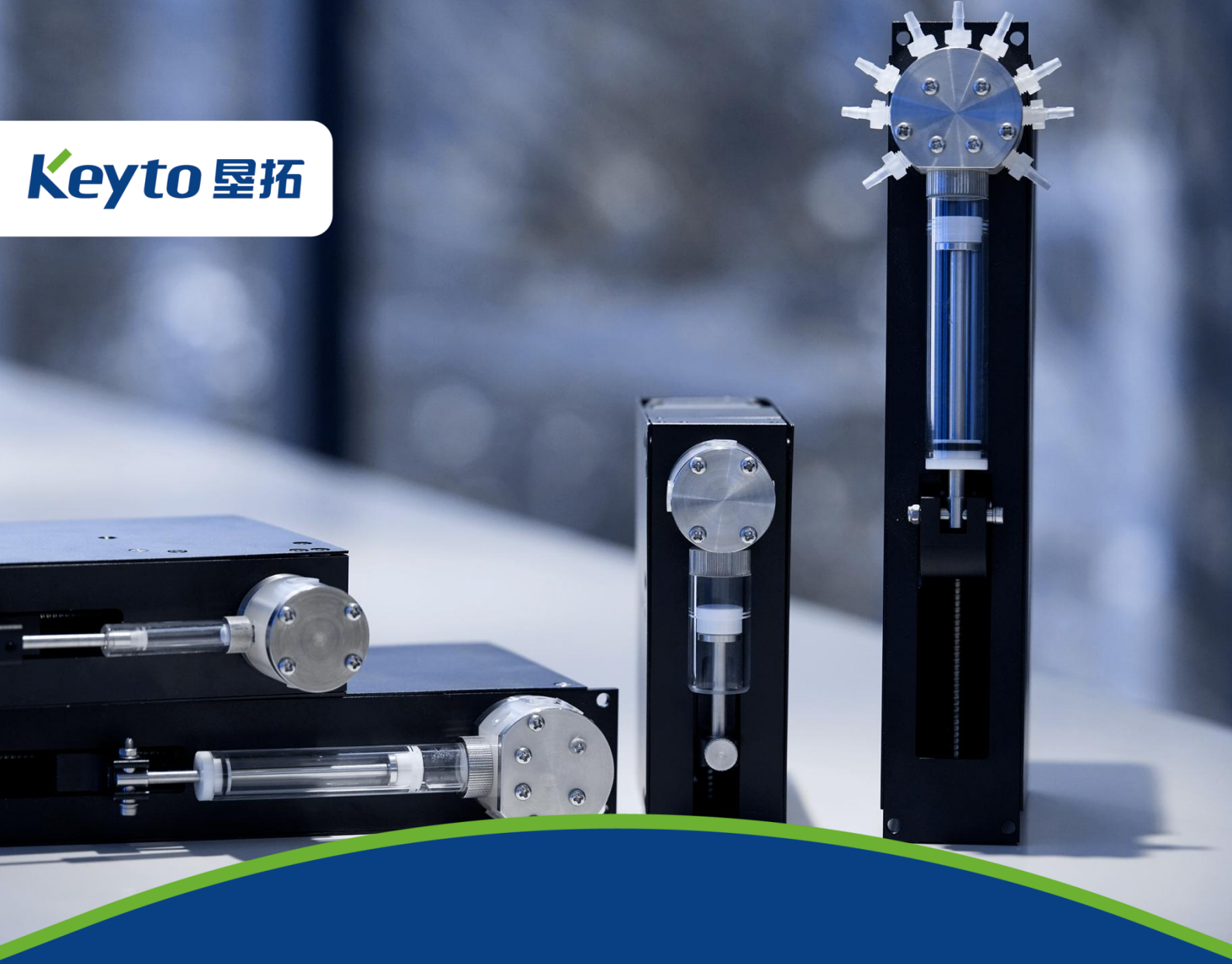


Keyto 昊拓

MSP Series Rotary Valve 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. By inputting the corresponding commands, users can easily perform the desired functions.

1.1 Features Overview

This product is a compact syringe pump with the following features and functions:

- Two modes: Standard mode with a resolution of 6000 steps and Microstep mode with a resolution of 48000 steps;
- Glass syringes compatible with 100 µL, 250 µL, 500 µL, and 1.0 mL volumes;
- Corrosion-resistant materials in contact with reagents, mainly made of borosilicate, UHMWPE, PEI, FFKM;
- Compatible with a variety of valve heads, see 1.3.2 for details;
- Dual, quad, hex and octa channel available for option
- Compatible with RS-232, RS-485 and CAN interfaces;
- Adjustable operating speed, the syringe pump 60mm stroke maximum speed at 1.2 s/60 mm and a minimum speed at 160min/60 mm; 30mm stroke maximum speed at 1.2s/30mm and a minimum speed at 20min/30mm;
- Transmission mechanism utilizing a ball screw with a linear encoder, featuring step loss detection;
- Easy maintenance: The valve head and syringe offer highly stable and precise liquid handling throughout their lifecycle. Replacing and maintaining these components outside their lifecycle is also straightforward.

