	The high-speed output channel, 0 means Q0.0, 1 means Q0.1.
EXEC	If *EN* is 1, the *EXEC* starts the relative motion on the rising edge.
MINF	Specifies the initial speed (i.e., the initial frequency) of the pulse train output. Unit: Hz.

	Note: the value of *MINF* must be equal to or less than 125Hz.
MAXF	Specifies the highest speed (i.e., the highest frequency) of the pulse train output. Unit: Hz. The available range of *MAXF* is 125Hz ~ 200KHz. *MAXF* must be larger than or equal to *MINF*.
TIME	Specifies the acceleration/deceleration time. Unit: ms. In the position control instructions, the acceleration time is the same as the deceleration time. The acceleration time is the time for the speed accelerating from *MINF* to *MAXF*. The deceleration time is the time for the speed decelerating from *MAXF* to *MINF*.
DIST	Specifies the target distance. It is represented with the number of pulses between the current position and the target position. As shown in the following figure, if the object is moved from A to B, the *DIST* should be set as '100'; If it is moved from B to C, the *DIST* should be set as '200'; If it is moved from C to B, the *DIST* should be set as '-200'. 
DONE	Indicates that the instruction has finished successfully. 0 = not finished; 1 = finished.
ERR	Indicates that error has occurred during the execution. 0 = no error; 1 = an error has occurred.
ERRID	Error identification.

This instruction controls the *AXIS* to execute a motion of a specified distance (*DIST*) relative to the current value at the time of the execution.

If the Direction Control Bit (SM201.3/SM231.3) is set to 0, the PREL instruction will generate the direction output signal at the corresponding direction output channel (Q0.2/Q0.3): If the *DIST* is positive, it generates a direction output of rotating forwards, then the current value (SMD212/SMD242) increases; If the *DIST* is negative, it generates a direction output of rotating backwards, and then the current value (SMD212/SMD242) decreases.

The timing diagram is as following:



- **LD**

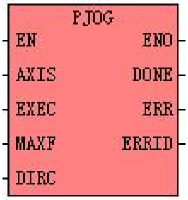
If *EN* is 1, this instruction is executed.

- **IL**

If CR is 1, this instruction is executed, and it does not influence CR.

6.16.6 PJOG (Jog)

➢ **Description**

	Name	Usage	Group	
LD	PJOG			☑ K5 ☑ K2
IL	PJOG	PJOG AXIS, EXEC, MINF, DIRC, DONE, ERR, ERRID	U	

Operands	Input/Output	Data Type	Acceptable Memory Areas
AXIS	Input	INT	Constant (0 or 1)
EXEC	Input	BOOL	I, Q, V, M, L, SM, RS, SR
MAXF	Input	DWORD	I, Q, M, V, L, SM, Constant
DIRC	Input	INT	I, Q, M, V, L, SM, AI, AQ, T, C, Constant
DONE	Output	BOOL	Q, M, V, L, SM
ERR	Output	BOOL	Q, M, V, L, SM
ERRID	Output	BYTE	Q, M, V, L, SM

Note: ***MAXF, DIRC should be constants or variables simultaneously.***

The following table describes all the operands detailedly.

Operands	Description
AXIS	The high-speed output channel, 0 means Q0.0, 1 means Q0.1.
EXEC	If *EN* is 1, the *EXEC* starts the jog motion on the rising edge.
MAXF	Specifies the speed of the pulse train output. Unit: Hz.
DIRC	Specifies the direction of the electric motors: 0 means rotating forwards, and 1 means rotating backwards.
DONE	Indicates that the instruction has finished successfully.

	0 = not finished; 1 = finished.
ERR	Indicates that error has occurred during the execution. 0 = no error; 1 = an error has occurred.
ERRID	Error identification.

This instruction controls the *AXIS* to execute a jog motion: generating a durative pulse train output, whose frequency is *MAXF*.

If the Direction Control Bit (SM201.3/SM231.3) is set to 0, the PJOG instruction will generate the direction output signal at the corresponding direction output channel (Q0.2/Q0.3): if the *DIRC* is 0 (rotating forwards), the current value (SMD212/SMD242) increases; if the *DIRC* is 1 (rotating backwards), the current value (SMD212/SMD242) decreases.

- **LD**

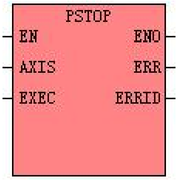
If *EN* is 1, this instruction is executed.

- **IL**

If CR is 1, this instruction is executed, and it does not influence CR.

6.16.7 PSTOP (Stop)

➢ **Description**

	Name	Usage	Group	
LD	PSTOP			☑ K5 ☑ K2
IL	PSTOP	PSTOP AXIS, EXEC, ERR, ERRID	U	

Operands	Input/Output	Data Type	Acceptable Memory Areas
AXIS	Input	INT	Constant (0 or 1)
EXEC	Input	BOOL	I, Q, V, M, L, SM, RS, SR
ERR	Output	BOOL	Q, M, V, L, SM
ERRID	Output	BYTE	Q, M, V, L, SM

The following table describes all the operands detailedly.

Operands	Description
AXIS	The high-speed output channel, 0 means Q0.0, 1 means Q0.1.
EXEC	If *EN* is 1, the *EXEC* stops the current motion on the rising edge.
ERR	Indicates that error has occurred during the execution. 0 = no error; 1 = an error has occured.
ERRID	Error identification.

This instruction stops the current motion of the *AXIS*. At the same time, the Emergency-Stop flag (SM201.7/ SM231.7) is set to 1, and no position control instruction can be executed until this flag is reset by your program.

➢ **LD**

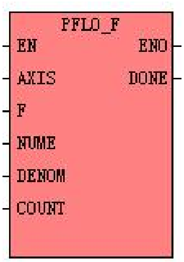
If *EN* is 1, this instruction is executed.

- **IL**

If CR is 1, this instruction is executed, and it does not influence CR.

6.16.8 PFLO_F

- **Description**

	Name	Usage	Group	
LD	PFLO_F			☑ K5 ☑ K2
IL	PFLO_F	PFLO_F AXIS, F, NUME, DENOM,COUNT, DONE	U	

Operands	Input/Output	Data Type	Acceptable Memory Areas
AXIS	Input	INT	Constant (0 or 1)
F	Input	DINT	L, M, V, Constant
NUME	Input	INT	L, M, V, Constant
DENOM	Input	INT	L, M, V, Constant
COUNT	Input	DWORD	L, M, V, Constant
DONE	Output	BOOL	Q, M, V, L

The following table describes all the operands detailedly.

Operands	Description
EN	Enable. If En is 1, this instruction will execute, otherwise PTO will stop.
AXIS	The pulse train output channel, 0 means Q0.0, 1 means Q0.1.
F	Frequency. Its sign means motion direction. Unit: Hz
NUME	Electronic gear numerator for PTO
DENOM	Electronic gear denominator for PTO
COUNT	Specifies the number of pulses to be output.
DONE	Indicates that the instruction has finished successfully. 0 = not finished; 1 = finished.

⚠ **Note: *F, NUME, DENOM* and *COUNT* must be all constants or all variables.**

This instruction controls the *AXIS* to generate a pulse-train output (PTO), and it generates *COUNT* pulses in total. The PTO's frequency is equal to *F*×(*NUME*÷*DENOM*), and its absolute value must be greater than or equal to 30Hz, otherwise K5 will stop the PTO until its frequency exceeds 30Hz again.

DONE indicates the completion of the pulse train output, it is set to be 0 as soon as PFLO_F begins, and it is set to be 1 as soon as the pulse train is completed.

If the Direction Control Bit (SM201.3/SM231.3) is set to 0, PFLO_F will generate a direction output signal at the corresponding direction output channel (Q0.2/Q0.3) according to the sign of *F*: If *F* is positive, PFLO_F generates a direction output of rotating forwards, then the current value (SMD212/SMD242) increases; If *F* is negative, it generates a direction output of rotating backwards, and then the current value (SMD212/SMD242) decreases.

If EN(or CR) is 1, this instruction executes and PTO starts, and now if EN(or CR) changes to 0, then PTO stops, and now if EN(or CR) changes to 1 again, PTO continues to run and generate the remaining pulses.

- **LD**

If EN is 1, this instruction executes, otherwise it stops.

- **IL**

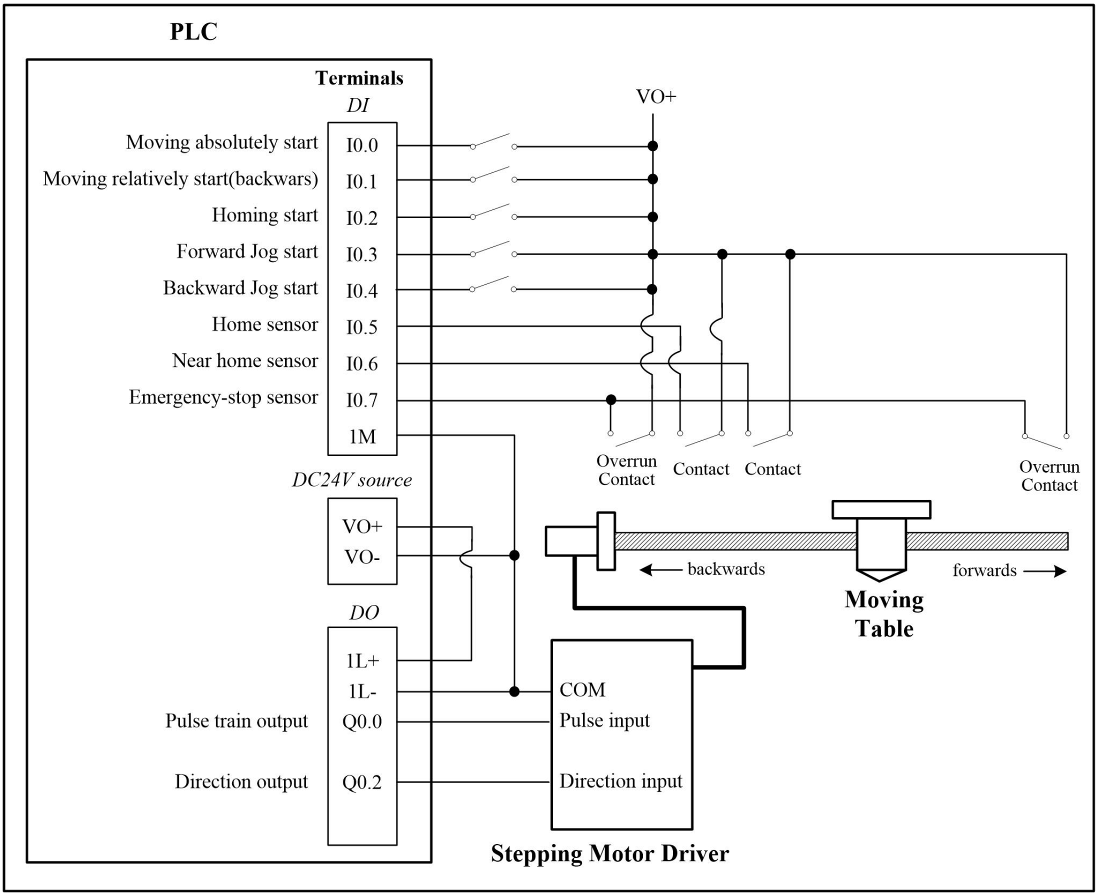
If CR is 1, this instruction executes, otherwise it stops.

This instruction does not influence CR.

6.16.9 Examples

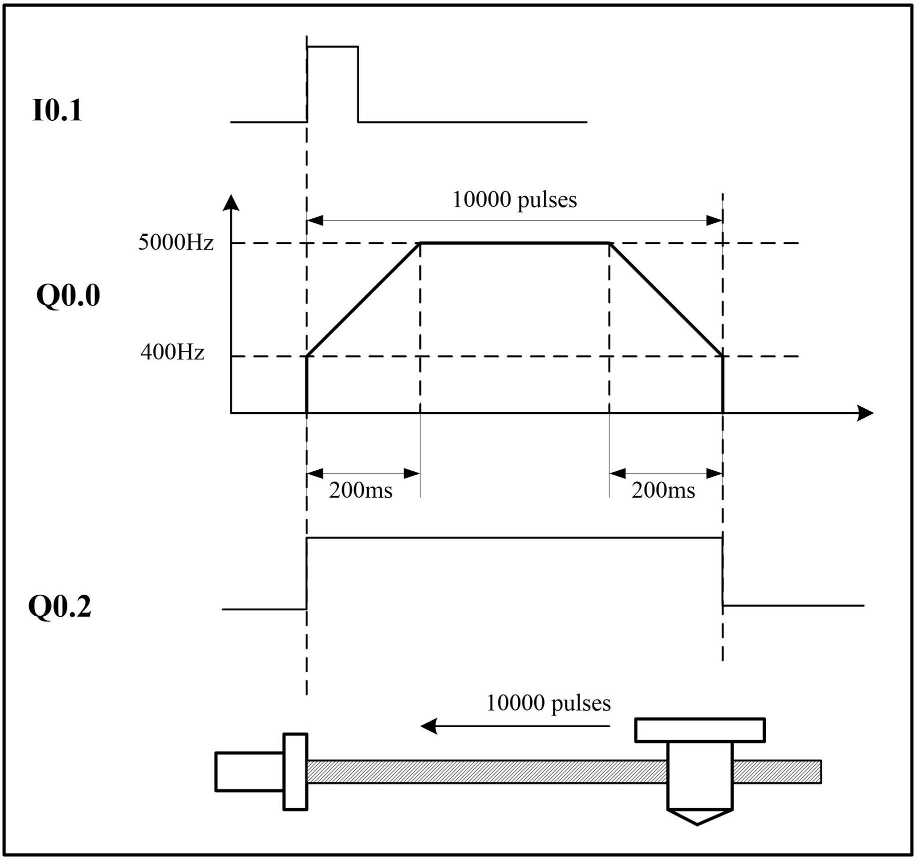
- **Wiring**

The following system is taken as the example to describe how to use the instructions PREL, PABS, PHOME, PJOG and PSTOP.



