VS070QS-1618MDM1 Integrated Machine

User Manual

SHENZHEN INVT ELECTRIC CO., LTD.

Preface

Overview

Thank you for choosing INVT VS070QS-1618MDM1 integrated machine.

This quick start manual is to offer you a quick guide to the design, installation, connection and maintenance of VS070QS-1618MDM1 integrated machine, convenient for on-site reference. Briefly introduced in this booklet are the hardware specs, features, and usage of VS070QS-1618MDM1 integrated machine, plus the optional parts and FAQ for your reference.

The manual is subject to change without prior notice. Please visit www.invt.com to download the latest manual version.

Readers

Personnel with electrical professional knowledge (such as qualified electrical engineers or personnel with equivalent knowledge).

About documentation obtaining

This manual is not delivered along with the product. To obtain an electronic version of the PDF file, you can:

- Visit www.invt.com, choose **Support** > **Download**, enter a keyword, and click **Search**.
- Scan the QR code on the product housing→Enter a keyword and download the manual.

Change history

The manual is subject to change irregularly without prior notice due to product version upgrades or other reasons.

No.	Change description	Version	Release date
1	First release.	V1.0	March 2024

Contents

1 Safety precautions

1.1 Safety declaration

Read this manual carefully and follow all the safety precautions before moving, installing, wiring, commissioning and running the programmable controller. Otherwise, equipment damage or physical injury or death may be caused.

We shall not be liable or responsible for any equipment damage or physical injury or death caused due to failure to follow the safety precautions.

1.2 Safety level definition

To ensure personal safety and avoid property damage, you must pay attention to the warning symbols and tips in the manual.

Symbols	Name	Description
	Danger	Severe personal injury or even death can result if related requirements are not followed.
	Warning	Personal injury or equipment damage can result if related requirements are not followed.

1.3 Personnel requirements

Trained and qualified professionals: People operating the equipment must have received professional electrical and safety training, and must be familiar with all steps and requirements of equipment installing, commissioning, running and maintaining and capable to prevent any emergencies according to experiences.

1.4 Safety guidelines

General principles	
	● Only trained and qualified professionals are allowed to carry out related operations. ● Do not perform wiring, inspection or component replacement when power supply is applied.

Delivery and installation	
	● Do not install the programmable controller on inflammables. In addition, prevent the programmable controller from contacting or adhering to inflammables. ● Install the programmable controller in a lockable control cabinet of at least IP20, which prevents the personnel without electrical

Delivery and installation	
	equipment related knowledge from touching by mistake, since the mistake may result in equipment damage or electric shock. Only personnel who have received related electrical knowledge and equipment operation training can operate the control cabinet. ● Do not run a damaged or incomplete product. ● Do not contact the product with damp objects or body parts. Otherwise, electric shock may result.

Wiring	
	● Fully understand the interface types, specifications, and related requirements before wiring. Otherwise, incorrect wiring cause abnormal running. ● Before power-on for running, ensure that each module terminal cover is properly installed in place after the installation and wiring are completed. This prevents a live terminal from being touched or misoperation. Otherwise, physical injury or equipment fault may result. ● Install proper protection components or devices when using external power supplies for the product. This prevents the programmable controller from being damaged due to external power supply faults, overvoltage, overcurrent, or other exceptions.

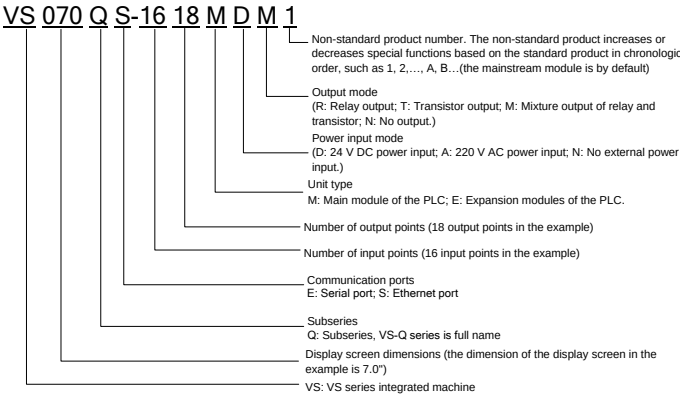
Commissioning and running	
	● Before power-on for running, ensure that the working environment of the product meets the requirements, the input power specifications meet the requirements, the wiring is correct, and a protection circuit has been designed to protect the product so that the product can run safely even if an external device fault occurs. ● For modules or terminals requiring external power supply, configure external safety devices such as fuses or circuit breakers to prevent damage caused due to external power supply or device faults.

Maintenance and component replacement	
	● During maintenance and component replacement, take measures to prevent screws, cables and other conductive matters from falling into the internal of the product.

Disposal	
	● This programmable controller contains heavy metals. Dispose of a scrap programmable controller as industrial waste.
	● Dispose of a scrap product separately at an appropriate collection point but not place it in the normal waste stream.

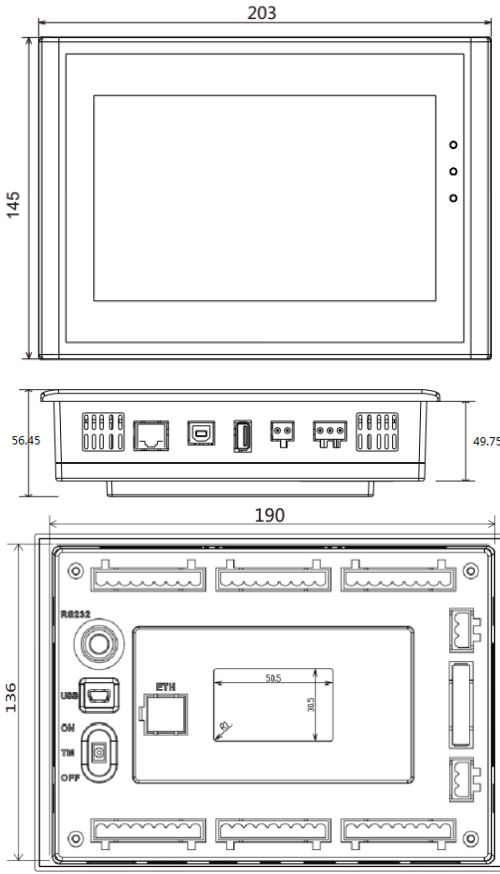
2 Product overview

2.1 Product nameplate and model



Model	Specifications
VS070QS-1618MDM1	● Finished PLC ● Touch screen ● VS series integrated machine ● 7.0-inch ● 16 digital inputs ● 18 digital outputs ● 2 analog inputs ● 1 analog outputs

2.2 Structure



The rounded port on the left side is a port for downloading. Elliptic port is the mode selection switch, providing three options: ON, TM, and OFF. For details about ports on the right side, see port description.

2.3 Product specifications

2.3.1 Basic parameters

Specification		VS070QS-1618MDM1
Resolution (pixel)		800×480
Contrast		400: 1
Brightness		450cd/m^2
Touch panel		4-wire high precision touchpad
Display color		16.77 million
Backlight module		LED
Total number of I/O points		34
Number of input points		16
Number of output points		18
Analog input		2
Analog output		1
RS485 (One for HMI, and one for PLC)		2
RS232		1
I/O configuration	Max. I/O points	256 points (theoretical value)
	Number of expansion modules	The total number of I/O expansion modules and special modules is not more than 3.
User file capacity	User program capacity	32k steps
	Data block size	10000 D elements
Command speed	Basic command	0.2μs/command
	Application command	μs~hundred μs/command
Number of commands	Basic command	32
	Application command	234
Soft element resources[Note5]	Input/output points	128 inputs/128 outputs (inputs X0–X177, outputs Y0–Y177)[Note1]
	Auxiliary relay	2048 points (M0–M2047)
	Local auxiliary	64 points (LM0–LM63)

Specification		VS070QS-1618MDM1	
	relay		
	Special auxiliary relay	512 points (SM0–SM511)	
	State relay	1024 points (S0–S1023)	
	Timer	256 (T0–T255)Note2	
	Counter	256 (C0–C255)Note 3	
	Data register	10000 (D0–D9999)	
	Local data register	64 (V0–V63)	
	Indexing register	16 (Z0–Z15)	
	Special data register	512 (SD0–SD511)	
Interrupt resources	External input interrupt	16 (interruption triggering edges can be defined by users, corresponding to the rising and falling edges of the X0 to X7 terminals)	
	High-speed counter interrupt	6	
	Internal timed interrupt	3	
	Serial port interrupt	12	
	Interruption after PTO output	4	
	Interruption at power outage	1	
Communication function	Communication port	Three asynchronous serial communication ports: Communication port 0: RS232 Communication port 1: RS485 Communication port 2: RS485 One Ethernet port: LAN port on the shell	
	Communication protocol	Modbus, free-port, N:N (INVT proprietary protocol, which can be applied to form 1:N or N:N communication networks)	
Special function	High-speed counter	X0, X1	Single input: 50 kHz Simultaneous inputs of X0 to X5:

Specification		VS070QS-1618MDM1	
			The total frequency is no more than 80 kHz.
		X2–X5	Single input: 10kHz
	High-speed pulse ouput	Y0, Y1, Y2, Y3	Four independent outputs: 100 kHz (transistor output)
	Digital filtering function	X0–X7 use digital filtering, while other ports use hardware filtering.	
	PID temperature control	Support Y element and M element control outputs and autotuning function	
	Subprogram call	A maximum of 64 user subprograms and six levels of nested subprograms are allowed. Local variables are supported, and each subprogram can provide a maximum of 16 parameters for information transmission. Variable aliases are also supported.	
	User program protective measures	Upload password	Three types of passwords are provided. A password is no more than 8 characters, and each character is alphanumeric and case sensitive.
		Download password	
		Monitoring password	
		Subprogram encryption	The functions of disabling formatting and upload are provided.
		Other protective measures	The functions of disabling formatting and upload are provided.
	Programming method[Note4]	Auto Station programming software	It needs to be installeded and run on IBM PC microcomputer or compatibles.
	Real-time clock	Built-in, and real-time clock internal rechargeable battery powered by backup battery (30 days)	

Note:

1: The addresses of the X and Y elements are numbered in octal, for example: Address X10 represents the 8th input point.