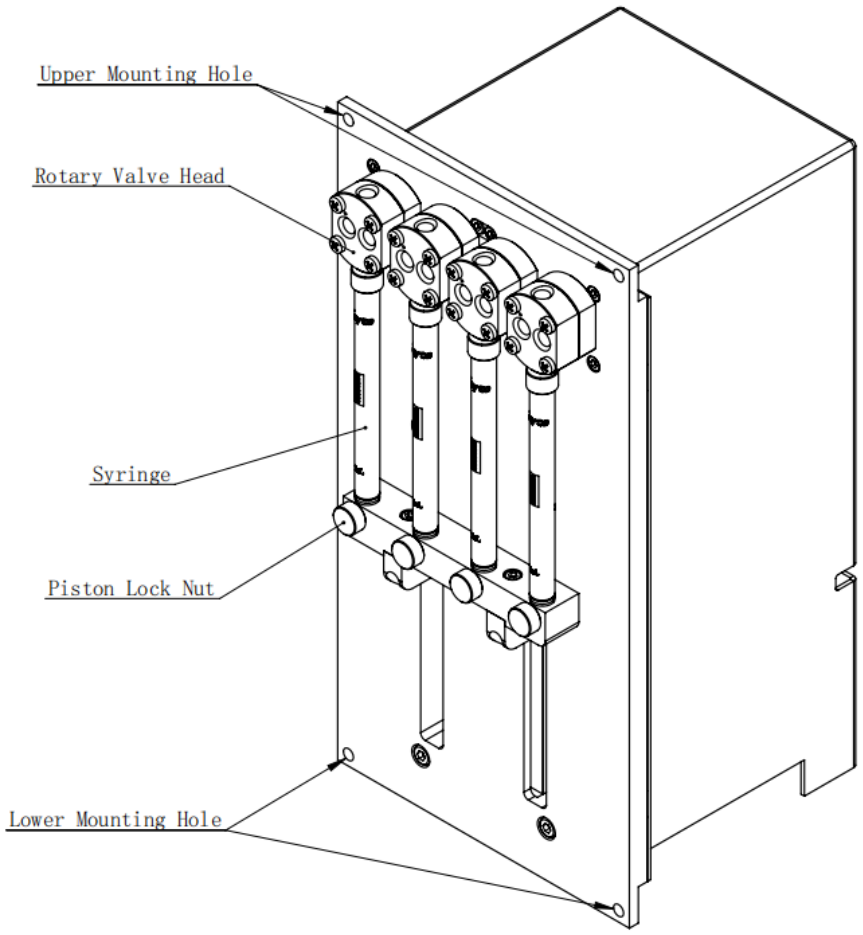
1.2 Terms Definition

- Increment: measurement unit of displacement. When the syringe subdivision is set to N0, 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 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 syringe is driven back and forth by a stepper motor with a ball screw drive, and step loss detection is performed using a linear encoder. The effective stroke of the syringe is 60mm. When set to N0 subdivision, the full stroke is 6000 increments; when set to N1 and N2 subdivision, the full stroke is 48000 increments. The base of the syringe plunger is secured to the nut by a knurled screw on the pusher plate. The top of the syringe is connected to the valve head with a 1/4-28 UNF-2A thread.

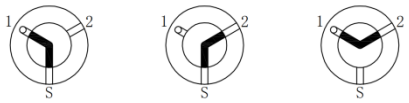
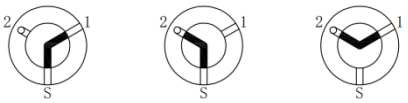
Applicable syringe sizes: 100μL, 250μL, 500μL, 1.0 mL.

Valve Head and Valve Head Drive

The valve head is made of PEEK stator and PTFE rotor. The rotor and stator rotate relative to each other, connecting the syringe port to the respective output ports. The valve head is driven by a stepper motor equipped with an encoder for position feedback.

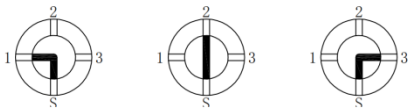
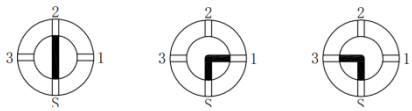
Applicable valve head specifications are as follows:

Three-Way Non-Distribution Rotary Valve Head

Z command reset example			Y command reset example		
					
I command Input syringe connects to the left port	O command Output syringe connects to the right port	B command Bypass the left port connects to the right port	I command Input syringe connects to the left port	O command Output syringe connects to the right port	B command Bypass the left port connects to the right port.

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

Three-Way Distribution Type Rotary Valve Head

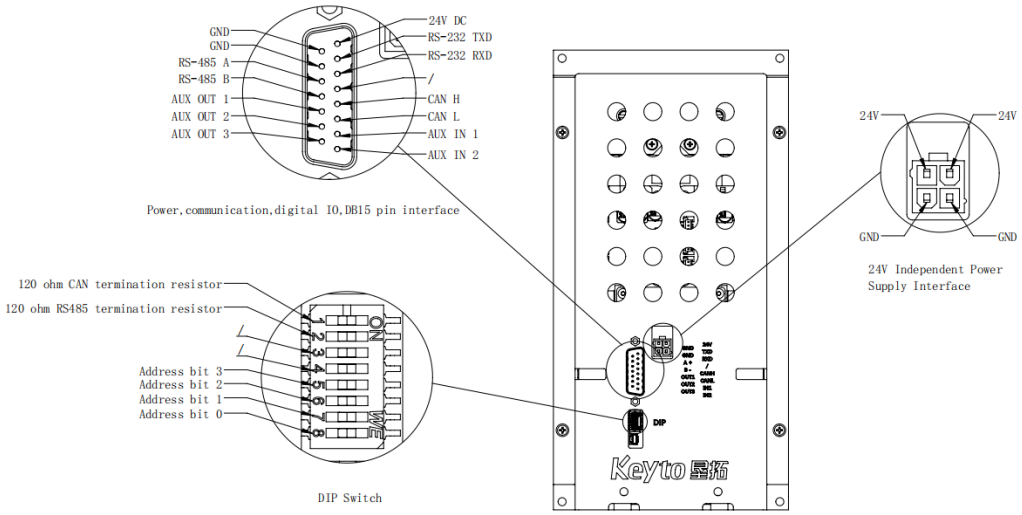
Z command reset example			Y command reset example		
					
I command Input syringe connected to the left port	O command Output syringe connected to the top port	B command Bypass syringe connects to the right port	I command Input syringe connected to the top port	O command Output syringe connected to the right port	B command Bypass syringe connects to the left port.

Three-Way Distribution Type Rotary Valve Head Port Description

Controller

This product includes a controller with a microprocessor and circuits to control the operation of the glass syringe and valve head. It also features a DB15 communication interface for power supply and communication, as well as a DIP switch to manage the address. It also includes a 4pin 24V independent power supply interface to provide additional current input.

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 operate individually or in a multi-channel configuration using the RS-232, RS-485, or CAN interface. The RS-232 and RS-485 support two baud rates: 9600(default) and 38400. CAN supports multiple baud rates: 100Kb(default), 125Kb, 250Kb, 500Kb, and 1Mb.

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, please refer to Chapter 2, Hardware Settings and Chapter 3 Software Communication.

Note:

1. Before using the syringe pump for any operation, please read this operating manual carefully.
2. 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 an upright position to avoid poor startup.
- Ensure that there is liquid flowing through the syringe and valve head while they are in operation to prevent from damaging the sealing.
- Always turn off the power when connecting or disconnecting the pump.

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

2. Hardware Settings

This chapter includes the following sections, which describes various parts of the hardware settings:

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

2.1 Power and Electrical Considerations

The MSP series syringe pumps require a 24V DC power supply. Different numbers of channels require different rated currents, as detailed in the table below. For power supply currents of 3.0A or less, connection can be made through the DB15 connector. For power supply currents greater than 3.0A, please use the 24V independent power supply interface for connection.

Suggested Power Supply Current for Different Syringe Pump Channels

Syringe Pump Channels Numbers	Suggested Safe Power Supply Current
2	2.0A
4	3.0A
6	4.0A
8	5.0A

Note:

1. External devices with insufficient current supply may cause the product to become unstable under certain loads. In some cases, it may cause the the syringe pump fail to operate.
2. It is recommended not to use 24V independent power supply interface and DB15 power at the same time. In some cases, this may damage the pump controller.

2.2 Hardware Interface

Each syringe pump has a DB15 hardware interface(refer to Table 2) and a 4pin power supply interface(refer to Table 3 and Table 4). DB15 interface can provide power input no more than 3A and communicate with the pump. Each syringe pump can be set with a unique address to identify each syringe pump.