- **Moving relatively**

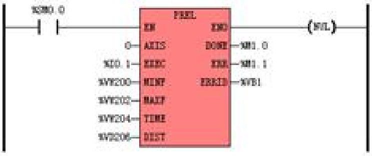
I0.1 is used for starting to move relatively (backwards).

Time Sequence Diagram	On the rising edge of I0.1, when Q0.0 is input, the output Q0.2 is 1 which means rotating backwards. 

<table>
<tr>
<td>LD</td>
<td>
(* Network 0 *)
(*Set the initial frequency and the maximum frequency*)


(* Network 1 *)
(*Set the acceleration/deceleration time and the distance*)


(* Network 2 *)
(*Reset the emergency-stop flag*)

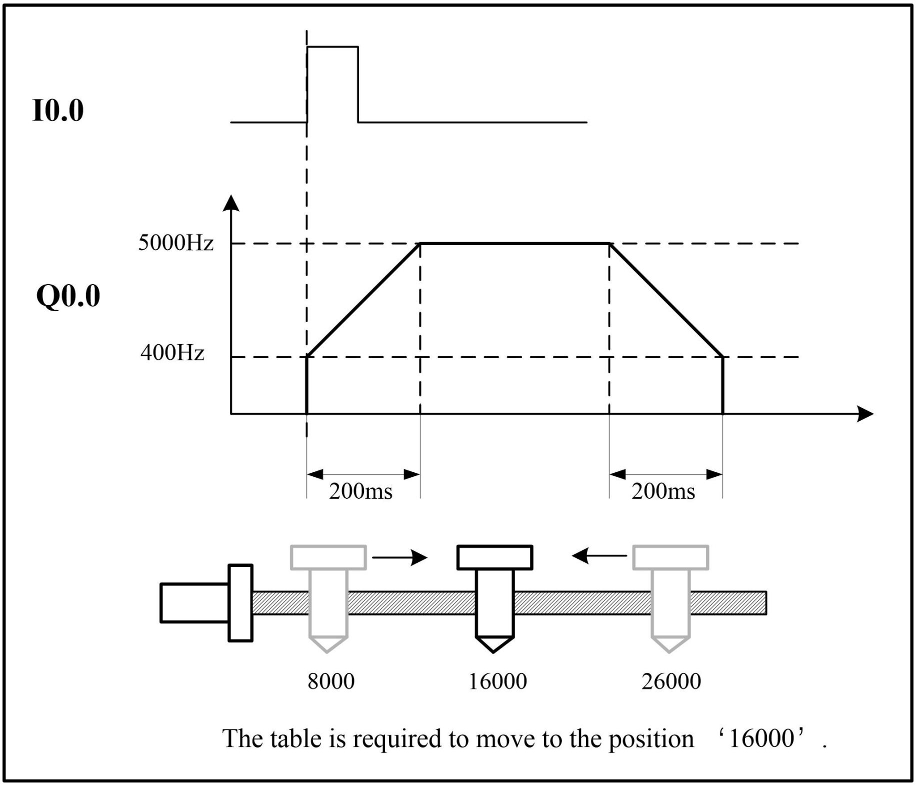

(* Network 3 *)
(*Call the PREL instruction*)


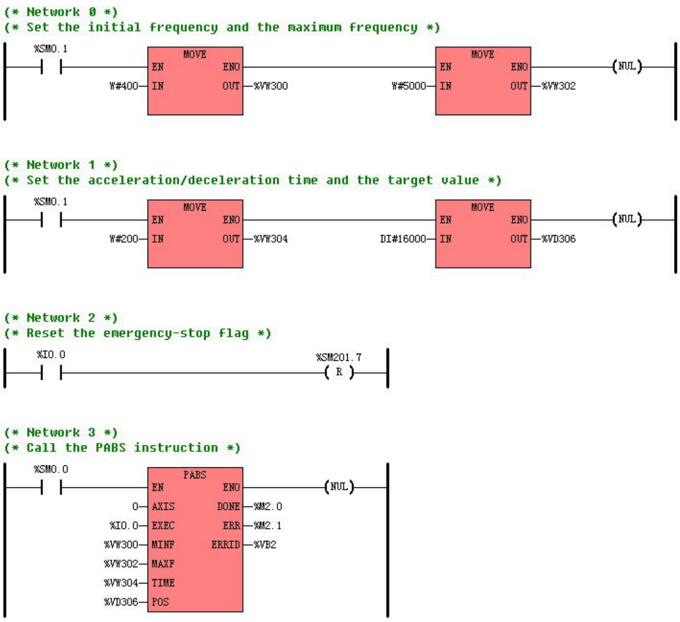
</td>
</tr>
</table>

IL	(* Network 0 *)
	(*Set the initial frequency and the maximum frequency*)
	LD %SM0.1
	MOVE W#400, %VW200
	MOVE W#5000, %VW202
	(* Network 1 *)
	(*Set the acceleration/deceleration time and the distance*)
	LD %SM0.1
	MOVE W#200, %VW204
	MOVE DI#-10000, %VD206
	(* Network 2 *)
	(*Reset the emergency-stop flag*)
	LD %I0.1
	R %SM201.7
	(* Network 3 *)
	(*Call the PREL instruction*)
	LD %SM0.0
	PREL 0, %I0.1, %VW200, %VW202, %VW204, %VD206, %M1.0, %M1.1, %VB1

- **Moving absolutely**

I0.0 is used for starting to move absolutely.

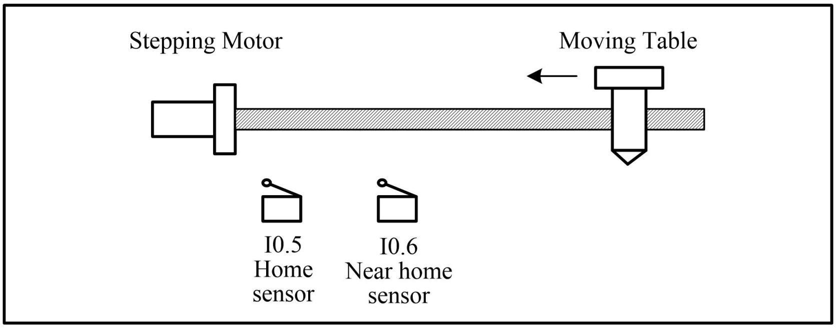
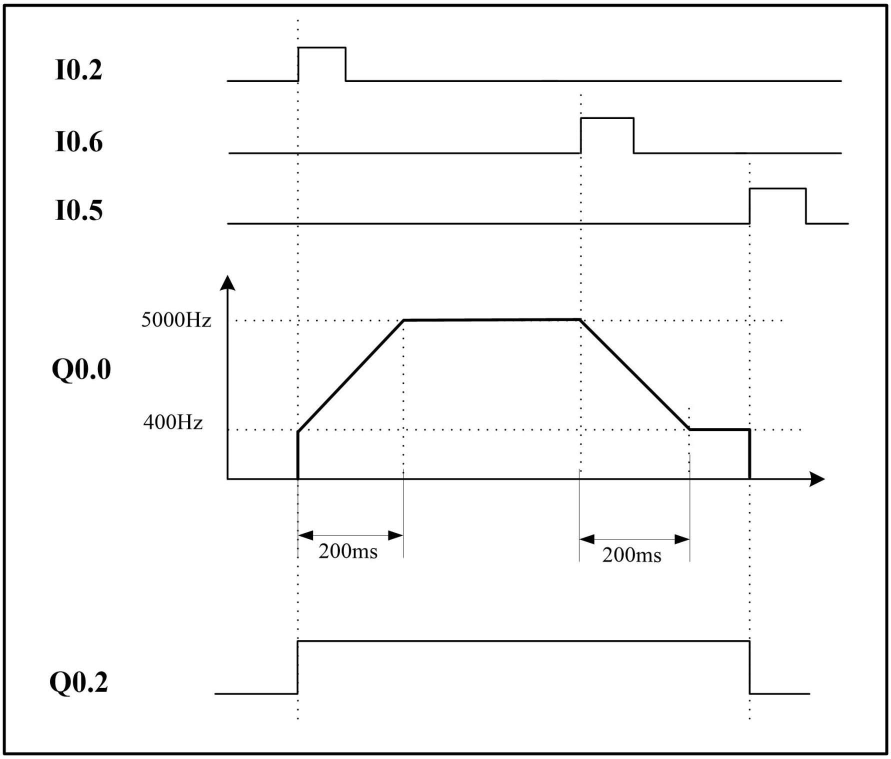
Time Sequence Diagram	

LD	

IL	(* Network 0 *)
	(*Set the initial frequency and the maximum frequency*)
	LD %SM0.1
	MOVE W#400, %VW300
	MOVE W#5000, %VW302
	(* Network 1 *)
	(*Set the acceleration/deceleration time and the target value*)
	LD %SM0.1
	MOVE W#200, %VW304
	MOVE DI#16000, %VD306
	(* Network 2 *)
	(*Reset the emergency-stop flag*)
	LD %I0.0
	R %SM201.7
	(* Network 3 *)
	(*Call the PABS instruction*)
	LD %SM0.0
	PABS 0, %I0.0, %VW300, %VW302, %VW304, %VD306, %M2.0, %M2.1, %VB2

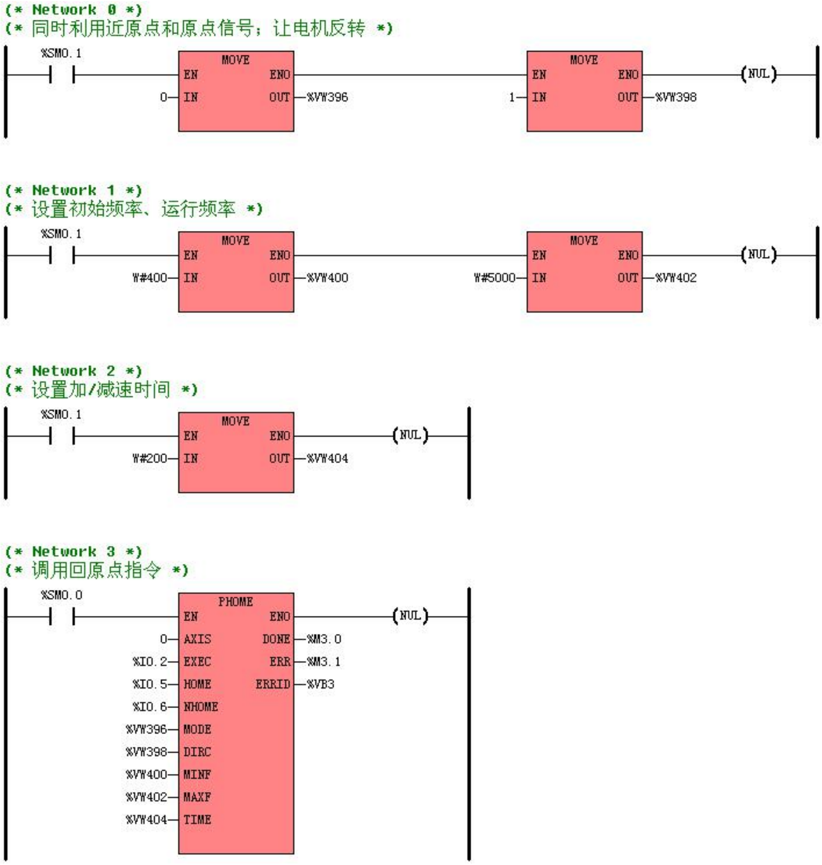
- **Home**

I0.2 is used for starting to return to the home position,

Time Sequence Diagram	Supposing that the moving is in the following initial status:  During the motion, Q0.2 is 1 because of moving backwards. 