2: The addresses of the T elements are classified into three categories according to timing precision:

- 100ms precision: T0–T209
- 10ms precision: T210–T251
- 1ms precision: T252–T255

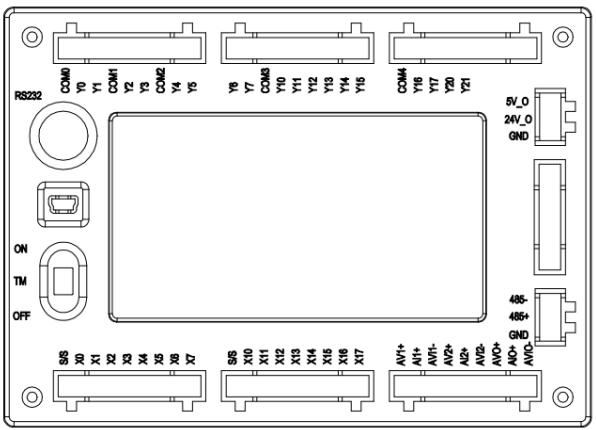
3: The addresses of the C elements are classified into three categories according to the width and function of count values:

- 16-bit increment counters: C0–C199
- 32-bit increment and decrement counters: C200–C235
- 32-bit high-speed counters: C236–C255

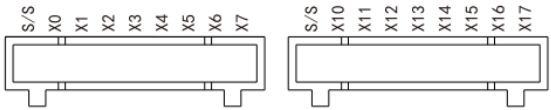
4: The element forcing function is provided to facilitate commissioning and user program analysis, and thus improve commissioning efficiency. A maximum of 128 bit elements and 16 word elements can be forced simultaneously.

5：Some internal soft element resources of PLCs have been reserved for internal use. Do not use these elements on the user program, if possible. For details, see the *IVC Series Micro-PLC Programming Manual*.

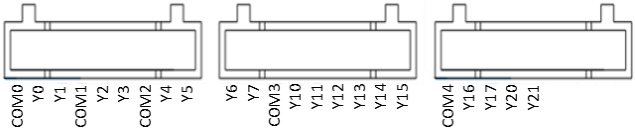
2.3.2 Terminal arrangement of VS070QS-1618MDM1 integrated machine



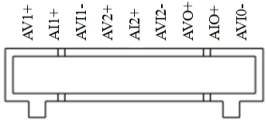
- Input ports



- Output ports

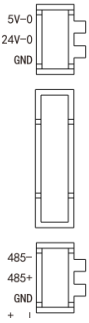


- Analog input/output ports



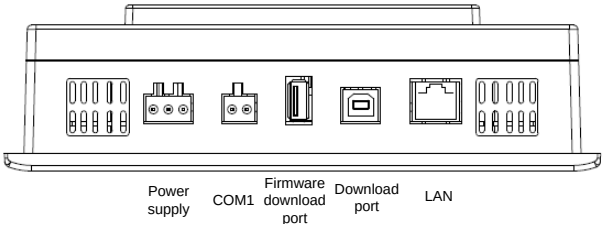
- Right-side ports

From top from bottom, the ports on the top are power output ports, the ports on the bottom are of 485 interfaces.



- Ports on the shell

The ports, from left to right, are power input interface, COM1, firmware download port (for firmware upgrade and program download), download port (conducting data exchange with HMI for downloading project) and LAN port (Ethernet port, supporting Modbus TCP master-slave communication).



2.3.3 Power supply specifications

The electrical specifications for the DC power supply built in the main module are shown in the following table (the machine can be expanded with up to 4 expansion modules at will).

Item		Unit	Min. value	Typical value	Max. value	Note
Input voltage range		VDC	21	24	30	Voltage range for proper start and operation; Relay output and digital input power supplies can use 24V voltage.
Current		A	-	0.3	1.5	-
Output current		mA	-	160	-	Right-side terminal 5V/24V
Current of expansion modules	5V/GND	mA	-	800	-	Support 4 expansion modules The total power of outputs 5V/GND and 24V/GND is used for equipment consumption and expansion modules.
	24V/GND	mA	-	600	-	

Note: Adopting non-isolated power and power input nominal voltage 24 V DC.

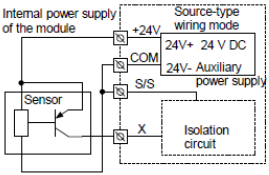
2.3.4 Digital input characteristics and specifications

The input characteristic and signal specification are shown as follows:

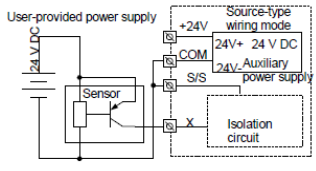
Item		Ultra-high speed input terminals X0–X1	High-speed input terminals X2–X7	General input terminal
Input mode		Source mode or sink mode, set through s/s terminal		
Electric parameters	Input voltage	24VDC		
	Input resistance	0.8kΩ	3kΩ	4kΩ
	Input ON	External circuit resistance < 400Ω		
	Input OFF	External circuit resistance > 24kΩ		
Filtering function	Digital filter	X0–X7 have digital filtering function. Filtering time: 0ms, 2ms, 4ms, 8ms, 16ms, 32ms or 64ms (selected through user programming)		
	Hardware filter	Terminals other than X0–X7 are of hardware filtering. Filtering time: about 10ms		
High-speed function		● X0–X7: High-speed counting, interrupt, and pulse catching ● X0 and X1: Up to 50kHz counting frequency ● X2 and X5: Up to 10kHz counting frequency		

The input terminal act as a counter has a limit over the maximum frequency. Any frequency higher than that may result in incorrect counting or abnormal system operation. Make sure that the input terminal arrangement is reasonable and external sensors used are proper.

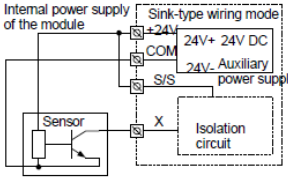
The PLC provides an S/S terminal for selecting signal input mode among source mode and sink mode. Connecting the S/S terminal to the +24 terminal, i.e. set the input mode to the sink mode, enables a connection with the NPN sensor.



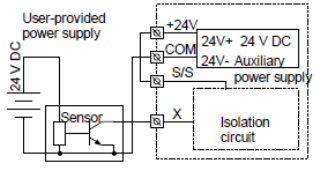
Wiring diagram of source-type input mode based on the internal power supply of the module



Wiring diagram of source-type input mode based on an external auxiliary power supply



Wiring diagram of sink-type input mode based on the internal power supply of the module



Wiring diagram of sink-type input mode based on an external auxiliary power supply

2.3.5 Transistor output electrical specifications

Item	Description
Output type	Transistor output
Number of output channels	4 channels
Output mode	Sink
Output voltage class	24VDC (-10% – +10%)
Output load (resistance)	0.5A/point, 2A/group
output load (inductance)	7.2W/point, 24W/group
Hardware response time	⩽2μs
Load current requirement	Load current ⩾ 12mA when output frequency is greater than 10kHz
Max. output frequency	100kHz for resistance load, 0.5Hz for resistance load, and 10Hz for light load
Leakage current at OFF	Below 30μA (24V typical voltage)
Max. residual voltage at ON	⩽0.5VDC
Isolation method	Capacitive isolation
Common terminal method	Y0/Y1/Y2/Y3－COM0/COM1 (share common terminal)
Short-circuit protection function	Supported
External inductive load requirement	Flyback diode needed for external inductive load connection. Refer to Figure2-1 for wiring diagram.

Item	Description
Output action display	When the output is valid, the output indicator is on (software control).
Output derating	The current at each group of common terminal cannot exceed 1A when the ambient temperature is 55℃. Refer to Figure 2-2 for the curve of derating coefficient.

Figure2-1 Inductive load flyback diode connection

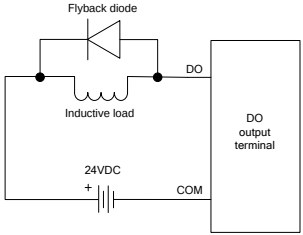
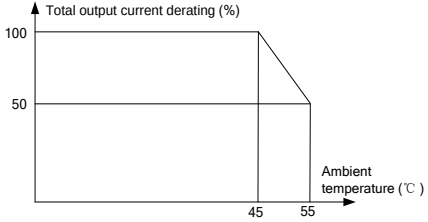
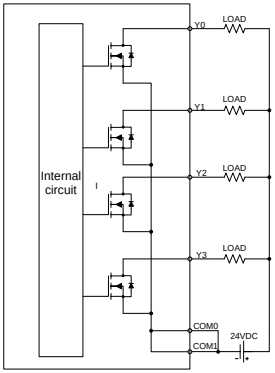


Figure 2-2 Output derating curve



The transistor sink type output wiring is shown as follows.



2.3.6 Relay output characteristics and specifications

2.3.6.1 Relay output electrical specifications

Item		Relay output
Switched voltage		Below 250VAC, 30VDC
Circuit isolation		By Relay
Operation indication		Relay output contacts closed
Leakage current of open circuit		-
Minimum load		2mA/5VDC
Max. output current	Resistive load	2A/1 point; 8A/4 points, using a COM 8A/8 points, using a COM
	Inductive load	220VAC, 80VA
	Illuminati on load	220VAC, 100W
Response time	OFF→ON	20ms Max
	ON→OFF	20ms Max
Output common terminal		Y04/Y07－COM2, Y10/Y15－COM3, Y16/Y21-COM4, and all the common terminals are isolated from each other.
Fuse protection		None

2.3.6.2 Relay output circuit

- Output terminal

  This model has a total of 4 common terminals for 14 relay outputs. Therefore, each common terminal block unit can drive loads with different supply voltage systems (such as 200VAC, 100VAC, and 24VDC).

- Loop insulation

  The internal circuit of the programmable controller and the load circuit of the external circuit are electrically insulated between the relay output coils and contacts. Besides, the common terminal blocks are separated from each other.

- Response time

  The response time from when the coil of the output relay is powered on or cut off to when the output contact is ON or OFF is about 20ms.

- Output current

  For <250VAC AC voltage, it can drive resistive loads of output current 2A/1 point, and support inductive loads of <80VA (100VAC or 200VAC) and lamp loads of <100W (100VAC or 200VAC).

- Service life of relay output contacts

  Standard life of inductive AC loads such as contactors and solenoid valves: According to the approximate relays standards derived from our life tests, the service life of relays is approximately 500,000 times for 20VA loads, 300,000 times for 35VA loads, and 100,000 times for 80VA loads. However, if the load is connected in parallel with a surge absorber, the service life will be significantly prolonged.