Note:

1. Before connecting or disconnecting the DB15 connector, make sure to turn off the power to the pump.
2. DB15 pin 1 supports maximum current 3A. Supply current exceeding 3A will damage DB15 interface. For any supply current greater than 3A, please use 24V independent power supply interface separately.

DB15 Interface Pin Definitions

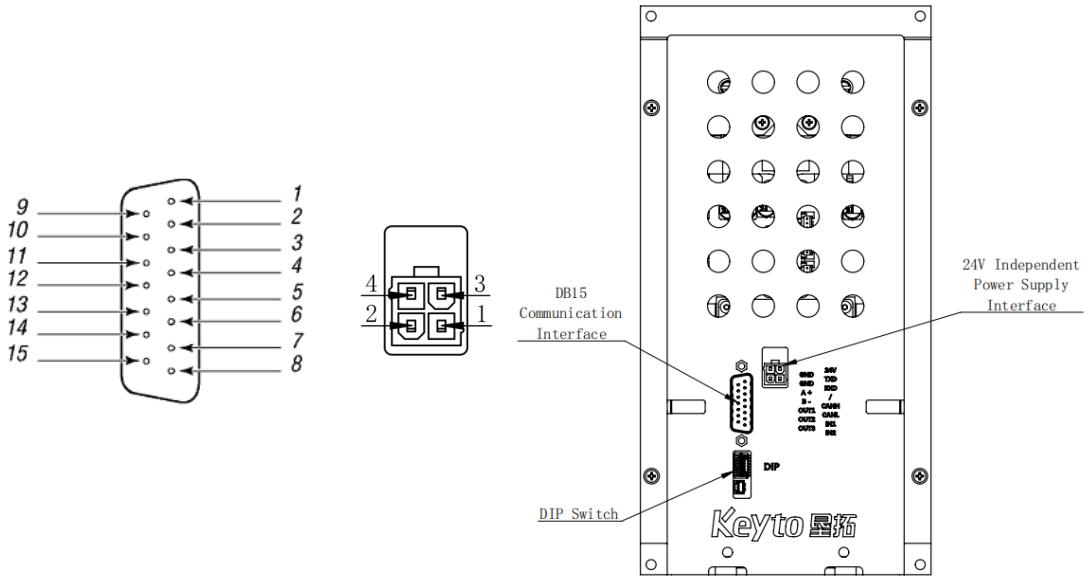
Pin	Function	Remark	Pin	Function	Remark
1	24V DC	Power input 24V ±5%, ≥ 2A	9	GND	Power Ground
2	RS-232 TXD	Communication Interface	10	GND	Power Ground
3	RS-232 RXD	Communication Interface	11	RS-485 A	Communication Interface
4	/	/	12	RS-485 B	Communication Interface
5	CAN H	Communication Interface	13	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	/	/	/

24V Independent Power Supply Interface Pin Definition

Pin	Function	Remark
1	GND	Power Ground
2	GND	Power Ground
3	24V DC	Power input 24V
4	24V DC	Power input 24V

24V Independent Power Supply Interface Wiring

Housing Model	Terminal Model	Wiring
Molex 39012040	Molex 39000038	AWG18-24

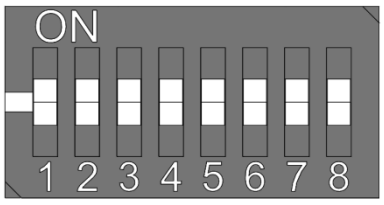


DB15 pin indication, 24V independent power supply interface pin indication and syringe pump DB15, power supply interface location indicator

2.3 Control Settings

DIP Switch

The DIP switch has 8 digits of DIP codes, (as belowError! Reference source not found.Address Setting Switch)located on the lower left side of the rear panel of the syringe pump. 4 positions are used to modify the address of each syringe pump for commissioning or linkage use. Users can send specific commands to the specified syringe pump to control the pump operation, and 4 positions are used to short the 120 ohm 485 shorting resistor and short the 120 ohm CAN shorting resistor. DIP address refer toError! Reference source not found. and 24V Independent Power Supply Interface Pin Definition. When you need to set the address, you can use tweezers or a small one-piece screwdriver to adjust the switch to the target address.



Address Setting Switch

DIP Switch Address Correspondence Table

Number	Function	Description
1	120 Ohm CAN Termination Resistor	ON: Connected OFF: Disconnected
2	120 Ohm RS485 Termination Resistor	ON: Connected OFF: Disconnected
3	Reserved	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	Reserved	
5	Address bit3	
6	Address bit2	
7	Address bit1	
8	Address bit0	

Address Setting Mapping Table

Address bit3	Address bit2	Address bit1	Address bit0	Dial code address	Single pump control address		2 pump control address		4 pump control 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 after issuing commands. Each device needs to be queried separately.

Self-test

When the DIP switch last four bits are “ON”, the syringe pump will run a self-test program 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 allow the syringe pump to run dry multiple times, i.e. without liquid.

2.4 Component Installation

Installing the syringe

To install the syringe, follow these steps:

1. Initialize the syringe pump.
2. Loosen the plunger lock nut about three turns.
3. Lower the plunger height by sending the command [A6000R].
4. Install the syringe:

- Screw the syringe into the valve head until the top of the syringe is in contact with the bottom hole of the valve head threads.
- Pull down the syringe plunger rod until it aligns with the bottom hole of the pusher plate.
- Tighten the syringe by rotating it 1/8 to 1/4 turn.
- Tighten the plunger lock nut.

5. Reinitialize the pump.

Note: If the syringe end is non-PTFE, an additional PTFE gasket is required to aid in sealing, given the reliability of the seal.

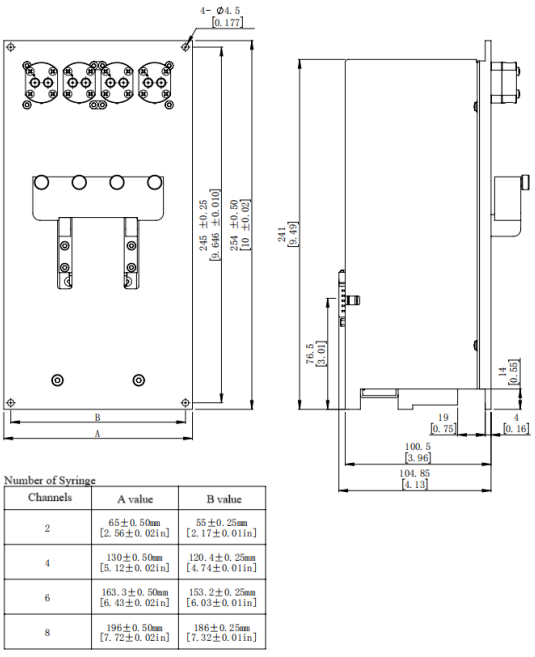
Install the Syringe Pump Valve Head

To install the syringe pump valve head, follow these steps:

1. Run the syringe pump to suck 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 valve to the home position.
3. Send the [A6000R] command to run the syringe plunger to its maximum stroke.
4. Remove the syringe and connection management.
5. Remove the set screw of the valve head and then remove the valve head from the pump.
6. Install the new valve head on the front panel, aligning the motor shaft of the rotary valve with the internal hole of the valve head. Align the valve head installation hole and dowel pin with the threaded holes and dowel pin holes on the front panel, then install the fixed screws.
7. Assemble the syringe by screwing it into the valve head for 2 to 3 turns and pulling the syringe plunger until the bottom of the plunger rod aligns with the pusher plate installation hole.
8. Use the plunger lock nut to align the push plate mounting holes for locking.
9. Rotate the syringe until the syringe top contacts the threaded bottom hole of the valve head, then tighten the syringe by rotating it 1/8 to 1/4 turn.