IL	(* Network 0 *)
	(*use both the home and the near home input; move backwards*)
	LD %SM0.1
	MOVE 0, %VW396
	MOVE 1, %VW398
	(* Network 1 *)
	(*set the initial frequency, maximum frequency and acceleration/deceleration time*)
	LD %SM0.1
	MOVE W#400, %VW400
	MOVE W#5000, %VW402
	MOVE W#200, %VW404
	(* Network 2 *)
	(*Reset the emergency-stop flag*)
	LD %I0.2
	R %SM201.7
	(* Network 3 *)
	LD %SM0.0
	PHOME 0, %I0.2, %I0.5, %I0.6, %VW396, %VW398, %VW400, %VW402, %VW404, %M3.0, %M3.1, %VB3

LD

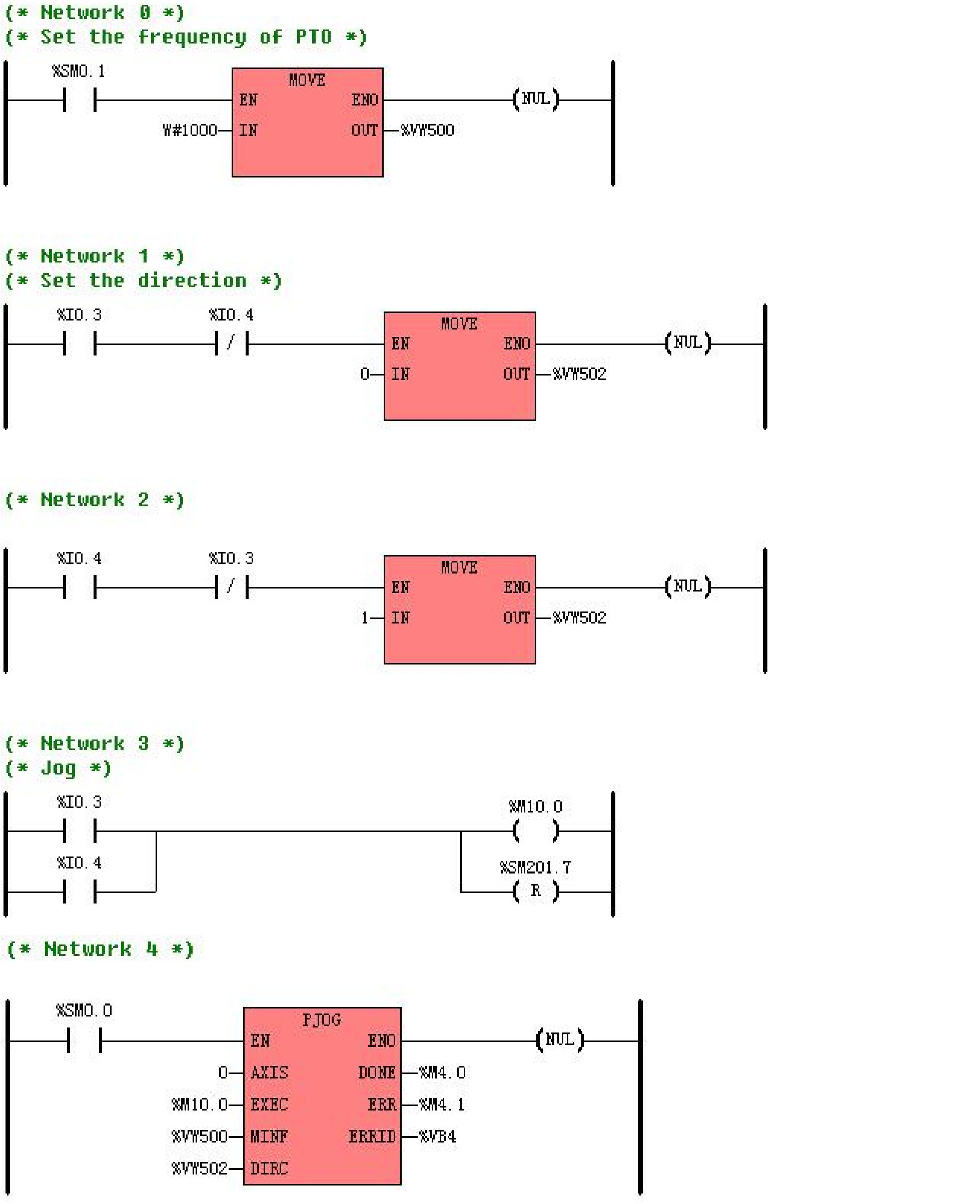

(* Network 0 *)
(* 同时利用近原点和原点信号；让电机反转 *)
%SM0.1
MOVE
EN ENO
0 IN OUT %VW396
MOVE
EN ENO
1 IN OUT %VW398
(NUL)
(* Network 1 *)
(* 设置初始频率、运行频率 *)
%SM0.1
MOVE
EN ENO
W#400 IN OUT %VW400
MOVE
EN ENO
W#5000 IN OUT %VW402
(NUL)
(* Network 2 *)
(* 设置加/减速时间 *)
%SM0.1
MOVE
EN ENO
W#200 IN OUT %VW404
(NUL)
(* Network 3 *)
(* 调用回原点指令 *)
%SM0.0
PHOME
EN ENO
0 AXIS DONE %M3.0
%I0.2 EXEC ERR %M3.1
%I0.5 HOME ERRID %VB3
%I0.6 NHOME
%VW396 MODE
%VW398 DIRC
%VW400 MINF
%VW402 MAXF
%VW404 TIME
(NUL)

➢ **Jog**

I0.3 is used for starting forward jog. I0.4 is used for starting backward jog.

If I0.3 and I0.4 are all 1, then the most recent direction is followed.

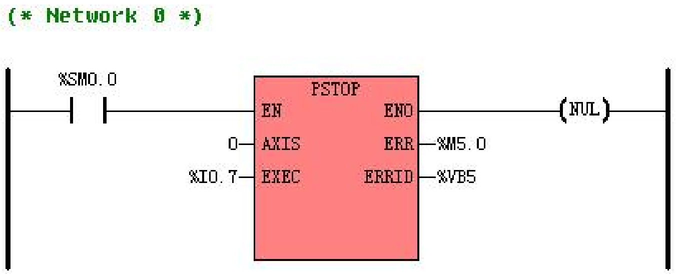
LD



IL	(* Network 0 *)
	(*Set the frequency of PTO*)
	LD %SM0.1
	MOVE W#1000, %VW500
	(* Network 1 *)
	(*Set the direction*)
	LD %I0.3
	ANDN %I0.4
	MOVE 0, %VW502
	(* Network 2 *)
	LD %I0.4
	ANDN %I0.3
	MOVE 1, %VW502
	(* Network 3 *)
	(*Jog*)
	LD %I0.3
	OR %I0.4
	ST %M10.0
	R %SM201.7
	(* Network 4 *)
	LD %SM0.0
	PJOG 0, %M10.0, %VW500, %VW502, %M4.0, %M4.1, %VB4

- **Stop**

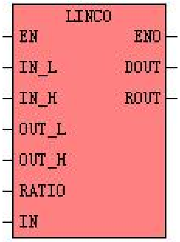
There are 2 overrun contacts at the 2 ends of the feed screw, and they are connected in parallel to I0.7 as the emergency-stop signal

LD	
IL	(* Network 0 *) LD %SM0.0 PSTOP 0, %I0.7, %M5.0, %VB5

6.17 Additional Instructions

6.17.1 LINCO (Linear Calculation)

➢ **Description**

	Name	Usage	Group	
LD	LINCO			☑ K5 ☑ K2
IL	LINCO	LINCO IN_L, IN_H, OUT_L, OUT_H, RATIO, IN, DOUT, ROUT	U	

Operands	Input/Output	Data Type	Acceptable Memory Areas
IN_L	Input	INT	I, Q, V, M, L, SM, T, C, AI, AQ, Constants
IN_H	Input	INT	I, Q, V, M, L, SM, T, C, AI, AQ, Constants
OUT_L	Input	REAL	V, L, Constants
OUT_H	Input	REAL	V, L, Constants
RATIO	Input	REAL	Constants
IN	Input	INT	I, Q, V, M, L, SM, T, C, AI, AQ
DOUT	Output	DINT	Q, M, V, L, SM
ROUT	Input	REAL	V, L

⚠ ***Note: IN_L, IN_H, OUT_L* and *OUT_H should be constants or variables simultaneously.***

This instruction calculates the input *IN* according to the specified linear relation, and multiplies the result with the coefficient *RATIO*, and then assigns the new result to *ROUT*. Also, the truncated DINT value of *ROUT* (by discarding the decimal part) to *DOUT*. The linear relation is specified according to the method '2 points decide a line', and the 2 points are (*IN_L*, *OUT_L*) and (*IN_H*, *OUT_H*).

The function of LINCO instruction can be described with the following formula:

$$ROUT = RATIO * (k*IN + b)$$

$$DOUT = \text{TRUNC}(ROUT)$$

Therein, $k = \dfrac{OUT\_H - OUT\_L}{IN\_H - IN\_L}$, $b = OUT\_L - k \times IN\_L$.

- **LD**

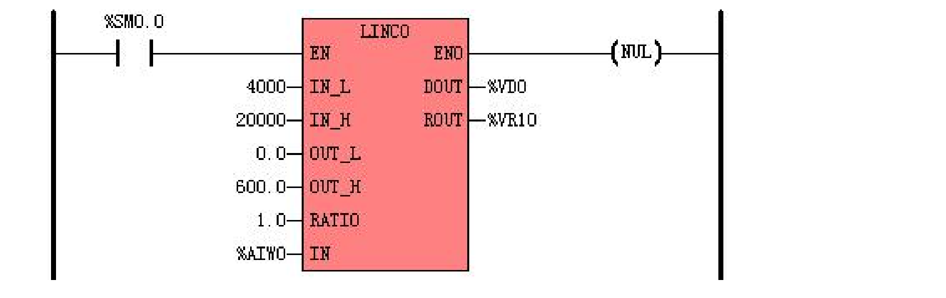
If *EN* is 1, this instruction is executed.

- **IL**

If CR is 1, this instruction is executed, and it does not influence CR.

- **Examples**

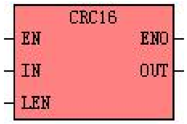
Assume that the measurement range of a temperature transducer is 0~600°C, and its output range is 4~20mA. The output signal of the transducer is connected to the channel AIW0 of the KINCO-K5. Now the KINCO-K5 needs to calculate the actual temperature value.

LD	

IL	LD %SM0.0 LINCO 4000, 20000, 0.0, 600.0, 1.0, %AIW0, %VD0, %VR10

6.17.2 CRC16 (16-Bit CRC)

- **Description**

	Name	Usage	Group	
LD	CRC16			☑ K5 ☑ K2
IL	CRC16	CRC16 IN, OUT, LEN	U	

Operands	Input/Output	Data Type	Acceptable Memory Areas
IN	Input	BYTE	I, Q, M, V, L, SM
LEN	Input	BYTE	I, Q, M, V, L, SM, Constant
OUT	Output	BYTE	Q, M, V, L, SM

This instruction calculates the 16-bit CRC (Cyclical Redundancy Check) for the number *LEN* of successive variables beginning with *IN*, and puts the result into 2 continuous byte variables beginning with *OUT*. Therein, *OUT* is the high byte of the CRC, and the succeeding byte variable after *OUT* is the low byte of the CRC.

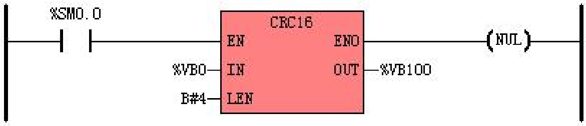
- **LD**

If *EN* is 1, this instruction is executed.

- **IL**

If CR is 1, this instruction is executed, and it does not influence CR.

➢ **Examples**

<table>
<tr><td>LD</td><td>
</td><td>SM0.0 is always 1, so CRC16 is always executed: calculates the CRC for the 4 continuous bytes beginning with VB0, then puts the high byte of the result into VB100, and the low byte into VB101.</td></tr>
<tr><td>IL</td><td colspan="2">LD %SM0.0
CRC16 %VB0, %VB100, B#4</td></tr>
<tr><td>Result</td><td colspan="2">The result is as the following:
<table>
<tr><th colspan="4">The data to be checked</th><th colspan="2">16-bit CRC</th></tr>
<tr><td>VB0</td><td>VB1</td><td>VB2</td><td>VB3</td><td>VB100</td><td>VB101</td></tr>
<tr><td>B#16#1A</td><td>B#16#2B</td><td>B#16#3C</td><td>B#16#4D</td><td>B#16#A6</td><td>B#16#1</td></tr>
</table></td></tr>
</table>

6.17.3 SPD (Speed detection)

- **Description**

	Name	Usage	Group	
LD	SPD			☑ K5 ☑ K2
IL	SPD	SPD HSC, TIME, PNUM	U	

Operands	Input/Output	Data Type	Acceptable Memory Areas
HSC	Input	INT	Constant（the number of a HSC）
TIME	Input	WORD	I, Q, M, V, L, SM, Constant
PNUM	Output	DINT	Q, M, V, L, SM

This instruction counts the number of the pulses received at the specified *HSC* in the specified *TIME* (Unit: ms), and writes the result to the *PNUM*.

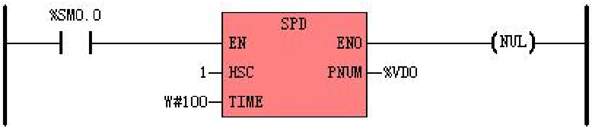
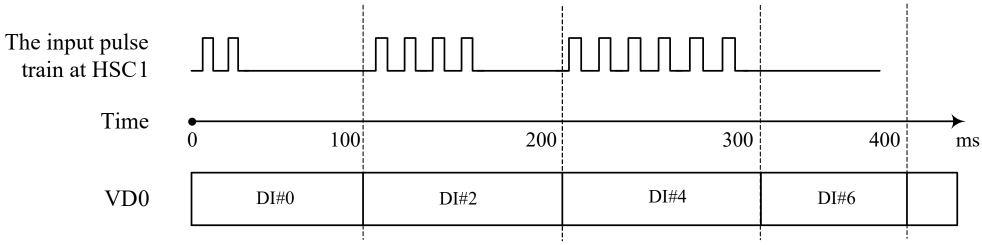
- **LD**

If *EN* is 1, this instruction is executed.

- **IL**

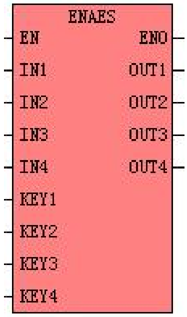
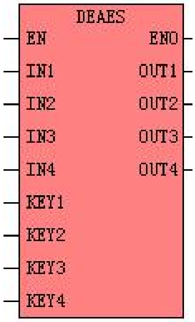
If CR is 1, this instruction is executed, and it does not influence CR.

