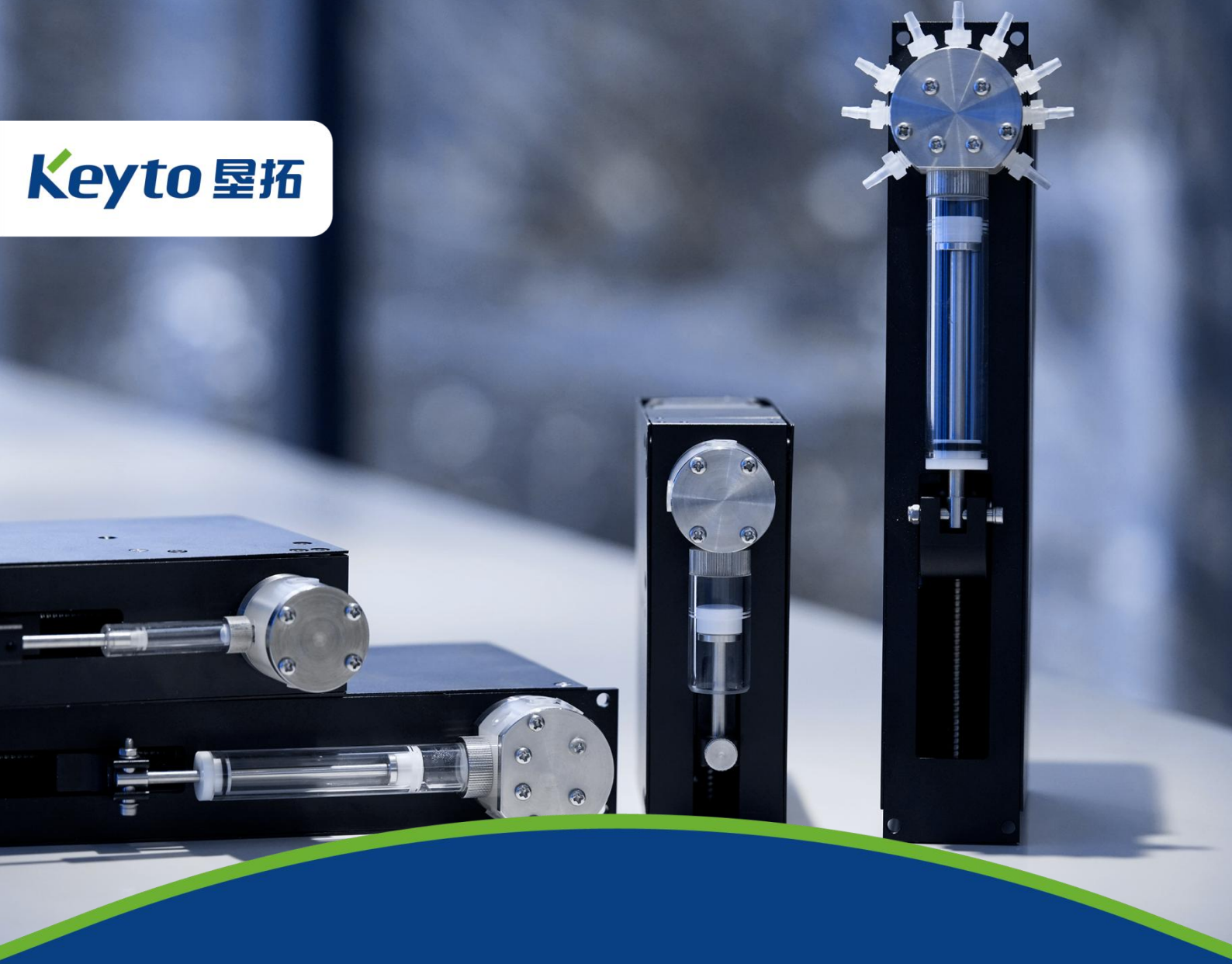


Keyto 昊拓

HSP Syringe Pump Operating Manual

Shenzhen Keyto Fluid Technology Co., Ltd.

Contents

1. Overview

This product is designed to achieve precise volumetric liquid aspiration and dispensing, as well as switching between different fluid path. The pump integrates a glass syringe and a rotary valve, and comes with a built-in control module. It offers extremely high accuracy and precision in liquid handling, and users can choose and switch between fluid path according to their specific application needs.

1.1 Features Overview

- This product is a compact syringe pump with the following features and functions:
- It has two modes, standard mode and microstep mode, with a resolution of 6000 in standard mode and 48000 in microstep mode;
- Glass syringes options: 100 μL, 250 μL, 500 μL, 1.0 mL, 2.5 mL, 5.0 mL, 10mL;
- High precision of aspiration and dispense, full-stroke accuracy <1%, full-stroke CV ≤ 0.1% and 1mL and above syringe, deionized water);
- Compatible with a variety of valve heads, see 1.2.2 for details;
- Wetted materials are corrosion-resistant and mainly made of borosilicate, zirconia, and sapphire;
- Compatible with RS-232, RS-485 and CAN interfaces;
- Adjustable running speed, with a maximum speed of 1.2s/60mm and a minimum speed of 160min/60mm;
- Transmission mechanism utilizing a ball screw with a linear encoder, featuring step-loss detection;
- Easy maintenance: The valve head and syringe offer high and stable accuracy in quantitative liquid handling during the service life. Replacement maintenance outside the life cycle is also very easy.

1.2 Terms Definition

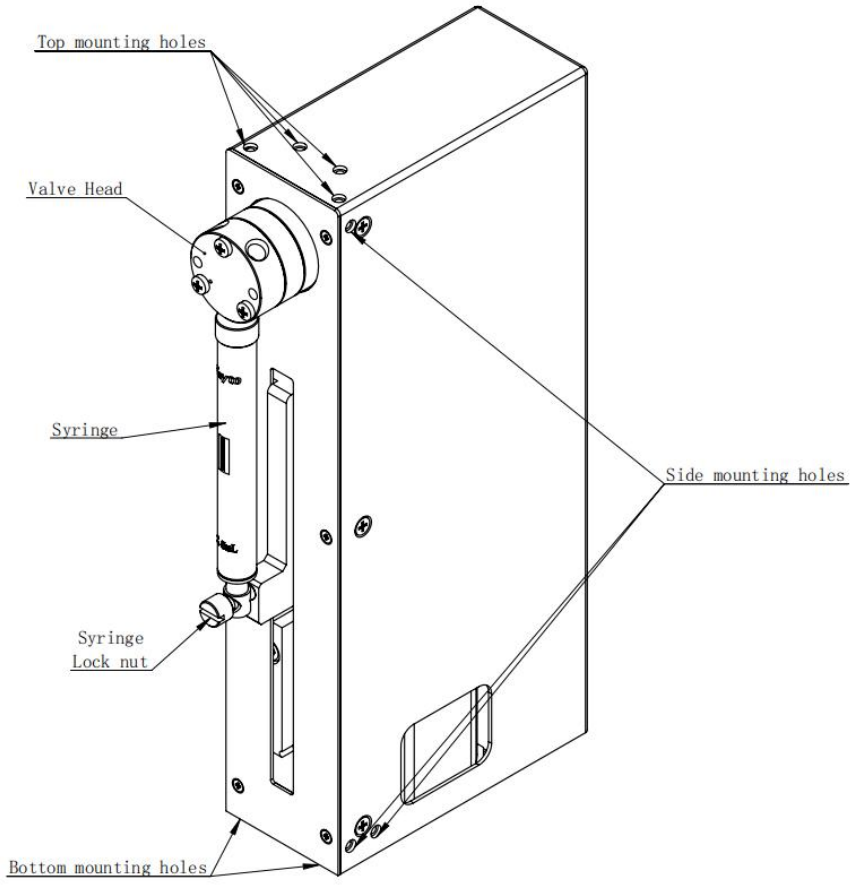
- Increment: measurement unit of displacement. When the syringe subdivision is set to NO, the full stroke is 3,000 increments. 1 increment corresponds to 0.01mm.
- Host Computer: client end
- Device: syringe Pump
- Backlash: used to compensate for the accumulative effects caused by the gaps between mechanical parts in syringe drive, to improve syringe accuracy.
- Dead Volume: the distance the motor moves down when the motor stops after the initialization

command.

- Bypass Port: connects input and output, bypass syringe. Aspiration and dispense are prohibited under the circumstance.
- Additional Port: port other than input, output and bypass port in four-port valve.
- 0x: hexadecimal sign

1.3 Descriptions of Functions

This product utilizes a glass syringe and a rotary shear valve for liquid allocation. Both the glass syringe and the valve head are replaceable. The following provides a description and explanation of each main component's functions.



HSP series syringe pump

Syringe and Syringe Drive

The stepper motor, with a linear encoder for step loss detection feedback, first drives the ball screw, and then the ball screw drives the syringe plunger to reciprocate. The effective stroke of the syringe is 60mm. When set to N0 subdivision, the full stroke is 6000 steps; when set to N1 and N2 subdivision, the full stroke is 48000. The base of the syringe plunger is fixed to the nut by a knurled screw. The top of the syringe is connected to the valve head with a 1/4-28 UNF

thread.

Applicable syringe sizes: 100μL, 250μL, 500μL, 1.0mL, 2.5mL, 5.0mL, and 10.0mL.

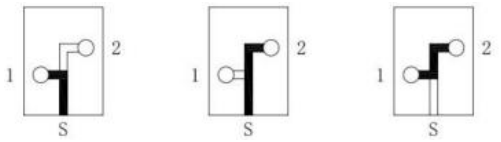
Valve Head and Valve Head Drive

The rotary shear valve head is made of a stator and a rotor. The rotor moves in relative rotation to the stator and is driven by a stepper motor that connects the syringe port to each output port. It is also equipped with an encoder for positioning feedback.

The solenoid head is made of diaphragm solenoid valve. It is opened and closed by a controller to connect the syringe port to each output port.

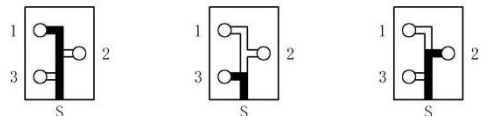
The specifications of the applicable valve head are as follows:

Two Way Non-Distribution Type Solenoid Valve Head

Z Command Reset Example			Y Command Reset Example		
					
Command I Set input port to Port 1	Command O Set output port to Port 2	Command B Port 1 connects to Port 2	Command I Set input port to Port 1	Command O Set output port to Port 2	Command B Port 1 connects to Port 2

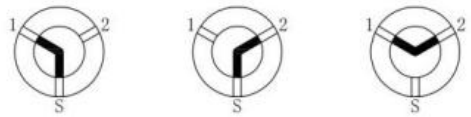
Two-Way Non-Distribution Type Solenoid Valve Head Port Description

Three-Way Distribution Type Solenoid Valve Head

Z Command Reset Example			Y Command Reset Example		
					
Command I Set input port to port 1	Command O Set output port to port 3	Command B Port 2 connects to the syringe	Command I Set input port to port 1	Command O Set output port to port 3	Command B Port 2 connects to syringe

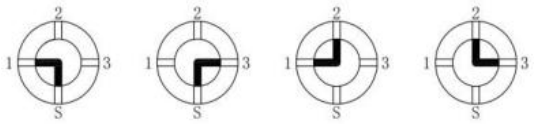
Three-Way Distribution Type Solenoid Valve Head Port Description

Three-Way Non-Distribution Type Rotary Valve Head

Z Command Reset Example			Y Command Reset Example		
					
Command I Set input port to Port 1	Command O Set output port to Port 2	Command B Port 1 connects to port 2	Command I Set input port to Port 1	Command O Set output port to Port 2	Command B Port 1 connects to port 2

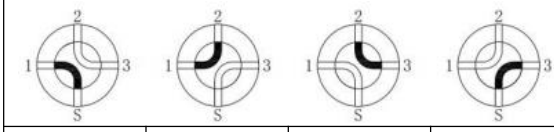
Three-Way Non-Distribution Type Rotary Valve Head Port Description

Four-way non-distribution type rotary valve head

Z Command Reset Example				Y Command Reset Example			
							
Command I Set input port to Port 1	Command O Set output port to Port 3	Command B Port 1 Connects to port 2	Command E Port 2 connects to port 3	Command I Set input port to Port 1	Command O Set output port to Port 3	Command B Port 1 connects to port 2	Command E Port 2 connects to port 3

Four-Way Non-Distribution Type Rotary Valve Head Port Description

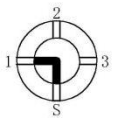
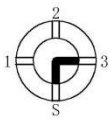
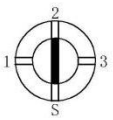
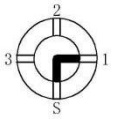
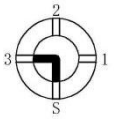
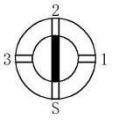
Four-Way Double Circuit Distribution Type Rotary Valve Head

Z Command Reset Example				Y Command Reset Example			
							
Command I Port 1 connects	Command E Port 1 connects	Command O Port 1 connects	Command B Port 1 connects	Command I Port 1 connects	Command E Port 1 connects	Command O Port 1 connects	Command B Port 1 connects

to the syringe, Port 2 connects to port 3	to Port 2, Port 3 connects to the syringe	to the syringe, Port 2 connects to Port 3	to Port 2, Port 3 connects to the syringe	to the syringe, Port 2 connects to Port 3	to Port 2, Port 3 connects to the syringe	to the syringe, Port 2 connects to Port 3	to Port 2, Port 3 connects to the syringe

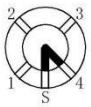
Four-Way Double Non-Distribution Type Rotary Valve Head Port Description

Three-Way Distribution Type Rotary Shear Valve Head

Z Command Reset Example			Y Command Reset Example		
					
Command I Set input port to Port 1	Command O Set output port to Port 3	Command B Port 2 connects to the syringe	Command I Set input port to Port 1	Command O Set output port to Port 3	Command B Port 2 connects to the syringe

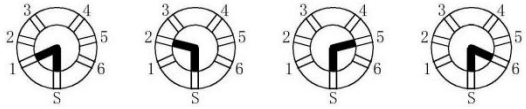
Three-Way Distribution Type Rotary Valve Head Port Description

Four-Way Distribution Type Rotary Shear Valve Head

Z Command Reset Example				Y Command Reset Example			
							
I<1> Command Port 1 connects to the syringe	I<2> Command Port 2 connects to the syringe	0<3> Command Port 3 connects to the syringe	0<4> Command Port 4 connects to the syringe	I<1> Command Port 1 connects to the syringe	I<2> Command Port 2 connects to the syringe	0<3> Command Port 3 connects to the syringe	0<4> Command Port 4 connects to the syringe

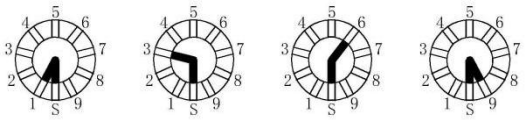
Four-Way Distribution Type Rotary Valve Head Port Description

Six-Way Distribution Type Rotary Shear Valve Head

Z Command Reset Example				Y Command Reset Example			
							
I<1> Command Port 1 connects to the syringe	I<2> Command Port 2 connects to the syringe	0<5> Command Port 5 connects to the syringe	0<6> Command Port 6 connects to the syringe	I<1> Command Port 1 connects to the syringe	I<3> Command Port 3 connects to the syringe	0<4> Command Port 4 connects to the syringe	0<6> Command Port 6 connects to the syringe

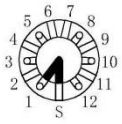
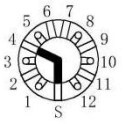
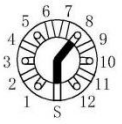
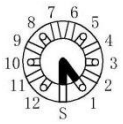
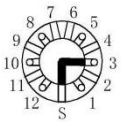
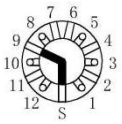
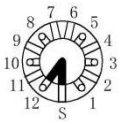
Six-Way Distribution Type Rotary Valve Head Port Description

Nine-Way Distribution Type Rotary Shear Valve Head

Z Command Reset Example				Y Command Reset Example			
							
I<1> Command Port 1 connects to the syringe	I<3> Command Port 3 connects to the syringe	0<6> Command Port 6 connects to the syringe	0<9> Command Port 9 connects to the syringe	I<1> Command Port 1 connects to the syringe	I<4> Command Port 4 connects to the syringe	0<7> Command Port 7 connects to the syringe	0<9> Command Port 9 connects to the syringe

Nine-Way Distribution Type Rotary Valve Head Port Description

Twelve-Way Distribution Type Rotary Shear Valve Head

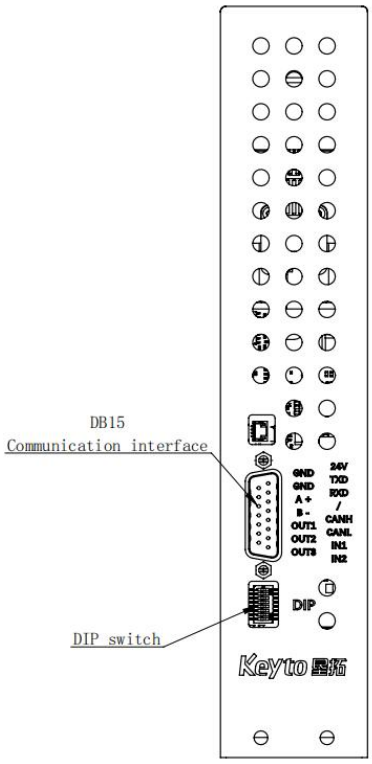
Z Command Reset Example				Y Command Reset Example			
							
I<1> Command Port 1 connects to the syringe	I<4> Command Port 4 connects to the syringe	0<8> Command Port 8 connects to the syringe	0<12> Command Port 12 connects to the syringe	I<1> Command Port 1 connects to the syringe	I<3> Command Port 3 connects to the syringe	0<9> Command Port 9 connects to the syringe	0<12> Command Port 12 connects to the syringe

Twelve-Way Distribution Type Rotary Valve Head Port Description

Controller

This product contains a controller with microprocessor and circuitry to control the glass tube syringe and valve head operation. It also contains a DB15 communication connector for power supply and communication and a DIP code address switch for address management.