2.5 Complete Device Installation

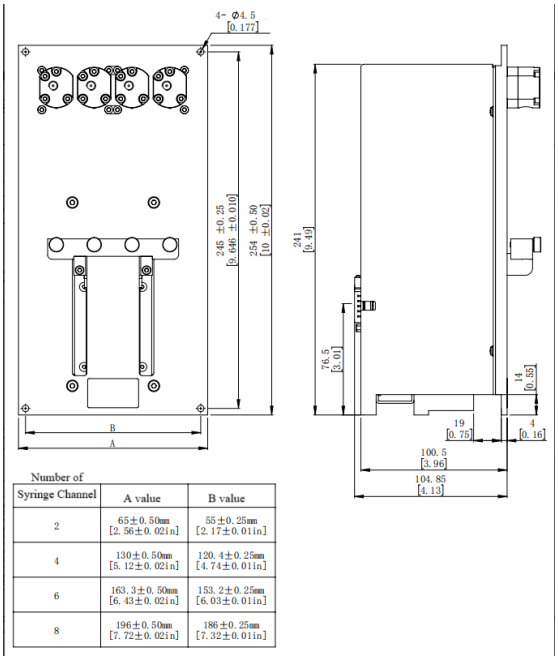
The syringe pump offers various installation options for convenience. Please refer to the following diagram:



Number of Syringe

Channels	A value	B value
2	65±0.50mm [2.56±0.02in]	55±0.25mm [2.17±0.01in]
4	130±0.50mm [5.12±0.02in]	120.4±0.25mm [4.74±0.01in]
6	163.3±0.50mm [6.43±0.02in]	153.2±0.25mm [6.03±0.01in]
8	196±0.50mm [7.72±0.02in]	186±0.25mm [7.32±0.01in]

MSP Series 30mm stroke syringe pump installation size diagram



Number of Syringe Channel

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6	163.3±0.50mm [6.43±0.02in]	153.2±0.25mm [6.03±0.01in]
8	196±0.50mm [7.72±0.02in]	186±0.25mm [7.32±0.01in]

MSP Series 60mm stroke syringe pump installation size diagram

Installation Diagram of the MSP Series Syringe Pump

3. Software Communication

3.1 Communication Interface

The syringe pump supports the following communication interfaces:

- RS232
- RS485
- CAN (standard frame)

Baud rate:

Serial port: 9600 (default), 38400

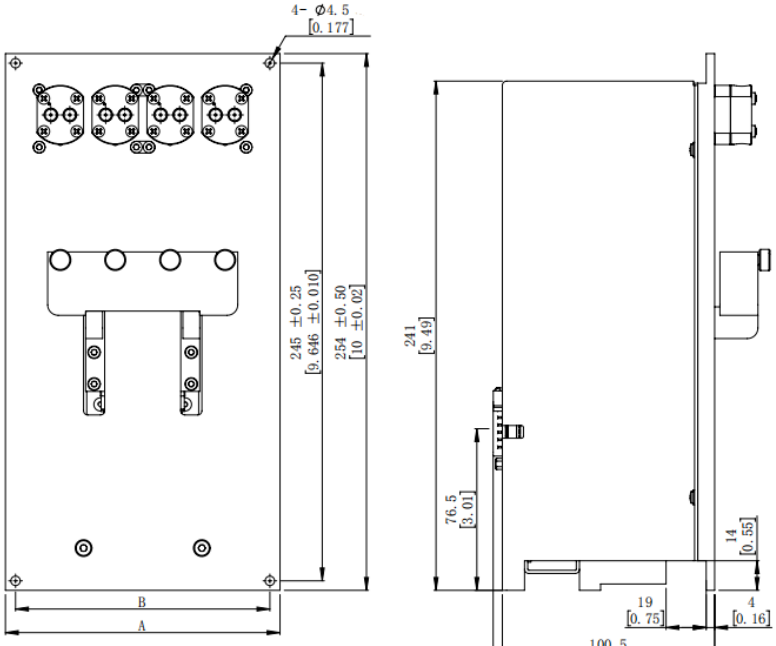
CAN: 100K (default), 125K, 250K, 500K, 1000K

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.

Cabling diagram of each communication method please refer to RS232 Communication and Cabling Diagram, RS485 Communication and Cabling Diagram and CAN Bus Communication and Cabling Diagram.

RS232 Communication and Cabling



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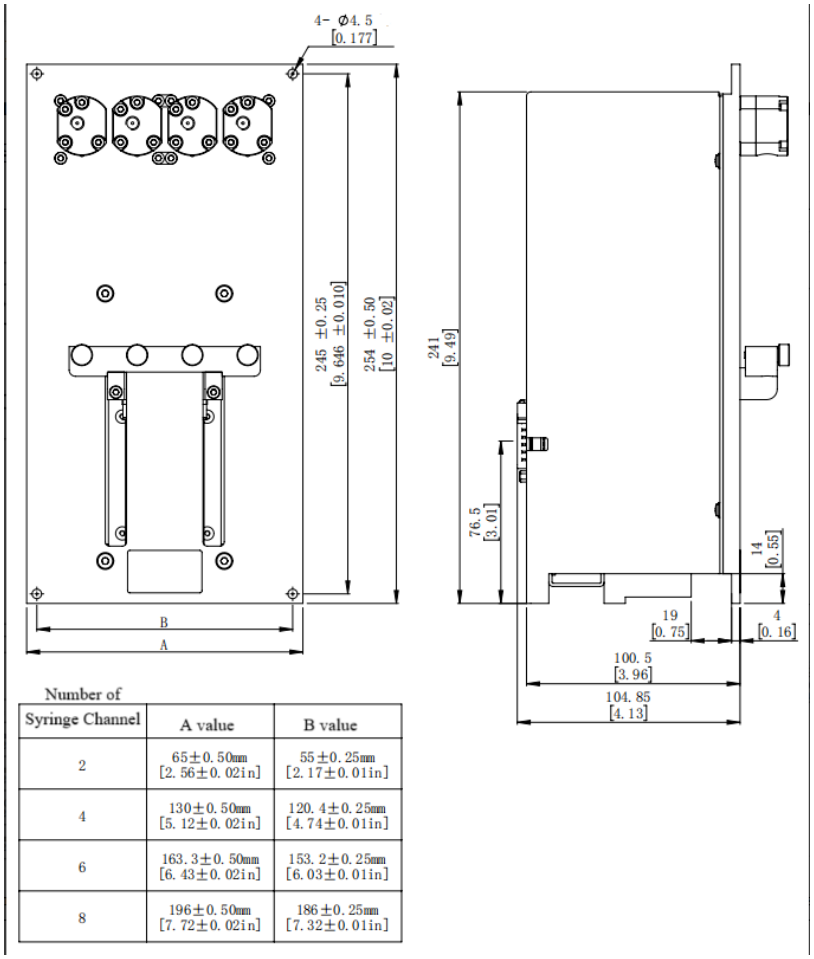
8	196±0.50mm [7.72±0.02in]	186±0.25mm [7.32±0.01in]