➢ **Examples**

LD		SM0.0 is always 1, so SPD is always executed: count the number of the pulses received at HSC1 every 100ms, and write the result to VD0.
IL	LD %SM0.0 SPD 1, W#100, %VD0	
Result	The result is as the following: 	

6.17.4 ENAES(AES-128 Encryption) DEAES(AES-128 Decryption)

➢ Description

<table>
<tr><th></th><th>Name</th><th>Usage</th><th>Group</th><th rowspan="5">☑ K5
☑ K2</th></tr>
<tr><td rowspan="2">LD</td><td>ENAES</td><td>
</td><td rowspan="2"></td></tr>
<tr><td>DEAES</td><td>
</td></tr>
<tr><td rowspan="2"></td><td>ENAES</td><td>ENAES IN1,IN2,IN3,IN4,KEY1,KEY2,KEY3, KEY4,OUT1,OUT2,OUT3,OUT4</td><td rowspan="2">U</td></tr>
<tr><td>DEAES</td><td>DEAES IN1,IN2,IN3,IN4,KEY1,KEY2,KEY3, KEY4,OUT1,OUT2,OUT3,OUT4</td></tr>
</table>

Operands	Input/Output	Data Type	Acceptable memory area
IN1	Input	DWORD	I, Q, L, M, V, SM, constant
IN2	Input	DWORD	I, Q, L, M, V, SM, constant
IN3	Input	DWORD	I, Q, L, M, V, SM, constant
IN4	Input	DWORD	I, Q, L, M, V, SM, constant

KEY1	Input	DWORD	I, Q, L, M, V, SM, constant
KEY2	Input	DWORD	I, Q, L, M, V, SM, constant
KEY3	Input	DWORD	I, Q, L, M, V, SM, constant
KEY4	Input	DWORD	I, Q, L, M, V, SM, constant
OUT1	Output	DWORD	Q、SM、L、M、V
OUT2	Output	DWORD	Q、SM、L、M、V
OUT3	Output	DWORD	Q、SM、L、M、V
OUT4	Output	DWORD	Q、SM、L、M、V

⚠ **IN1, IN2, IN3, IN4, KEY1, KEY2, KEY3, KEY4 should be constant or memory variables at the same time.**

ENAES and DEAES are encryption instruction and decryption instruction for AES-128 respectively.

IN1/IN2/IN3/IN4 are source data for encryption/decryption; *KEY1/KEY2/KEY3/KEY4* are secret keys specified by user; *OUT1/OUT2/OUT3/OUT4* are data after encrypted/decrypted data.

- LD

If EN is 1, this instruction will be executed. The rise change of EN will trigger this command once and vice versa.

- IL

If CR is 1, this instruction will be executed.

This instruction does not influent CR.

6.17.5 Read/Write unique memory area

The permanent memory area of K5 provides a 128-byte unique memory area, which is divided into 32 separate blocks with 4 bytes as a group. Users could read/write unique memory area freely.

The unique memory area is cleared before PLCs leave factory. User only can write nonzero data into each block for once. PLC will lock the nonzero data, and do not allow write again. But the data can be read freely. Please note that, the 4 bytes to be written should not be all zero. Otherwise PLC will ignore the write operation.

In Kinco Builder, executing [PLC]->[Clear] menu command could clear all the data in PLC, including user project, unique memories. Data of unique memory area cannot be cleared dependently.

Manufacturers can use the unique memory area to write S/N number.

➢ Description

	Name	Usage	Group	
LD	UNID_W			☑ K5 ☑ K2
	UNID_R			
	UNID_W	UNID_W ADDR, IN	U	
	UNID_R	UNID_W ADDR, OUT		

Operands	Input/Output	Data Type	Acceptable memory area
ADDR	Input	INT	I, Q, V, L, M, T, C, SM, AI, AQ, constant
OUT	Output	DWORD	Q, L, M, V, SM
IN	Input	DWORD	I, Q, L, M, V, SM, constant

The permanent memory area of K5 provides a 128-byte unique memory area, which is divided into 32 separate blocks with 4 bytes as a group. Users could read/write unique memory area freely.

The unique memory area is cleared before PLCs leave factory. User only can write nonzero data into each block for once. PLC will lock the nonzero data, and do not allow write again. But the data can be read freely. Please note that, the 4 bytes to be written should not be all zero. Otherwise PLC will ignore the write operation.

In Kinco Builder, executing [PLC]->[Clear] menu command could clear all the data in PLC, including user project, unique memories. Data of unique memory area cannot be cleared dependently.

Manufacturers can use the unique memory area to write S/N number.

UNID_W is for write specified data of IN into a specified block. ADDR specifies the block number, range0~31.

UNID_R is for read data of a certain block and put the read data in OUT. ADDR specifies the block number, range0~31.

Note: IN should be a nonzero data, otherwise, PLC will ignore the write operation.

Data of the unique memory area only can be cleared by [Clear] command, cannot be cleared dependently.

- LD

  If EN is 1, this instruction will be executed.

- IL

  If CR is 1, this instruction will be executed.

  This instruction does not influent CR.

Appendix A Communicate Using Modbus RTU Protocol

Default, the Kinco-K5 serves as a slave using Modbus RTU Protocol, and can communicate with a Modbus RTU master directly.

1. PLC Memory Area

1.1 Accessible Memory Areas

The memory areas that can be accessed by a Modbus RTU master are classified as follows:

Type	Available Function Code	Corresponding Memoery Area of PLC
DO (Digital Output, 0XXXX)	01, 05, 15	Q, M
DI (Digital Input, 1XXXX)	02	I, M
AO (Analog Output, 4XXXX)	03, 06, 16	AQ, V
AI (Analog Input, 3XXXX)	04	AI, V
Error record (16-bit whole number without sign)	03, 04	PLC error recording area

The maximum resistor number which one instruction can visit:

1. Read Bit: read 1600 bits(200 bytes) once at most.(function code 01,02)
2. Write Bit: write 800 bits once at most.(function code 15)
3. Read Word: read 100 words once at most.(function code 03,04)
4. Write Word: write 100 words once at most.(function code 16)
5. If the memory range is smaller than the above maximum value, user can not only read or write the whole memory, but cannot read or write the maximum register number, for example, user cannot read 90 words in AI (analog input) area, because there are only 32 words in this area.

1.2 Modbus Register Number

In some equipment, Modbus RTU registers begin with 1, so 1 should be added to each data in this column.

- **For CPU504**

Area	Range	Type	Corresponding Modbus Registers*
I	I0.0 --- I0.7	DI	0 --- 7
Q	Q0.0 --- Q0.5	DO	0 --- 5
M	M0.0 --- M1023.7	DI/DO	320 -- 8511
AI	---	AI	---
AQ	---	AO	---
V	VW0 ---VW4094	AI/AO	100 -- 2147

- **For CPU504EX(whose firmware version is below V3.0)**

Area	Range	Type	Corresponding Modbus Registers*
I	I0.0 --- I4.7	DI	0 --- 39
Q	Q0.0 --- Q4.7	DO	0 --- 39
M	M0.0 --- M1023.7	DI/DO	320 -- 8511
AI	AIW0 --- AIW14	AI	0 --- 7
AQ	AQW0 --- AQW14	AO	0 --- 7
V	VW0 ---VW4094	AI/AO	100 -- 2147

- **For CPU506, CPU506EA and CPU508, and for CPU504EX(whose firmware version is V3.0 or above.)**

Area	Range	Type	Corresponding Modbus Registers*
I	I0.0 --- I31.7	DI	0 --- 255
Q	Q0.0 --- Q31.7	DO	0 --- 255
M	M0.0 --- M1023.7	DI/DO	320 -- 8511
AI	AIW0 --- AIW62	AI	0 --- 31
AQ	AQW0 --- AQW62	AO	0 --- 31
V	VW0 ---VW4094	AI/AO	100 -- 2147

- **Error Records**

Modbus Register No.	Description

9000-9127	Latest 128 common error codes after PLC power on this time. Among which 9000 is the latest error and 9001 is the second latest.
9128-9255	Latest 128 serious error codes after PLC power on this time Among which 9128 is the latest error and 9129 is the second latest.
9256-9383	Latest 128 common error codes during PLC power on previous time. Among which 9256 is the latest error and 9257 is the second latest.
9384-9511	Latest 128 serious error codes after during power on previous time. Among which 9384 is the latest error and 9385 is the second latest.

2. Basic Report Format of Modbus RTU

In CRC identification codes, usually high bytes is in prior to low bytes

Interval that is not less than 3.5 characters	Target Slave	Function Code	Data	CRC
	1 byte	1 byte	N bytes	2 bytes

2.1 Modbus RTU

The following “response forma” indicates correct response from slave station. If response is abnormal , then the “function code” part of the response format will be different: the highest bit of function code is set to 1 to get new value. Take function code 0x01 for example, if slave station response abnormal, then the returned function code in response format is 0x81.

2.1.1 Function Code 01: Read Coil (DO)

Request format:

Target Slave Number	Function Code	Starting Address		Amount		CRC
1 byte	01	High byte	Low byte	High byte	Low byte	2 bytes

Correct response format

Slave Number	Function Code	Bytes of Returned data	Byte 1	Byte 2	…	CRC
1 byte	01	1 byte	1 byte	1 byte	…	2 bytes

2.1.2 Function Code 02: Read input status (DI)

Request Format: Request Format

Target Slave Number	Function Code	Starting Address		Amount		CRC
1byte	02	High byte	Low byte	High byte	Low byte	2byte

Correct Response Format:

Slave Number	Function Code	Bytes of Returned data	Byte 1	Byte 2	…	CRC
1byte	02	1byte	1byte	1byte	…	2byte

2.1.3 Function Code 03:Read Hold Register (AO)

Request Format:

Target Slave Number	Function Code	Starting Address		Amount		CRC
1byte	03	High byte	Low byte	High byte	Low byte	2 bytes

Correct Response Format:

Slave Number	Function Code	Bytes of Returned data	High byte of Register 1	Low byte of Register 1	…	CRC
1byte	03	1byte	1byte	1byte	…	2bytes

2.1.4 Function Code 04:Read Input Register (AI)

Request Format:

Target Slave Number	Function Code	Starting Address		Amount		CRC
1byte	04	High byte	Low byte	High byte	Low byte	2 bytes

Correct Response Format:

Slave Number	Function Code	Bytes of Returned data	High byte of Register 1	Low byte of Register 1	…	CRC
1byte	04	1byte	1byte	1byte	…	2 byte

2.1.5 Function Code 05:Force Single Coil (DO)

Request Format:

Target Slave Number	Function Code	Coil Address		Force Value		CRC
1byte	05	High byte	Low byte	High byte	Low byte	2 bytes

NOTE: Force Value = 0xFF00 then the Coil is ON; Force Value = 0x0000 then the Coil is OFF

Response Format: If the target slave finish forcing successfully then response the original report

2.1.6 Function Code 06: Force Single Hold Register (AO)

Request Format:

Target Slave Number	Function Code	Register Address		Force Value		CRC
1byte	06	High byte	Low byte	High byte	Low byte	2 bytes

Response Format: If the target slave finish forcing successfully then response the original report

2.1.7 Function Code 15:Force Multiple Coils (DO)

Request Format:

Target Slave Number	Function Code	Starting Address		Coil Amount		Bytes of Force Value	Force Value Byte 1	…	CRC
1byte	15	High byte	Low byte	High byte	Low byte	1byte	1byte	…	2bytes

Correct Response Format:

Slave Number	Function Code	Starting Address		Coil Amount		CRC
1byte	15	High byte	Low byte	High byte	Low byte	2bytes

2.1.8 Function Code 16: Force Multiple Hold Registers (AO)

Request Format:

Target Slave Number	Function Code	Starting Address		Register Amount		Bytes of Force Value	Force Value 1, High byte	Force Value 1, Low byte	…	CRC
1byte	16	High byte	Low byte	High byte	Low byte	1byte	1byte	1byte	…	2byte

Correct Response Format:

Slave Number	Function Code	Starting Address		Register Amount		CRC
1byte	16	High byte	Low byte	High byte	Low byte	2byte

2.2 CRC Algorithm for Modbus RTU Protocol

In Modbus RTU Protocol, a message is checked by CRC. The CRC algorithms are as follows:

2.2.1 Direct CRC Calculation

```
/*   Parameter: chData  ——  const BYTE*, a pointer to the buffer which stores the data to be verified
                uNO     ——  the number of the data to be verified, Unit: byte.
     Return Value: WORD, the CRC value                          */
WORD CalcCrc(const BYTE* chData, WORD uNo)
{
       WORD crc=0xFFFF;
        WORD wCrc;
        UCHAR i,j;
        for (i=0; i<uNo; i++)
        {
               crc ^= chData[i];
               for (j=0; j<8; j++)
               {
                      if (crc & 1)
```

```
                {
                        crc >>= 1;
                        crc ^= 0xA001;
                }
                else
                {
                        crc >>= 1;
                }
        }
    }

    wCrc=( (WORD)LOBYTE(crc) )<<8;
    wCrc=wCrc|( (WORD)HIBYTE(crc) );
    return (wCrc);
}
```