For more information about the controller’s DB15 communication interface and DIP switch, please refer to Chapter 2 Hardware Settings.



Communication Interface And Dip Switch Of The Syringe Pump Controller

Communication Interface

This product can be operated individually or in multiple connections via RS-232, RS-485 or CAN interfaces.

RS-232 and RS-485 support 9600(default) and 38400 baud rates, while CAN supports 100Kb(default), 125Kb, 250Kb, 500Kb and 1Mb baud rates.

For detailed information about the communication interfaces, please refer to Chapter 2, Hardware Settings.

1.4 Tips for Setting Up the Syringe Pump

For complete information on setting up the syringe pump, see Chapter 2 Hardware Settings and Chapter 3 Software Communication.

NOTE: Before using the syringe pump for any operation, please read this operating manual carefully.

NOTE: After the device is powered on, the LED indicator light will flash blue once and turn off. If it does not occur, please refer to Chapter 4 Q&A for troubleshooting.

To ensure proper operation, please follow these tips:

- Always install the syringe pump in the upright position. Failure to do so may result in poor syringe pump startup.
- Always have fluid passing through the syringe and valve when the syringe and valve head are running. Failure to do so may damage the entire seal.
- Always power down the instrument when connecting or disconnecting pumps.

Note: Keep your fingers away from the syringe slot when the pump is running to prevent from injury.

2. Hardware Settings

This chapter includes these sections describing the various parts of hardware settings:

- Power and Electrical Considerations
- Hardware Interfaces
- Control Settings
- Component Installation
- Complete Device Installation

2.1 Power and Electrical Considerations

The HSP series syringe pump requires a 24V DC power supply rated at least 2.0A, provided through a DB15 connector. It is recommended to use one power cable for every two pumps for EMC safety.

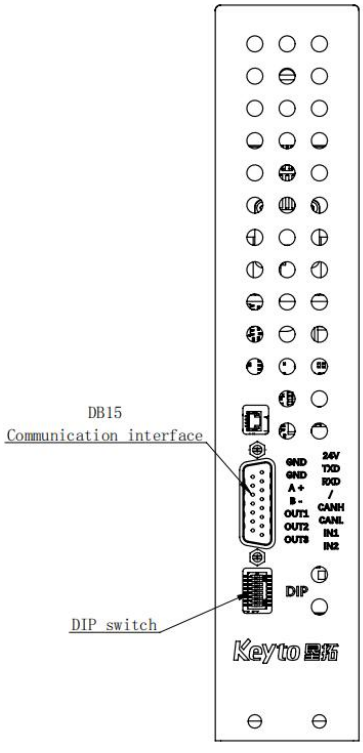
2.2 Hardware Interface

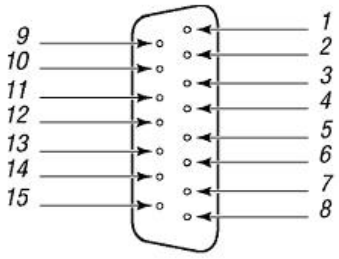
Each syringe pump has a hardware interface through which it can provide power and communicate with the pump. Each syringe pump can be set up with a unique address to identify each syringe pump.

Note: Before connecting or disconnecting the DB15 connector, make sure to turn off the power to the pump.

Connector pin assignments

Pin	Function	Remark	Pin	Function	Remark
1	24V DC	Power input ±1%, ≥ 2A	9	GND	POWER GROUND
2	RS-232 TXD	Communication Interface	10	GND	POWER GROUND
3	RS-232 RXD	Communication Interface	11	RS-485 A	Communication Interface
4	/	/	12	RS-485 B	Communication Interface
5	CAN H	Communication Interface	13	AUXOUT1	Auxiliary output 1
6	CAN L	Communication Interface	14	AUXOUT2	Auxiliary output 2
7	AUXIN1	Auxiliary input 1	15	AUXOUT3	Auxiliary output 3
8	AUXIN2	Auxiliary input 2	/	/	/



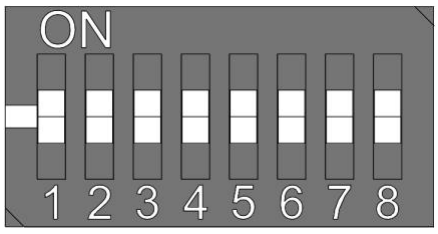


DB15 Connector pin assignments and the positions of the DB15 connector in syringe pumps

2.3 Control Settings

DIP Switch

The DIP switch has 8 bits, (as in figure 14) located at the lower left of the syringe pump rear panel, 4 bits are used to modify the address of each syringe pump for debugging or linkage, and the user can send specific commands to the specified syringe pump to control the pump. The remaining four bits are used to connect the 120-ohm termination resistor for RS-485 or CAN communication. Please refer table 2 and table 3 for DIP switch. To set the address, a pair of tweezers or a small screwdriver can be used to switch to the target address.



DIP Switch

DIP Switch Address Correspondence Table

Number	Functions	Descriptions

1	120 ohm CAN termination resistor	ON: Connect OFF: Disconnect
2	120 ohm RS485 termination resistor	ON: Connect OFF: Disconnect
3	Reserve	The DIP switch address is expressed in a 4-bit binary; bit0 is the lowest bit. To get serial port address, convert the binary number to a hexadecimal value, +1 is the ID (address value), and the ID range is 1-15. The automatic aging function is enabled after the address is set to 16. To get CAN address, convert the binary number to a hexadecimal value, and the value is the ID(address value), address value ranging from 0-14. The automatic aging function is enabled after the address is set to 15. When each bit of the DIP switch is turned to the upper position, ON is 1, and when it is moved to the lower position, OFF is 0. For example, if the serial port address value is configured as 6(CAN address as 5), the corresponding binary value is 5 (0101), and address bit3-bit0 bit dialing code is: OFF, ON, OFF, ON.
4	Reserve	
5	Address bit3	
6	Address bit2	
7	Address bit1	
8	Address bit0	

Switch Address Correspondence Table

Address bit3	Address bit2	Address bit1	Address bit0	Dial-up Address	Single Device Address		Dual Devices Address		Quad Devices Address		All Devices	
					HEX	ASCII	HEX	ASCII	HEX	ASCII	HEX	ASCII
OFF	OFF	OFF	OFF	0	0x31	1	0x41	A	0x51	Q	0x5F	_
OFF	OFF	OFF	ON	1	0x32	2						
OFF	OFF	ON	OFF	2	0x33	3	0x43	C				
OFF	OFF	ON	ON	3	0x34	4						
OFF	ON	OFF	OFF	4	0x35	5	0x45	E	0x55	U		
OFF	ON	OFF	ON	5	0x36	6						
OFF	ON	ON	OFF	6	0x37	7	0x47	G				
OFF	ON	ON	ON	7	0x38	8						
ON	OFF	OFF	OFF	8	0x39	9	0x49	I	0x59	Y		

ON	OFF	OFF	ON	9	0x3A	:						
ON	OFF	ON	OFF	A	0x3B	;	0x4B	K				
ON	OFF	ON	ON	B	0x3C	<						
ON	ON	OFF	OFF	C	0x3D	=	0x4D	M	0x5D	]		
ON	ON	OFF	ON	D	0x3E	>						
ON	ON	ON	OFF	E	0x3F	?	0x4F	O				
ON	ON	ON	ON	F	Automatic Power-on Self-test							

Note: The Multi-pump control address only supports serial port and does not support CAN. When using multi-pump address to control devices, devices will not return responding information with given instructions. Each device needs to be queried separately.

Self-test

When the DIP switch last four bits are “ON”, the syringe pump activate self-test upon power-up. The self-test process includes initialization, valve port switching, and a series of plunger movements at different speeds. If any errors occur during the operation, the syringe pump will stop and provide an alarm message.

Note: Do not run more than a few cycles without fluid in the syringe.

2.4 Component Installation

Installing the Syringe Pump Valve Head

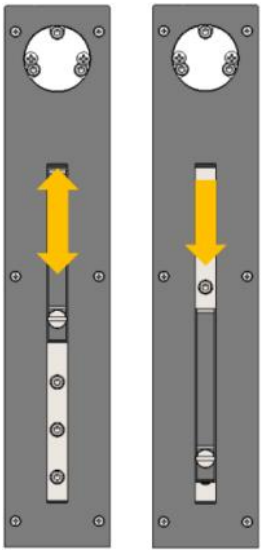
To install the syringe pump head, follow the steps below,

1. Run the syringe pump to aspirate air to empty the fluid in the syringe pump.
2. Initialize the pump using the [ZR] command to reset the motor shaft of the rotary shear valve to the home position.
3. Issue the [A6000R] command to run the syringe plunger to its maximum stroke.
4. Remove the syringe and connecting tubing.
5. Remove the valve head captive screws, then remove the valve head from the pump.
6. Install the new head on the front panel so that the rotary shear valve motor shaft is aligned with the internal holes in the head, the head mounting holes and pins are aligned with the front panel threaded hole screws and pin holes, and the captive screws are installed.
7. To install the syringe, refer to Installation of Syringe.

Installation of Syringe

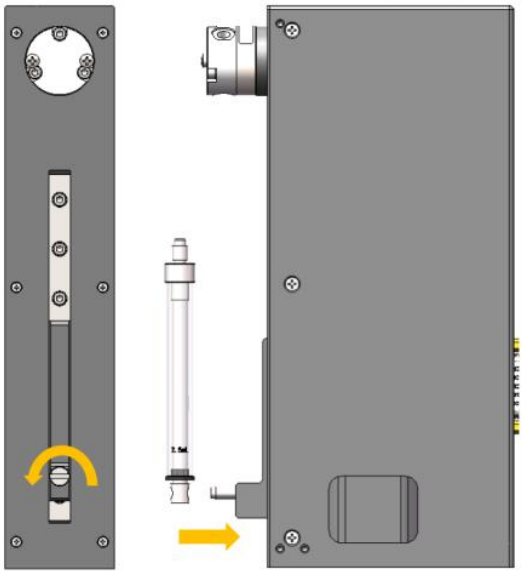
To install the syringe, follow the steps below(below figs for reference):

1. Initialize the syringe pump and lower the plunger height by sending the command [A6000R] as shown below.



Reset And Lower The Plunger Height Diagram

2. Remove the plunger lock nut and place the syringe parallel to the panel, ensuring that the plunger rod mounting holes fit perpendicularly into the push plate shaft as shown below.

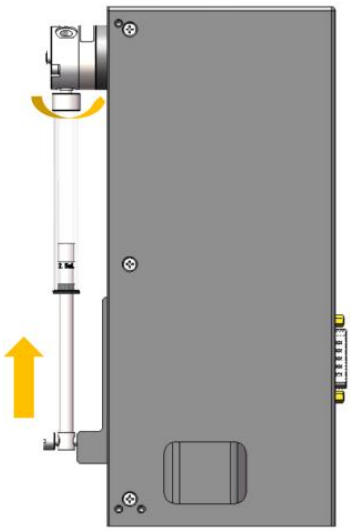


Remove lock nut and install syringe

3. When the plunger rod is placed into the push plate shaft, tighten it with the plunger lock nut as shown below.

Installation of Lock Nut

4. Pull the syringe apart and screw the syringe threaded port into the valve head, wait until the top of the syringe makes contact with the bottom hole of the valve head threads, then tighten the syringe 1/8 turn to 1/4 turn, making sure that the syringe is parallel to the main panel during this time, as shown below:



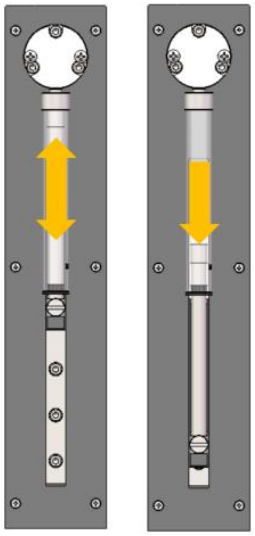
Tighten The Syringe

5. Reinitialize the pump.

Replacement of Syringe

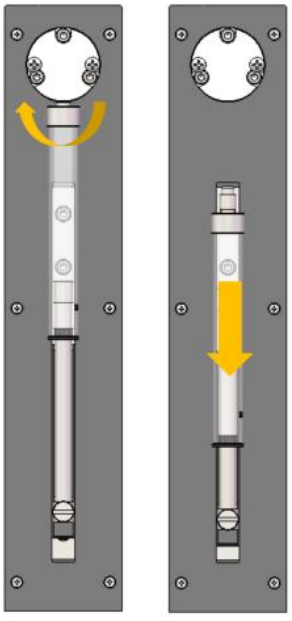
To replace the syringe, follow the steps below (refer to the figure below):

1. Initialize the syringe pump and lower the plunger height by sending the command [A6000R] as follows



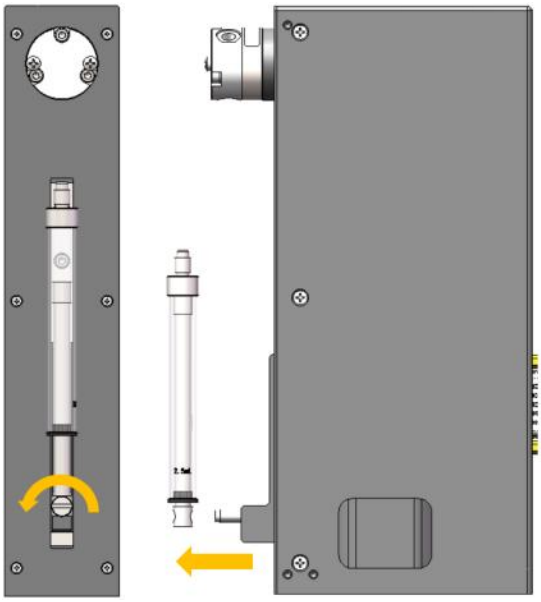
Reset And Lower Plunger Height

2. Screw the syringe threaded port out of the valve head and pull out the syringe, making sure the syringe is parallel to the main panel during the operation, as shown below.



Unscrew The Valve Head And Pull Out The Syringe

3. Remove the plunger lock nut, keeping the syringe parallel to the panel, and remove the syringe vertically from the push plate shaft as shown below.