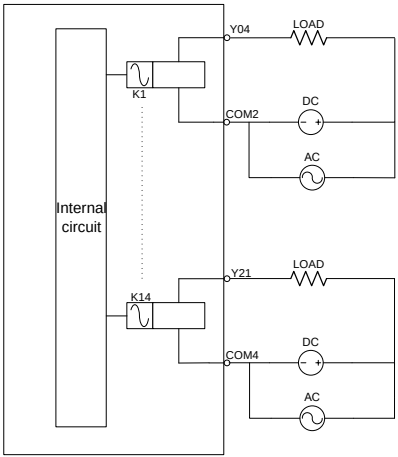
- Inductive load

  When an inductive load stops, a large directional electromotive force will be generated between the load and the contacts, and there is an arc discharge in the process.

- Capacitive load

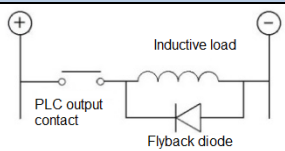
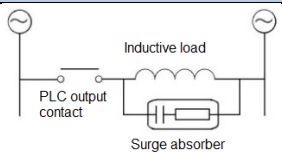
  During the use of capacitive loads, the instantaneous inrush current is about 20 to 40 times the conventional current, so please note that the inrush current shall be in accordance with the current values in the resistive load specifications.

The external load wiring of the relay output circuit is shown as follows.



2.3.6.3 Relay output reliability protection circuits

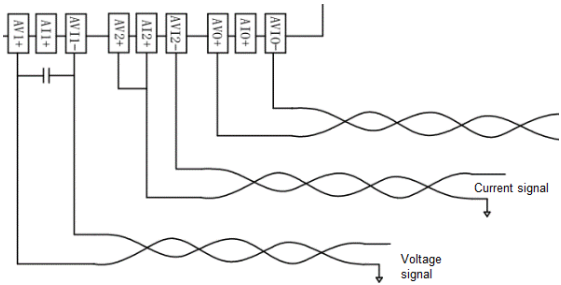
For DC inductive loads, it is necessary to connect a flyback diode in parallel. If the flyback diode is not connected, the service life of contacts will be significantly reduced due to the long-term effect of the counter electromotive force. Use a diode that allows the reverse withstand voltage to exceed the load voltage by 5 to 10 times and the forward current to exceed the load current. The AC inductive load connected in parallel with a surge absorber will reduce noise and prolong the service life of the output relay.

DC load	AC load
	
Note: The flyback diode shall comply with the following requirements:	**Note:** The surge absorber shall comply with the following requirements:

DC load	AC load
● Reverse voltage = (5–10) * Load voltage ● Forward current > Load current	● The rated voltage shall match with the load. ● Electrostatic capacity = 0.1μF ● Resistance value = 100–200Ω

2.3.7 Analog input/output characteristics

2.3.7.1 Input connection instance of analog signal



- For analog input, it is recommended to use shielded twisted-pair cables. The cable shall be kept away from power cables or other cables that may cause electrical interference.
- If there is fluctuation in input signals or electrical interference during the external wiring, a smoothing capacitor (0.1μF–0.47μF/25 V) is recommended.
- If the current channel uses the power input, the voltage and current input ports should be shorted.
- Analog power supply not only can use 24 V DC power supply output by the main module, but can use other power supplies that meet the requirements.
- Do not use the unconnected pin on the user terminals.

2.3.7.2 Output connection instance of analog signal

Figure 2-3 Voltage mode output

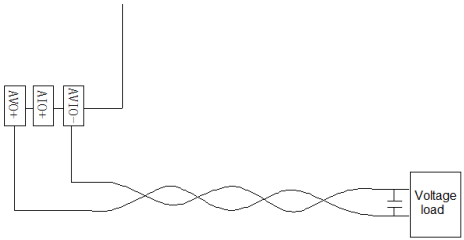
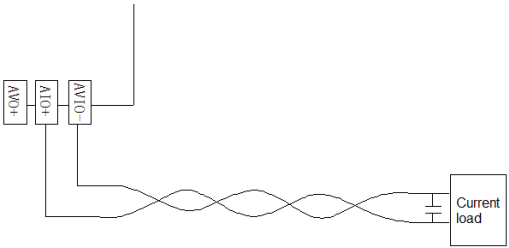


Figure 2-4 Current mode output



- For analog output, it is recommended to use shielded twisted-pair cables. The cable shall be kept away from power cables or other cables that may cause electrical interference.
- Using single-point grounding on the load end of the output cable.
- If there is electrical noise or voltage fluctuation during outputting, a smoothing capacitor (0.1 μF–0.47 μF/25 V) is recommended.
- If voltage output short circuit occurs or the current load is connected to the voltage output end, VS070-1614MDR1 integrated machine may be damaged.
- Analog power supply not only can use 24 V DC power supply output by the main module, but can use other power supplies that meet the requirements.
- Do not use the unconnected pin on the user terminals.

The analog signal input/output specification is listed in the following table. The analog quantity is non-isolated.

Item	Parameters
Analog input range	0–10 V DC, 0–20 mA
Analog output range	0–10 V DC, 0–20 mA
Total precision	±1% of the full range
Resolution	5mV, 10μA
Converting speed	2ms/channel

2.3.8 Communication ports

VS070QS-1618MDM1 integrated machine provides three asynchronous serial communication ports, namely COM1, PORT0, and PORT1. They support the baud rates of 115200, 57600, 38400, 19200, 9600, 4800, 2400, and 1200 bps. The communication protocol of PORT0 is determined by the mode selection switch as shown in the following figure.

PORT0

Pin No.	Name	Description
3	GND	Grounding pin
4	RxD	Serial data receiving pin (from RS232 to the PLC)
5	TxD	Serial data transmitting pin (from the PLC to RS232)
1, 2, 6, 7, 8	Reserved	Undefined pin Do not connect to these pins.

As a specialized interface for user programming, PORT0 can be forcibly switched to the programming protocol through the mode selection switch. The relationship between PLC operation status and the protocol used by PORT0 is shown in the following table.

Mode selection switch position	State	PORT0 running protocol
ON	Run	Depend on the user program and its system configuration. It can be the programming port, Modbus, free-port, or

Mode selection switch position	State	PORT0 running protocol
		N:N network protocol.
TM (ON→TM)	Running	Converted to programming protocol
OFF→TM	Stop	
OFF	Stop	If the system configuration of user program is free-port protocol, it converts to programming protocol automatically after stop; or system protocol keeps unchanged

Both COM1 and PORT1 are RS485 ports that can be connected to devices with communication functions, such as VFDs. These ports can be used to control multiple devices in networking mode through the RS485 terminal free protocol. They are terminals fastened with screws. You can make the communication signal cables by yourself. It is recommended that you use shielded twisted pairs (STPs) to connect the ports, as shown in the following figure.

Figure 2-5 HMI

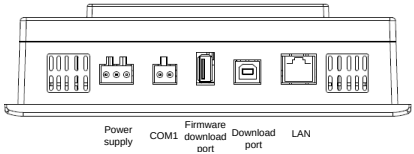
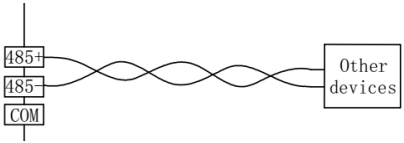


Figure 2-6 PLC PORT1



3 Mechanical installation

3.1 Installation environment requirements

The integrated machine is applicable to scenarios with installation environments of standard II and pollution level of 2.

Item	Specifications
IP rating	IP20
Pollution level	Level 2: Generally there is only non-conductive pollution, but you shall consider transient conductivity accidentally caused by condensation.
Altitude	2000m (80kPa)
Overcurrent protection device	1.1A fuse
Max. working temperature	45°C in full load Derating is required when the ambient temperature is 55°C. For details, see Figure 2-2.
Storage temperature and humidity range	Temperature: -20°C–60°C RH < 90%, without condensation
Transportation temperature and humidity range	Temperature: -40°C–70°C RH < 95%, without condensation
Working temperature and humidity range	Temperature: -20°C–55°C RH < 95%, without condensation

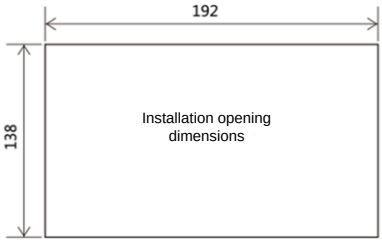
3.1.1 Dimensions and specifications

Model	Length	Width	Height	Net weight
VS070QS-1618MDM1	203mm	145mm	56.45mm	800g

3.1.2 Installation method

Ensure that the power cable, PLC output module, contactor, starter, relay, and other types of electrical interface devices keep a certain distance from the VS series products when installing devices behind the product.

Note: What calls for special attention is that a longer distance should be kept between the variable-frequency klystron and the switching power supply. Besides, input and output of this kind of device must adopt shielded cables, and connect the shielded net to the star-shaped ground of the system.


192
138
Installation opening
dimensions

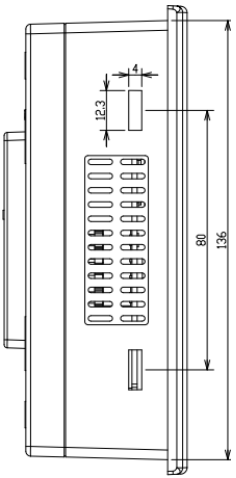
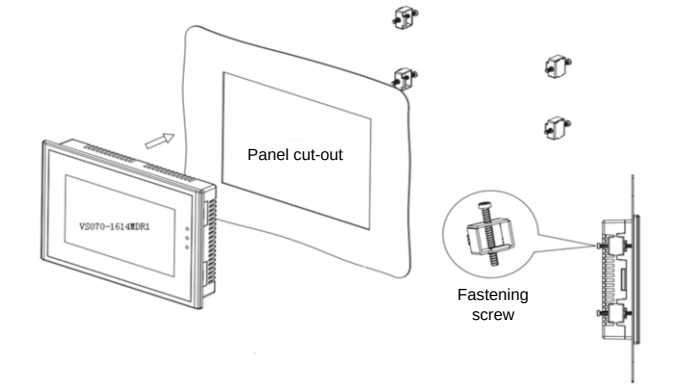

4
12.3
80
136

Figure 3-1 NEMA-4 standard installation



- VS series products can be installed in the machine cabinet whose depth is more than 56.5 mm. It is recommended to install on the front panel of the cabinet. For convenience, please keep a space distance of at least 22 mm around the VS series product so as to open the front panel of the cabinet and connect power supply and communication cables normally.
- Put the product into the mounting hole made on the panel, insert the mounting screws into the four fixing holes around the product shell from the back of the panel, and fasten the mounting screws one by one until the product is firmly fixed on the panel.
- To ensure that NEMA-4 sealing standard is complied, the mounting screws delivered with the product must be used, and the bending of the mounting panel cannot exceed 0.010".