2.2.2 Fast CRC Calculation

```
/* High Byte CRC Table */
const UCHAR auchCRCHi[] =
{
0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41, 0x01, 0xC0,
0x80, 0x41, 0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41,
0x00, 0xC1, 0x81, 0x40, 0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0,
0x80, 0x41, 0x01, 0xC0, 0x80, 0x41, 0x00, 0xC1, 0x81, 0x40,
0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41, 0x00, 0xC1,
0x81, 0x40, 0x01, 0xC0, 0x80, 0x41, 0x01, 0xC0, 0x80, 0x41,
0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41, 0x00, 0xC1,
0x81, 0x40, 0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41,
0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41, 0x01, 0xC0,
0x80, 0x41, 0x00, 0xC1, 0x81, 0x40, 0x00, 0xC1, 0x81, 0x40,
0x01, 0xC0, 0x80, 0x41, 0x01, 0xC0, 0x80, 0x41, 0x00, 0xC1,
0x81, 0x40, 0x01, 0xC0, 0x80, 0x41, 0x00, 0xC1, 0x81, 0x40,
0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41, 0x01, 0xC0,
```

```
0x80, 0x41, 0x00, 0xC1, 0x81, 0x40, 0x00, 0xC1, 0x81, 0x40,
0x01, 0xC0, 0x80, 0x41, 0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0,
0x80, 0x41, 0x01, 0xC0, 0x80, 0x41, 0x00, 0xC1, 0x81, 0x40,
0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41, 0x01, 0xC0,
0x80, 0x41, 0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41,
0x00, 0xC1, 0x81, 0x40, 0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0,
0x80, 0x41, 0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41,
0x01, 0xC0, 0x80, 0x41, 0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0,
0x80, 0x41, 0x00, 0xC1, 0x81, 0x40, 0x00, 0xC1, 0x81, 0x40,
0x01, 0xC0, 0x80, 0x41, 0x01, 0xC0, 0x80, 0x41, 0x00, 0xC1,
0x81, 0x40, 0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41,
0x00, 0xC1, 0x81, 0x40, 0x01, 0xC0, 0x80, 0x41, 0x01, 0xC0,
0x80, 0x41, 0x00, 0xC1, 0x81, 0x40
} ;

/* Low Byte CRC Table */
const UCHAR auchCRCLo[] =
{
0x00, 0xC0, 0xC1, 0x01, 0xC3, 0x03, 0x02, 0xC2, 0xC6, 0x06,
0x07, 0xC7, 0x05, 0xC5, 0xC4, 0x04, 0xCC, 0x0C, 0x0D, 0xCD,
0x0F, 0xCF, 0xCE, 0x0E, 0x0A, 0xCA, 0xCB, 0x0B, 0xC9, 0x09,
0x08, 0xC8, 0xD8, 0x18, 0x19, 0xD9, 0x1B, 0xDB, 0xDA, 0x1A,
0x1E, 0xDE, 0xDF, 0x1F, 0xDD, 0x1D, 0x1C, 0xDC, 0x14, 0xD4,
0xD5, 0x15, 0xD7, 0x17, 0x16, 0xD6, 0xD2, 0x12, 0x13, 0xD3,
0x11, 0xD1, 0xD0, 0x10, 0xF0, 0x30, 0x31, 0xF1, 0x33, 0xF3,
0xF2, 0x32, 0x36, 0xF6, 0xF7, 0x37, 0xF5, 0x35, 0x34, 0xF4,
0x3C, 0xFC, 0xFD, 0x3D, 0xFF, 0x3F, 0x3E, 0xFE, 0xFA, 0x3A,
0x3B, 0xFB, 0x39, 0xF9, 0xF8, 0x38, 0x28, 0xE8, 0xE9, 0x29,
0xEB, 0x2B, 0x2A, 0xEA, 0xEE, 0x2E, 0x2F, 0xEF, 0x2D, 0xED,
0xEC, 0x2C, 0xE4, 0x24, 0x25, 0xE5, 0x27, 0xE7, 0xE6, 0x26,
0x22, 0xE2, 0xE3, 0x23, 0xE1, 0x21, 0x20, 0xE0, 0xA0, 0x60,
0x61, 0xA1, 0x63, 0xA3, 0xA2, 0x62, 0x66, 0xA6, 0xA7, 0x67,
0xA5, 0x65, 0x64, 0xA4, 0x6C, 0xAC, 0xAD, 0x6D, 0xAF, 0x6F,
0x6E, 0xAE, 0xAA, 0x6A, 0x6B, 0xAB, 0x69, 0xA9, 0xA8, 0x68,
```

```
0x78, 0xB8, 0xB9, 0x79, 0xBB, 0x7B, 0x7A, 0xBA, 0xBE, 0x7E,
0x7F, 0xBF, 0x7D, 0xBD, 0xBC, 0x7C, 0xB4, 0x74, 0x75, 0xB5,
0x77, 0xB7, 0xB6, 0x76, 0x72, 0xB2, 0xB3, 0x73, 0xB1, 0x71,
0x70, 0xB0, 0x50, 0x90, 0x91, 0x51, 0x93, 0x53, 0x52, 0x92,
0x96, 0x56, 0x57, 0x97, 0x55, 0x95, 0x94, 0x54, 0x9C, 0x5C,
0x5D, 0x9D, 0x5F, 0x9F, 0x9E, 0x5E, 0x5A, 0x9A, 0x9B, 0x5B,
0x99, 0x59, 0x58, 0x98, 0x88, 0x48, 0x49, 0x89, 0x4B, 0x8B,
0x8A, 0x4A, 0x4E, 0x8E, 0x8F, 0x4F, 0x8D, 0x4D, 0x4C, 0x8C,
0x44, 0x84, 0x85, 0x45, 0x87, 0x47, 0x46, 0x86, 0x82, 0x42,
0x43, 0x83, 0x41, 0x81, 0x80, 0x40
} ;

/*   Parameter: chData  ——  const BYTE*, a pointer to the buffer which stores the data to be verified
                uNO     ——  the number of the data to be verified, Unit: byte.
     Return Value: WORD, the CRC value                    */
WORD CKINCOSerialCom::CalCrcFast(const BYTE* puchMsg , WORD usDataLen)
{
     BYTE uchCRCHi = 0xFF ;    /* CRC High Byte Initialization */
     BYTE uchCRCLo = 0xFF ;    /* CRC Low Byte Initialization */
      WORD uIndex ;                /* CRC Table Index*/

      while (usDataLen--)
      {
            uIndex = uchCRCHi ^ *puchMsg++ ;          /* Calculate CRC */
            uchCRCHi = uchCRCLo ^ auchCRCHi[uIndex];
            uchCRCLo = auchCRCLo[uIndex] ;
      }
      return (uchCRCHi << 8 | uchCRCLo) ;
}
```

Appendix B　Dynamically Operating The Parameters of RS485 Port

It is default that the parameters of each communication port can only take effect after they are configured in the [**Hardware Configuration**] and downloaded into PLC.

In the meantime, K5 provides the function for user to use certain SM registers to modify the parameters of the RS485 port (PORT1 and PORT2).　PORT 0 is the programming port that may be frequently used, therefore it is not allowed to be modified.

1. General Description

- Allow to dynamically modify the PLC **【Address】**, **【Baud Rate】** and **【Parity】**.
- Dynamically modified parameter values are stored in the permanent memory and always effective.
- The priority of the communication parameters dynamically modified is higher than those in the **【Hardware Configuration】**. If you re-download a new project, K5 will give priority to using the dynamically modified parameters.

  You can use **【PLC】** → **【Clear...】** menu command to clear all parameters.
- After the communication parameters are modified, the PLC **【Address】** will take effect immediately but **【Baud Rate】** and **【Parity】** is not for certain: If the communication port is free then the two parameters will take effect immediately; otherwise not.

All modified parameters will take effect immediately when PLC reboot next time.

2. Register Instruction

K5 uses SMB20--SMB25 for modifying the communication parameters of RS485 port.

Please find below:

- **Values: SMB23, SMB24 and SMB25**

SMB	Description
SMB23	PLC Address. Valid range: 1-31 If execute Write operation, SMB23 is the new PLC address; if execute Read operation, SMB23 is current PLC address; if execute Clear operation, SMB23 will be ignored.
SMB24	Baudrate. Valid rage 0-5: 0 represents 2400, 1 represents 4800, 2 represents 9600, 3 represents 19200, 4 represents 38400 and 5 represents 1200. If execute Write operation, SMB24 is the new Baudrate value; if execute Read operation, SMB24 is current Baudrate value; if execute Clear operation, SMB24 will be ignored.
SMB25	Parity. Valid range: 0-2. 0 represent None, 1 represents Odd and 2 represents Even. If execute Write operation, SMB25 is the new Parity value; if execute Read operation, SMB25 is the current Parity value; if execute Clear operation, SMB25 will be ignored.

- **Control byte: SMB20 and SMB21**

Bit	Description
SMB20: Assign the port and operation.	
SM20.7	Value = 1 represents starting Write operation immediately. PLC will reset this bit to 0 after finishing writing.
SM20.6	Value = 1 represents starting Read operation immediately. PLC will reset this bit to 0 after new finishing reading.
SM20.5	Value = 1 represents starting Clear operation immediately. PLC will reset this bit to 0 after finishing clearing.
SM20.4	Reserved, must be valued to 0.
SM20.3 ∽ SM20.0	These four bits are combined as the numbers of the port to be operated. 1 represents PORT1 and 2 represents PORT2. If the bits are set to other values, error will occur and PLC will stop operating.

SMB21: Assign the communication parameters to be operated (modifying or clearing).	
SM21.7 ∽ SM21.3	Reserved. Must be valued to 0.
SM21.2	1 represents operating the Parity value of the designated port.
SM21.1	1 represents operating the Baudrate of the designated port.
SM21.0	1 represents operating the PLC Address of the designated port.

At the same moment, only one bit of SM20.5, SM20.6 and SM20.7 is allowed to be 1, otherwise error will occur and PLC will stop operating.
If execute Read operation, SMB21 will be ignored and PLC will read all communication parameters in one-time
If one parameter is cleared, PLC will use the corresponding parameter in the hardware configuration.

- **Status bit: SMB22**

In SMB22 the operation result of this dynamic modification of communication parameters is saved

Bit (read-only)	Description
SM22.7	1 represents completion of operation. If the operation is completed, regardless of success or failure, SM22.7 will be set to 1 automatically. Only when SM22.7 is set to 1, other bits will be valid in SMB22.
SM22.6	When SM22.7 is set to 1, if SM22.6 set to 1 represents success operation and if set to 0 represents failure.
SM20.5 ∽ SM20.0	If operation fails these bits will show error codes, please see below.

Error Code	Error Description
1	Wrong command, e.g. SM20.7 and SM20.6 is 1 at the same time.
2	Wrong port number.
3	Wrong SMB21 value.
4	Wrong SMB23 value.
5	Wrong SMB24 value.
6	Wrong SMB25 value.
10	Fail to read the PORT1's PLC Address saved in the permanent memory.
11	The PORT1's PLC Address is not be modified dynamically yet.

12	Fail to read the PORT1's Baudrate saved in the permanent memory.
13	The PORT1's Baudrate is not be modified dynamically yet.
14	Fail to read the PORT1's Parity saved in the permanent memory.
15	The PORT1's Parity is not be modified dynamically yet.
20	Fail to read the PORT2's PLC Address saved in the permanent memory.
21	The PORT2's PLC Address is not be modified dynamically yet.
22	Fail to read the PORT2's Baudrate saved in the permanent memory.
23	The PORT2's Baudrate is not be modified dynamically yet.
24	Fail to read the PORT2's Parity saved in the permanent memory.
25	The PORT2's Parity is not be modified dynamically yet.
61	Fail to write dynamic communication parameters into the permanent momory.

3. Instructions

- **Modify the communication parameters**
  - Set low four bits of SMB20 to the number of the port to be operated

e.g. SMB20=B#1 represents PORT1 to be operated

  - Give corresponding value to SMB21 in accordance with the type of parameter

e.g. SMB21=B#16#03 represents PLC Address and baud rate to be modified.

  - Give new parameters to corresponding register: SMB23 is the new PLC Address, SMB24 is the new baud rate and SMB25 is the new Parity.

E.g. SMB23=B#03 represents modifying PLC Address to 3, SMB24=B#3 represents modifying baud rate to 19200.

  - (Optional) If a parameter operation just started (read, write or clear), SM22.7 should be checked in prior. Only when SM22.7 be set to 1 can the operation starts.
  - Set SM20.7 to 1 to start write operation. PLC will clear SM20.7 after the operation is completed.
  - (Optional) Check SM22.7 and SM22.6. Both are 1 represents successful operation.

- **Read the communication parameters**
  - Set low four bits of SMB20 to the number of the port to be operated.

e.g. SMB20=B#1 represents PORT1's parameter to be read.

  - (Optional) If a parameter operation just started (read, write or clear), SM22.7 should be checked in prior. Only when SM22.7 be set to 1 can the operation starts.
  - Set SM20.6 to 1 to start read operation. PLC will clear SM20.6 after the operation is completed.
  - Check SM22.7 and SM22.6. Both are 1 represents successful operation, and now SMB23 is current PLC Address, SMB24 is current baud rate and SMB25 is current Parity.

- **Clear the communication parameters**
  - Set low four bits of SMB20 to the number of the port to be operated.

e.g. SMB20=B#1 represents PORT1 parameter to be read.

- Give the corresponding value to SMB21 in accordance with the parameter types to be cleared.

e.g. SMB21=B#16#03 represents dynamic PLC Address and baud rate in permanent memory to be cleared.

- (Optional) If a parameter operation just started (read, write or clear), SM22.7 should be checked in prior. Only when SM22.7 be set to 1 can the operation starts..
- Set SM20.5 to 1 to start clear operation. PLC will clear SM20.5 after the operation is completed.
- (Optional) Check SM22.7 and SM22.6. Both are 1 represents successful operation.

4. Example

The following example demonstrates how to modify the Address of PORT1 and PORT2 through HMI.

The example is in IL, you may copy them into the KincoBuilder's IL editor and execute [Project]→[LD] menu command to translate it to LD.

VW48 is the new Address which can be edited through HMI, and VW48 also be saved in VW3690 permanently. PLC will check the real-time value of VW48 and compare it whit that saved in VW3690. If the value of VW48 changes and it is a valid value, then it will be regarded as the new Address of PORT1 and PORT2, and the write operation starts.

```
(* Network 0 *)
(*At power on, use values that saved permanently to initialize VW48*)
LD          %SM0.1
MOVE        %VW3690, %VW48
(* Network 1 *)
(*Check if VB48 changes and if   it is valid.*)
LD          %SM0.0
GE          %VB48, B#1
LE          %VB48, B#31
NE          %VW48, %VW3690
MOVE        %VW48, %VW3690
ST          %M999.7
```

```
(* Network 2 *)
(*Start modifying PORT1's Address*)
LD          %M999.7
R_TRIG
MOVE        B#1, %SMB20
MOVE        B#1, %SMB21
MOVE        %VB48, %SMB23
S           %SM20.7
S           %M999.6
(* Network 3 *)
(*Start modifying PORT2's Address after previous operation successfully completed *)
LD          %M999.6
AND         %SM22.7
R_TRIG
AND         %SM22.6
MOVE        B#2, %SMB20
S           %SM20.7
R           %M999.6
```

Appendix C　Permanent Data Backup

Permanent Data backup means save data into permanent memory to allow PLC retain the data even when power off.