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 Diagram

RS485 Communication and Cabling



Number of

Syringe Channel	A value	B value
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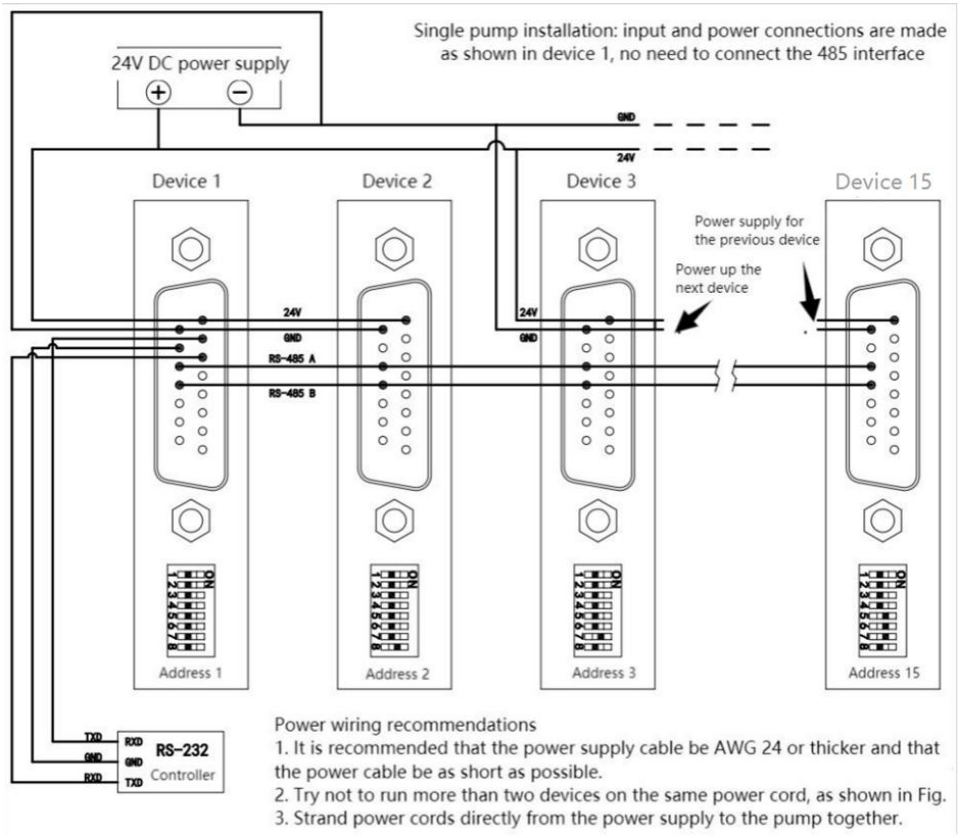
RS485 Communication and Cabling Diagram

CAN Bus Communication and Cabling



CAN Bus Communication and Cabling 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. The CAN extended frame protocol supports a maximum of 255 devices on the same communication link and uses an object dictionary in a more concise structure.

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	Function	Number of bytes	ASCII	HEX	Description
1	Start Character	1	/	0x2F	Indicates the start of a command frame
2	Device Address	1			ASCII character, see Control Address in Address Setting Mapping Table
2+n	Command string	n			ASCII command strings, see operation commands for details

DT Return Data Protocol Format

Serial number	Function	Number of bytes	ASCII	HEX	Description
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

					Address Setting Mapping Table
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 return data
5+n		1	Carriage return [CR]	0x0D	
6+n		1	Line break [LF]	0x0A	

For example, to initialize the syringe pump at address 1, send the command "/1ZR" followed by a carriage return[CR].

Status Table

Status Bytes								Error Code	Description
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 error
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 blocking
5	Plunger zero optocoupler error	6	Plunger motor blocking
7	Storage error	8	CAN communication error
9	Pressure sensor error		

OEM Protocol Format

OEM Send 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 character, see Control Address in Table 6
3	Serial Number	1			Range “0x30-0x3F”, please refer to Table 10 for details
2+n	Command String	n			ASCII command strings, see Operation Commands
3+n	End Character	1	End-of-Text [ETX]	0x03	Indicates the end of a frame of return data
4+n	Calibration	1			XOR checksum of the preceding 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 of a frame of return data
2	Host Address	1	0	0x30	Fixed host address

3	Status	1			Current device status, see Table 9
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 return data
5+n	Calibration	1			XOR checksum of the preceding 4+n data bytes

OEM Serial Number Byte Meanings

Serial Number No.	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 with the previous command string. If they match, the internal execution is skipped, and the previous error status is returned. Otherwise, the current command string is executed normally. This feature can be used to resend command strings in case of communication abnormalities.

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

CAN Standard Frame Protocol Format

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.

CAN 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).

Group: Group number 0-7 (3 bits). Each type of device is assigned with a group number. The syringe pump has a group number of 2, and group number 1 is used for initiating the transmission process.

Device Address: Address 0-15 (4 bits). During the transmission process, the address can be reassigned to the syringe pump through a DIP switch. Once the host confirms the start message, this address becomes the address assigned by the host to the syringe pump.

Frame Type: Types 0, 1, 2, 3, 4, and 6 (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 OEM Return Data Protocol Format.

CAN General Frame Commands

Command	Description
0	Restart the syringe pump and initiate a startup request
1	Execute command or command string, same as the R command
2	Clear command cache
3	Repeat the previous action command string, same as the X command
4	Terminate command execution, same as the X command

Type 3, Multi-Frame Start Frame: When the command or syringe pump response string length exceeds 8 bytes, the multi-frame message format is used, and the start frame is sent using type 3. When the syringe pump receives this frame, it clears the command cache and stores the command from this frame in the cache.