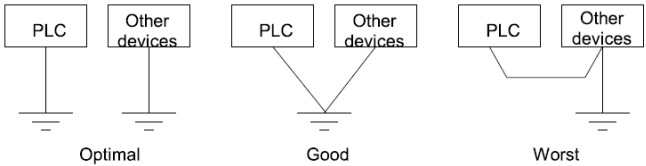
Note: Do not tighten the mount screws too hard to prevent from damaging the touch screen.

3.1.3 Cable connection and specifications

- It is recommended that you add an air switch on the power side of the PLC and fuse protection circuit in PLC power input when connecting power and grounding cables.
- The anti-electromagnetic interference capability of the PLCs can be improved by configuring reliable grounding cables. When installing a PLC, connect the

power supply terminal to the ground. It is recommended that you use connection wires of AWG12 to AWG16 and try to shorten the wires.

- It is recommended that you configure independent grounding and keep the grounding cables away from those of other devices (especially those generating strong interference), as shown in the following figure.



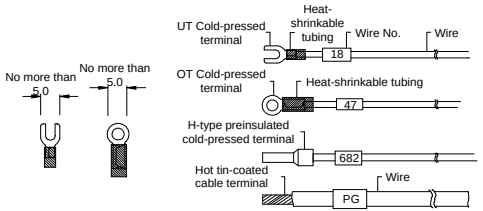
3.1.3.1 Cable specification

For the wiring of the PLC, it is recommended that you use multi-stranded copper wire and prepare insulated terminals to ensure the wiring quality. The following table describes the recommended wire cross-sectional areas and models.

Cable	Cross-sectional area of wire	Wire model	Cable lug and heat-shrink tube
Power cable	1.0–2.0mm²	AWG12, 18	H1.5/14 preinsulated tube-like terminal, or hot tin-coated cable terminal
Grounding cable ⏚	2.0mm²	AWG12	H2.0/14 preinsulated tube-like terminal, or hot tin-coated cable terminal
Input signal cable (X)	0.8–1.0mm²	AWG18, 20	UT1-3 or OT1-3 solderless lug Ø3 or Ø4 heat shrinkable tube
Output signal cable (Y)	0.8–1.0mm²	AWG18, 20	

Fix the processed cable terminals onto the wiring terminals of the PLC by using screws. Pay attention to the positions of the screws. The tightening torque for the screws is 0.5 to 0.8 Nm, which can be used to complete reliable connection without damaging the screws.

The recommended cable processing-method is shown in the following figure.



3.2 Power-on, operation, and routine maintenance

3.2.1 Power-on and operation

After the wiring is complete, check all the connections. Ensure that no foreign matters have dropped inside the housing and heat dissipation is in good conditions. The power-on procedures are as follows:

Step 1 Power on the PLC. The POWER indicator of the PLC is on.

Step 2 Start the Auto Station software on the PC and download the compiled user program to the PLC.

Step 3 After the program is downloaded and verified, set the mode selection switch to ON. The RUN indicator is on. If the ERR indicator is on, it indicates that errors occur on the user program or the system. In this case, rectify the errors by referring to the instructions in the *IVC Series Micro-PLC Programming Manual*.

Step 4 Power on the PLC external system to perform commissioning on the system.

3.2.2 Routine maintenance

Pay attention to the following aspects when performing routine maintenance and inspection:

1. Ensure that the PLC operates in a clean environment, preventing foreign matters or dust from dropping into the machine.
2. Keep the PLC in good ventilation and heat dissipation conditions.
3. Ensure that the wiring is properly performed and all the wiring terminals are well fastened.

Appendix A Addressing mode of the PLC elements

A.1 Mapping between R/W element function codes and the elements

Function code	Name	Modicon data address	Type of operable elements	Remarks
01	Read coils	0: xxxx	Y, X, M, SM, S, T, and C	Read bit
02	Read discrete input	1: xxxx	X	Read bit
03	Read registers	4: xxxx	D, SD, Z, T, C, and R	Read word
05	Write single coil	0: xxxx	Y, M, SM, S, T, and C	Write bit
06	Write single register	4: xxxx	D, SD, Z, T, C, and R	Write word
15	Write multiple coils	0: xxxx	Y, M, SM, S, T, and C	Write bit
16	Write multiple registers	4: xxxx	D, SD, Z, T, C, and R	Write word

Note: The definition of Modicon data addresses is as follows.

- 0 indicates coil.
- 1 indicates discrete input.
- 4 indicates register.
- xxxx indicates the range of 1–9999. Each type has an independent logic address range from 1 to 9999 (protocol address starts from 0).
- 0, 1 and 4 do not have the physical meaning and are not involved in actual addressing.
- Users shall not write X element with function codes 05 and 15, otherwise, the system does not feed back the error information if the written operands and data are correct, but the system does not perform any operation on the write instruction.

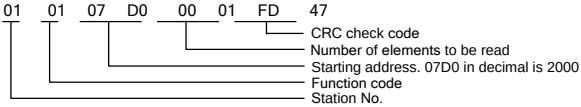
A.2 Mapping between the PLC elements and Modbus communication protocol addresses

Element	Type	Physical element	Protocol address	Supported function code	Remarks
Y	Bit element	Y0–Y177 (octal code) 256 points in total	0000–0127	01, 05, and 15	Output state, element number: Y0–Y177
X	Bit element	X0–X177 (octal code) 256 points in total	1200–1327 (0000–0127)	01, 05, and 15 (02)	Input state, it supports two kinds of addresses, and the element number is same as the above
M	Bit element	M0–M2047	2000–4047	01, 05, and 15	-
SM	Bit element	SM0–SM255 SM256–SM511	4400–4655 30000–30255	01, 05, and 15	-
S	Bit element	S0–S1023	6000–7023	01, 05, and 15	-
T	Bit element	T0–T255	8000–8255	01, 05, and 15	State of T element
C	Bit element	C0–C255	9200–9455	01, 05, and 15	State of C element
D	Word element	D0–D7999 D8000–D9999	0000–7999 50000–51999	03, 06, and 16	-
SD	Word element	SD0–SD255 SD256–SD511	8000–8255 12000–12256	03, 06, and 16	-
Z	Word element	Z0–Z15	8500–8515	03, 06, and 16	-
T	Word element	T0–T255	9000–9255	03, 06, and 16	Current value of T element
C	Word element	C0–C199	9500–9699	03, 06, and 16	Current value of C element (WORD)

Element	Type	Physical element	Protocol address	Supported function code	Remarks
C	Double word element	C200–C255	9700–9811	03, 16	Current value of C element (DWORD)

Note:

The protocol address is the address used in data transmission and corresponds with the logic address of Modicon data. The protocol address starts from 0 while the logic address of Modicon data starts from 1, that is, protocol address + 1 = logic address of Modicon data. For example, if M0 protocol address is 2000, and its corresponding logic address of Modicon data is 0:2001. In practice, the read and write of M0 is completed through the protocol address, such as frame for reading M0 element (sent by the master).



Appendix B High-speed counter

B.1 Configuration of the high-speed counter

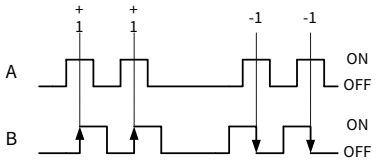
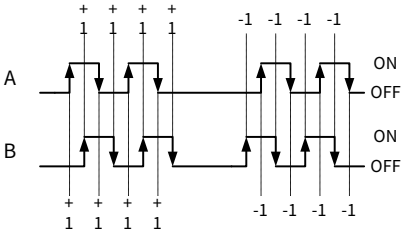
Counter \ Input point		X0	X1	X2	X3	X4	X5	X6	X7	Max. frequency (kHz)
1PH single-end counting input mode	C236	Up/ Down	-	-	-	-	-	-	-	50
	C237	-	Up/ Down	-	-	-	-	-	-	50
	C238	-	-	Up/ Down	-	-	-	-	-	10
	C239	-	-	-	Up/ Down	-	-	-	-	10
	C240	-	-	-	-	Up/ Down	-	-	-	10
	C241	-	--	-	-	-	Up/ Down	-	-	10
	C242	Up/ Down	-	Reset	-	-	-	-	-	50
	C243	-	-	-	Up/ Down	-	Reset	-	-	10
	C244	Up/ Down	-	Reset	-	-	-	Startup	-	50
	C245	-	-	-	Up/ Down	-	Reset	-	Startup	10
1PH counting up/down input	C246	Up	Down	-	-	-	-	-	-	50
	C247	Up	Down	Reset	-	-	-	-	-	50
	C248	-	-	-	Up	Down	Reset	-	-	10
	C249	Up	Down	Reset	-	-	-	Startup	-	-
	C250	-	-	-	Up	Down	Reset	-	Startup	10
2PH counting input mode	C251	Phase A	Phase B	-	-	-	-	-	-	50
	C252	Phase A	Phase B	Reset	-	-	-	-	-	50
	C253	-	-	-	Phase	Phase	Reset	-	-	-

Counter \ Input point		X0	X1	X2	X3	X4	X5	X6	X7	Max. frequency (kHz)
					A	B				
	C254	Phase A	Phase B	Reset	-	-	-	Startup	-	50
	C255	-	-	-	Phase A	Phase B	Reset	-	Startup	-
SPD frequency measurement command		Input point	Input point	Input point	Input point	Input point	Input point	Input point	Input point	-
Pulse capture function		Input point	Input point	Input point	Input point	Input point	Input point	Input point	Input point	-
External interrupt number		0/10	1/11	2/12	3/13	4/14	5/15	6/16	7/17	-

In the modes listed in the preceding table, after the the counting method of the high-speed counter is determined by external input, the high-speed counter performs counting.The counting of the high-speed counter is triggered by interrupts, which is unrelated to the PLC scanning cycle.

This kind of high-speed counters are of the 32-bit bi-directional counting type. According to different counting switching methods, it can be divided into the following four types.

Counting method	Counting action
1PH single-end counting input	Counters C236–C245 count down/up when SM236–SM245 are ON/OFF.
1PH counting up/down input	Corresponding to the action of counting up or down input, the counters C246–C250 are automatically incremented/decremented. You can know the current counting direction of the corresponding counter through SM246–SM250. The counter counts up when the SM element is OFF, or counts down when it is ON.