K5 use FARM permanent memory, which allows 10 billion times of write operation. You should be noted that: **you may only backup data if necessary. If FRAM loses its efficacy it will cause CPU errors**.

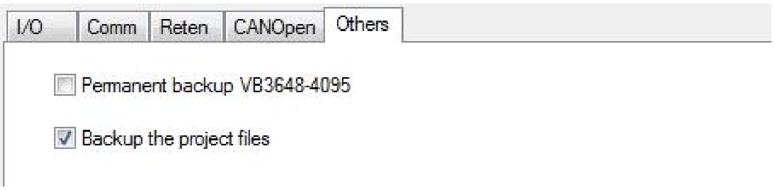
K5 provides a Data Backup area in V area, in which data will be automatically saved into the permanent memory. You just need write the data to be stored permanently into this area.

The following table is Data Backup area:

Length	448 bytes
Range	VB3648 - VB4095

To be compatible with Kinco-K3, K5 will enable VB3648-VB3902 as the Data Backup area when creating a new project, which means the area after VB3902 cannot be backed up automatically. If you need to enable the Data Backup area after VB3903, you may set in the PLC 【**Hardware Configuration**】→【**Others**】.

Please see the following figure:



- [Permanent backupVB3648-4095]

  If this item is checked, VB3648-4095 will become the Data Backup area.

- [Backup the whole project files]

  It is default in K5 to only save the information of hardware configuration and program. If this item is clicked, all the project information will be saved in PLC, including comments and symbols, and you can upload them.

Appendix D Error Diagnose

K5 has three levels of errors: fatal error, serious error and common error. When an error occurs PLC will take measures according to the level and record the error code by time sequence for future analysis. PLC will record a same error maximum 4 times.

⚠ **Regardless of the level, we strongly suggest you to analyze and check after error occur at your own risk.**

1. Error Level

➢ **Fatal Error**

A fatal error occurs when PLC detects the chips are encountering unexpected stoppage. A fatal error may cause breaking down of PLC and further errors. The solution to fatal errors is to make PLC into safety status.

When a fatal error occurs PLC will automatically quit normal scanning and reset or enter into independent safe sub-OS according to SM2.0. SM2.0 decides the actions when fatal error occurs: if the value is 0, the PLC will enter into safe sub-OS; if 1 PLC will reset and reboot.

Below are descriptions of safety status:

- All outputs (DO and AO) will output the value defined in **【PLC Hardware Configuration】**.
- STOP indicator stays on, ERR indicators stays flashing, indicating a fatal error occurs. **(NOTE: If SM2.0==1, PLC will restart when a fatal error occurs. Users may be unable to see the STOP indicator stays on and ERR indicator stays flashing.)**
- Record error point and code and allow you to record the information with certain software. NOTE: Fatal errors will cause PLC unable to run normally, which can be recorded.

⚠ **Besides the fatal error which caused by unknown reasons, the following reasons may also cause the fatal error, like too many nesting of For instruction, endless loop of JMP instruction and so on.**

Because the PLC executes the program by scanning periodically, it cannot allow the program be stuck too long in scanning (Check the details in the FOR, JMP and WDR instructions).

- **Serious Error**

A serious error will cause PLC unable to execute some important functions but the results are within expectation. If serious errors occur PLC will take measures automatically:

- Set PLC to STOP status, all outputs (DO and AO) output the "Stop and Output" value accordingly.
- ERR and STOP indicators stay on.
- Record the error code and allow you to read the records through KincoBuilder and Modbus RTU protocol.

- **Common Error**

A common error occurs when PLC executes some functions but PLC is able to run other program. The results are within expectation. . for example, if the divisor is 0 in the division operation error happens, plc will consider it as a common error, but the calculation result is not right as user expect, user needs to check the program.PLC will take measures as follows:

- PLC continues running.
- ERR indicator stays on.
- Record the error code and allow you to read the records through KincoBuilder and Modbus RTU protocol.

2. Error codes

Code	Description
Serious Error	
20	CPU type in the Hardware Configuration is not the same with that actual type connects
21	Wrong expansion module in the Hardware Configuration
25	At power on, CPU fails to read out the protection type.
26	At power on, CPU fail to read out the object file(plain text).
27	At power on, CPU fail to read out the object file(cipher text).
28	At power on, CPU fail to check CRC of target file.
29	At power on, CPU detects unknown instructions.
30	At power on, number of parameters out of limitation.
35	At power on, fail to read data from permanent.
40	Fail to execute JMP command.
41	Fail to call sub-program.
42	Fail to call interruption sub-program.
60	At power on, no response from the 1st extension module due to out of limitation.
61	At power on, the 1st extension responds error.
62	The 1st extension module is not the same with that of hardware configuration.
65	At power on, no response from the 2nd extension module due to out of limitation.
66	At power on, the 2nd extension responds error.
67	The 2nd extension module is not the same with that of hardware configuration.
70	At power on, no response from the 3rd extension module due to out of limitation.
71	At power on, the 3rd extension responds error.
72	The 3rd extension module is not the same with that of hardware configuration.
75	At power on, no response from the 4th extension module due to out of limitation.
76	At power on, the 4th extension responds error.
77	The 4th extension module is not the same with that of hardware configuration.
80	At power on, no response from the 5th extension module due to out of limitation.
81	At power on, the 5th extension responds error.
82	The 5th extension module is not the same with that of hardware configuration.

85	At power on, no response from the 6^{th} extension module due to out of limitation.
86	At power on, the 6^{th} extension responds error.
87	The 6^{th} extension module is not the same with that of hardware configuration.
90	At power on, no response from the 7^{th} extension module due to out of limitation.
91	At power on, the 7^{th} extension responds error.
92	The 7^{th} extension module is not the same with that of hardware configuration.
100	At power on, no response from the 8^{th} extension module due to out of limitation.
101	At power on, the 8^{th} extension responds error.
102	The 8^{th} extension module is not the same with that of hardware configuration.
105	At power on, no response from the 9^{th} extension module due to out of limitation.
106	At power on, the 9^{th} extension responds error.
107	The 9^{th} extension module is not the same with that of hardware configuration.
110	At power on, no response from the 10^{th} extension module due to out of limitation.
111	At power on, the 10^{th} extension responds error.
112	The 10^{th} extension module is not the same with that of hardware configuration.
115	At power on, no response from the 11^{th} extension module due to out of limitation.
116	At power on, the 11^{th} extension responds error.
117	The 11^{th} extension module is not the same with that of hardware configuration.
120	At power on, no response from the 12^{th} extension module due to out of limitation.
121	At power on, the 12^{th} extension responds error.
122	The 12^{th} extension module is not the same with that of hardware configuration.
95	At power on, CPU fails to send extension report.
96	At power on, CPU extension bus enters error passive status.
97	At power on, CPU extension bus enters bus closure status.
Common Error	
136	At power on, fail to be read out the calibration values of AI channels.
137	At power on, fail to be read out the calibration values of AI channels.
138	The calibration values of AI channels fail to save.
139	The calibration values of AO channels fail to save.
150	When running, heartbeat of the first extend module is timeout, the extension bus maybe break off.
151	When running, received the 1^{st} extension error report.

154	When running, heartbeat of the second extend module is timeout, the extension bus maybe break off.
155	When running, received the 2nd extension error report.
158	When running, heartbeat of the third extend module is timeout, the extension bus maybe break off.
159	When running, received the 3rd extension error report.
162	When running, heartbeat of the fourth extend module is timeout, the extension bus maybe break off.
163	When running, received the 4th extension error report.
166	When running, heartbeat of the fifth extend module is timeout, the extension bus maybe break off.
167	When running, received the 5th extension error report.
170	When running, heartbeat of the sixth extend module is timeout, the extension bus maybe break off.
171	When running, received the 6th extension error report.
174	When running, heartbeat of the seventh extend module is timeout, the extension bus maybe break off.
175	When running, received the 7th extension error report.
178	When running, heartbeat of the eighth extend module is timeout, the extension bus maybe break off.
179	When running, received the 8th extension error report.
182	When running, heartbeat of the ninth extend module is timeout, the extension bus maybe break off.
183	When running, received the 9th extension error report.
186	When running, heartbeat of the tenth extend module is timeout, the extension bus maybe break off.
187	When running, received the 10th extension error report.
190	When running, heartbeat of the eleventh extend module is timeout, the extension bus maybe break off.
191	When running, received the 11th extension error report.
194	When running, heartbeat of the twelfth extend module is timeout, the extension bus maybe break off.
195	When running, received the 12th extension error report.

300	When running, body AI tunnel has DMA error.
301	When running, body AI tunnel stopped when conducting sample conversion.
320	When running, expansion bus communication has frame format error.
321	When running, expansion bus communication has entered into error active status.
322	When running, expansion bus communication has entered into error passive status.
323	When running, expansion bus has been closed.
324	When running, expansion communication error: receiving buffer area full.
325	When running, expansion communication error: sending buffer area full.
326	When running, expansion communication error: sending report fail.
327	When running, detect CANOpen salve error (heartbeat or node guard time-out, SDO no response, etc.)
329	When running, error occurs: divided by zero
330	When running, error occurs: type conversion commands (I_TO_B, DI_TO_I) overflow
331	When running, error occurs: LN command set to 0 or negative numbers.
332	When running, error occurs: LOG command set to 0 or negative numbers.
333	When running, error occurs: SQRT command set to 0 or negative numbers.
334	When running, error occurs: I_TO_BCD command has invalid input value.
335	When running, error occurs: A_TO_H command has invalid input value.
336	When running, error occurs: R_TO_A command has invalid input value.
341	When running, error occurs: FOR command has invalid input value.
350	When running, error occurs: fail to save permanent data.
351	At power on, power-failure in RAM data missing
360	Low backup battery.

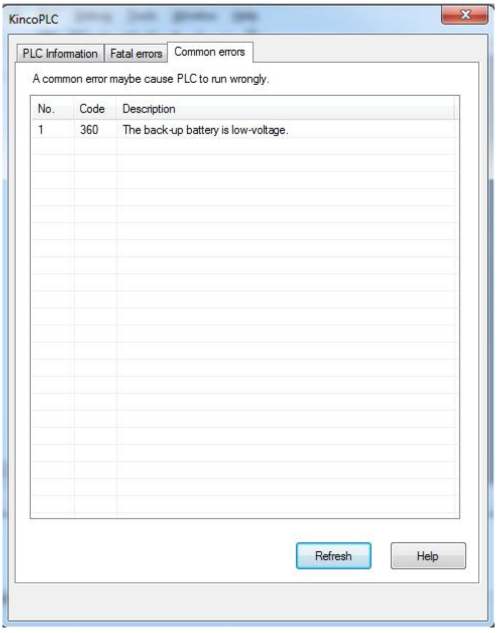
3. How to Read Errors Occur Before

PLC will automatically record the error code. You may read the error with ways as follows:

- **Through KincoBuilder**

You may execute **【PLC】→ 【Serious Error】** or **【Common Error】** in Kincobuilder to open the error dialog.

You may click **【Refresh】** button to refresh the information.



- **Through Modbus RTU**

You may use Modbus RTU command (function code 03 or 04) to read error records through PORT0, PORT1 and PORT2. The modubs register No. is as follow:

Modbus Register No.	Description
9000-9127	Latest 128 common error codes after PLC power on this time. Among which 9000 is the latest error and 9001 is the second latest.

9128-9255	Latest 128 serious error codes after PLC power on this time Among which 9128 is the latest error and 9129 is the second latest.
9256-9383	Latest 128 common error codes during PLC power on previous time. Among which 9256 is the latest error and 9257 is the second latest.
9384-9511	Latest 128 serious error codes after during power on previous time. Among which 9384 is the latest error and 9385 is the second latest.

4. Error Register

K5 provides an error register in SM and will record error when error occurs. You may directly read the register.

➢ **SMB2: control bytes**

Bit (RW)	Description
SM2.0	Its value decides the actions when fatal error occurs. Initial value is 0. If it is 0: PLC enters into independent sub-OS to run safely. If it is 1: PLC reset when fatal error occurs.

➢ **SMB0 and SMB1: memory and command error**

SM	Description
SMB0 (read only)	
SM0.2	If the data in RAM is lost, this bit is ON during the first scan cycle, and later cleared to FALSE.
SMB1 (read only)	
SM1.0	1 represents errors occur: DIV and MOD divided by zero.
SM1.1	1 represents errors occur: LN, LOG and SQRT command is invalid (0 or negative number)
SM1.2	1 represents errors occur: I_TO_B, DI_TO_I overflow
SM1.3	1 represents errors occur: I_TO_BCD invalid BCD code input
SM1.4	1 represents errors occur: A_TO_H input alphabet string has undefined bytes
SM1.5	1 represents errors occur: R_TO_A represents conversion result overflow.
SM1.6	1 represents errors occur: FOR input parameter invalid

➢ **SMB3 和 SMB96-SMB110: extension module error**

If PLC detects any communication error or sending error reports in extension bus, it will set corresponding extension bus and place the error code in the error register for future checking. If no errors are detected then the bit and register will be set to 0.