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

Command	Description
0	Report absolute position of the syringe
1	Report 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 plunger movements
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 actions
30-34	Report command string in non-volatile memory
76	Report configuration of syringe pump

When the syringe pump receives a command, completes a command, or encounters an execution error, it sends a response frame to the host using the same frame type as the corresponding command. The first two bytes of the response frame represent the status, where the first byte is 0x20 plus the error code from Table 9, and the second byte is fixed at 0x60. The remaining bytes contain the response in ASCII format. All messages of frame types 1 and 2 use a blank message with a data length of zero for acknowledgment.

During power-up, the syringe pump initiates a startup request by sending a request message every 100 milliseconds. The ID of the message has direction 1, group number 1, device class address according to the DIP switch settings (refer to Table 6), frame type 2, and message length 0. The syringe pump only stops sending request messages and starts accepting commands after receiving confirmation of the startup request from the host. The ID of the host's confirmation startup request message has direction 0, group number 1, device address 0, frame type 0, message length 2. The first byte represents the target syringe pump's DIP switch address (see Table 6) + 0x20, and the second byte represents the address assigned by the host to the syringe pump + 0x20. The address assigned

by the host can be different from the syringe pump's own DIP switch address (see Table 6) and can be any number from 0 to 15.

Command Execution Instructions

- Except for reporting and query commands, all other commands must end with the R command.
- Individual commands and command strings can be executed sequentially. For example, "/1ZIA800R\r" will initialize the syringe pump at address 1, switch the valve to the input channel, and then move the syringe to a position 800 increments away.
- The syringe pump can receive command strings of up to 255 bytes in length. If a command or command string sent does not end with the R command, it will be stored in the cache without execution.
- Once a command is executed, the syringe pump enters a busy state until the command string is completed or a stop command (T command) is received to exit the busy state. The status can be queried using the Q command.
- Prior to controlling movement, the syringe pump must be initialized using the initialization command.
- 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 Command

Syringe Pump Configuration Commands

<N>[n] Set Syringe Step Division

Syringe Step Division Settings

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

Setting the syringe step division to N2 allows for finer control of syringe movement. This parameter returns to the default value after the syringe pump is reset.

<K>[n] Set Syringe Backlash

Syringe the 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

Setting the 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 for the syringe not to 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 CAN baud rate to 250K
		53		Set the CAN baud rate to 500K
		54		Set CAN baud rate to 1M
		57		Set 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, 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 and then switch to the output port. If the current position of the plunger's zero position optocoupler is in the triggered state, the plunger will move in the liquid aspiration direction until the zero position optocoupler is no longer triggered, then the plunger will move in the liquid dispense direction until it reaches the glass tube's vertex. After that, the plunger will move in the liquid aspiration direction for a distance set by the k command. Finally, 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.

<Z>[n] Clockwise Initialization of Valve and Plunger

Clockwise Initialization Plunger and Valve

Command	Parameters	Parameter Range	Default Value	Description
Z	n	0	0	Initialize plunger at default speed
		10-40		Initialize the plunger with speed code [n] speed, the list of speed codes is shown inError! Reference source not found.

Using this command, the valve ports will be numbered clockwise from 1, and subsequent valve switch commands will be executed according to that number;

<Y>[n] Counterclockwise Initialization of Valve and Plunger

Counterclockwise Initialization Plunger and Valve

Command	Parameters	Parameter Range	Default Value	Description
Y	n	0	0	Initialize plunger at default speed
		10-40		Initialized with speed code [n] speed, the list of speed codes is shown inError! Reference source not found.

Using this command, the valve ports will be numbered clockwise from 1, and subsequent valve switch commands will be executed according to that number;

<W>[n] Initialize Plunger Only

Initialize Plunger Only

Command	Parameters	Parameter Range	Default Value	Description
W	n	0	0	Initialize the plunger at the default speed
		10-40		Initialize the plunger with speed code [n] speed, the list of speed codes is shown inError! Reference source not found.

<x>[n1] Percentage of Motor Power When Initializing the Plunger

Percentage of Motor Power When Initializing the Plunger

Command	Parameters	Parameter Range	Default Value	Description
x	n	25-100	100	Percentage of motor drive power when initializing the plunger

<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.
		0-4800		When setting the syringe subdivision to N1 or N2, n is set to the plunger position and clears the plunger operation error.

This command can be used after a piston 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 Commands

<I> Switching Valve to Input 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.

<O> Switching Valve to Output 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.

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

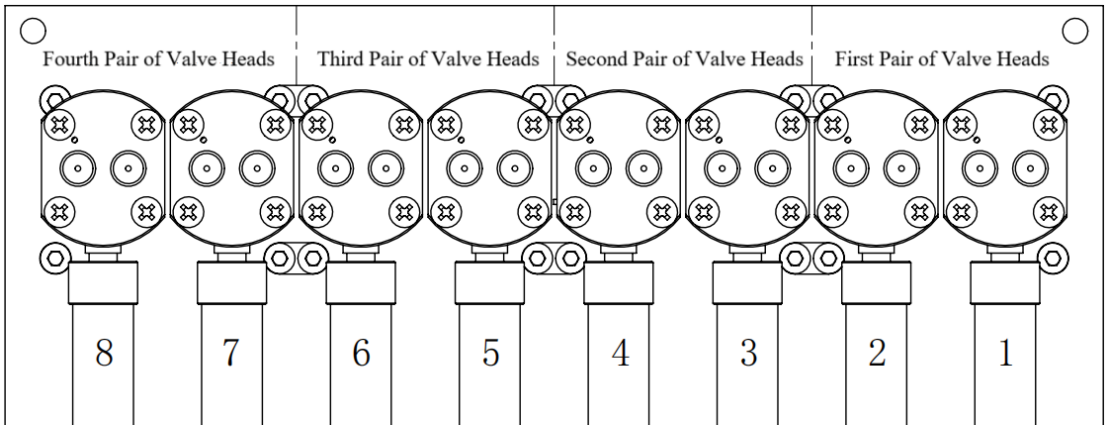
Switching Valve to the Bypass Ports

Command	Parameters	Parameter Range	Default Value	Description
B	n	None		Optimal path switching valve to bypass port
		SeeError! Reference source not found.		Optimal path switching valve to the set 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 switched to the set port. Detailed valve head comparison refers to below Fig 10.

Meaning of <B>[n] Command Parameters

Parameters (decimal)	Fourth pair of valve heads	Third pair of valve heads	Second pair of valve heads	First pair of valve heads
0	Input Port	Input Port	Input Port	Input Port
1	Input Port	Input Port	Input Port	Output Port
10	Input Port	Input Port	Output Port	Input Port
11	Input Port	Input Port	Output Port	Output Port
100	Input Port	Output Port	Input Port	Input Port
101	Input Port	Output Port	Input Port	Output Port
110	Input Port	Output Port	Output Port	Input Port
111	Input Port	Output Port	Output Port	Output Port
1000	Output Port	Input Port	Input Port	Input Port
1001	Output Port	Input Port	Input Port	Output Port
1010	Output Port	Input Port	Output Port	Input Port
1011	Output Port	Input Port	Output Port	Output Port
1100	Output Port	Output Port	Input Port	Input Port
1101	Output Port	Output Port	Input Port	Output Port
1110	Output Port	Output Port	Output Port	Input Port
1111	Output Port	Output Port	Output Port	Output Port



Valve Pair and Number Diagram

<E>[n] Switching Valves to Additional Ports

Switching Valves to Additional Ports/Optimal Path Switching Valves

Command	Parameters	Parameter Range	Default Value	Description
E	n	None		Optimal path switching valve to additional ports
		See Switching Valve to the Bypass Ports		Optimal path to move the valve to port n

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.