Counting method	Counting action
2PH counting input	When SM100–SM104 are set to OFF, counters C251–C255 are automatically incremented and decremented according to 2PH input. You can know the current counting direction of the corresponding counter through SM251–SM255. The counter counts up when the SM element is OFF, or counts down when it is ON. The counting direction is defined as follows: 
2PH quadruple frequency counting input	When SM100–SM104 are set to ON, counters C251–C255 automatically perform quadruple frequency counting according to 2PH input. You can know the current counting direction of the corresponding counter through SM251–SM255. The counter counts up when the SM element is OFF, or counts down when it is ON. The counting direction is defined as follows: 

B.2 Relationship between high-speed counters and SM auxiliary relays

Special auxiliary relay number for counting direction switching/monitoring corresponding to counter number.

Type	Counter number	Counting direction switching/monitoring special auxiliary relay
1PH count up/down input	C246	SM246
	C247	SM247
	C248	SM248
	C249	SM249
	C250	SM250
2PH counting input	C251	SM251
	C252	SM252
	C253	SM253
	C254	SM254
	C255	SM255

Type	Counter number	Up/Down setting
1PH single-end counting input	C236	SM236
	C237	SM237
	C238	SM238
	C239	SM239
	C240	SM240
	C241	SM241
	C242	SM242
	C243	SM243
	C244	SM244
	C245	SM245

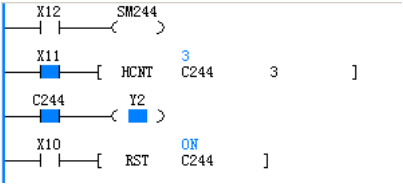
Special auxiliary relay number for single/quadruple frequency switching corresponding to the counter number.

Type	Counter number	Quadruple frequency setting
2PH counting input	C251	SM100
	C252	SM100
	C253	SM102
	C254	SM100
	C255	SM102

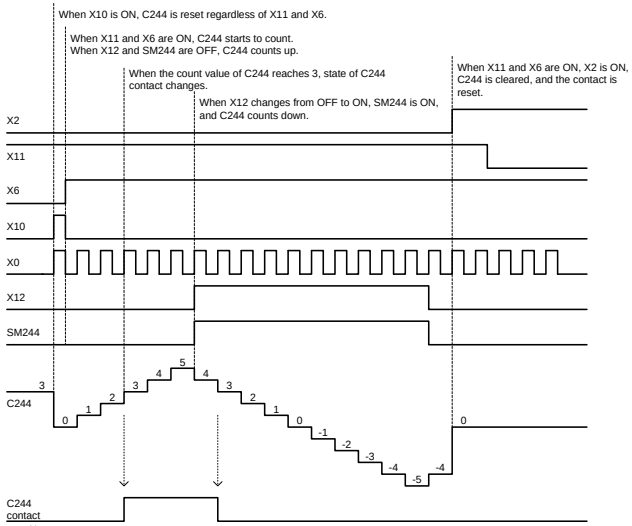
B.3 Usage methods of the high-speed counters

B.3.1 1PH single-end counting input high-speed counter

Features: A counter starts to count only when the pulse input changes from OFF to ON, and the count direction is determined by its corresponding special auxiliary relay SM. An example of the action is shown in the following figure.



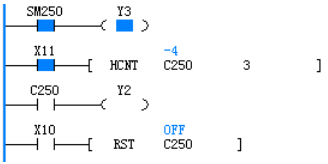
The time sequence chart of the contact actions in the program is shown in the following figure.



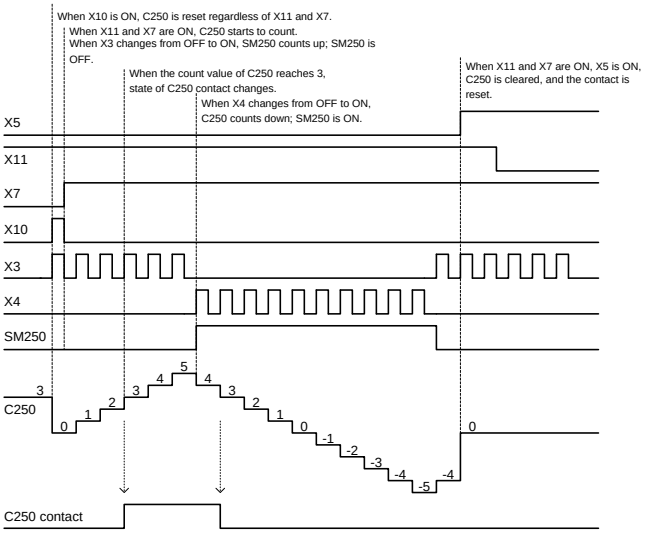
Note:
1. Counter input points: X0.
2. High-speed counters, when used in DHSCS, DHSCR, DHSZ, DHSP, and DHST commands, can trigger operations or controls free from the scan cycle.

B.3.2 1PH counting up/down input high-speed counter

Features: A counter starts to count only when the pulse input changes from OFF to ON, and the count direction is determined by two input points. The state of the high-speed counter is determined by its corresponding special auxiliary relay (SM element), and an action example is shown as follows.



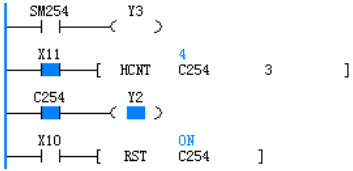
The time sequence chart of the contact actions in the program is shown in the following figure.



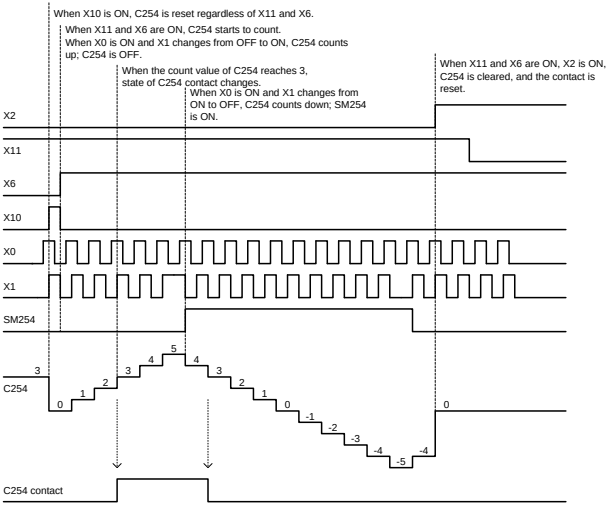
Note:
1. Counter input points: X3 and X4.
2. High-speed counters, when used in DHSCS, DHSCR, DHSZ, DHSP, and DHST commands, can trigger operations or controls free from the scan cycle.

B.3.3 2PH counting input high-speed counter

Features: A counter starts to count only when the pulse input changes from OFF to ON, and the count direction is determined by the phase difference of two input points. The state of the high-speed counter is determined by its corresponding special auxiliary relay (SM element), and an action example is shown as follows.



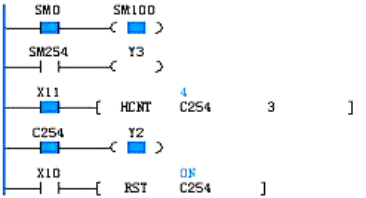
The time sequence chart of the contact actions in the program is shown in the following figure.



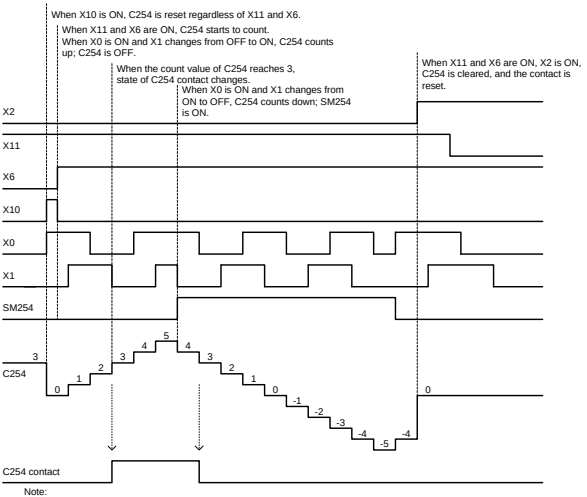
Note:
1. Counter input points: X0 and X1.
2. High-speed counters, when used in DHSCS, DHSCR, DHSZ, DHSP, and DHST commands, can trigger operations or controls free from the scan cycle.

B.3.4 2PH quadruple frequency counting input high-speed counter

Features: A counter starts to count when the dual pulse inputs change from OFF to ON or the dual pulse inputs change from ON to OFF, and the count direction is determined by the phase difference of two input points. The state of the high-speed counter is determined by its corresponding special auxiliary relay (SM element), and an action example is shown as follows.



The time sequence chart of the contact actions in the program is shown in the following figure.



Note:
1. Counter input points: X0 and X1.
2. High-speed counters, when used in DHSCS, DHSCR, DHSZ, DHSP, and DHST commands, can trigger operations or controls free from the scan cycle.

Appendix C Temperature autotuning PID

This command function block realizes the autotuning PID temperature control function, and you can select one of the following five control modes as needed, including: slow autotuning PID control mode, default manual PID control mode, manual PID control mode, ON/OFF control mode, and fast autotuning PID control mode.

C.1 Operand description

LAD														Applicable model	VS070QS-1618MDM1
														Influenced flag bit	-
Command list: TPID (S1) (S2) (S3) (D1) (D2)														Step length	13
Operand	Type	Applicable soft elements													Indexing
S1	INT							D							
S2	INT							D							
S3	REAL							D							
D1	BOOL		Y	M											
D2	REAL							D							

S1: Set target temperature

S2: Present measured temperature

S3: Set the first address number of the soft element of the control parameter. Range of proportional gain (Kp): 0–32767 (must be greater than 0), floating-point type

S3 + 2: Integral time (Ti). Range: 0–32767 (s). No integral processing is performed when it is 0, floating point type.

S3 + 4: Differential time (Td). Range: 0–32767 (s). No differential processing is performed when it is 0, floating point type.

S3 + 6: Sampling time (Ts). Range: 1–32767 (ms). Time values shorter than the operation cycle cannot be executed.

S3 + 7: Sampling period. Range: 1–32767 (ms). When S+16 is 1,namely PWM high-speed output is enabled, the relay switching period range changes to 1–32767 (μs).

S3 + 8: Upper limit of input temperature change. Range: -32168–32767. Temperature upper limit > Temperature lower limit.

S3 + 9: Lower limit of input temperature change. Range: -32168–32767. Temperature upper limit > Temperature lower limit.