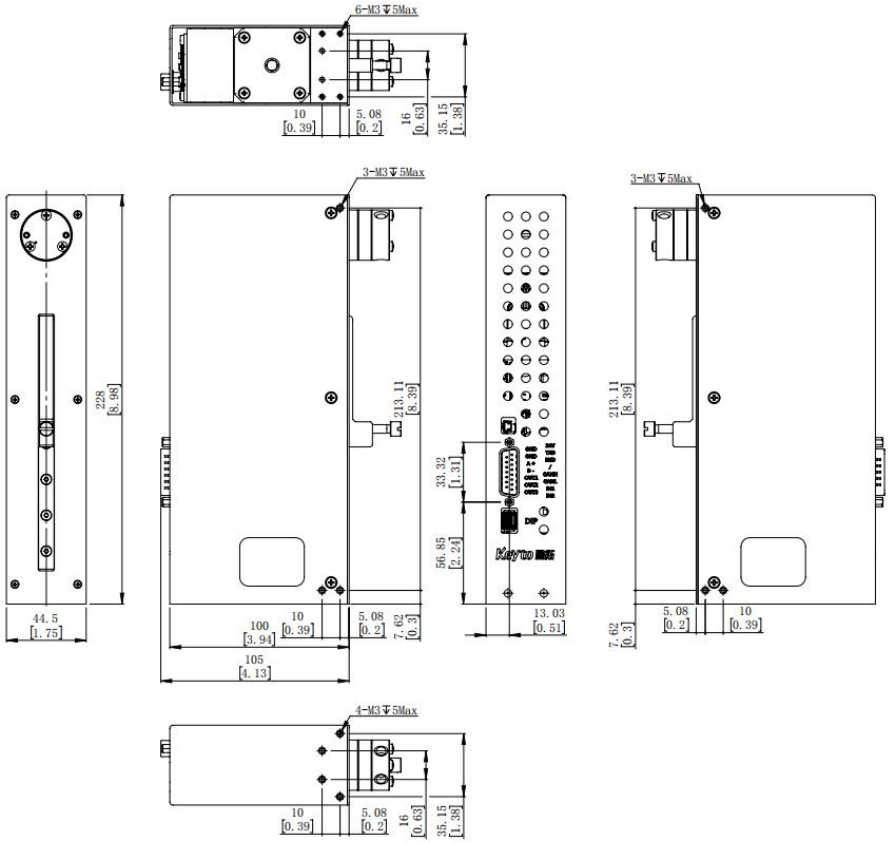


Remove The Lock Nut And The Syringe

4. Install the syringe, refer to Installation of Syringe

2.5 Complete Device Installation

The HSP series syringe pumps are available in a variety of mounting options for easy installation, see Installation of The HSP Series Rotary Shear Valve Syringe Pump



Installation of The HSP Series Rotary Shear Valve Syringe Pump

3. Software Communication

3.1 Communication Interface

There are several communication methods to support syringe pump:

- RS232
- RS485
- CAN(extended and standard frames)

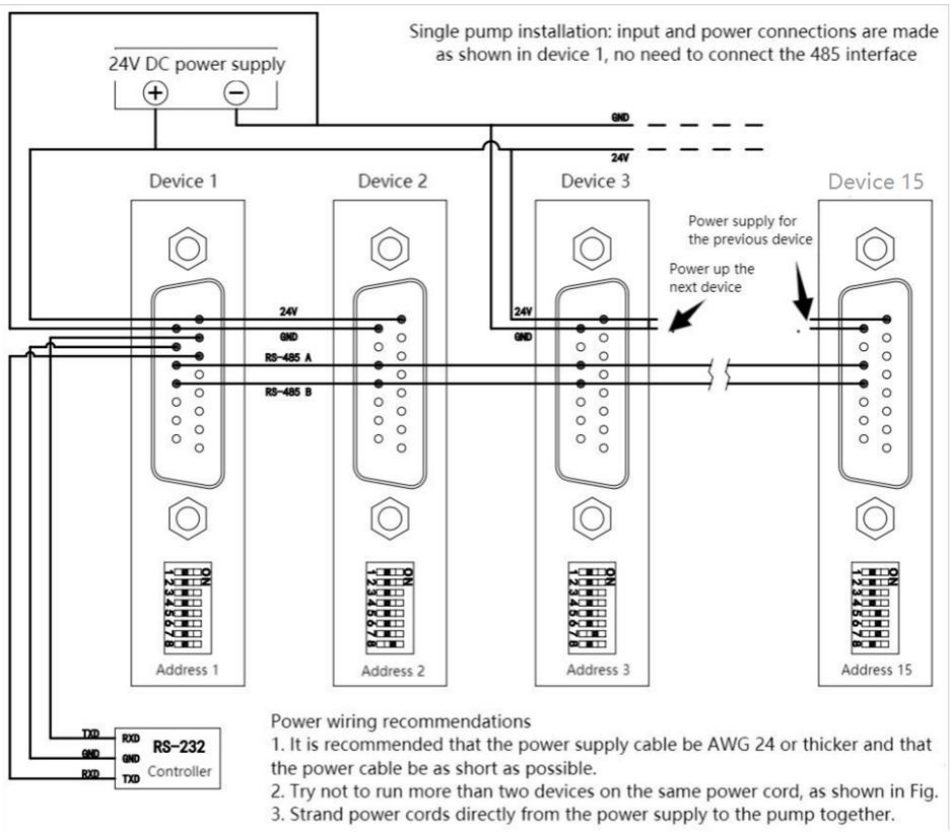
Baud rate:

Serial port: 9600 (default), 38400

CAN: 100K (default), 125K, 250K, 500K, 1000K

When selecting a communication interface, prioritize CAN communication (highest reliability and supports networking with multiple devices), followed by RS485 (supports networking with multiple devices), and finally RS232. It is recommended to use OEM protocol when using 232 or 485 serial port communication.

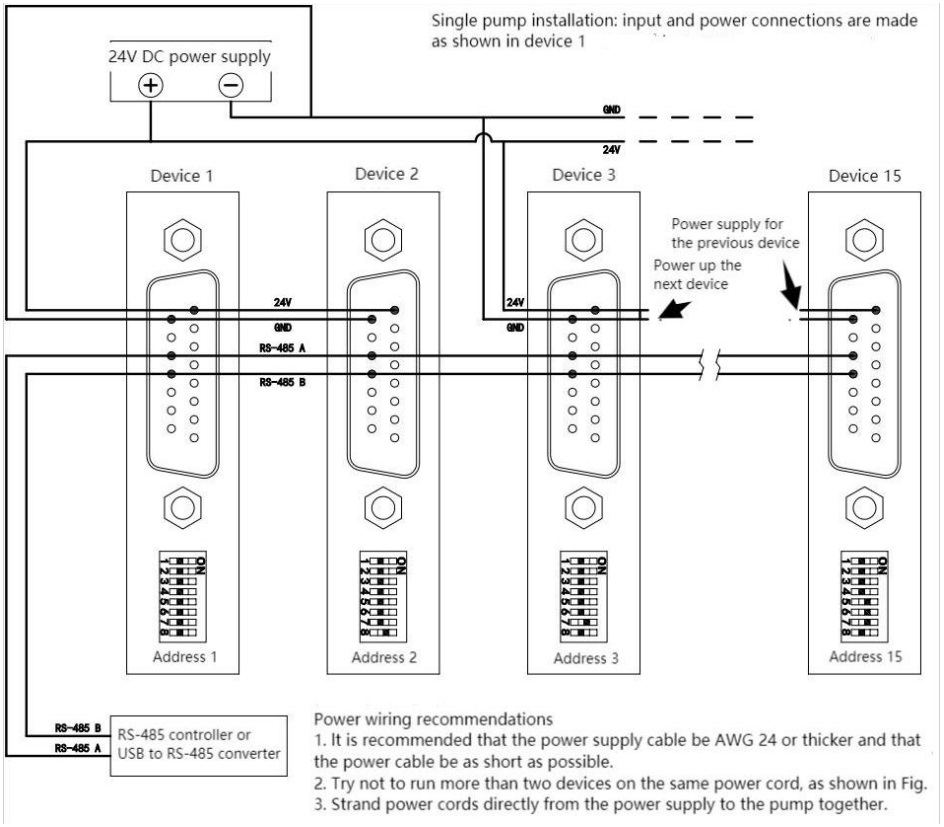
RS232 Communication and Cabling



Syringe Pump DB15 Male Pin Definition		DB9 Female Pin Definition	
Define	Pin Number	Define	Pin Number
TXD	2	TXD	2
RXD	3	RXD	3
GND	10	GND	5

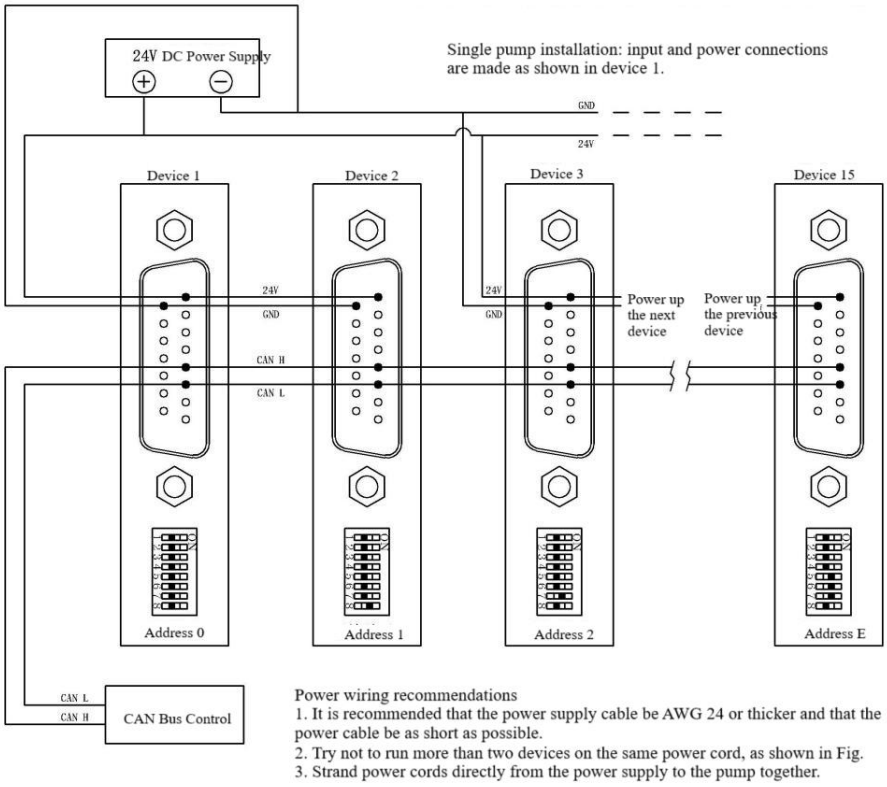
RS232 Communication and Cabling

RS485 Communication and Cabling



RS485 Communication and Cabling Diagram

CAN Bus Communication and Cabling



CAN Bus Communication And Power Supply Wiring Diagram

3.2 Communication Protocols

The syringe pump supports serial port and CAN communication, where the serial port includes RS232 and RS485 with the same communication protocol.

RS-232 interface automatically converts the protocols to RS-485 and sends out to 485 bus for any device to connect with the RS-485 communication bus of the syringe pump.

The command characters for the DT protocol, OEM protocol, and CAN standard frame protocol are the same. When the syringe pump receives a string, it parses the string, validates the address, and checks the syntax. It returns the status of the first executed command. If multiple commands exist, the status needs to be queried to confirm the success of subsequent commands.

The DT protocol, OEM protocol, and CAN standard frame protocol support a maximum of 15 devices on the same communication link.

DT Protocol

This protocol is based on RS232 and RS485 communication. It does not include a parity bit and allows easy control of the syringe pump using a serial debugging tool. Data transmission is in ASCII characters, making it convenient for user debugging. Due to the lack of parity, there is a risk of data transmission errors, resulting in execution and response errors. For detailed information, refer to the DT protocol.

OEM Protocol

This protocol is based on RS232 and RS485 communication. It includes a communication sequence number and a check byte to effectively prevent data transmission errors. During operation, the controller polls the syringe pump status and interprets the queried status to determine whether the syringe pump has executed the command or encountered an error. For detailed information, refer to the OEM protocol.

CAN Standard Frame Protocol

This communication protocol is used for CAN communication in a local area network. It utilizes standard frames for communication and sends string commands in frames. There is no need to poll the syringe pump status.

The status is automatically uploaded upon completion of the command. For detailed information, refer to the CAN standard frame protocol.

DT Protocol Format

DT Command Protocol Format

Serial number	Functions	Number of Bytes	ASCII	HEX	Descriptions
1	Start Character	1	/	0x2F	Indicates the start of a command frame
2	Device Address	1			ASCII character, see Table 3
2+n	Command String	n			ASCII command strings, see operation commands for details

DT Return Data Protocol Format

Serial number	Functions	Number of Bytes	ASCII	HEX	Descriptions
1	Start Character	1	/	0x2F	Indicates the start of a frame of return data
2	Host Address	1	0	0x30	Fixed host address
3	Status	1			The current status of the device, see Table 6
3+n	Data String	n			Return data ASCII string
4+n	End Character	1	Terminator [ETX]	0x03	Indicates the end of a frame of return data
5+n		1	Carriage Return[CR]	0x0D	

6+n		1	Line Feed[LF]	0x0A	

Example: To initialize the syringe pump at address 1, send the command /1ZR carriage return [CR]

Status Table

Status Byte								Error Code	Descriptions
bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0		
0	1	x	0	0	0	0	0	0	No errors
0	1	x	0	0	0	0	1	1	Initialization errors
0	1	x	0	0	0	1	0	2	Invalid command
0	1	x	0	0	0	1	1	3	Invalid operand
0	1	x	0	0	1	0	0	4	Invalid command sequence
0	1	x	0	0	1	1	0	6	Non-volatile memory error
0	1	x	0	0	1	1	1	7	Device not initialized
0	1	x	0	1	0	0	1	9	Plunger overload
0	1	x	0	1	0	1	0	10	Rotary shear valve overload
0	1	x	0	1	0	1	1	11	Plunger motion not allowed
0	1	x	0	1	1	0	0	12	Internal error
0	1	x	0	1	1	1	1	15	Command cache overflow

The status bytes bit7, bit6 and bit4 are fixed to 0, 1, 0. bit5 indicates the current status of the syringe pump. When bit5 is 1, the syringe pump is idle. When bit5 is 0 the syringe pump is busy, and bit3 to bit0 indicate the error status of the syringe pump.

Led Light Flashing Description

Number of flashes	Description	Number of flashes	Description
1	Drive failure	2	Valve zero optocoupler Error
3	Rotary shear valve position optocoupler error	4	Rotary shear valve Plugging
5	Plunger Zero Optocoupler Error	6	Plunger motor blocking

7	Storage error	8	CAN communication error
9	Pressure sensor error		

OEM Protocol Format

OEM Command Protocol Format

Serial Number	Function	Number of Bytes	ASCII	HEX	Description
1	Start Character	1	Start of Text[STX]	0x02	Indicates the start of a command frame
2	Device Address	1			ASCII characters, see Table 3
3	Serial Number	1			Scope “0x30-0x3F”, see details in Table 9
2+n	Command String	n			ASCII command strings, see Operation Commands for details.
3+n	End Character	1	[ETX]	0x03	Indicates the end of a command frame
4+n	Calibration	1			Heterodyne checksum for the first 3+n command bytes

OEM Return Data Protocol Format

Serial Number	Function	Number of Bytes	ASCII	HEX	Description
1	Start Character	1	Start of Text[STX]	0x02	Indicates the start identifier of a returned data frame
2	Host Address	1	0	0x30	Fixed host address
3	Status	1			The current status of the device, see Table 6
3+n	Data String	n			Return data ASCII string
4+n	End Character	1	End-of-Text [ETX]	0x03	Indicates the end of a frame of returned data
5+n	Calibration	1			Heterodyne checksum for the first 4+n data bytes

OEM Serial Number Byte Meanings

Serial Number	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
Meaning	0	0	1	1	REP	SQ2	SQ1	SQ0

Bits 4-7 are fixed, REP is 0 for non-repetitive command strings and 1 for repetitive command strings. When REP is 1, compare SQ0-SQ2 of the previous command string. If they are consistent, the internal execution will not be executed and the last error status will be returned. Otherwise, the current command string will be executed normally; This function can be used to resend the command string when communication is abnormal.