Meaning of <E>[n] Command Parameters

Parameters (decimal)	Fourth pair of valve heads	Third pair of valve heads	Second pair of valve heads	First pair of valve heads
0	Input Port	Input Port	Input Port	Input Port
1	Input Port	Input Port	Input Port	Output Port
2	Input Port	Input Port	Output Port	Input Port
3	Input Port	Input Port	Output Port	Output Port

4	Input Port	Output Port	Input Port	Input Port
5	Input Port	Output Port	Input Port	Output Port
6	Input Port	Output Port	Output Port	Input Port
7	Input Port	Output Port	Output Port	Output Port
8	Output Port	Input Port	Input Port	Input Port
9	Output Port	Input Port	Input Port	Output Port
10	Output Port	Input Port	Output Port	Input Port
11	Output Port	Input Port	Output Port	Output Port
12	Output Port	Output Port	Input Port	Input Port
13	Output Port	Output Port	Input Port	Output Port
14	Output Port	Output Port	Output Port	Input Port
15	Output Port	Output Port	Output Port	Output Port

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 in 6000 increments, and when set to N1 or N2, the full stroke is in 48000 increments.

<A>[n] Move Plunger to Absolute Position

Moving 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 to Idle)

The same function as the A command, except that when the a command is used, the status queried is the idle status;

<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 to Idle)

The same function as the P command, except that the status queried when using the p command is the idle status;

<D>[n] Relative Position Dispense

Relative Position Dispense

Command	Parameters	Parameter Range	Default Value	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 Dispense (Return to Idle)

The same function as the D command, except that when the d command is used, the status queried is the idle status;

Syringe Parameter Setting Command

When the plunger is initialized, the set acceleration, start speed, maximum speed and stop speed are restored to the system default; when the start speed is greater than the maximum speed, the actual running start speed is equal to the maximum speed, and when the stop speed is greater than the running speed, the actual running stop speed is equal to the maximum speed; the stop speed setting is only valid when dispensing liquid, and the stop speed is equal to the start speed when aspirating liquid.

When the subdivision is modified with the N command, the acceleration, start speed, maximum speed and stop speed values remain unchanged, and the actual operation will change by a factor of 8; when modified from N0 or N1 to N2, it will be 8 times slower, and when set from N2 to N1 or N0 it will be 8 times faster.

<L>[n] Set Acceleration

Set Acceleration

Command	Parameters	Parameter Range	Default Value	Description

L	n	1-20	7	When subdivision is N0 or N1, set acceleration to n*2500 increments per square second
		1-160		When subdivision is N2, set acceleration to n*2500 increments per square second

<v>[n] Set the Startup Speed

Set the Start-up Speed

Command	Parameters	Parameter Range	Default Value	Description
V	n	50-1000	900	When subdivision is N0 or N1, set the syringe start speed to n increments per second
		50-8000		When subdivision is N2, set the syringe start 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
		5-48000		When the subdivision is N2, set the syringe start speed to n increments per second

<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 Set the Start-up Speed

Speed Code Table

Speed Code	Speed (increments per second)	Seconds / Full stroke (N0 or N1)	Seconds / Full stroke (N2)	Speed Code	Speed (increments per second)	Seconds / Full stroke (N0 or N1)	Seconds / Full stroke (N2)
0	6000	1.25	8.25	21	160	37.50	300
1	5600	1.30	8.80	22	150	40.00	320
2	5000	1.39	9.79	23	140	42.86	343
3	4400	1.52	11.1	24	130	46.15	369
4	3800	1.71	12.8	25	120	50.00	400
5	3200	1.97	15.1	26	110	54.55	436
6	2600	2.37	18.5	27	100	60.00	480
7	2200	2.77	21.9	28	90	66.67	533
8	2000	3.03	24.0	29	80	75.00	600
9	1800	3.36	26.7	30	70	85.71	686
10	1600	3.77	30.0	31	60	100.00	800
11	1400	4.30	34.3	32	50	120.00	960
12	1200	5.00	40.0	33	40	150.00	1200
13	1000	6.00	48.0	34	30	200.00	1600
14	800	7.50	60.0	35	20	300.00	2400
15	600	10.00	80.0	36	18	333.33	2667
16	400	15.00	120	37	16	375.00	3000
17	200	30.00	240	38	14	428.57	3429
18	190	31.58	253	39	12	500.00	4000
19	180	33.33	267	40	10	600.00	4800
20	170	35.29	282	/	/	/	/

<c>[n] Set Stop Speed

Set the 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 last action command string, or do not repeat the previous action command string if the previous action command string execution reports an error.

<G>[n] Execute Commands or Command Strings in a Loop

Execute Commands or Command Strings in a Loop

Command	Parameters	Parameter Range	Default Value	Description
G	n	0-48000		Number of times to execute the command or command string 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 loop count is set to 0, the execution will continue indefinitely.

<g> Loop Execution Starting Marker for Command or Command String

This command is used as the starting marker for executing a command or command string in a loop. For example, sending the command string "ZgIA300BA0G5R" will initialize the valve and plunger with default parameters, and then execute the loop command string "IA300BA0" five times. This means the valve will be switched to the input port, the plunger will move to a position incremented by 300(liquid aspiration), the valve will be switched to the additional port, and the plunger will move to a position incremented by 0(liquid dispense). This sequence will be repeated five times.

<M>[n] Delayed Execution

Delayed Execution

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

This command can be used between the move plunger command and the switch valve port command. When the move plunger is finished, it delays for a certain time before switching the valve port to reduce the pressure fluctuation; if the R command is received during the delay, it can terminate the delay process 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 command description, it can interrupt the execution of the command string and continue the execution when the R command or the falling edge signal of the auxiliary input is

received. This command will not interrupt the execution of the action command, but only terminate the execution of the delay command, so it is routinely nested in the command string and executed separately only for interrupting the execution of the delay command.

<T> Terminate Command

The terminate command terminates running plunger motion, loop execution, and delayed execution; it does not interrupt valve switching. If the plunger motion is interrupted, when the R command is received to continue operation, it will not continue to run the plunger, 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		Auxiliary output 3 output is low, auxiliary output 2 output is high, auxiliary output 1 output is high
		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

Auxiliary outputs can be used to synchronize actions with other devices or to mark the process of command string execution.