S3 + 10: Upper limit of target temperature setting. Range: 0–32767. Temperature lower limit < Set value of target temperature < Temperature upper limit.

S3 + 11: Setting word of function modes.

Function mode	Set value
Default PID mode	0
Slow autotuning PID mode	1
Manual PID mode	2
ON/OFF mode	3
Fast autotuning PID mode	4

S3 + 12: Stop heating function, when the value is 1, stop heating.

S3 + 13: Reset function, when the value is 1, reset the parameters of autotuning TPID command.

S3 + 14: Analog output of 0–1000 corresponds to relay output of 0–220V.

S3 + 15: Autotuning coefficient 0–10 are used to control the intensity of autotuning process, and the recommended set value is 5.

S3 + 16: Enable high-speed PWM output, and only support Y0–Y3.

D1: Output the operation result when executing the program (the switch is ON or OFF).

D2: First address number of autotuning mode output proportional gain (Kp). Range: 0–32767 (must be greater than 0), floating-point type. Only the autotuning mode output is effective.

D2+2: Autotuning mode output integral time (Ti). Range: 0–32767 (s). No integral processing is performed when it is 0, floating point type. Only the autotuning mode output is effective.

D2+4: Differential time (Td). Range: 0–32767 (s). No differential processing is performed when it is 0, floating point type. Only the autotuning mode output is effective.

C.2 Function description

- When the energy flow is valid, starts the TPID command and execute the corresponding function according to the control mode selected by the user. When the energy flow is invalid, the PID function stops, and the output will be maintained.

- TPID command control modes include: default manual PID control mode, slow autotuning PID control mode, manual PID control mode, ON/OFF control mode, and fast autotuning PID control mode.

✧ Default manual PID control mode: It is the default mode of the command, in which a set of default PID initial parameters are given internally, and you just need to set the target temperature, real-time temperature, temperature upper and lower limits, and the control cycle time. The command will have a certain degree of overshooting for the first temperature rise, and then the temperature will be stabilized at the target temperature after a few minutes. The autotuning time of the mode is relatively fast.

✧ Slow autotuning TPID control mode: When you select this control mode, you must set the following parameters.

A. Target temperature
B. Real-time temperature
C. Temperature upper and lower limits
D. Control cycle time
E. Sampling time and other parameters
F. Autotuning coefficient

After enabling the energy flow, the command auto-tunes a set of suitable control parameters according to the control object in the heating process. After the completion of the autotuning mode, the system outputs the autotuning parameters, and automatically adjusts these parameters. The next time you use the tuned parameters, you need to adjust to the manual mode and enter the autotuning parameters for control. There will be a small temperature overshoot, but the error will be within ± 1 ℃ after stabilization.

The first tuning needs to take relatively long time. The autotuning effect is the best when it runs in room temperature environment, which is applicable to scenarios with high temperature requirements. The autotuning sampling time can be set to 200ms, and the control cycle can be set to 2000ms. In an example, the autotuning coefficient is 5, the autotuning temperature is 60°C, and the target temperature is 90°C. The curve is as follows.

The slow autotuning mode uses the relay autotuning method and must meet the following conditions:

A. Target temperature > actual temperature
B. The actual temperature is not 0.

After the autotuning conditions are met, the autotuning temperature (digital temperature) for relay autotuning are defined as follows:

$$\text{Autotuning temperature} = \begin{cases} \text{Target temperature, target temperature} < 60℃ \\ 60℃, \quad 60℃ \leq \text{target temperature} \leq 90℃ \\ \text{Target temperature} - 30℃, \quad \text{target temperature} > 90℃ \end{cases}$$

Note: Autotuning is not performed when actual temperature > target temperature or actual temperature > autotuning temperature, and only performed when actual temperature < target temperature and actual temperature < autotuning temperature.

✧ Manual PID control mode: This control mode requires the user to manually enter the PID parameters, proportional gain, integral time constant and differential time constant, and the PID output is adjusted according to the adjustment equation.

The PID adjustment equation is as follows:

$$\mathrm{u(k)} = \mathrm{K}_p \left[e(k) + \frac{T}{T_i} \sum_{j=0}^{k} e(j) + \frac{T_d}{T} [e(k) - e(k-1)] \right]$$

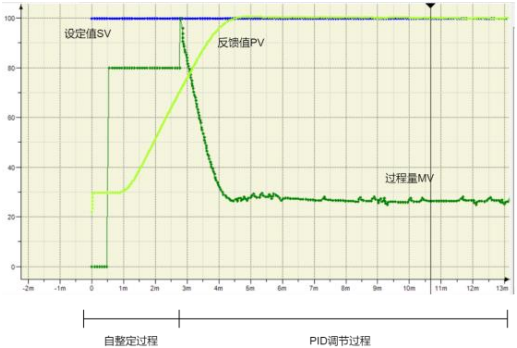
In which, $e(k)$ is the error, $e(k-1)$ is the error at the previous moment, K_p is the proportional gain, T_i is the integral time, T_d is the differential time, and T is the sampling period.

- ✧ ON/OFF control mode: This control mode is switch control, namely disconnecting the relay when exceeding the target temperature, and opening the relay according to a certain control cycle when it is lower than the target temperature value. This control mode still has partial errors after stabilizing, which is applicable to scenarios without demanding requirements on control accuracy.
- ✧ Fast autotuning TPID control mode: When you select this control mode, you must set the following parameters.
  A. Target temperature
  B. Real-time temperature
  C. Control cycle time
  D. Sampling time and other parameters
  E. Temperature upper and lower limits
  F. Autotuning coefficient

This mode requires that the target temperature shall meet the formula:
|Set value-target value|＞30℃.

After enabling the energy flow, the command auto-tunes a set of suitable control parameters according to the control object in the heating process. After the completion of the autotuning mode, the system outputs the autotuning parameters, and automatically adjusts these parameters. The next time you use the tuned parameters, you need to adjust to the manual mode and enter the autotuning parameters for control. There will be a small temperature overshoot, but the error will be within ± 1 ℃ after stabilization.

The tuning takes relatively short time. The autotuning effect is the best when it runs in room temperature environment, which is applicable to scenarios with high temperature requirements. The autotuning sampling time can be set to 200ms, and the control cycle can be set to 2000ms. In an example, autotuning temperature is 60°C, the autotuning coefficient is 5, and the target temperature is 90°C. The curve is as follows.



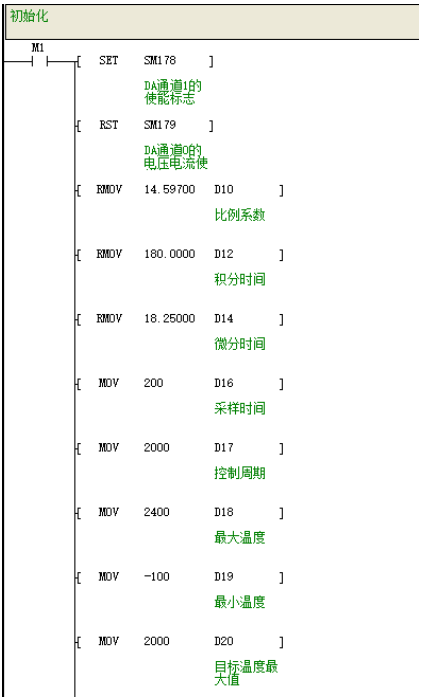
- Before executing the above control modes, you need to confirm whether the sampling cycle, control cycle, temperature upper and lower limits and control modes are applicable to the heating requirements of the specific control object. If not, please modify these parameters before heating. The sampling cycle shall be set according to the heating object, and it is generally set to 200ms. The temperature system changes slowly, so the scanning cycle shall not be too small. Considering the service life of the relay, the control cycle shall be ⩾2000ms.
- The average sampling times of analog input channels and analog output channels shall not be too large or too small. If it is too small, the temperature jump on a small scale may occur, which is unfavorable to autotuning. If it is too large, the temperature change will lag behind the actual temperature, which is unfavorable to temperature control. it is recommended to set the average sampling times⩾2.
- If S+16 (high-speed PWM enabling bit) is 0, the output is normal PWM and the unit of the output relay switching cycle is ms. If high-speed PWM speed is required, enable S+16 (high-speed PWM enabling bit) and configure the output bits as Y0–Y3, then the unit of the relay switching cycle will be changed from ms to μs.

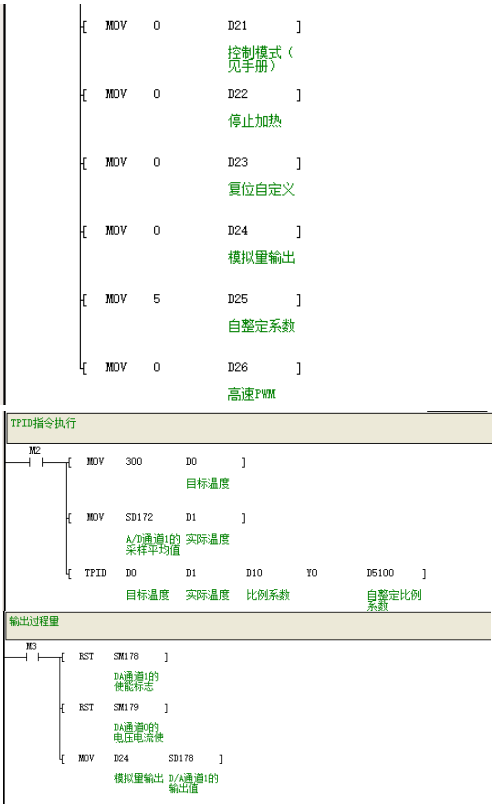
C.3 Application example

The TPID command execution program mainly consists of the following three parts: initialization program, TPID command execution, and analog output. When the main module starts to run the first scanning cycle, operands of TPID will be initialized, and the changes of TPID parameters will also be scanned in real time in the subsequent scanning cycles.

The temperature acquisition port of the special machine reads the current temperature value through the thermocouple, and fills it in the measured value unit to execute the TPID operation.

The command ladder diagram is written as follows.





Note:

- The control parameters to be set by the TPID command need to occupy 25 data registers starting from the first address number of the S3 soft element.
- The temperature changes slowly, so the value of the temperature sampling time shall not be too small. When the value of the sampling time is small, it will

affect the effect of TPID. The value of the sampling time shall not be large, and it needs to be smaller than the relay switching cycle time.