For example: To initialize the syringe pump at address 1, send the command 0x02 0x31 0x30 0x5A 0x52 0x03 0x08

CAN Standard Frame Protocol

The CAN standard frame protocol uses the standard frame type, where the ID (11 bits) of the standard frame message indicates communication direction, device address, and other information. The data block of the standard frame message represents command characters.

Standard Frame Message ID Construction

Direction	Group			Device Address				Frame Type		
bit10	bit9	bit8	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0

Direction: 0 indicates a message from the host computer to the slave computer (direction of command sent from the host computer to the syringe pump), 1 indicates a message from the slave computer to the host computer (data returned from the syringe pump to the host computer).

The group number is 0-7 (occupies 3 digits). Each type of equipment has a group number. The group number for the syringe pump is 2. The group number 1 is used to start the transfer process.

Device address: The address is 0-15 (occupies 4 bits). During the startup transmission process, the address of the syringe pump can be reassigned through the address of the DIP switch. This address is the address assigned to the syringe pump after the host confirms the startup message.

Frame Type: Types 0, 1, 2, 3, 4, and 6 (occupies 3 bits). Type 0 is the dynamic frame, type 1 is the action frame, type 2 is the general frame, type 3 is the start frame of a multi-frame message, type 4 is the middle frame of a multi-frame message, and type 6 is the report/response frame.

Type 0, dynamic frame: used for real time instructions that take effect during actions, namely V(real time modification of velocity) and T(terminate). Establishment of host connection is also the same frame type.

Type 1, Action frame: Used for operation commands such as initialization, movement, valve, and parameter settings. When sending a command string using a multi-frame message, this frame serves as the end message sent to the syringe pump.

Type 2, General frame: Uses a single ASCII character command, as specified in CAN Standard Frame Message ID Construction.

CAN General Frame Commands

Command	Description
0	Reset restart, syringe pump restarts and starts startup request
1	Execution command or command string, same as R command
2	Clearing the command cache
3	Repeat the last action command string, same as X command.
4	Terminate command execution, same as X command

Type 3, Multi-frame message start frame: when the length of the string for sending a command or syringe pump response is greater than 8 bytes, the multi-frame message format will be used, and the start frame will be sent with type 3; when the syringe pump receives this frame of data, it will first clear the command cache, and then store the command of this frame into the command cache;

Type 4, Multi-frame message intermediate frame: When sending a command string using a multi-frame message format, type 1 must be the last frame, type 3 as the start frame, and type 4 as the middle frame. When the multi-frame message format is used, type 6 must be used as the last frame, type 3 as the start frame, and type 4 as the middle frame.

Type 6, Report/Response frame: This frame can be used to allow the syringe pump to report information about itself, same as the ? command, just use this frame to send the parameters of the ? command. Report commands as following chart:

CAN Report/Response Command

Command	Description
0	Report absolute position of the syringe
1	Reports the encoder position of the syringe
3	Report valve port
4	Report the maximum speed of the syringe
6	Report the activation speed of the syringe
7	Report the stopping speed of the syringe

10	Report the status of the cache area, 0: empty cache area, 1: command in cache area
12	Report the syringe backlash set by K command
13	Report the status of auxiliary input 1, 0:low level, 1:high level
14	Report the status of auxiliary input 2, 0:low level, 1:high level
15	Report the number of syringe initialization
16	Report the number of piston moves
17	Report valve switching times
18	Report the number of valve switches since the last report
19	Report if the pump has been initialized
20	Report the unique code of the board
23	Report firmware version
24	Report syringe dead volume set by K command
25	Report syringe acceleration set by L command
28	Report the subdivision mode set by N command
29	Report current status of moves
30-34	Report command string in non-volatile memory
76	Report configuration of syringe pump

When sending response frames, the first two bytes of the response frame are status bytes, and the first byte is 0x20 plus Error codes in Table 6; the second byte is fixed to 0x60, and the rest are characters in the ASCII format of the response; all messages of frame type 1 and 2 are acknowledged with a blank message with a data length of zero;

At power-up, the syringe pump initiates a request to send a request message at 100ms intervals, where the direction of the message ID is 1, the group number is 1, and the device class address is the dialing address in Table 3, the frame type is 2, and the message length is 0. Only after receiving the host' s confirmation startup request will it stop sending the request message and receive commands; the host' s confirmation startup request message has an ID direction of 0, a group number of 1, a device class address of 0, a frame type of 0, a message length of 2, and the first byte indicates the dialing address of the syringe pump that is the target of the host's confirmation startup message (see Table 3) +0x20, and the second byte indicates the address + 0x20 assigned to the syringe pump by the host; the address assigned to the syringe pump by the host can be the same as the dialed address of the syringe pump itself (see Table 3). The address assigned by the host to the syringe pump can be different from the dialed address of the syringe pump itself (see Table 3) and can be assigned to any number from 0 to 15;

Command Execution Instructions

- Other than report and query commands, all commands must end with R command;

- Single commands and command strings can be executed sequentially, such as /1ZIA800R\r. The syringe pump at address 1 to be initialized first, followed by the valve switched to the input channel, and then the syringe moves to the 800 increment position;
- The maximum length of the command string received by the syringe pump is 255 bytes. If the command or command string is sent without ending by R command, the command or command string will be stored in cache area and will not be executed.
- Once the command is executed and the syringe pump will enter into busy status. The busy status will not exit until command execution is completed or termination T command is received. Status can be queried by query Q command or ? 29.
- Prior to action control, initialization command must be performed to initialize syringe pump.
- The syringe pump has a protocol lock that automatically locks the protocol format used in the first frame valid messages received after power-on. If changing the protocol is required, please reset the software or power-off to restart.

3.3 Operating Command

Syringe Configuration Command

<N>[n] Set Syringe Subdivision

Syringe Subdivision Setting

Command	Parameters	Parameter Range	Default Value	Descriptions
N	n	0	0	Speed and position not subdivided. Position at full-stroke 6000 increments, speed at 6000 increments per second.
		1		Position changes to 8 subdivisions, full-stroke 48000 increments; speed not subdivided, 6000 increments per second.
		2		Position and speed both change to 8 subdivisions, position full stroke 48000 increments; speed 48000 increments per second.

Setting the syringe subdivision to N2 allows for finer control of syringe movement. This parameter returns to the default value after the syringe pump resets and restarts.

<K>[n] Set Syringe Backlash

Syringe Backlash Setting

Command	Parameters	Parameter Range	Default Value	Description
K	n	0-255		When setting the syringe subdivision to N0
		0-2040		When setting the syringe subdivision to N1 or N2

Set to compensate the backlash of the syringe drive structure to improve the aspiration and dispense accuracy. This parameter will return to its default value after the syringe pump is reset and restarted.

<k>[n] Set Syringe Dead Volume

Set Syringe Dead Volume

Command	Parameters	Parameter Range	Default Value	Description
k	n	0-255	122	When setting the syringe subdivision to N0
		0-2040	976	When setting the syringe subdivision to N1 or N2

Set the distance the plunger retreats after it hits the apex of the glass tube during initialization of the plunger, to ensure that the plunger does not hit the apex when dispensing liquid to position zero and to extend the life of the plunger seal. This parameter will return to its default value after the syringe pump is reset and restarted.

Under default initialization, the piston moves upward until it contacts the top of the syringe, causing the motor to lose steps and stop initialization. The piston then moves down and up, leaving a small gap (namely the dead volume) between the syringe tip seal and the top of the piston. This small gap is designed so that the syringe does not hit the top of the plunger every time it moves to the syringe zero position. It helps avoid affecting the service life of the piston and syringe.

Note: It is not recommended to set k command parameter less than 10 unless in some special circumstances. If otherwise, piston and syringe are more likely to get damaged.

<U>[n] Syringe Pump Configuration

Syringe Pump Configuration

Command	Parameters	Parameter Range	Default Value	Description
U	n	30		Set the command string mode to automatically run from non-volatile memory
		31		Disable the automatic execution of the command string from non-volatile memory
		41		Set the serial port baud rate to 9600
		47		Set the serial port baud rate to 38400
		51		Set CAN baud rate to 100K
		52		Set the CAN baud rate to 250K
		53		Set the CAN baud rate to 500K
		54		Set CAN baud rate to 1M
		57		Set the CAN baud rate to 125K

All configurations made through the U command can take effect by using the ! command or by restarting the power. The configurations are automatically saved to non-volatile memory after being set.

Initialization Commands

Initialization can configure the rotation direction of the valve, input output ports, the speed of the syringe plunger, and the driving force based on different commands and parameters. When initializing the valve and plunger, first initialize the valve. Switch the valve to the input port if the current position of the plunger’s optocoupler is in the triggered state. The plunger will move in the liquid aspiration direction until the optocoupler is no longer triggered. Switch the valve to output port, and the plunger will move in the liquid dispense direction until it reaches the glass tube’s vertex. Then switch the valve to input port, the plunger will move in the liquid aspiration direction for twice of the distance set by the k command. Lastly, switch the valve to the output port, and the plunger will move in the liquid dispense direction for a distance set by the k command. The current position is then set as the zero position, and the initialization is completed. If only the plunger needs to be initialized, the valve operations can be omitted from the initialization steps. If only the valve needs to be initialized, initialize the valve in the specified direction and switch it to the specified port.

Note: To avoid damaging the piston and injector when resetting the small displacement injector, it is recommended to use drive force mentioned in below chart accordingly when resetting.

Suggested Syringe Initialization Drive Force

Syringe Displacement	Drive Force
1.0mL or above	Full Drive Force
250uL、500uL	One Half Drive Force
50uL、100uL	One Third Drive Force

<Z>[n1],[n2],[n3] Clockwise Initialization of Valve and Plunger

Clockwise Initialization of Plunger and Valve

Command	Parameters	Parameter Range	Default Value	Descriptions
Z	n1	0	0	Full drive force and initialize plunger at default speed
		1		One-half drive force and initialize plunger at default speed
		2		One-third drive force and initialize plunger at default speed
		10-40		Full Drive force and initialize the plunger with speed code [n1] speed, the list of speed codes is shown in Table 33
	n2	0	0	Set the initialized valve input port to Port 1
		1-X		Set the initialization valve input number, X is the maximum number for the valve port
	n3	0	0	Set the initialization valve output port X;
		1-X		Set initialization valve output number, X for the maximum number of valve port;

Using this command, the valve ports will be numbered clockwise from 1, and subsequent valve switch commands will be executed according to that number; the valve input must connect with the syringe, otherwise initialization will be prohibited.

<Y>[n1],[n2],[n3] Counterclockwise Initialization Valve and Plunger

Counterclockwise Initialization Plunger And Valve

Command	Parameters	Parameter Range	Default Value	Description
Y	n1	0	0	Full drive force and Initialize plunger at default speed

		1		One half drive force and initialize plunger at default speed.
		2		One third drive force and initialize plunger at default speed
		10-40		Full Driving force and Initialize the plunger with speed code [n1] speed, the list of speed codes is shown in Table 35
	n2	0	0	Set the initialization valve input port to Port 1
		1-X		Set the initialization valve input number, X is the maximum number for the valve port
	n3	0	0	Setting the initialization valve output port X;
		1-X		Set initialization valve output number, X for the maximum number of valve port;

Using this command, the valve ports will be numbered counterclockwise from 1, and subsequent valve switch commands will be executed according to that number; the valve input must connect with the syringe, otherwise initialization will be prohibited.

<W>[n1] Initialize Plunger only

Initialize Plunger Only

Command	Parameters	Parameter Range	Default Value	Description
W	n	0	0	Full drive force and initialize plunger at default speed
		1		One-half drive force and Initialize plunger at default speed
		2		One-third drive force and Initialize plunger at default speed
		10-40		Full Driving force and initialize the plunger with speed code [n] speed, the list of speed codes is shown in Table 35

<w>[n1],[n2] Initialize Valve Only

Initialize Valve Only

Command	Parameters	Parameter Range	Default Value	Description
w	n1	1-X	1	Set the initialization valve port number, X for the

				maximum valve port number;
	n2	0	0	Initialize the valve clockwise
		1		Initialize the valve counterclockwise

<z>[n] Analog Plunger Initialization

Analog Plunger Initialization

Command	Parameters	Parameter Range	Default Value	Description
z	n	None		Set the encoder position to the plunger position and clear any plunger running errors
		0-6000		When setting the syringe subdivision to N0, n is set to the plunger position and the plunger operation error is cleared.
		0-48000		When setting the syringe subdivision to N1 or N2, n is set to the plunger position and the plunger operation error is cleared.

This command can be used after a plunger overload error occurred to re-control the pump. When using the [z] command to recover from an overload condition, it is recommended that the pump be reinitialized using the Z<n1, n2, n3> or Y<n1, n2, n3> commands to set the true master position.

Note: Improper use of this command will cause the plunger to exceed its stroke, risking damage to the syringe pump.

Valve Control Command

<I>[n] Switching Valve To The Input Port/Switch Valve Clockwise

Switching Valve To The Input Port/Switch Valve Clockwise

Command	Parameters	Parameter Range	Default Value	Description
I	n	None		Optimal path to switch valve to input port, also known as Port 1
		1-X		Switch valve clockwise to N port

If the valve is not initialized before using this command, it will initialize the valve and switch to the set port in clockwise direction. Only distribution type valves can be used with parameter [n], non-distribution type valves cannot be used with parameters.

<O>[n] Switching Valve to Output Port/Switching Valve Counterclockwise

Switching Valve to Output Port/Switching Valve Counterclockwise

Command	Parameters	Parameter Range	Default Value	Description
O	n	None		Optimal path to switch valve to output port, also known as X port
		1-X		Switch valve counterclockwise to n port

If the valve is not initialized before using this command, the valve will be initialized and switch to the set port in counterclockwise direction. Only distribution type valves can be used with parameter [n], non-distribution type valves cannot be used with parameters.

<B>[n] Switching Valve to the Bypass Port/Optimal Path Switching Valve

Switching Valves to the Bypass Ports/Optimal Path Switching Valve

Command	Parameters	Parameter Range	Default Value	Description
B	n	None		Optimal Path to switch valve to bypass port
		1-X		Optimal path to switch valve to N port

If the valve is not initialized before using this command, the valve will be initialized in clockwise direction and the optimal path will be switch to the set port. Only distribution type valves can be used with parameter [n], non-distribution type valves cannot be used with parameters.

<E>[n] Switching Valves to Additional Ports/Optimal Path Switching Valve

Switching Valves to Additional Ports/Optimal Path Switching Valve

Command	Parameters	Parameter Range	Default Value	Description
E	n	None		Optimal path to switch valve to other ports
		1-X		The optimal path moves the valve to port n if it is a rotary shear valve head, or controls each solenoid independently to switch on and off if it is a solenoid head.

If the valve is not initialized before using this command, the valve will be initialized in clockwise direction and the optimal path will be switched to the set port. Only distribution

type valves can be used with parameter [n], non-distribution type valves cannot be used with parameters.

If the valve head is solenoid, the command <E>[n] controls all solenoid valves independently, and the binary of the parameter n represents the switch for each valve; for example, the E3 command, which opens valves at ports 2-3, the E0 command, all port valves are closed and E5, port 1 and port 3 valves are open.

Syringe Control Commands

The units of the syringe control commands are all increments; when the syringe subdivision is set to N0, the full stroke is 3,000 increments; when it is set to N1 or N2, the full stroke is 24,000 increments.