NOTE: If PLC detects error in extension bus or extension module, it will enter STOP status and lit up ERR indicator. It will not set corresponding register due to no executions by CPU.

SM	Description
SMB3, SMB5 (read only): extension bus error signal	
SMB3.0	If the 1st extension module has errors it will be set to 1.
SMB3.1	If the 2nd extension module has errors it will be set to 1.
SMB3.2	If the 3rd extension module has errors it will be set to 1.
SMB3.3	If the 4th extension module has errors it will be set to 1.
SMB3.4	If the 5th extension module has errors it will be set to 1.
SMB3.5	If the 6th extension module has errors it will be set to 1.
SMB3.6	If the 7th extension module has errors it will be set to 1.
SMB3.7	If the 8th extension module has errors it will be set to 1.
SMB5.0	If the 9th extension module has errors it will be set to 1.
SMB5.1	If the 10th extension module has errors it will be set to 1.
SMB5.2	If the 11th extension module has errors it will be set to 1.
SMB5.3	If the 12th extension module has errors it will be set to 1.
SMB5.7	If CPU detects error in extension bus communication it will be set to 1.
SMB96 - SMB110 (read only): extension bus error code	
SMB96	If the 1st extension module has error then the code will be saved here.
SMB97	If the 2nd extension module has error then the code will be saved here.
SMB98	If the 3rd extension module has error then the code will be saved here.
SMB99	If the 4th extension module has error then the code will be saved here.
SMB100	If the 5th extension module has error then the code will be saved here.
SMB101	If the 6st extension module has error then the code will be saved here.
SMB102	If the 7th extension module has error then the code will be saved here.
SMB103	If the 8th extension module has error then the code will be saved here.
SMB104	If the 9th extension module has error then the code will be saved here.
SMB105	If the 10th extension module has error then the code will be saved here.
SMB106	If the 11th extension module has error then the code will be saved here.
SMB107	If the 12th extension module has error then the code will be saved here.
SMB110	Error code of CPU extension bus error is saved here.

Error Code	Description
0	No error.
6	Hearbeat message of expansion modules is timeout during running. Expansion modules send heartbeat messages to CPU periodically. If CPU does not receive heartbeat messages of the expansion module during the set time, then it indicates communication of the expansion module is abnormal.
10	ADC of AI tunnel conversion error
11	Adjustment value saving error
12	Adjustment value reading error
14	1st tunnel input signal of stimulation module out of measurement
15	2nd tunnel input signal of stimulation module out of measurement
16	3rd tunnel input signal of stimulation module out of measurement
17	4th tunnel input signal of stimulation module out of measurement

Figure 1 Extension Error

Code	Description
0	No error
1	Communication frame format error
2	Extension bus enters into error warning status
3	Extension bus enters into error passive status
4	Extension bus enters into bus shutdown status and just recovered
5	Extension bus receiving buffer area full
6	Extension bus sending buffer full
7	CPU fails to send the report.

Figure 2 Error code of CPU extension bus communication error

5. How to restore CPU to factory setting?

The following methods are provided to restore CPU to factory setting:

The below operation will clear CPU memories, including user program, configuration data, password and soon. CPU is reset to factory default settings.

⚠**Note: After clear, the PLC cannot realize the required function and process again. If you do not have the program copy running in the PLC, you'd better not clear it. Otherwise you have to ask for the equipment supplier and download again.**

Steps to clear:

① Set program port of CPU to default communication parameters.

Power off CPU, and put the switch at "STOP". Then repower on the CPU, the program port will restore to default communication parameters: Address: 1; Baudrate: 9600; Parity: None; DataBits:8; StopBits:1.

Not: Please don't change the switch position before clear complete.

② Set communication parameter of PC port.

In [Communication] page, set Local parameter be the same with CPU program port.

More details please refer to 3.7 how to connect PC with Kinco-K5.

③ Execute "Clear" command

In KincoBuilder, execute [**PLC**]→[Clear…] menu command to clear all the data saved in CPU memories. After execute the "Clear" command, CPU will restore to factory default setting. After clear, the communication parameters of the program port will be set as default: Address: 1; Baudrate: 9600; Parity: None; DataBits: 8; StopBits: 1.

6. Fault phenomenon: RUN or STOP indicators blink.

Possible reasons and countermeasures（Only suitable for K5）:

- Set SM2.0 to 1.

In this condition, once error occurs, PLC will automatically restart. If fatal errors keep occurring, PLC will keep restarting. Then the RUN indictor will keep blinking. Under this condition, the STOP indicator usually does not blinking. User could set the switch to STOP, then re-download program or clear PLC.

- For some customized K5 PLC, when user update its firmware to standard K5 PLC firmware when customized user programming is running inside.

In this condition, RUN indicators may blink. The solution is to clear PLC by KincoBuilder before update firmware. If the STOP indicator also blinks, then users have to restore to firmware matched with user program, then clear PLC or contact with us for technical support directly.

- Hardware damage

There are kinds of hardware damages. EEPROM damage may lead to fatal error, but won't lead RUN/STOP indicators blink. Memory chip damage might lead RUN/STOP indicators blink. MCU chip damage might lead all the indicators off. If there is no lightning stoke or voltage vibration and only for normal use hardwares seldom get damaged.

7. Fault phenomenon: Upon K5 PLC power on, RUN/STOP/ERR indicators are all ON.

The reason is that self-inspection upon power on fail:

- K5 PLC EEPROM is totally damaged

Kinds of data is saved in EEPROM, including boot data. When EEPROM is damaged, PLC cannot read the boot code.

- User changed EEPROM by themselves.

Kind of data is saved in EEPROM, including boot data. If user changes new EEPROM, all the data will be lost. Then PLC cannot read the boot code.

- User changed MCU by themselves.

It is forbidden that users change MCU or EEPROM by themselves, which is for protecting intellectual property of manufacturer.

If users changed EEPROM or MCU, then users need to change them back.

For other conditions, please return faulty models to the factory.

Appendix E　Definition of SM Area

This Appendix describes the definition of system register area, SM area. This area is used to assist Kinco-K5 to realize certain functions. You may also use it to read PLC status.

1. **SMB0: system status byte**

Sm0.0-SM0.7 is valued by CPU software and cannot be controlled by user. You can only call some functions (read only):

Bit	Description
SM0.0	Always be ON
SM0.1	ON during the first scan cycle only. Usually used for some initializations.
SM0.2	If the data in RAM is lost, this bit is ON during the first scan cycle, and later cleared to FALSE.
SM0.3	Provide a pulse train (50% duty cycle) with a cycle time of 1s.
SM0.4	Provide a pulse train (50% duty cycle) with a cycle time of 2s.
SM0.5	Provide a pulse train (50% duty cycle) with a cycle time of 4s.
SM0.6	Provide a pulse train (50% duty cycle) with a cycle time of 60s.

2. SMB2: system control byte

Bit	Description
SM2.0	Its value decides the actions taken when fatal errors occur. Initial value is 0. If it is 0: PLC enters into sub-OS to run safely If it is 1: PLC resets
SM2.1	Its value decides the status of AI/AO tunnels. Initial value is 0. If it is 0: body AI/AO tunnel run normally If it is 1: body AI/AO tunnel enters into adjustment

3. **Communication Port Reset**

K5 provides function to reset communication port (PORT0, PORT1 and PORT2). After reset K5 will clear the buffer area of the communication ports and start initialization. After reset the parameters and functions of the port will remain the same.

- **Control Register and Status Register**

Bit			Value	Description
PORT 0	PORT 1	PORT 2		
SM87.0	SM187.0	SM287.0	1	Set the two bits to certain value and use RCV command.
SM87.7	SM187.7	SM287.7	0	
SM4.0	SM4.1	SM4.2	-	After success reset K5 will value the bit to 1. It requires manual reset

- Reset (PORT0 as example)

1) (Optional) Set SM4.0 to 0.
2) Set SM87.7 to 0 and SM87.0 to 1.
3) Call RCV and set its PORT parameters as the communication number. Need to be valued to 0.
4) (Optional) Check SM4.0. If 1 means success reset, other operation according to the need of the communication port.

- Example

Let's illustrate how to reset the PORT1. The example program adopted IL language, the user can copy it to the editor of KincoBuilder and perform 【Project】→【LD】menu commands into ladder diagram.

(* Network 0 *)

(*Use rise change of I0.0 to trigger PORT1 resetting*)

(*RCV command will not affect the resetting.*)

```
LD          %I0.0
R_TRIG
MOVE        B#0, %SMB4
AND         B#16#7F, %SMB187
OR          B#16#1, %SMB187
RCV         %VB222, 1
(* Network 1 *)
(*After resetting you may delay until PORT1 stays stable and continue operation, in theory, don’t delay is also OK.*)
(*PORT1 will enter into receiving status after resetting*)
LD          %SM4.1
TON         T4, 3
OR          B#16#80, %SMB187
RCV         %VB222, 1
R           %SM4.1
```

4. Other functional variables

SM	Description
SMB6	Read-only. Save the last PLC scanning time. Unit: ms.
SMW10	Read-only. Save voltage of back-up battery. Unit: 0.01V. If the power supply of back-up battery be lower than 2.6V constantly, PLC will warn “Low Back-up Battery”
SMB274-SMB285	The composite value of 12 bytes represents the ID value of the CPU module. Each CPU module is given a unique ID value.

5. SMD12 and SMD16: Timer Interrupt Events List

K5 can provide two Timer Interruptions based on 0.1ms: Timer Interrupt 0 with Event No. 3; Time Interrupt 1 with Event No. 4.

SMD12 is used to define the cycle of Timer Interruption 0, with a unit of 0.1ms. If SMD12 is set to 0 then Timer Interrupt 0 will be forbidden. The default value of SMD12 is 0;

SMD16 is used to define the cycle of Timer Interruption 1, with a unit of 0.1ms. If SMD12 is set to 0 then Timer Interrupt 0 will be forbidden. The default value of SMD16 is 0;

Timer Interrupt will generate periodically and you may use it to complete periodical tasks. Timer Interrupt will not be affected by PLC scanning period and can be used for precise timing.

Appendix F CANOpen Master

CANopen is a networking system based on the CAN serial bus. It was originally designed for motion-oriented industrial control systems, such as handling systems, but it can also be used in other application fields, e.g. vehicles, medical equipment and building automation.

1. CANOpen Communication Objects

CANOpen Application Layer and Communication Profile (CiA DS-301) is suitable for all CANOpen devices. In DS-301, various communication objects are defined, and they are described by the services and protocols. Here we introduce some commonly used communication objects.

1.1 Network management (NMT)

The network management (NMT) is CANopen device oriented and follows a master-slave structure. It requires one device in the network, which fulfills the function of the NMT Master. The other nodes are NMT Slaves. An NMT slave is uniquely identified in the network by its node-ID, a value in the range of [1..127].

NMT objects are used for executing NMT services. Through NMT services, CANopen devices are initialized, started, monitored, reset or stopped.

1.1.1 NMT Node Control

Through node control services, the NMT master controls the NMT state of the NMT slaves. The NMT state attribute is one of the values {Stopped, Pre-operational, Operational, Initialisation}.

The format of the node control message is as following.

Master -> Slave

COB-ID	Byte 0	Byte 1
0x000	CS（Command Specifier）	Node ID

The Node-ID defines the destination of the message. If it is zero the message addresses all NMT slaves.

The Command Specifier (CS) represents the following services:

Start Remote Node (CS=1),

Stop Remote Node (CS=2),

Enter Pre-Operational (CS=128),

Reset Node (CS=129) and

Reset Communication (CS=130).

1.1.2 NMT Error Control

The error control services supervise the nodes and network communication status. There exist two possibilities to perform error control.

The Node Guarding is achieved by transmitting guarding requests by the NMT master. If a NMT slave has not responded within a defined span of time (node life time) or if the NMT slave's communication status has changed, the NMT master informs its NMT master application about that event.

The Heartbeat mechanism for a CANopen device is established by cyclically transmitting the heartbeat message by the heartbeat producer. If the heartbeat cycle fails for the heartbeat producer the local application on the heartbeat consumer will be informed about that event.

It is highly recommend to implement the heartbeat protocol for new device designs.

- **NMT Node Guarding**

The NMT master transmits a special remote frame, within which there is no data.

COB-ID
0x700 + Node ID

The corresponding slave responds:

COB-ID	Byte 0
0x700 + Node ID	Bit7：toggle-bit. Bit0-6：the state of the slave. 4 STOPPED; 5 Operational; 127 Pre-Operational.

- **Heartbeat**

A heartbeat producer transmits a heartbeat message cyclically. One or more heartbeat consumer receives the indication. The heartbeat consumer guards the reception of the heartbeat within the heartbeat consumer time. If the heartbeat is not received within the heartbeat consumer time a heartbeat event will be generated.

COB-ID	Byte 0
0x700 + Node ID	the state of the slave. 4 STOPPED; 5 Operational; 127 Pre-Operational.

1.2 Service Data Object (SDO)

A SDO is providing direct access to object entries of a CANopen device's object dictionary through index and sub-index. By means of a SDO a peer-to-peer communication channel between two CANopen devices is established. Always the client initiates an SDO transfer for any type of transfer. The owner of the accessed object dictionary is the server of the SDO.

SDOs allow to transfer data of any size. The transfer of messages of less than 5 data bytes an ‘expedited’ transfer may be performed. The transfer of messages of more than 4 data bytes has to be performed by means of the ‘segmented’ transfer. The ‘expedited transfer’ messages are as following.

Request, Client -> Server:

COB-ID	Byte 0	Byte 1-2	Byte 3	Byte 4-7
0x600 + Node ID	CS	index	Sub-index	Data

Response，Server -> Client：

COB-ID	Byte 0	Byte 1-2	Byte 3	Byte 4-7
0x580 + Node ID	CS	index	Sub-index	Data

1.3 Process Data Object (PDO)

The real-time data transfer is performed by means of "Process Data Objects (PDO)". PDO communication can be described by the producer/consumer model. Process data can be transmitted from one device (producer) to one another device (consumer) or to many other devices (broadcasting). PDOs are transmitted in a non-confirmed mode.