- Set 14 error descriptions for TPID, and see Table C-1 for details. If any of the errors occurs, the system reports an operand error and does not perform TPID operation.
- Sampling time ⩽ 1 scan cycle, and data overflow and result overflow during operation will lead to error alarm and stopping TPID operation.
- Initialize operands before performing the TPID command for the first time. If operands change during operation, the underlying data of TPID will be updated in the next cycle.
- Support up to 18 TPID commands to be executed in the same project simultaneously, and an error will be reported if the number of commands exceeds 18.

Table C-1 Error alarm code description

Error alarm code	Error description
100	Direct temperature jump occurs
101	Exceed the temperature upper limit
102	Exceed the temperature lower limit
103	The temperature deviation exceeds the upper limit of deviation
104	Autotuning failure
105	Temperature not detected
106	Parameters not saved at power failure
107	PID parameter setting exceeds limits
108	The target temperature exceeds temperature limit
109	Temperature upper and lower limits are set unreasonably
110	The sampling cycle exceeds control cycle
111	Control mode setting is incorrect
112	Temperature display abnormality
113	The number of executed commands exceeds the range, and up to 18 commands are supported.
114	When the high-speed PWM points are set incorrectly, i.e. not Y0–Y3.

Appendix D Analog input/output

D.1 Analog special soft elements

Table D-1 Special soft elements for analog input

Special soft elements	Description	R/W
SM172	A/D channel 1 enabling flag OFF: Disable ON: Enable	R/W
SM173	A/D channel 2 enabling flag OFF: Disable ON: Enable	R/W
SM174	A/D channel 1 output mode flag OFF: Voltage input ON: Current input	R/W
SM175	A/D channel 2 output mode flag OFF: Voltage input ON: Current input	R/W
SD172	Sampling average of A/D channel 1 Range: 0–10000, corresponding to 0–10V or 0–20mA	R
SD173	Sampling times of A/D channel 1 (i.e., average number of filters) Range: 0–1000. There is no filtering when the sampling times is 0.	R/W

Table D-2 Special soft elements for analog output

Special soft elements	Description	R/W
SM178	D/A channel 1 enabling flag OFF: Disable ON: Enable	R/W
SM179	D/A channel 1 output mode flag OFF: Voltage output ON: Current output	R/W
SD178	Sampling average of D/A channel 1 Range: 0–10000, corresponding to 0–10V or 0–20mA	R/W

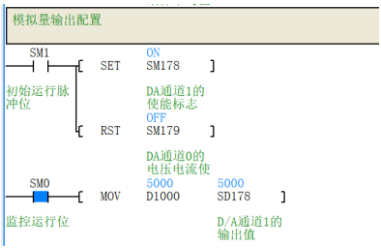
Note:

- When the special soft element SM179 selects voltage mode output, if the physical connection is a current-type connection, in which case there is still a current output, and vice versa, but the output analog value is not the expected analog value.
- Different devices shall be matched with corresponding output modes, otherwise unexpected consequences may be resulted.

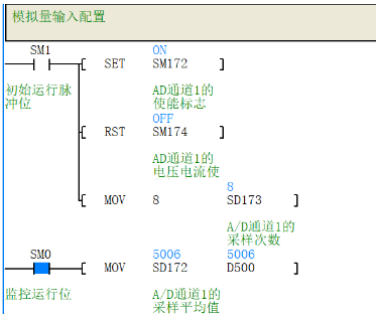
D.2 Application example

1. Connect the voltage mode analog output D/A channel 1 to the voltage mode analog input A/D channel 1. For details, see 2.3.7 Analog input/output characteristics.

   First, set SM178 (D/A channel 1 enabling flag) to ON, SM179 (D/A channel 1 output mode flag) to OFF and SD178 to 5000.

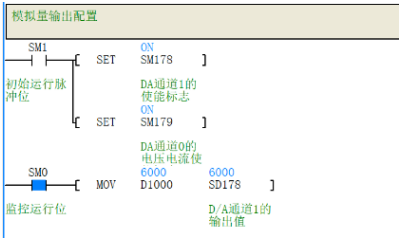


   Then, set SM172 (A/D channel 1 enabling flag) to ON and SM173 (A/D channel 1 output mode flag) to OFF, you can see that the voltage output of D/A channel 1 has been given to the voltage input of A/D channel 1, i.e., SD172 = 5006.

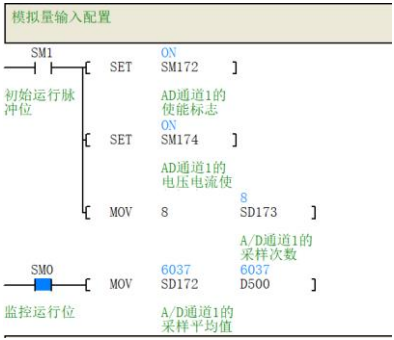


2. Connect the current mode analog output D/A channel 1 to the current mode analog input A/D channel 1. For details, see 2.3.7 Analog input/output characteristics.

   First, set SM178 (D/A channel 1 enabling flag) to ON, SM179 (D/A channel 1 output mode flag) to ON and SD178 to 6000.



   Then, set SM172 (A/D channel 1 enabling flag) to ON and SM173 (A/D channel 1 output mode flag) to OFF, you can see that the current output of D/A channel 1 has been given to the current input of A/D channel 1, i.e., SD172 = 6037.



Note: This manual introduces the key functions of VS070QS-1618MDM1 integrated machine. For other PLC functions, see the *IVC Series Micro-PLC Programming Manual*.

Appendix E Single word data sorting

The single word data sorting (SORT) instruction is used to sort the overall matrix data of a data table by the sorting results of the particular column.

E.1 Operand description

LAD	Applicable model	VS070QS-1618MDM1
	Influenced flag bit	-
IL: SORT (S1) (S2) (S3) (D1) (S4)	Step length	11

Operand	Type	Applicable soft element												Indexing
S1	INT							D						
S2	INT	Constant						D						
S3	INT	Constant						D						
D1	INT							D						
S4	INT	Constant						D						

S1: The address of the starting element of the original data sheet.

S2: The number of groups of sorted data. Range: 1–32.

S3: The number of data in each group. Range: 1–32.

D1: The address of the starting element where the sorted result data sheet is stored.

S4: The partitioning column that the data table is sorted. Range: 1–S3.

E.2 Function description

1. This instruction sorts S2 × S3 data tables starting with S1 unit by the parameters in column S4, and is placed in the variable domains starting with D1. The following is the 3×3 data sorting process:

Before sorting:

S3 \ S2	1	2	3
1	S1	S1+3	S1+6
	1	2	8
2	S1+1	S1+4	S1+7
	2	6	7

S3 \ S2	1	2	3
3	S1+2	S1+5	S1+8
	3	4	3

After sorting in ascending order by the second column:

S3 \ S2	1	2	3
1	D1	D1+3	D1+6
	1	2	8
2	D1+1	D1+4	D1+7
	3	4	3
3	D1+2	D1+5	D1+8
	2	6	7

2. One-dimensional data sorting function: S2 and S3 are 1 at the same time
   When the user sets S2 and S3 to 1 at the same time, the instruction becomes one-dimensional data sorting, the function of S4 is changed to number of data, the value range of 1–32. This function will sort S4 data starting from operand S1. The sorted data is placed in the variable domains starting with operand D1. This function uses only 1 scan time, SM451 (complete flag bit) = ON when the sorting is complete.
3. The sorting is set by SM450 (sorting flag bit) = ON or OFF. ON is descending, and vice versa.
   Note: By default, SM450 is in OFF state and sorted in ascending order.
4. When the instruction energy flow is at the rising edge, the data sorting starts, after S3 scan cycles are passed, the sorting is complete. The instruction completes and sets SM451 (complete flag bit) to ON. If the sorting is restarted, SM451 needs to be reset manually by the user.

Note:

- The SORT instruction supports up to 128 instructions.
- The operand cannot be modified during the execution of the instruction, otherwise the result may be incorrect.
- Source operand S1 data table range cannot partially overlap D1 data table range, and only complete overlap or no overlap is allowed. Otherwise, the system will report "Source operand overlaps destination operand" error.
- The SM451 (complete flag bit) is ON when the sorting is complete, and if multiple instructions are sorted, the value of SM451 will be overwritten by the subsequent sorting instructions.

- To reorder, turn the energy flow from OFF to ON and reset the SM451 (complete flag).

E.3 Application instance

- Multidimensional array sorting

When M1=ON, the SORT instruction starts to be performed. Sort the 5*5 data table elements starting from D0 in ascending order according to column 3 (SM450 is OFF by default), and the sorting result is placed in the 5*5 table data starting from D50. SM451 is ON after sorting is complete, resulting that M3 is ON. Its data change is shown in the following figure.

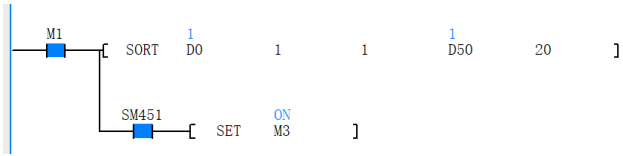
Before sorting:

	Element Name	data type	display format	current value
1	D0	INT	Decimal	1
2	D1	INT	Decimal	2
3	D2	INT	Decimal	3
4	D3	INT	Decimal	4
5	D4	INT	Decimal	5
6	D5	INT	Decimal	90
7	D6	INT	Decimal	55
8	D7	INT	Decimal	80
9	D8	INT	Decimal	70
10	D9	INT	Decimal	95
11	D10	INT	Decimal	75
12	D11	INT	Decimal	65
13	D12	INT	Decimal	98
14	D13	INT	Decimal	60
15	D14	INT	Decimal	79
16	D15	INT	Decimal	66
17	D16	INT	Decimal	54
18	D17	INT	Decimal	89
19	D18	INT	Decimal	99
20	D19	INT	Decimal	75
21	D20	INT	Decimal	79
22	D21	INT	Decimal	63
23	D22	INT	Decimal	90
24	D23	INT	Decimal	50
25	D24	INT	Decimal	69

After sorting by column 3 in ascending order:

	Element Name	data type	display format	current value
1	D50	INT	Decimal	4
2	D51	INT	Decimal	2
3	D52	INT	Decimal	1
4	D53	INT	Decimal	5
5	D54	INT	Decimal	3
6	D55	INT	Decimal	70
7	D56	INT	Decimal	55
8	D57	INT	Decimal	90
9	D58	INT	Decimal	95
10	D59	INT	Decimal	80
11	D60	INT	Decimal	60
12	D61	INT	Decimal	65
13	D62	INT	Decimal	75
14	D63	INT	Decimal	79
15	D64	INT	Decimal	98
16	D65	INT	Decimal	99
17	D66	INT	Decimal	54
18	D67	INT	Decimal	66
19	D68	INT	Decimal	75
20	D69	INT	Decimal	89
21	D70	INT	Decimal	50
22	D71	INT	Decimal	63
23	D72	INT	Decimal	79
24	D73	INT	Decimal	69
25	D74	INT	Decimal	90

- One-dimensional array sorting



When M1=ON, the SORT instruction starts to be performed. Sort 20 elements starting from D0 in ascending order (SM450 is OFF by default), and the sorting result is placed in 20 elements starting from D50. SM451 is ON after sorting is complete, resulting that M3 is ON. Its data change is shown in the following figure.