<A>[n] Move the Plunger to Absolute Position

Move the Plunger to Absolute Position

Command	Parameters	Parameter Range	Default Value	Description
A	n	0-6000	0	When setting the syringe subdivision to N0
		0-48000		When setting the syringe subdivision to N1 or N2

<a>[n] Move Plunger to Absolute Position(Return is Idle)

The same function as the A command, except that when you use the a command, the queried state is the idle state;

<P>[n] Relative position aspiration

Relative Position Aspiration

Command	Parameters	Parameter Range	Default Value	Description
P	n	0-6000	0	When setting the syringe subdivision to N0
		0-48000		When setting the syringe subdivision to N1 or N2

<p>[n] Relative Position Aspiration(Return is Idle)

Same function as the p command, except that when you use the p command, the queried state is the idle state;

<D>[n] Relative Position Dispense

Relative Position Dispense

Command	Parameters	Parameter Range	Default Valve	Description
D	n	0-6000	0	When setting the syringe subdivision to N0
		0-48000		When setting the syringe subdivision to N1 or N2

<d>[n] Relative Position Drain(Return is Idle)

The same function as the D command, except that when you use the d command, the queried state is the idle state.

Syringe Parameter Setting Command

When the plunger is initialized, the set acceleration, starting speed, maximum speed and stopping speed will be restored to the system default values; when the starting speed is greater than the maximum speed, the actual running starting speed will be equal to the maximum speed; when the stopping speed is greater than the running speed, the actual running stopping speed will be equal to the maximum speed; the stopping speed setting is valid only when liquid is dispensed, and the stopping speed will be equal to the starting speed when liquid is aspirated.

When the N command is used to modify the subdivision, the values of acceleration, starting speed, maximum speed and stopping speed remain unchanged, and the actual running will change by 8 times; when it is modified from N0 or N1 to N2, it will be slowed down by 8 times; and when it is set from N2 to N1 or N0, it will be fastened by 8 times.

<L>[n] Set acceleration

Set Acceleration

Command	Parameters	Parameter Range	Default Value	Description
L	n	1-20	7	When the subdivision is set to N0 or N1, set acceleration to n*2500 increments per square second
		1-160		When the subdivision is set to N2, set acceleration to n*2500 increments per square second

<v>[n] Set the Startup Speed

Set the Startup Speed

Command	Parameters	Parameter Range	Default Value	Description
v	n	50-1000	900	When the subdivision is N0 or N1, set the syringe startup speed to n increments per second
		50-8000	900	When the subdivision is N2, set the syringe startup speed to n increments per second

<V>[n] Set the maximum speed

Set the maximum speed

Command	Parameters	Parameter Range	Default Value	Description
V	n	5-6000	900	When the subdivision is N0 or N1, set the maximum speed of the syringe to n increments per second
		6-48000	900	When the subdivision is N2, set the maximum speed of the syringe to n increments per second

Note: when the liquid outlet of the syringe pump is connected to a relatively longer or relatively thinner pipeline, due to the resistance of change of diameter and frictional resistance along the pipeline, certain back pressure will be generated in the pipeline. The back pressure is positively correlated with the flow rate and pipe length, and negatively correlated with the pipe diameter. Therefore, it is suggested not to set high dispense speed for the pump to avoid the situation where the hydraulic pressure inside the syringe exceeds the pressure resistance of the valve. Specific maximum speed can be set according to actual liquid circuit test result.

<S>[n] Set the Maximum Speed(Table Lookup Method)

Set the Maximum Speed(Table Lookup Method)

Command	Parameters	Parameter Range	Default Value	Description
S	n	0-40	14	Set the maximum speed to speed code [n], see Table

				35

Speed Code Table

Speed Code	Speed (increments per second)	Seconds / Full stroke (N0 or N1)	Seconds / Full stroke (N2)
0	6000	1.25	8.25
1	5600	1.30	8.80
2	5000	1.39	9.79
3	4400	1.52	11.1
4	3800	1.71	12.8
5	3200	1.97	15.1
6	2600	2.37	18.5
7	2200	2.77	21.9
8	2000	3.03	24.0
9	1800	3.36	26.7
10	1600	3.77	30.0
11	1400	4.30	34.3
12	1200	5.00	40.0
13	1000	6.00	48.0
14	800	7.50	60.0
15	600	10.00	80.0
16	400	15.00	120
17	200	30.00	240
18	190	31.58	253
19	180	33.33	267
20	170	35.29	282

Speed Code	Speed (increments per second)	Seconds / Full stroke (N0 or N1)	Seconds / Full stroke (N2)
21	160	37.50	300
22	150	40.00	320
23	140	42.86	343
24	130	46.15	369
25	120	50.00	400
26	110	54.55	436
27	100	60.00	480
28	90	66.67	533
29	80	75.00	600
30	70	85.71	686
31	60	100.00	800
32	50	120.00	960
33	40	150.00	1200
34	30	200.00	1600
35	20	300.00	2400
36	18	333.33	2667
37	16	375.00	3000
38	14	428.57	3429
39	12	500.00	4000
40	10	600.00	4800
/	/	/	/

<c>[n] Set Stop Speed

Set Stop Speed

Command	Parameters	Parameter Range	Default Value	Description
c	n	50-2700	900	Set the syringe stop speed to n increments per second

Stop speed setting is only valid when dispensing liquid, and it is equal to the startup speed when aspirating liquid.

The Start Speed [v], Maximum Speed [V] and Cutoff Speed [c] commands interact according to the following rules.

$$[v] \leqq [c] \leqq [V]$$

1. The start speed should always be less than or equal to the maximum speed.
2. The maximum speed should always be greater than or equal to the start speed and the cutoff speed.
3. The stop speed shall always be less than or equal to the maximum speed and greater than or equal to the start speed.

System Control Commands

<R> Execute a Command or Command String

If there is an unexecuted command string in the command cache, when a command string with R command at the end of the command string is received, the command string is saved to the cache and the command string in the cache is executed; when the command string stops execution due to H command or T command, the command string with only R command can be sent to continue the execution of the unexecuted command string; when in the process of delayed M command execution, sending the command string with only R command will stop the delayed M command and continue the execution of subsequent commands.

<X> Repeat the Last Action Command String

Repeat the execution of the previous action command string, and does not repeat the execution of the previous action command string if it reports an error.

<G>[n] Loop Execution of a Command or a Command String

Loop Execution of a Command or a Command String

Command	Parameters	Parameter Range	Default Value	Description
G	n	0-48000		The number of times a command or command string is executed in a loop

This command is used to execute a command or command string in a loop for the specified number of times. If the number is set to 0, the execution will keep looping.

<g> Start Tag for Loop Execution of a Command or Command String

The start tag is for executing a command or command string in a loop. For example, sending the command string “ZgIA300BA0G5R” will make syringe pump to initialize the valve and plunger with default parameters, and then execute the loop command string “IA300BA0” five times. This means that the valve will be switched to the input port, the plunger will move to a position of 300 increments (liquid aspiration), the valve will be switched to the output port, and the plunger will move to a position of 0 increment (liquid dispense). This sequence will be repeated five times.

<M>[n] Delay execution

Delay Execution

Command	Parameters	Parameter Range	Default Value	Description
M	n	0-30000		Delay execution time (milliseconds)

This command can be used between the move plunger command and the switch valve port command. When the plunger moving is finished, this command allows the syringe pump to delay a certain amount of time before switching the valve port in order to reduce the pressure fluctuation; if the R command is received during the delay command, the delay process can be terminated, and continue to execute the subsequent command string.

<H>[n] Interrupt execution

Interrupt Execution

Command	Parameters	Parameter Range	Default Value	Description
H	n	0	0	Execution can be continued by receiving the R command or the falling edge signal of auxiliary input 1 or 2
		1		Execution can be continued by receiving the R command or the falling edge signal of auxiliary input 1
		2		Execution can be continued by receiving the R command or the falling edge signal of auxiliary input 2

As shown in the description, the execution of a command string can be interrupted. The interrupt command will not interrupt the execution of the action command, but only terminate the execution of the delay command when the R command or the falling edge signal of the auxiliary input is received. Therefore, it is normally nested in the command string and executed separately only for

interrupting the execution of the delay command.

<T> Terminate Command

The terminate command can terminate operating plunger motion, loop execution, and delayed execution; it does not interrupt valve switching. If the plunger motion is interrupted, the syringe pump will not continue to move the plunger when received the R command, but will run the next command in the command string.

The terminate command may cause the plunger to lose steps, and it is recommended to re-initialize the device after executing the termination command.

<J>[n] Auxiliary Output Control

Auxiliary Output Control

Command	Parameters	Parameter Range	Default Value	Description
J	n	0	0	Low output of auxiliary output 3, low output of auxiliary output 2, low output of auxiliary output 1
		1		Low output of auxiliary output 3, low output of auxiliary output 2, high output of auxiliary output 1
		2		Low output of auxiliary output 3, high output of auxiliary output 2, low output of auxiliary output 1
		3		Low output of auxiliary output 3, high output of auxiliary output 2, high output of auxiliary output 1
		4		High output of auxiliary output 3, low output of auxiliary output 2, low output of auxiliary output 1
		5		High output of auxiliary output 3, low output of auxiliary output 2, high output of auxiliary output 1
		6		High output of auxiliary output 3, high output of auxiliary output 2, low output of auxiliary output 1
		7		High output of auxiliary output 3, high output of auxiliary output 2, high output of auxiliary output 1

Being able to use auxiliary output is a tag for synchronized actions of other devices or the process of command string execution.

<!> Reset Command

When the syringe pump configurations are modified with the U command, the reset command can be used to restart the syringe pump to make configurations take into effect.

Non-volatile Memory Command

<s>[n] Store Command String to Non-volatile Memory

Store Command String to Non-Volatile Memory

Command	Parameters	Parameter Range	Default Value	Description
s	n	0-14		Store the command string to the location of command string n in non-volatile memory

The user can store the command string into non-volatile memory by putting the s command at the beginning of the command string, and each command string can be up to 128 bytes, which can be accessed by the ? command to query the command string stored into non-volatile memory, see Set User Data;

For example, the s1ZgIA3000BA0G10R command string containing 14 bytes, will store the ZgIA3000BA0G10R command to the location of command string 1 in the non-volatile memory.

<e>[n] Execute a Command String in Non-Volatile Memory

Execute a Command String in Non-Volatile Memory

Command	Parameters	Parameter Range	Default Valve	Description
e	n	0-14		Execute Command String in Non-Volatile Memory

Execute the command string stored in non-volatile memory by the s command. Another way of executing the command string in non-volatile memory is to configure the syringe pump U30, i.e., to allow automatic operation of the command string in non-volatile memory mode, where the command string is executed is decided by the DIP switch address (see Table 3).

The command string stored by the s command can be nested with the e command to achieve the execution of multiple command strings. When the execution of another command string executed by the e command is finished, it will not return to the previous command for further execution, so usually the e command is placed at the end of the command when it is nested.

<>>n1,n2 Set User Data

Set User Data

Command	Parameters	Parameter Range	Default Value	Description
>	n1	0-15		Position index in non-volatile memory
	n2	0-255		Data values need to be stored by the user

<<>[n] Read User Data

Read User Data

Command	Parameters	Parameter Range	Default Valve	Description
<	n1	0-15	0	Position index in non-volatile memory

Query the Command

<?>[n] Report syringe pump information

Report Syringe Pump Information

Command	Parameters	Parameter Range	Default Value	Description
?	n	0	0	Report absolute syringe position
		1		Report syringe startup speed
		2		Report maximum syringe speed
		3		Report syringe stop speed
		4		Report the encoder position of the syringe
		6		Report valve port
		10		Report command cache status, 0: cache is empty, 1: cache has commands
		12		Report the syringe backlash set by the K command
		13		Reports the status of auxiliary input 1, 0: low, 1: high
		14		Reports the status of auxiliary input 2, 0: low, 1: high

		15		Report the number of times of syringe initialization
		16		Report the number of times of plunger movements
		17		Report the number of times of valve switching
		18		Report the number of times of valve switching since the last report
		19		Report if the pump is initialized
		20		Report board unique number
		23		Report firmware version
		24		Report the dead volume of the syringe set by the k command
		25		Report the syringe acceleration set by the L command
		28		Report the subdivision mode set by the N command
		29		Report current motion status
		30-44		Report command strings in non-volatile memory
		76		Report syringe pump configuration

<F> Report the Status of the Command Buffer

As the ?10 command, if the command cache is empty, 0 will be reported, otherwise 1.

<%> Report the Number of Times of Valve Switching Since the Last Report

As the ?18 command, the number of times of valve switching since the last report will be reported. Note that the times of syringe initialization, the times of plunger movements and the times of valve switching are the number of times changed 50 times before the data is saved to non-volatile memory, therefore, there are some differences between the number read after power down and the actual number.

<#> Report Board Unique Number

As the ?20 command, report the unique number of the board, which can be used for device binding.

<&> Report Firmware Version

As the ?23 command, report the firmware version in ASCII characters.

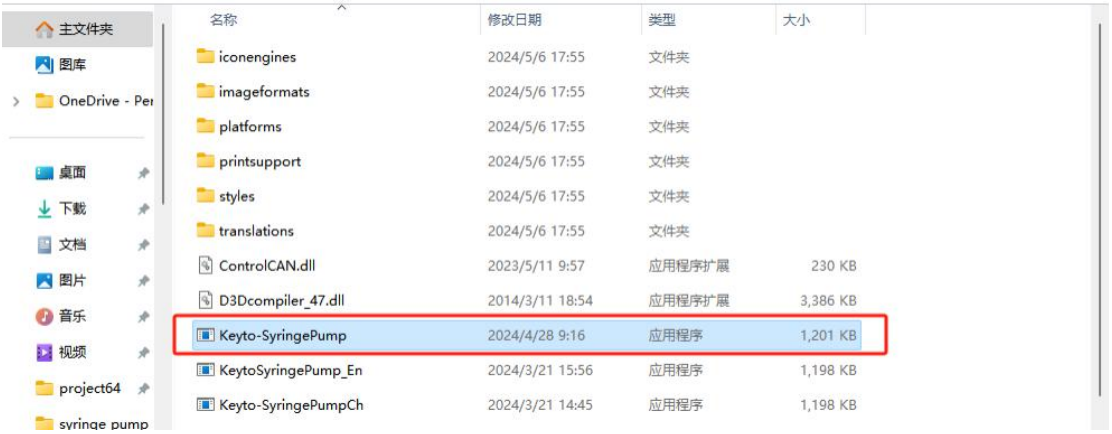
<Q> Report Status

As the ?29 command, report the current status of the syringe pump, see Table 6

3.4 Instructions for the Host Computer Testing Software

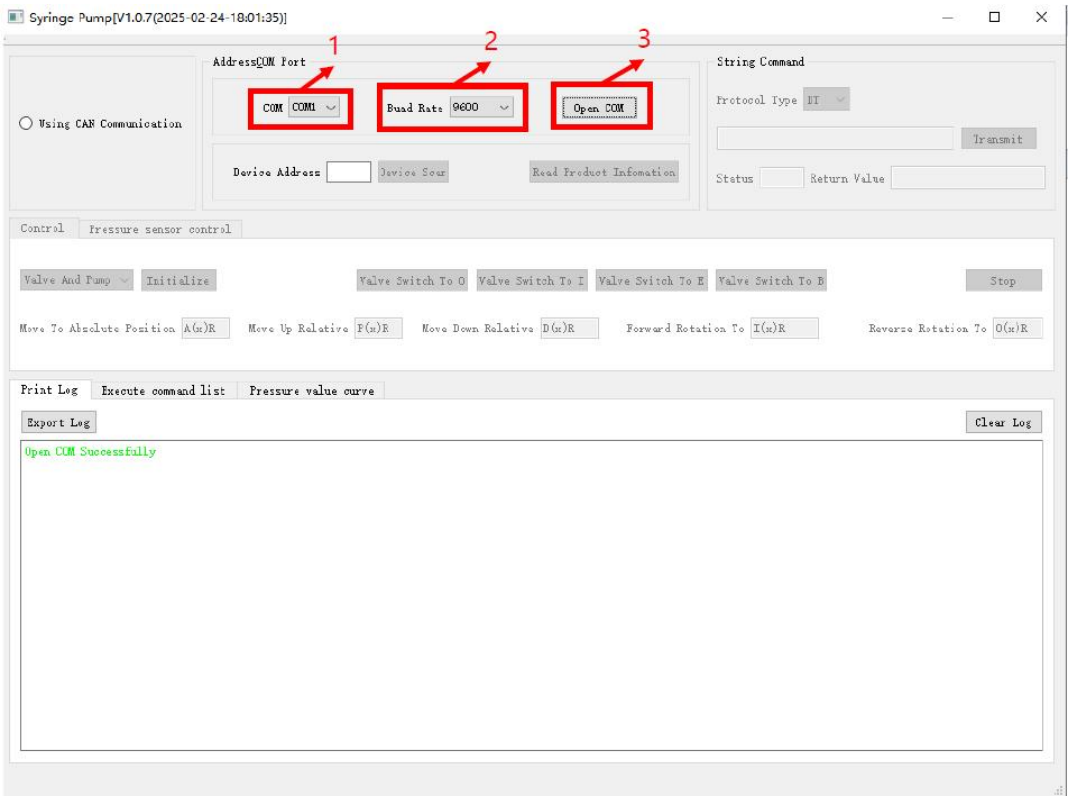
Opening Up Host Computer Testing Software

First, connect the circuits of the device according to Chapter 2 Hardware Settings and power it on, then open Keyto - Syringe Pump.exe testing software:



Selection of Serial Port, Baud Rate

Select the corresponding port number, select the baud rate to 9600(factory default value is 9600), single click “Open Serial Port” to open serial port.