There are two kinds of use for PDO. The first is data transmission and the second data reception. It is distinguished in Transmit-PDO (TPDO) and Receive-PDO (RPDO). CANopen devices supporting TPDO are PDO producer and CANopen devices supporting RPDO are called PDO consumer.

PDO is performed with no protocol overhead. The contents and parameters of a PDO are defined by the user through a network configuration tool.

PDO are described by the PDO communication parameter and the PDO mapping parameter. The PDO communication parameter describes the communication capabilities of the PDO. The PDO mapping parameter contains information about the contents of the PDO. Here we describe the PDO communication parameters.

- **COB-ID**

The COB-ID of the PDO, and it is the unique identifier.

- **Transmission Type**

It represents the triggering mode of PDO transmission. It is an 8-bit unsigned integer value.

- **Event- and timer-driven**

Message transmission is either triggered by the occurrence of an application-specific event specified in the device profile, application profile or manufacturer-specific, or if a specified time (event-time) has elapsed without occurrence of an event.

Transmission type 254 means manufacturer-specific event.

Transmission type 255 means that the event is specified in the device profile, application profile.

- **Remotely requested**

The transmission of an event-driven PDO is initiated on receipt of a RTR initiated by a PDO consumer.

The transmission type value is 252 or 253.

- **Synchronously triggered**

Message transmission is triggered by the occurrence of the SYNC object. The trigger condition is the number of Sync and optionally an internal event.

Cyclic (transmission types 1-240) means that the transmission of the PDO shall be related to the SYNC object.

Acyclic (transmission type 0) means that the message shall be transmitted synchronously with the SYNC object but not periodically.

Transmission type 252 means that the transmission of the PDO shall be related to the SYNC object and RTR.

- **Inhibit Time**

To guarantee that no starvation on the network occurs for communication objects with low priorities, PDOs can be assigned an inhibit time. The inhibit time defines the minimum time that has to elapse between two consecutive invocations of a PDO.

The value of 0 shall disable the inhibit time.

- **Event Timer**

It is an 8-bit unsigned integer value. The value of 0 shall disable the event-timer.

If the specified time (event-time) has elapsed, PDO transmission shall be triggered, even without occurrence of a specific event.

2. The CANOpen master function of Kinco-K5

Besides K504, all other CPU modules can combine with K541 to serve as a CANOpen master.

2.1 Main Features

- Supporting CAN2.0A, and accords with DS301 V4.2.0.
- Supporting NMT (Network Management) services and serving as a NMT master.
- Supporting normal expedited SDO as a client, and providing SDO_READ and SDO_WRITE instructions.
- Supporting for 72 CANOpen slaves.
- At most 8 TPDOs and 8 RPDOs for a slave,and 256 TPDOs and 256 RPDOs for all.
- Supporting Heartbeat protocol and Node-guarding protocol.
- Network error management

2.2 How to use?

2.2.1 CANOpen network configuration tool

In Kincobuilder, enter the **[Hardware]** window, then click and select the CPU module in the upper table, and then click **[CANOpen]** tab in the under window, and now you can configure the network and all the devices.

2.2.2 Manage EDS files

In **[CANOpen]->[Network Settings]** window, there are 4 buttons for operating eds files:

- **[Import EDS…]**: Click this button, then select an eds file to import it into Kincobuilder. After importing an eds file, the corresponding device appears in the under **[Available Devices]** tree list.
- **[Delete]:** Click and select a device in the **[Available Devices]**, then click **[Delete]** button, and this device is deleted from the **[Available Devices]** tree list, also its eds file is deleted from Kincobuilder.
- **[Export All EDS]:**
- **[Import All EDS]:**

2.2.3 Configuration Steps of a CANOpen network

1) Configure the global parameters

Enter [Global Settings] tab, as the following picture:

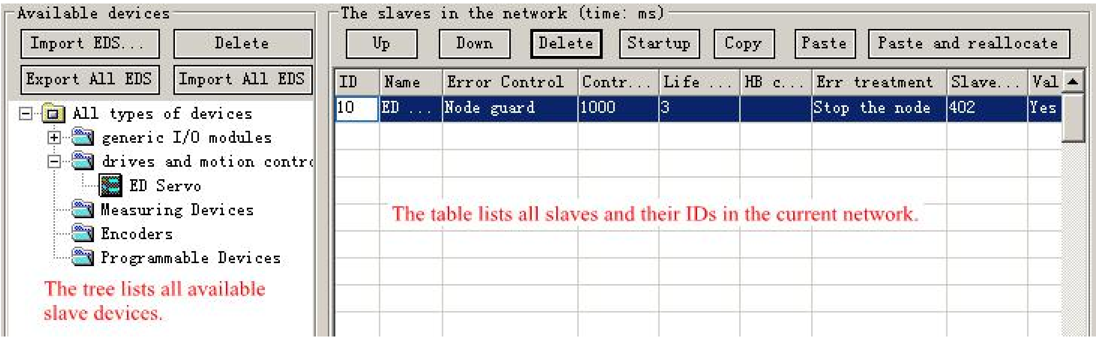
[Baudrate]: Select the master's baudrate. Notice that all devices in a network must use the same baudrate.

[SDO Timeout]: Set a time for waiting for the SDO response after the master transmits a SDO request. If the master doesn't receive the SDO response until this time has elapsed, the master shall report an error. Usually this value is less than 100ms.

[Configure slaves at startup]: The master controls the NMT state of all the slaves. Besides, if this checkbox is checked, then at startup the master also transmits messages to configure all slaves (such as PDO mapping) according to their configurations.

2) Configure all slaves

Enter **[Network Setting]** tab and continue to configure the slave nodes and their parameters.



All the functional buttons correspond to a right-click menu. Users right click mouse on related location, corresponding menu will pop up.

a) Add a slave device into the network:

Select a slave device and double click it from the left tree list, then this device is added into the network and listed in the right table.

b) Configure the slave's parameter (such as ID, Error control):

In the right table, the **[ID]** column lists the ID of each slave. The first row is the slave of ID No.10.

After a slave device is added, the default parameter configuration will display. Slave devices are added from top to bottom to the list by default. User could single click one row to select a slave device, then single click [UP] and [Down] to modify its station number, or single click [Delete] to delete the slave device.

[Error Control] is used to select a NMT Error Control method (NMT Node Guarding or Heartbeat). If a slave supports these two methods, it is highly recommended to use Heartbeat.

[Control Cycle] is the cycle time of node guarding or heartbeat. It is recommended to set this time to be more than 2000ms.

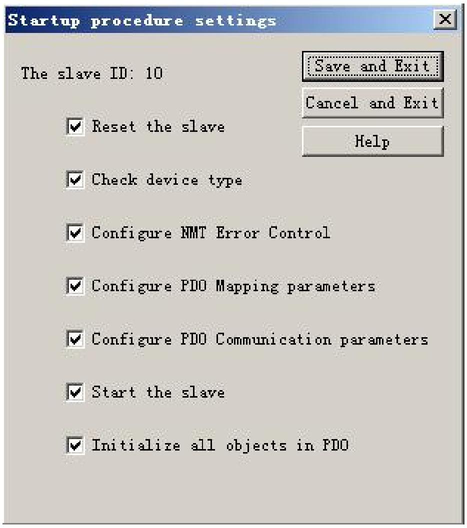
[HB consumer time] is the heartbeat consumer time. The Heartbeat Consumer guards the reception of the

Heartbeat within the Heartbeat consumer time. If the Heartbeat is not received within this time a Heartbeat Error will be generated. It is recommended to set this time to be more than 3000ms.

[Error treatment] is used to select a treatment method (including 'None', 'Stop the node' and 'Stop network') when the master detects an error of this slave. The slave errors that can be detected include SDO Time-out, Node Guarding time-out, Heartbeat time-out, some Emergency objects, etc.

c) Configure the startup procedures of a slave:

Click and select a slave in the table, then click **[Startup]** button, now you can configure the startup procedures of this slave.



[**Reset the slave]:** Whether sent "Reset Note" message before master station send configuration command to slave station.

[**Check device type:** Whether read and check device information before master station send configuration command to slave station.

[**Configure NMT Error Control]:** Whether configure node management type and corresponding parameters for slave station.

[**Configure PDO Mapping parameters]:** Configure PDO mapping parameters of slave station.

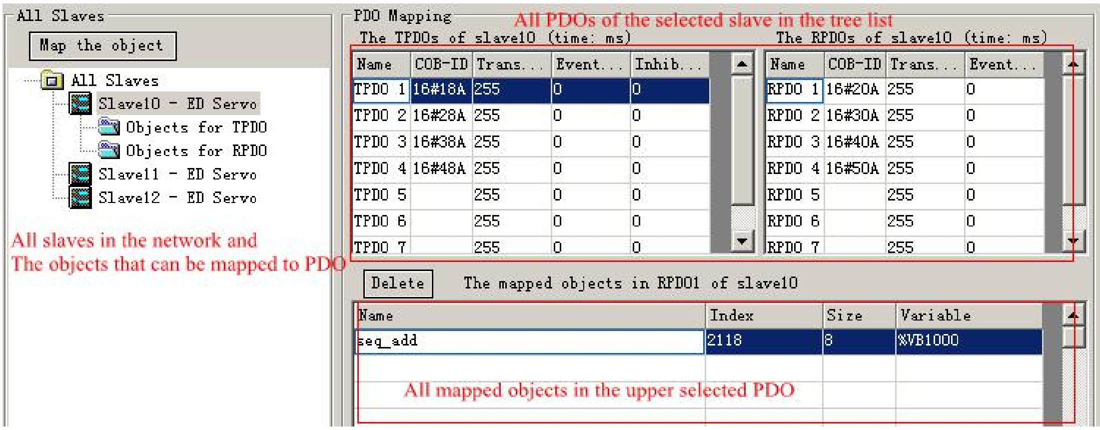
[Configure PDO Communication parameters]: Configure PDO communication parameters of slave station.

[Start the slave]: Whether send 'Start Node' message to slave station.

[Initialize all objects in PDO]: After slave station start, whether master station should set all PDOs of salve station to 0.

d) Configure the PDO mappings of the slaves:

Enter the **[Mapping parameters]** tab and configure the PDO mappings of the slaves.



On the left hand, **[All Slaves] tap** lists all the slaves in the network and all the objects of each slave that can be mapped into PDO. [Objects for TPDO] can only be mapped into TPDO, and [Objects for RPDO] can only be mapped into RPDO. The steps of configuring a PDO are as following:

i) Click a slave in the [All Slaves] tree list, then all PDOs of this slave appear in the right table.

ii) Click and select a PDO in the table, then you can modify its communication parameters, such as Event-timer, Inhibit time, etc.

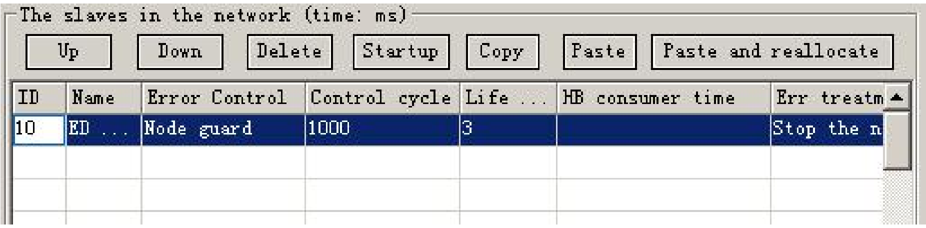
The COB-IDs of TPDO1-4 and RPDO1-4 can't be modified, because they use the default COB-ID in the pre-defined connection set of DS301. You can freely assign legal COB-IDs for TPDO5-8and RPDO5-8.

Besides, double click on any object of left list, the object will be added in to the current PDO. At the same time, KincoBuilder assigns a V area address for the object automatically, for example: VW1006. Then users could operate the object by operate VW1006 in the program.

iii) Repeat the above until all the PDOs of current slave station are configured.

e) Copy, paste slave station

In the **[Network Setting]** tab, there are **[Copy], [Paste]** and **[Paste and reallocate]** buttons.



[Copy]: Select one slave station which is already configured, then single click [Copy] button to copy all the information of the selected slave station (All PDO mapping/communication parameters). If no PDOs are configured for the selected slave station, then it reports copy fail.

[Paste]: After copy one slave station successfully, select one blank row and single click the [Paste] button to paste the copied configuration information, a new station is created at the same time. Note: PDOs mapping addresses of the new slave station are the same with source slave station, users have to modify by themselves.

[Paste and reallocate]: Operation method is the same with [Paste]. But by [Paste and reallocate], PDOs addresses will be relocated automatically, users no need to modify by themselves.

2.1 ERR LED of K541

Usually, CAN controller chip realized fully CAN2.0 protocol. According to error detect mechanism defined by CAN2.0, CAN controller chip could automatically detect bit error, CRC error, ACK error and so on, and set corresponding error registers for access by external MCU.

K541 reads error registers of the CAN controller chip. Once error message is detected, ERR light will be ON. If the error value is 0, ERR light will be OFF. So when ERR light is ON, it indicates communication is bad and many errors occur. Once ERR light is ON, users could check from the following aspects:

1) Check whether CAN bus wiring is correct or virtual connection.
2) Whether all the nodes are with same baud rate.
3) In the CAN bus network, the 1st node and last node should connect with a 120ohm terminal resistor.
4) Whether there is strong interference source near the network.
5) It is better to set prober “Inhibit time” for frequently read/written PDOs (Position, speed and so on).