Before sorting:

	Element Name	data type	display format	current value
1	D0	INT	Decimal	1
2	D1	INT	Decimal	2
3	D2	INT	Decimal	3
4	D3	INT	Decimal	4
5	D4	INT	Decimal	5
6	D5	INT	Decimal	90
7	D6	INT	Decimal	55
8	D7	INT	Decimal	80
9	D8	INT	Decimal	70
10	D9	INT	Decimal	95
11	D10	INT	Decimal	75
12	D11	INT	Decimal	65
13	D12	INT	Decimal	98
14	D13	INT	Decimal	60
15	D14	INT	Decimal	79
16	D15	INT	Decimal	66
17	D16	INT	Decimal	54
18	D17	INT	Decimal	89
19	D18	INT	Decimal	99
20	D19	INT	Decimal	75
21	D20	INT	Decimal	79
22	D21	INT	Decimal	63
23	D22	INT	Decimal	90
24	D23	INT	Decimal	50
25	D24	INT	Decimal	69

After sorting:

	Element Name	data type	display format	current value
1	D50	INT	Decimal	1
2	D51	INT	Decimal	2
3	D52	INT	Decimal	3
4	D53	INT	Decimal	4
5	D54	INT	Decimal	5
6	D55	INT	Decimal	54
7	D56	INT	Decimal	55
8	D57	INT	Decimal	60
9	D58	INT	Decimal	65
10	D59	INT	Decimal	66
11	D60	INT	Decimal	70
12	D61	INT	Decimal	75
13	D62	INT	Decimal	75
14	D63	INT	Decimal	79
15	D64	INT	Decimal	80
16	D65	INT	Decimal	89
17	D66	INT	Decimal	90
18	D67	INT	Decimal	95
19	D68	INT	Decimal	98
20	D69	INT	Decimal	99

Appendix F Double word data sorting

The double word data sorting (DSORT) instruction is used to sort the overall matrix data of a double word data table by the sorting results of the particular column.

F.1 Operand description

LAD	Applicable model	VS070QS-1618MDM1
	Influenced flag bit	-
IL: DSORT (S1) (S2) (S3) (D1) (S4)	Step length	13

Operand	Type	Applicable soft element												Indexing
S1	DINT							D						
S2	DINT	Constant						D						
S3	DINT	Constant						D						
D1	DINT							D						
S4	DINT	Constant						D						

S1: The address of the starting element of the original data sheet.

S2: The number of groups of sorted data. Range: 1–32.

S3: The number of data in each group. Range: 1–32.

D1: The address of the starting element where the sorted result data sheet is stored.

S4: The partitioning column that the data table is sorted. Range: 1–S3.

F.2 Function description

1. This instruction sorts S2 × S3 double word data tables starting with S1 unit by the parameters in column S4, and is placed in the variable domains starting with D1. The following is the 3×3 data sorting process:

Before sorting:

S3 \ S2	1	2	3
1	S1	S1+3	S1+6
	1	2	8
2	S1+1	S1+4	S1+7
	2	6	7
3	S1+2	S1+5	S1+8
	3	4	3

After sorting in ascending order by the second column:

S3 \ S2	1	2	3
1	D1	D1+3	D1+6
	1	2	8
2	D1+1	D1+4	D1+7
	3	4	3
3	D1+2	D1+5	D1+8
	2	6	7

2. One-dimensional data sorting function, S2 and S3 are 1 at the same time
   When the user sets S2 and S3 to 1 at the same time, the instruction becomes one-dimensional data sorting, the function of S4 is changed to number of data, the value range of 1–32. This function will sort S4 data starting from operand S1. The sorted data is placed in the variable domains starting with operand D1. This function uses only 1 scan time, SM451 (complete flag bit) = ON when the sorting is complete.
3. The sorting is set by SM450 (sorting flag bit) = ON or OFF. ON is descending, and vice versa.

   Note: By default, SM450 is in OFF state and sorted in ascending order.

4. When the instruction energy flow is at the rising edge, the data sorting starts, after S3 scan cycles are passed, the sorting is complete. The instruction completes and sets SM451 (complete flag bit) to ON. If the sorting is restarted, SM451 needs to be reset manually by the user.

Note:

- The DSORT instruction supports up to 128 instructions.
- The operand cannot be modified during the execution of the instruction, otherwise the result may be incorrect.
- Source operand S1 data table range cannot partially overlap D1 data table range, and only complete overlap or no overlap is allowed. Otherwise, the system will report "Source operand overlaps destination operand" error.
- The SM451 (complete flag bit) is ON when the sorting is complete, and if multiple instructions are sorted, the value of SM451 will be overwritten by the subsequent sorting instructions.
- To reorder, turn the energy flow from OFF to ON and reset the SM451 (complete flag).

F.3 Application example

- Multidimensional array sorting

When M2=ON, the DSORT instruction starts to be performed. Sort the 5*5 double word data table elements starting from D100 in ascending order according to column 3 (SM450 is OFF by default), and the sorting result is placed in the 5*5 double word table data starting from D200. SM451 is ON after sorting is complete, resulting that M3 is ON. Its data change is shown in the following figure.

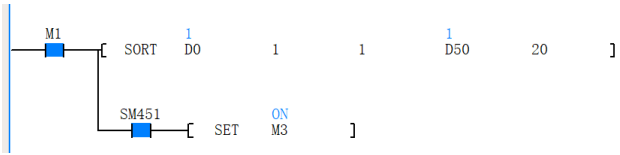
Before sorting:

	Element Name	data type	display format	current value
1	D100	DINT	Decimal	1
2	D102	DINT	Decimal	2
3	D104	DINT	Decimal	3
4	D106	DINT	Decimal	4
5	D108	DINT	Decimal	5
6	D110	DINT	Decimal	90
7	D112	DINT	Decimal	55
8	D114	DINT	Decimal	80
9	D116	DINT	Decimal	70
10	D118	DINT	Decimal	95
11	D120	DINT	Decimal	75
12	D122	DINT	Decimal	65
13	D124	DINT	Decimal	98
14	D126	DINT	Decimal	60
15	D128	DINT	Decimal	79
16	D130	DINT	Decimal	66
17	D132	DINT	Decimal	54
18	D134	DINT	Decimal	89
19	D136	DINT	Decimal	99
20	D138	DINT	Decimal	75
21	D140	DINT	Decimal	79
22	D142	DINT	Decimal	63
23	D144	DINT	Decimal	90
24	D146	DINT	Decimal	50
25	D148	DINT	Decimal	69

After sorting by column 3 in ascending order:

	Element Name	data type	display forma	current value
1	D200	DINT	Decimal	4
2	D202	DINT	Decimal	2
3	D204	DINT	Decimal	1
4	D206	DINT	Decimal	5
5	D208	DINT	Decimal	3
6	D210	DINT	Decimal	70
7	D212	DINT	Decimal	55
8	D214	DINT	Decimal	90
9	D216	DINT	Decimal	95
10	D218	DINT	Decimal	80
11	D220	DINT	Decimal	60
12	D222	DINT	Decimal	65
13	D224	DINT	Decimal	75
14	D226	DINT	Decimal	79
15	D228	DINT	Decimal	98
16	D230	DINT	Decimal	99
17	D232	DINT	Decimal	54
18	D234	DINT	Decimal	66
19	D236	DINT	Decimal	75
20	D238	DINT	Decimal	89
21	D240	DINT	Decimal	50
22	D242	DINT	Decimal	63
23	D244	DINT	Decimal	79
24	D246	DINT	Decimal	69
25	D248	DINT	Decimal	90

- One-dimensional array sorting



When M2=ON, the DSORT instruction starts to be performed. Sort 20 double word elements starting from D100 in ascending order (SM450 is OFF by default), and the sorting result is placed in 20 double word elements starting from D200. SM451 is ON after sorting is complete, resulting that M3 is ON. Its data change is shown in the following figure.

Before sorting:

	Element Name	data type	display format	current value
1	D100	DINT	Decimal	1
2	D102	DINT	Decimal	2
3	D104	DINT	Decimal	3
4	D106	DINT	Decimal	4
5	D108	DINT	Decimal	5
6	D110	DINT	Decimal	90
7	D112	DINT	Decimal	55
8	D114	DINT	Decimal	80
9	D116	DINT	Decimal	70
10	D118	DINT	Decimal	95
11	D120	DINT	Decimal	75
12	D122	DINT	Decimal	65
13	D124	DINT	Decimal	98
14	D126	DINT	Decimal	60
15	D128	DINT	Decimal	79
16	D130	DINT	Decimal	66
17	D132	DINT	Decimal	54
18	D134	DINT	Decimal	89
19	D136	DINT	Decimal	99
20	D138	DINT	Decimal	75
21	D140	DINT	Decimal	79
22	D142	DINT	Decimal	63
23	D144	DINT	Decimal	90
24	D146	DINT	Decimal	50
25	D148	DINT	Decimal	69

After sorting:

	Element Name	data type	display forma	current value
1	D200	DINT	Decimal	1
2	D202	DINT	Decimal	2
3	D204	DINT	Decimal	3
4	D206	DINT	Decimal	4
5	D208	DINT	Decimal	5
6	D210	DINT	Decimal	54
7	D212	DINT	Decimal	55
8	D214	DINT	Decimal	60
9	D216	DINT	Decimal	65
10	D218	DINT	Decimal	66
11	D220	DINT	Decimal	70
12	D222	DINT	Decimal	75
13	D224	DINT	Decimal	75
14	D226	DINT	Decimal	79
15	D228	DINT	Decimal	80
16	D230	DINT	Decimal	89
17	D232	DINT	Decimal	90
18	D234	DINT	Decimal	95
19	D236	DINT	Decimal	98
20	D238	DINT	Decimal	99

Your Trusted Industry Automation Solution Provider

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66001-01265

202403 (V1.0)