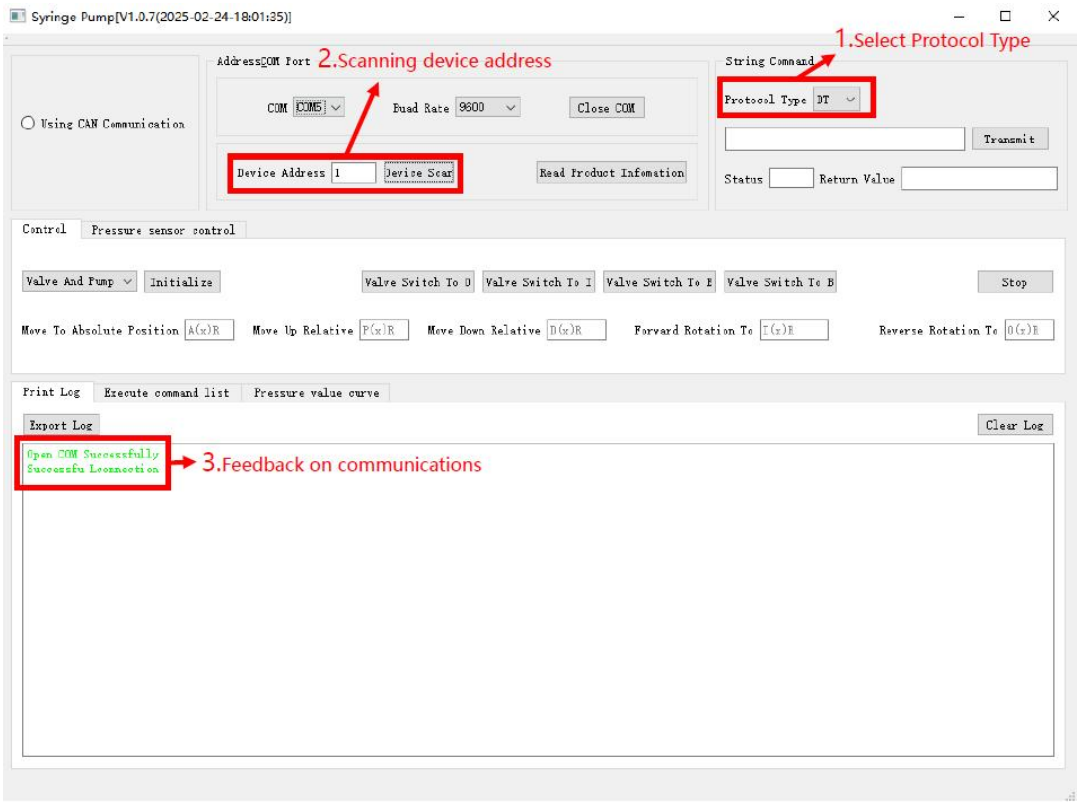


Selection of Serial Port, Device Scanning

Single click on the drop-down protocol type where you can choose DT or OEM protocol, and click automatic scanning button after selection. The device default address is 1. Once scanning is completed, the scanned address will automatically be filled into the address bar. Note that subsequent operations can be performed only after the address is scanned successfully.

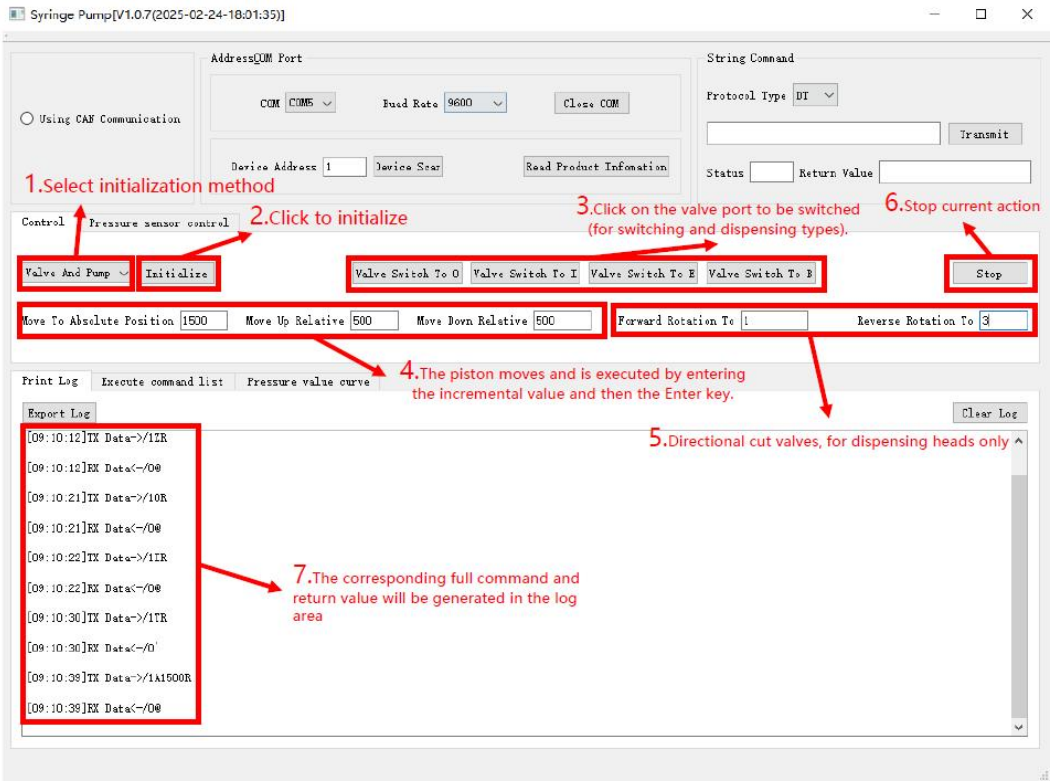
Notes:

1. Setting will lock current protocol type once protocol type is selected and address is scanned. If change of protocol is necessary, restart the device.
2. If failed to scan the address, please refer to *Q&A* Question No.2 for troubleshooting.



Quick Control

Simple control of the pump can be achieved by single clicking the button or entering values and press the Enter key. Specific control methods are as below chart.



Manual Issuance

In this area, all commands for the syringe pump can be issued manually. When choosing the DT protocol, only need to enter the ASCII command string, and the host computer will automatically convert it into a complete DT protocol command for issuance. The status bar will display the current status of the pump. It will show "Busy" if the pump is in motion and "Completed" when the motion

is finished. If the sent command is a query command, the host computer will display the parsed return value in the return value area. When the OEM protocol is selected, only need to enter the ASCII command string, and the host computer will convert it into a complete OEM protocol command for issuance. Detailed issued commands can be viewed in the log area. After the command is executed, the execution time of the command will also be displayed in the log area.

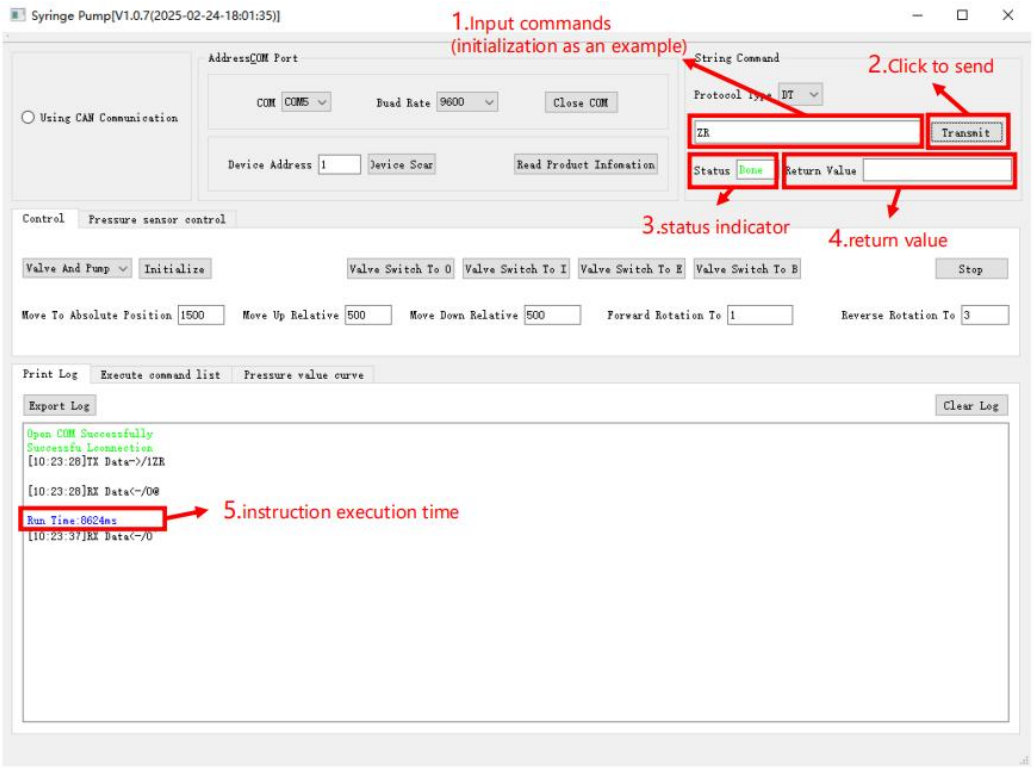
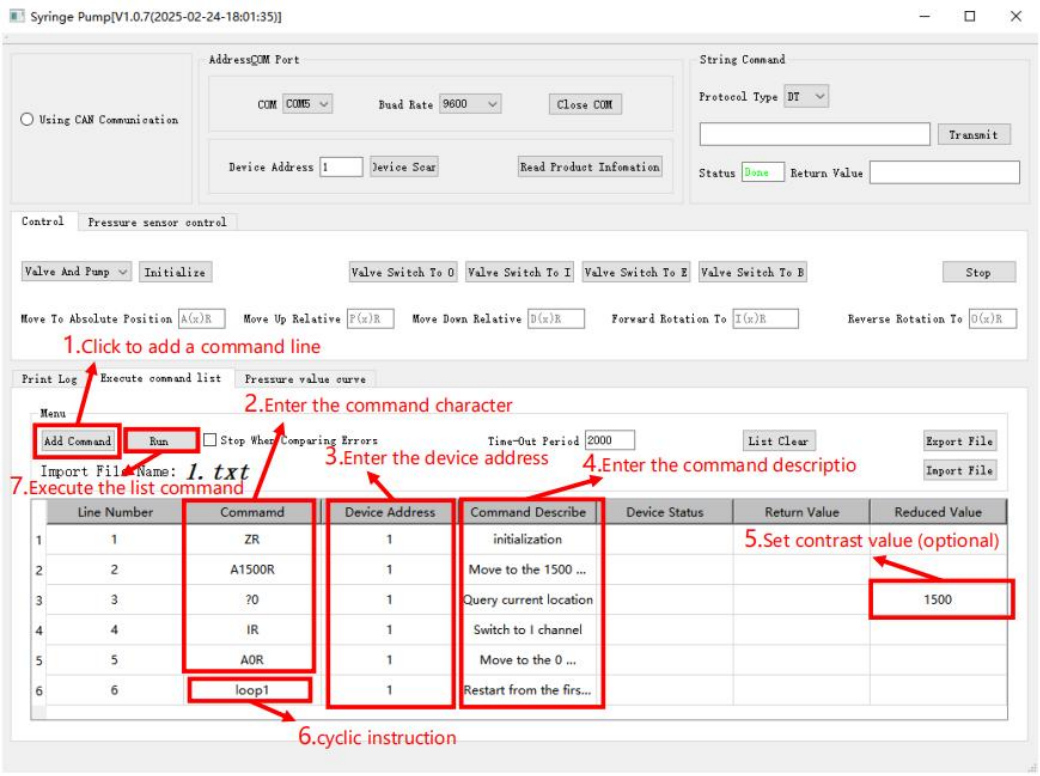


Table Execution

The table execution bar allows edition of simple processes. After the process editing is completed, click "Auto Run" and the host computer will start issuing commands from the first one. Once the issuance is completed, it will poll the current status. When the status changes to "idle", the host computer will continue to issue the next command. When an error occurs during the process operation or when there is an exception command, the host computer will report an error and stop

issuing subsequent commands.



3.5 Application Examples

Before sending a motion command, query the current operating status with Q command, and send the motion command only when it is idle. The status returned by other non-Q commands cannot be used to identify the running or idle status of the device, and can only be used for exception handling.

DT Protocol

Execute a Single Command Action

Function	Direction	Data	Description
Set the serial	Send	/1U41R[CR]	/ start-stop character; 1 device address;

port baud rate to 9600	Receive	/0`[ETX][CR][LF]	U41 set the serial port baud rate to 9600; R execute command; [CR] Carriage Return / start-stop character; 0 host PC address; `status idle; [ETX] End of Text Terminator, [CR] Carriage Return; [LF] Line Feed
Initialization	Send	/1ZR[CR]	/ start-stop character; 1 device address; Z initialization command; R execute command; [CR] Carriage Return
	Receive	/0@[ETX][CR][LF]	/ start-stop character; 0 host PC address; @ status busy; [ETX] End of Text Terminator, [CR] Carriage Return; [LF] Line Feed
Switch valve to input port command	Send	/1IR[CR]	/ start-stop character; 1 device address; I switch valve to input port command; R execute command; [CR] Carriage Return
	Receive	/0@[ETX][CR][LF]	/ start-stop character; 0 host PC address; @ status busy; [ETX] End of Text Terminator, [CR] Carriage Return; [LF] Line Feed
Plunger moves to absolute position at 300 increments	Send	/1A300R[CR]	/ start-stop character;1 device address; A300 plunger moves to absolute position at 300 increments; R execute command; [CR] Carriage Return
	Receive	/0@[ETX][CR][LF]	/ start-stop character; 0 host PC address; @ status busy; [ETX] End of Text Terminator; [CR] Carriage Return; [LF] Line Feed
Set the maximum speed to 3000 increments/second	Send	/1V3000R[CR]	/ start-stop character; 1 device address; V3000 set the maximum speed to 3000 increments/second; R execute command; [CR] Carriage Return
	Receive	/0`[ETX][CR][LF]	/start-stop character; 0 host PC address; `status idle; [ETX] End of Text Terminator, [CR] Carriage Return; [LF] Line Feed
Reset Restart	Send	/1!R[CR]	/ start-stop character; 1 device address; ! reset restart; R execute command; [CR] Carriage Return
	Receive	/0`[ETX][CR][LF]	/ start-stop character; 0 host PC address; ` status idle; [ETX] End of Text Terminator, [CR] Carriage Return; [LF] Line Feed
Store Z at the	Send	/1s0ZR[CR]	/start-stop character; 1 device address;

position of command string 0 in the non-volatile memory	Receive	/0@[ETX][CR][LF]	s0Z store Z at the position of command string 0 in the non-volatile memory; R execute command; [CR] Carriage Return / start-stop character; 0 host PC address; @ status busy; [ETX] End of Text Terminator, [CR] Carriage Return; [LF] Line Feed
Query the firmware version	Send	/1?23[CR]	/ start-stop character; 1 device address; ?23 query firmware version; [CR] Carriage Return
	Receive	/0`231227106 [ETX][CR][LF]	/ start-stop character; 0 host PC address; ` status idle; 231227106 firmware version code; [ETX] End of Text Terminator, [CR] Carriage Return; [LF] Line Feed

Execute Multiple Command Actions

Function	Direction	Data	Description
Set the subdivision to N0, and initialize, then switch the valve to input port, then set the speed at 600 increments per second, lastly the plunger moves to absolute position at 300 increments	Send	/1N0ZIV600A300R[CR]	/ start-stop character; 1 device address; N0 set subdivision; Z initialization; I switch valve to input port; V set speed at 600 increments per second; A300 plunger moves to absolute position at 300 increments; [CR] Carriage Return
	Receive	/0@[ETX][CR][LF]	/ start-stop character; 0 host computer address; @ status busy; [ETX] End of Text Terminator, [CR] Carriage Return; [LF] Line Feed

OEM Protocol

Execute a Single Command Action

Function	Direction	Data	Description
Set serial port baud rate to 9600	Send	02 31 30 55 34 31 52 03 02	02 Frame Header; 31 Device Address; 30 Serial Number; 55 34 31 (U41); 52(R); 03 Serial Trailer;02 XOR Checksum
	Receive	02 30 60 03 51	02 Frame Header; 30 Host PC Address; 60 idle status; 03 Frame Trailer; 51 XOR Checksum
Initialization	Send	02 31 30 5A 52 03 08	02 Frame Header; 31 Device Address; 30 Serial Number; 5A(Z); 52(R); 03 Serial Trailer; 08 XOR Checksum
	Receive	02 30 40 03 71	02 Frame Header;30 Host PC Address; 40 busy status; 03 Frame Trailer; 71 XOR Checksum
Switch valve to input port	Send	02 31 30 49 52 03 1B	02 Frame Header; 31 Device Address; 30 Serial Number; 49(I); 52(R); 03 Frame Trailer; 1B XOR Checksum
	Receive	02 30 40 03 71	02 Frame Header; 30 Host PC Address; 40 busy status; 03 Frame Trailer; 71 XOR Checksum
Plunger moves to absolute position at 300 increments	Send	02 31 30 41 33 30 30 52 03 20	02 Frame Header; 31 Device Address; 30 Serial Number; 41 33 30 30(A300); 52(R); 03 Frame Trailer; 20 XOR Checksum
	Receive	02 30 40 03 71	02 Frame Header;30 Host PC Address; 40 busy status; 03 Frame Trailer; 71 XOR Checksum
Set the maximum speed to 3000 increments/second	Send	02 31 30 56 33 30 30 30 52 03 07	02 Frame Header; 31 Device Address; 30 Serial Number; 56 33 30 30 30(V3000); 52(R); 03 Frame Trailer; 07 XOR Checksum
	Receive	02 30 60 03 51	02 Frame Header; 30 Host PC; 60 idle status; 03 Frame Trailer; 51 XOR Checksum
Rest Restart	Send	02 31 30 21 52 03 73	02 Frame Header; 31 Device Address; 30 Serial Number; 21(!); 52(R); 03 Frame Trailer; 73 XOR Checksum
	Receive	02 30 60 03 51	02 Frame Header; 30 Host PC; 60 idle status; 03 Frame Trailer; 51 XOR Checksum
Store Z at the position of command string 0 in the non-volatile memory	Send	02 31 30 73 30 5A 52 03 4B	02 Frame Header; 31 Device Address; 30 Serial Number; 73 30 5A 52(s0ZR); 03 Frame Trailer; 4B XOR Checksum
	Receive	02 30 40 03 51	02 Frame Header; 30 Host PC Address; 40 Busy status; 03 Frame Trailer; 51 XOR Checksum
Query firmware version number	Send	02 31 30 3F 32 33 03 3E	02 Frame Header; 31 Device Address; 30 Serial Number; 3F 32 33(?23); 03 Frame Trailer; 3E XOR Checksum
	Receive	02 30 60 32 33 31 32 32	02 Frame Header; 30 Host PC Address; 60 idle status; 32 33 31 32 32 37 31 30 36(231227106);

		37 31 30 36 03 61	03 Frame Trailer; 61 XOR Checksum

Execute Multiple Command Actions

Function	Direction	Data	Description
Set subdivision to N0, initialize, then switch valve to input port, then set the speed to 600 increments per second, lastly piston moves to absolute position at 300 increments	Send	02 31 30 4E 30 5A 49 56 36 30 30 41 33 30 30 52 03 2D	02 Frame Header; 31 Device Address; 30 Serial Number; 4E 30 5A 49 56 36 30 30 41 33 30 30 52(N0ZIV600A300R); 03 Frame Trailer; 2D XOR Checksum
	Receive	02 30 40 03 51	02 Frame Header; 30 Host PC Address; 40 Busy status; 03 Frame Trailer; 51 XOR Checksum

CAN Standard Frame Protocol

Host Acknowledges the Startup Request

Function	Direction	Frame ID	Frame Data (HEX)	Description
Request connection	Receive	0x0482	None	The syringe pump sends a startup request to the host at fixed intervals.
Request connection	Send	0x0080	20 20	20 Device address(DIP Address+0x20); 20 Allocation address(allocation address+0x20)

Frame ID Description Example:

Direction	Group			Device Address				Frame Type		
bit10	bit9	bit8	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0
0	0	0	1	0	0	0	0	0	0	0
0			8				0			
This ID is the frame ID used when sending a connection establishment request. The sending direction is from the host to the slave, so the direction bit is 0. The group number for connection establishment is 1, so the group bit is 001. The device address is 0, so the device address bit is 0000. The frame type is 0, so the frame type bit is 000.										

Execute Single Command Action

Function	Direction	Frame ID	Frame Data(HEX)	Description
Set the serial port baud rate to 9600	Send	0x0101	55 34 31 52	The direction of the frame ID is 0, the group number is 2, the device address is 0, and the frame type is 1 (001 0000 0001); the frame data is 55 34 31 52 (U41R).
	Receive	0x0501	None	Return immediately. The direction of the frame ID is 1, the group number is 2, the device address is 0, and the frame type is 1 (101 0000 0001).
	Receive	0x0501	20 60	Return after the movement is completed. The direction of the frame ID is 1, the group number is 2, the device address is 0, and the frame type is 1 (101 0000 0001). The frame data 20 indicates that there is no error in the status; 60 is a fixed return value without practical meaning.
Initialization	Send	0x0101	5A 52	The direction of the frame ID is 0, the group number is 2, the device address is 0, and the frame type is 1 (001 0000 0001). The frame data is 5A 52 (ZR).
	Receive	0x0501	None	Return immediately. The frame ID direction is 1, the group number is 2, the device address is 0, and the frame type is 1 (101 0000 0001).
	Receive	0x0501	20 60	Return after the movement is completed. The direction of the frame ID is 1, the group number is 2, the device address is 0, and the frame type is 1 (101 0000 0001). Frame data 20 indicates that the status has

				no error; 60 is a fixed return value without practical significance.
Switch Valve to Input Port	Send	0x0101	49 52	The direction of the frame ID is 0, the group number is 2, the device address is 0, and the frame type is 1 (001 0000 0001). The frame data is 49 52 (IR).
	Receive	0x0501	None	Return immediately. The frame ID direction is 1, group number is 2, device address is 0, and a frame type is 1 (101 0000 0001). Return after the movement is completed.
	Receive	0x0501	20 60	The frame ID direction is 1, group number is 2, device address is 0, and a frame type is 1 (101 0000 0001). Frame data 20 indicates that there is no error in the status; 60 is a fixed return value without practical meaning.
Plunger moves to absolute position at 300 increments	Send	0x0101	41 33 30 30 52	Frame ID direction is 0, group number is 2, the device address is 0, and the frame type is 1 (001 0000 0001). The frame data is 41 33 30 30 52 (A300R).
	Receive	0x0501	None	Return immediately. The frame ID direction is 1, group number is 2, device address is 0, and the frame type is 1 (101 0000 0001). Return after the movement is completed.
	Receive	0x0501	20 60	The frame ID direction is 1, group number is 2, device address is 0, and the frame type is 1 (101 0000 0001). For the frame data, 20 indicates that the status has no error, and 60 is a fixed return value without practical significance.
Set the maximum speed to 3000 increments/second	Send	0x0101	56 33 30 30 30 52	The direction of the frame ID is 0, the group number is 2, the device address is 0, and the frame type is 1 (001 0000 0001). The frame data is 56 33 30 30 30 52 (V3000R).
	Receive	0x0501	None	Return immediately. The frame ID direction is 1, group number is 2, device address is 0, and the frame type is 1 (101 0000 0001). Return after the movement is completed.
	Receive	0x0501	20 60	The frame ID direction is 1, group number is 2, device address is 0, and the frame type is 1 (101 0000 0001). The frame data 20 indicates that the status has no error; 60 is a fixed return value with no

				practical meaning.
Reset Restart	Send	0x0101	21 52	The direction of the frame ID is 0, group number is 2, device address is 0, and the frame type is 1 (001 0000 0001); frame data is 21 52 (!R).
	Receive	0x0501	None	Return immediately. The frame ID direction is 1, group number is 2, device address is 0, and frame type is 1 (101 0000 0001).
	Receive	0x0501	20 60	Return after the movement is completed. The frame ID direction is 1, group number is 2, device address is 0, and the frame type is 1 (101 0000 0001). Frame data 20 indicates there is no error in the status; 60 is a fixed return value without practical meaning.
Store Z at the position of command string 0 in the non-volatile memory	Send	0x0101	56 33 30 30 30 52	The frame ID direction is 0, the group number is 2, the device address is 0, and the frame type is 1 (001 0000 0001). The frame data is 73 30 5A 52 (sOZR).
	Receive	0x0501	None	Return immediately. The frame ID direction is 1, group number is 2, device address is 0, and the frame type is 1 (101 0000 0001).
	Receive	0x0501	20 60	Return after the movement is finished. The frame ID direction is 1, group number is 2, device address is 0, and a frame type is 1 (101 0000 0001). The frame data 20 indicates that there is no error in the status; 60 is a fixed return value without practical meaning.
Query firmware version number	Send	0x0106	32 33	The direction of the frame ID is 0, group number is 2, device address is 0, and the frame type is 6 (001 0000 0110). Frame data is 32 33 (23).
	Receive	0x0503	20 60 32 33 31 32 32 37	The frame ID direction is 1, group number is 2, device address is 0, and a frame type is 3 (101 0000 0011). Frame data 20 indicates that the status has no error; 60 is a fixed return value without practical meaning; Frame data 32 33 31 32 32 37 (231227).
	Receive	0x0506	31 30 36	Return after the movement is completed. The frame ID direction is 1, group number is 2, device address is 0, and frame type is 1 (101 0000 0110). Frame data 31 30 36

(106).

Execute Multiple Command Actions

Function	Direction	Frame ID	Frame Data (HEX)	Description
Set subdivision to N0, initialize, and switch valve to input port, then set the speed to 600 increments per second, lastly plunger moves to absolute position at 300 increments	Send	0x0103	4E 30 5A 49 56 36 30 30	The frame ID direction is 0, group number is 2, device address is 0, and frame type is 3 (001 0000 0011). Frame data 4E 30 5A 49 56 36 30 30 (N0ZIV600).
	Send	0x0104	4D 31 30 30 30 41 33 30	The direction of the frame ID is 0, group number is 2, the device address is 0, and the frame type is 3 (001 0000 0100). Frame data 4D 31 30 30 30 41 33 30 (M1000A30).
	Send	0x0101	30 52	The direction of the frame ID is 0, the group number is 2, the device address is 0, and the frame type is 3 (001 0000 0001). Frame data is 30 52 (0R).
	Receive	0x0501	None	Return immediately. Frame ID direction is 1, group number is 2, device address is 0, and frame type is 1 (101 0000 0001).
	Receive	0x0501	20 60	Return after the movement is completed. Frame ID direction is 1, group number is 2, a device address is 0, and frame type is 1 (101 0000 0001). Frame data 20 indicates that there is no error in the status; 60 is a fixed return value without practical meaning.

The entire movements will start from syringe pump initializing valve and plunger in clockwise direction; then the valve switched to input port, followed by moving the plunger to 300 increments. Next the valve will be switched to additional port, and piston moved to 0 increment. The syringe pump will switch back the valve to input port, and move the piston to 300 increments position. The last step is switching the valve to output port and moving it to the position of 0 increment.

4. Q&A

Note: Below descriptions are troubleshooting methods for faults that may occur for operation complying required working environment and under rated operating conditions.

Q	A

1	After power on, the LED indicator of the syringe pump did not flash once and then go off	Poor connection of the B15 plug power cable. Use a multimeter to test the connection between DB15 and the cable. Check if the DB15 plug is loosen. Confirm if the power supply 24V and the ground end are well-connected.
		Power supply short-circuit. Confirm if there is a short-circuit between the DB15 plug, the 24V output at the power supply end and the ground.
		Incorrect cable connection. Refer to Chapter 2.2 and check cable connections.
2	Failure to establish connection with the syringe pump	Incorrect baud rate. Default baud rate of the syringe pump serial port is 9600, and CAN baud rate is 100k.
		Incorrect cable connection. Refer to Chapter 2.2 to check cable connection.
		Incompatible serial port tools. Replace other manufacturer's serial port cable, adapter or serial port communication assistant.
		Incorrect address. Refer to Chapter 2.3.1 to check current device address.
		Incorrect command format. Check command format. Refer to Chapter 3.5 Applications Example.
		The protocol is locked. Commands of other protocols were sent during power on, which are inconsistent with the protocol currently in use. Try powering off or resetting and restarting, and then send the required protocol commands.
3	Unstable communication with the syringe pump	There is noise on the communication line. Please ensure that the communication line is as short as possible, separate the communication cable from the high current cable, and keep the two phases CAN and RS485 terminating resistance at 60Ω.
		The communication mode is unstable. Use a slower baud rate for communication and use one question one answer communication method. Keep an interval of over 10ms between serial port commands. Use the retransmission mechanism to ensure the reliability of communication.
4	Recommendation for communication method	It is recommended to use the CAN standard frame communication mode. The device will actively report when an action is completed or there is an exception command. Next action command can be issued after the device action is completed. Query commands can be used during the movement process.
		For serial port, it is recommended to use OEM protocol and adopt the one question one answer method. You can send the next frame only after receiving the response. The interval between sending

		and receiving should be at least 10ms. During actions, current status can be queried by sending "Q" or "?29". Once the status changes from "busy" to "idle", next movement command can be issued.	
5	How to determine if an action is completed?/Can a flag bit be reported once a movement is completed?	When using serial port communication, query the device status using the "Q" or "?29" command. When the status changes from "busy" to "idle", once the current movement is completed, the next movement command can be issued.	
		When using CAN communication, the device will automatically report a frame indicating the movement completion once the action is finished. It indicates the next movement command is available to issue after current action is completed once the flag is reported.	
6	Which parameters can be saved during a power outage?/How to save the set parameters during a power outage?	For parameters stored in non-volatile memory, after the settings are completed, restart the device or send a reset and restart command, and the parameters will be automatically saved. There is no separate save command. The main commands are mainly as follows: U, s, >.	
		Syringe parameter setting commands: L, v, V, S, and c, after setting the commands, the values will resume to default value after initializing the syringe pump or resetting and restarting.	
7	What to do if trying to use N2 subdivision mode to control the pump for aspiration and dispense, but hoping the initialization speed to be same as the N0 subdivision mode?	Use a combined command to achieve this function. For example, use "N0ZN2R" as the initialization command. The function of this command is to first set the syringe pump to the N0 subdivision mode, then initialize it with default parameters, and then set it to N2 subdivision mode. Similarly, as long as the byte length does not exceed 255, other functions can combine together to use.	
8	What to do if the device reports an error?	Record the status feedback by the device and the current execution process when the error occurs. If the following solutions fail to provide effective assistance, please contact our company. Here are some scenarios and corresponding solutions.	
		Error code 1	Initialization error. Error occurs when the pump fails to initiate initialization or the initialization fails. Please check if the plunger is stuck by foreign objects. If there is no abnormality, please initialize the pump again.
		Error code 2	Invalid command. This error occurs when an unrecognizable command is issued. Please

	refer to Chapter 3.2 Communication Protocols and Chapter 3.5 Application Examples for the command format and usage.
Error code 3	Invalid operand. This error occurs when the parameter of the instruction is invalid, please check the writable range of the parameter.
Error code 4	Invalid command sequence. When using the "s" and "e" commands, this error will occur if the command structure is incorrect. Please check the command format.
Error code 6	This error will occur when the EEPROM malfunctions. If this error occurs, please try restarting the device. If the problem persists, please contact our company.
Error code 7	Device not initialized. This error occurs when the pump is not initialized. To clear this error, please initialize the pump.
Error code 9	Plunger overload. This error occurs when the syringe plunger encounters excessive resistance. Please check if the pipeline is blocked. Use initialization operation to clear the error.
Error code 10	Valve overload. This error occurs when the valve fails to move due to blockage or excessive obstruction. Please initialize the valve to clear this error.
Error code 11	Plunger movement is not allowed. This error occurs when a plunger movement command is sent but the valve is not connected to the syringe. Please check the current channel position.
Error code 12	Internal error. If this error occurs, please contact our company.
Error code 15	Command overflow. This error occurs when a movement command is sent while the syringe pump is in motion. Please send the next movement command after the current movement is completed.

5. Maintenance

Maintenance intervals vary depending on the application, but it is recommended that the maintenance intervals below are followed in order to maintain optimal syringe pumps performance.

5.1 Routine Maintenance

Perform the following tasks on a daily basis to ensure proper syringe pump operation:

- Check the pump for leaks and correct any potential faults.
- Clean up the pump and spills around the pump
- Thoroughly rinse the pump(including the syringe) with distilled or DI water after use it and when it is not in use.

Note: Prohibit dry grinding operation many times without liquid infiltration.

5.2 Weekly Maintenance

Deposits in the fluid path, such as salt, must be cleaned weekly to inhibit bacterial growth. One of the three cleaning solutions below can be used:

- Diluted cleaning solution
- Weak acids and bases
- 10% bleach
- The cleaning process for the above solutions is described in the following sections.

Diluted Cleaning Solution Cleaning Process

To clean the pump with diluted cleaning solution, follow these steps:

1. Fill the pump with diluted cleaning solution and remain the solution in the pump for 30 minutes.
2. After 30 minutes, empty all liquid from the syringe and lines into the waste container.
3. Suction and discharge at least 10 times with a full pump of distilled or DI water.
4. The flow paths need to be filled with distilled or DI water when storing the pump.

Note: Cleaning solution is a reagent that can be similar to and be miscible with the application medium or a neutral solution

Weak Acids and Weak Bases Cleaning Process

To clean the pump with weak acids and bases, follow these steps:

1. Fill the pump with 0.1 mol/L NaOH and remain the solution in the pump for 10 minutes.
2. Flush the pump with distilled or DI water.

3. Fill the pump with 0.1 mol/L Hcl and remain the solution in the pump for 10 minutes.
4. After 10 minutes, empty all liquid from the syringe and lines into the waste container.
5. Suction and discharge at least 10 times with a full pump of distilled or DI water.
6. The flow paths need to be filled with distilled or DI water when storing the pump.

10% Bleach Cleaning Process

To clean the pump with 10% bleach, follow these steps:

1. Prepare 10% bleach (1x bleach and 9x water)
2. Fill the pump with 10% bleach and remain the solution in the pump for 30 minutes.
3. After 30 minutes, empty all liquid from the syringe and lines into the waste container.
4. Suction and discharge at least 10 times with a full pump of distilled or DI water.
5. The flow path needs to be filled with distilled or DI water when storing the pump.

5.3 Periodic Maintenance

The pipes, syringe seals and valve head require periodic maintenance. Determine to replace them or not based on the following situations.

- poor accuracy or repeatability
- glass pipe full of liquid with bubbles
- liquid spill

If one of the above situations occur and it cannot be determined which part is causing the problem, replacing
parts in the following order is easier to recognize as well as more effective:

- the paths of inlet and outlet
- piston seals (or glass syringes)
- valve head

The frequency of replacement will depend on the number of uses, the liquid in contact with the flow path, and the maintenance of the instrument.

Quality Control Assurance

Periodically check the accuracy and repeatability of the syringe pump. It is recommended to use an analytical balance with 0.01 mg accuracy to check the accuracy of the syringe pump by gravimetric analysis. The syringe can be calibrated according to the weight of the target liquid compared to the weight of the actual dispensed liquid.

To determine precision and repeatability, at least 20 replicate runs of assay data are recommended. Precision, mean, standard deviation and coefficient of variation are then calculated

(see formulas below). The specific gravity of water needs to be taken into account when calculating, and the specific gravity of water is directly related to room temperature. Generally, the specific gravity of water is 0.99707 at a room temperature of 25℃. In addition, the liquid may adsorb at the tip of the line during discharge, and in order to prevent measurement errors caused by the liquid sticking to the tip of the line, a small amount of surfactant (e.g., 0.01% concentration of Fluorad®) needs to be added to the water.

Coefficient of variation = (standard deviation / mean) * 100

$$\%CV = \left(\frac{\sqrt{\frac{1}{n-1}\left\{\sum_{i=1}^{n} X_i^2 - n\bar{X}^2\right\}}}{\bar{X}} \right) * 100$$

$$\%Accuracy = \left[\frac{\left(\frac{\bar{X}}{sg}\right) * 100}{Vol_{expected}} \right] - 100$$

Here:

Sg: specific gravity of pure water at 25 ° C, Sg = 0.99707;

$Vol_{expected}$: the expected dispensed volume

n: number of fluid dispensing

X: the result of a single test

$\bar{X}$: The average of all results

Replace the Dispensing Line or Reagent Line

To replace the dispensing or reagent line, follow these steps:

1. Remove the old fitting and use the corresponding threaded wrench to gently loosen the fitting and remove the line.
2. Install a new line, screw the fitting into the valve head, and tighten it with your fingers.
3. Set the upper limit of the torque of the threaded wrench to 1.5-3kgf • cm, and use the threaded wrench to tighten the pipe joint.

Replace the Valve Head of the Syringe Pump

To replace the valve head of the syringe pump, refer to 2.4.1 Installation of Syringe Valve;

Replace the Syringe

To replace the syringe, refer to 2.4.2 Installation of Syringe.

6. Appendix A ASCII Chart

Bin	Oct	Dec	Hex	Abbreviation/Bytes	Description
0000 0000	0	0	0x00	NUL(null)	Null
0000 0001	1	1	0x01	SOH(start of headline)	start of headline
0000 0010	2	2	0x02	STX (start of text)	start of text
0000 0011	3	3	0x03	ETX (end of text)	end of text
0000 0100	4	4	0x04	EOT (end of transmission)	end of transmission
0000 0101	5	5	0x05	ENQ (enquiry)	enquiry
0000 0110	6	6	0x06	ACK (acknowledge)	acknowledge
0000 0111	7	7	0x07	BEL (bell)	bell
0000 1000	10	8	0x08	BS (backspace)	backspace
0000 1001	11	9	0x09	HT (horizontal tab)	Horizontal tab
0000 1010	12	10	0x0A	LF (NL line feed, new line)	NL Line feed
0000 1011	13	11	0x0B	VT (vertical tab)	vertical tab
0000 1100	14	12	0x0C	FF (NP form feed, new page)	NP form feed
0000 1101	15	13	0x0D	CR (carriage return)	Carriage return
0000 1110	16	14	0x0E	SO (shift out)	Shift out
0000 1111	17	15	0x0F	SI (shift in)	Shift in
0001 0000	20	16	0x10	DLE (data link escape)	Data link escape
0001 0001	21	17	0x11	DC1 (device control 1)	Device control 1
0001 0010	22	18	0x12	DC2 (device control 2)	Device control 2
0001 0011	23	19	0x13	DC3 (device control 3)	Device control 3
0001 0100	24	20	0x14	DC4 (device control 4)	Device control 4
0001 0101	25	21	0x15	NAK (negative acknowledge)	Negative acknowledge
0001 0110	26	22	0x16	SYN (synchronous idle)	Synchronous idle
0001 0111	27	23	0x17	ETB (end of trans. block)	End of trans. block
0001 1000	30	24	0x18	CAN (cancel)	Cancel
0001 1001	31	25	0x19	EM (end of medium)	End of medium
0001 1010	32	26	0x1A	SUB (substitute)	Substitute
0001 1011	33	27	0x1B	ESC (escape)	Escape
0001 1100	34	28	0x1C	FS (file separator)	File separator
0001 1101	35	29	0x1D	GS (group separator)	Group separator
0001 1110	36	30	0x1E	RS (record separator)	Record separator
0001 1111	37	31	0x1F	US (unit separator)	Unit separator

0010 0000	40	32	0x20	(space)	Space
0010 0001	41	33	0x21	!	Exclamation mark
0010 0010	42	34	0x22	″	Double quote
0010 0011	43	35	0x23	#	Number sign
0010 0100	44	36	0x24	$	Dollar
0010 0101	45	37	0x25	%	Percent sign
0010 0110	46	38	0x26	&	Ampersand
0010 0111	47	39	0x27	’	Single quote
0010 1000	50	40	0x28	(	Open parenthesis
0010 1001	51	41	0x29	)	Close parenthesis
0010 1010	52	42	0x2A	*	Asterisk
0010 1011	53	43	0x2B	+	Plus
0010 1100	54	44	0x2C	,	Comma
0010 1101	55	45	0x2D	-	Hyphen-minus
0010 1110	56	46	0x2E	.	Period, dot or full stop
0010 1111	57	47	0x2F	/	Slash or divide
0011 0000	60	48	0x30	0	Zero
0011 0001	61	49	0x31	1	One
0011 0010	62	50	0x32	2	Two
0011 0011	63	51	0x33	3	Three
0011 0100	64	52	0x34	4	Four
0011 0101	65	53	0x35	5	Five
0011 0110	66	54	0x36	6	Six
0011 0111	67	55	0x37	7	Seven
0011 1000	70	56	0x38	8	Eight
0011 1001	71	57	0x39	9	Nine
0011 1010	72	58	0x3A	:	Colon
0011 1011	73	59	0x3B	;	Semi colon
0011 1100	74	60	0x3C	<	Less than(or open angled bracket)
0011 1101	75	61	0x3D	=	Equals
0011 1110	76	62	0x3E	>	Greater than(or close angled bracket)
0011 1111	77	63	0x3F	?	Question mark
0100 0000	100	64	0x40	@	At sign
0100 0001	101	65	0x41	A	Uppercase A
0100 0010	102	66	0x42	B	Uppercase B
0100 0011	103	67	0x43	C	Uppercase C
0100 0100	104	68	0x44	D	Uppercase D

0100 0101	105	69	0x45	E	Uppercase E
0100 0110	106	70	0x46	F	Uppercase F
0100 0111	107	71	0x47	G	Uppercase G
0100 1000	110	72	0x48	H	Uppercase H
0100 1001	111	73	0x49	I	Uppercase I
1001010	112	74	0x4A	J	Uppercase J
0100 1011	113	75	0x4B	K	Uppercase K
0100 1100	114	76	0x4C	L	Uppercase L
0100 1101	115	77	0x4D	M	Uppercase M
0100 1110	116	78	0x4E	N	Uppercase N
0100 1111	117	79	0x4F	O	Uppercase O
0101 0000	120	80	0x50	P	Uppercase P
0101 0001	121	81	0x51	Q	Uppercase Q
0101 0010	122	82	0x52	R	Uppercase R
0101 0011	123	83	0x53	S	Uppercase S
0101 0100	124	84	0x54	T	Uppercase T
0101 0101	125	85	0x55	U	Uppercase U
0101 0110	126	86	0x56	V	Uppercase V
0101 0111	127	87	0x57	W	Uppercase W
0101 1000	130	88	0x58	X	Uppercase X
0101 1001	131	89	0x59	Y	Uppercase Y
0101 1010	132	90	0x5A	Z	Uppercase Z
0101 1011	133	91	0x5B	[	Opening bracket
0101 1100	134	92	0x5C	\	Backslash
0101 1101	135	93	0x5D	]	Closing bracket
0101 1110	136	94	0x5E	^	Caret-circumflex
0101 1111	137	95	0x5F	_	Underscore
0110 0000	140	96	0x60	`	Grave accent
0110 0001	141	97	0x61	a	Lowercase a
0110 0010	142	98	0x62	b	Lowercase b
0110 0011	143	99	0x63	c	Lowercase c
0110 0100	144	100	0x64	d	Lowercase d
0110 0101	145	101	0x65	e	Lowercase e
0110 0110	146	102	0x66	f	Lowercase f
0110 0111	147	103	0x67	g	Lowercase g
0110 1000	150	104	0x68	h	Lowercase h
0110 1001	151	105	0x69	i	Lowercase i
0110 1010	152	106	0x6A	j	Lowercase j
0110 1011	153	107	0x6B	k	Lowercase k

0110 1100	154	108	0x6C	l	Lowercase l
0110 1101	155	109	0x6D	m	Lowercase m
0110 1110	156	110	0x6E	n	Lowercase n
0110 1111	157	111	0x6F	o	Lowercase o
0111 0000	160	112	0x70	p	Lowercase p
0111 0001	161	113	0x71	q	Lowercase q
0111 0010	162	114	0x72	r	Lowercase r
0111 0011	163	115	0x73	s	Lowercase s
0111 0100	164	116	0x74	t	Lowercase t
0111 0101	165	117	0x75	u	Lowercase u
0111 0110	166	118	0x76	v	Lowercase v
0111 0111	167	119	0x77	w	Lowercase w
0111 1000	170	120	0x78	x	Lowercase x
0111 1001	171	121	0x79	y	Lowercase y
0111 1010	172	122	0x7A	z	Lowercase z
0111 1011	173	123	0x7B	{	Opening brace
0111 1100	174	124	0x7C	|	Vertical bar
0111 1101	175	125	0x7D	}	Closing brace
0111 1110	176	126	0x7E	~	Equivalency sign - tilde
0111 1111	177	127	0x7F	DEL (delete)	Delete

7. Safety precautions

For the personal safety of you and other users and to prevent damage caused by improper operation, please read the safety precautions carefully.

This manual uses the following symbols. Please fully understand what they represent before continuing.

Warning	Where the content with the mark is related to the safe use of the product and the personal safety of the user, it must be operated in strict accordance with the requirements, otherwise it may cause damage to the product or endanger the personal safety of the user.
Caution	The content with the mark is the part that users must pay attention to, otherwise it will cause product damage or other losses due to improper operation.

Caution
Confirm the specification: Please fully consider the use, fluid, environment and other conditions of use, and use within the scope of the specification to avoid damage to the product;
Material selection: For the media tolerance is not clear, first do the corresponding experiment to confirm the material, and then confirm whether the selected model is suitable;
The electromagnetic coil of this product has no waterproof function. If water or liquid drops accidentally splash on the solenoid valve during use, please wipe it as soon as possible to avoid water penetrating into the coil and causing short circuit. If you need to contact with water frequently, please configure waterproof protective devices;
Special fluorinated rubber and perfluorinated rubber are greatly affected by temperature, please avoid high frequency use at low temperatures;

Warning
1. Installation position: Do not put the inlet and outlet of the valve towards the position where the human body may contact, to avoid high pressure air impact on the human body after the solenoid valve is accidentally loosened;
2. Installation operation: The rotation of the coil assembly of this product will cause poor product performance. Do not use hands or tools to twist or rotate the proportional valve coil when installing this product;
3. Installation environment: Avoid using the solenoid valve near the heat source with high temperature;
4. Maintenance and repair: For abnormal occurrence, please contact the manufacturer first, do not directly disassemble and assemble, to avoid irreparable damage, and avoid failure to confirm the cause of the abnormal.

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VERSION NUMBER 1.0