<!> Restart Command

When the syringe pump configuration is modified with the U command, the reset restart command can be used to restart the syringe pump to make the configuration take effect.

Non-Volatile Storage Command

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

Store Command String to Non-Volatile Storage

Command	Parameters	Parameter Range	Default Value	Description
s	n	0-14		Store the command string to the command string n location 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 Execute Command String in Non-Volatile Memory;

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

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

Execute Command String in Non-Volatile Memory

Command	Parameters	Parameter Range	Default Value	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, which is to enable automatic operation of the command string in non-volatile memory mode, where the command string is executed at the DIP switch address (seeError! Reference source not found.).

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		Location indexing in non-volatile memory
	n2	0-255		Data values to be stored by the user

<<>[n] Read User Data

Reading User Data

Command	Parameters	Parameter Range	Default Value	Description
<	n1	0-15	0	Location indexing 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 start-up 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 syringe initializations
		16		Report the number of plunger movements
		17		Report the number of valve switching
		18		Report the number of valve switches 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 Cache

As with the ?10 command, reports 0 if the command cache is empty, otherwise reports 1.

<%> Report the Number of Valve Switches Since the Last Report

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

<#> Report Board Unique Number

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

<&> Report Firmware Version

As with the ?23 command, the firmware version is reported in ASCII characters.

<Q> Report Status

As with the ?29 command, the current status of the syringe pump is reported, seeError! Reference source not found..

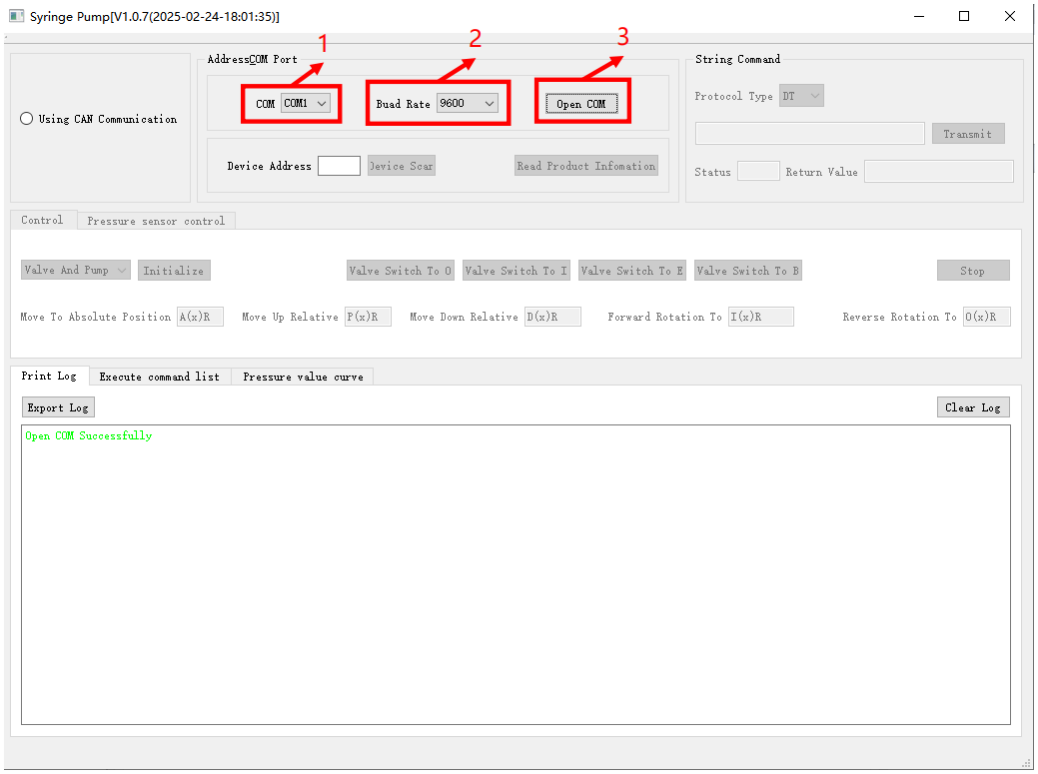
3.4 Instructions for the Host Computer Testing Software

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-SyringePump.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.



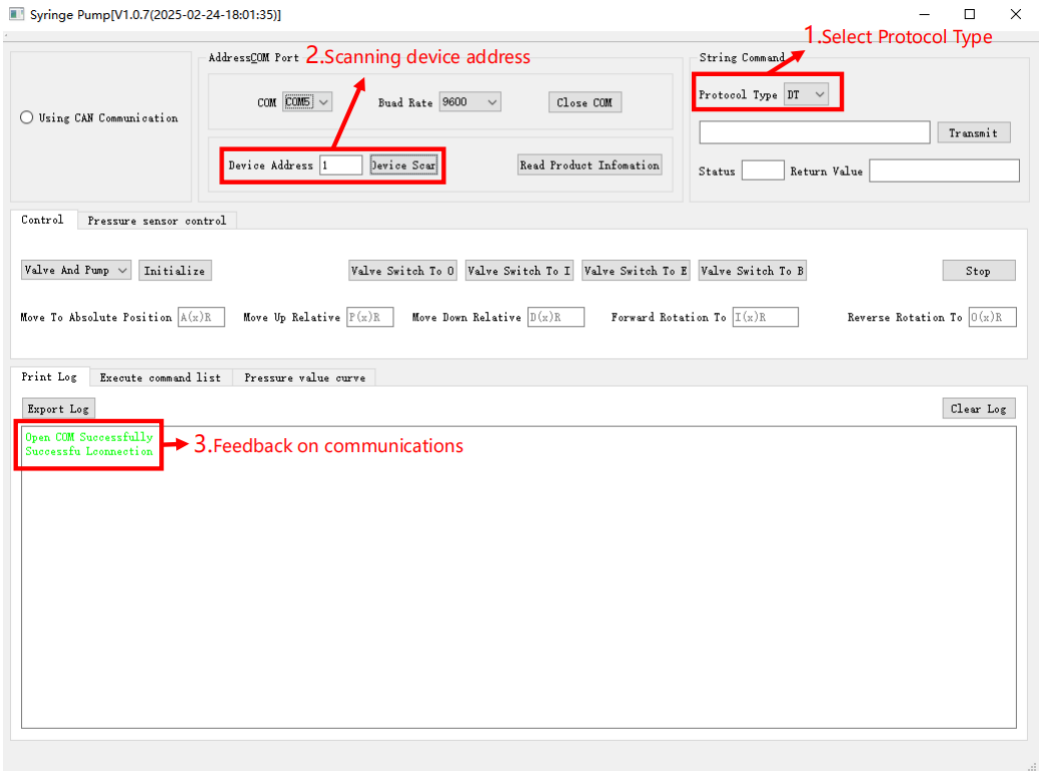
Selection of Serial Port, Device Scanning

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:

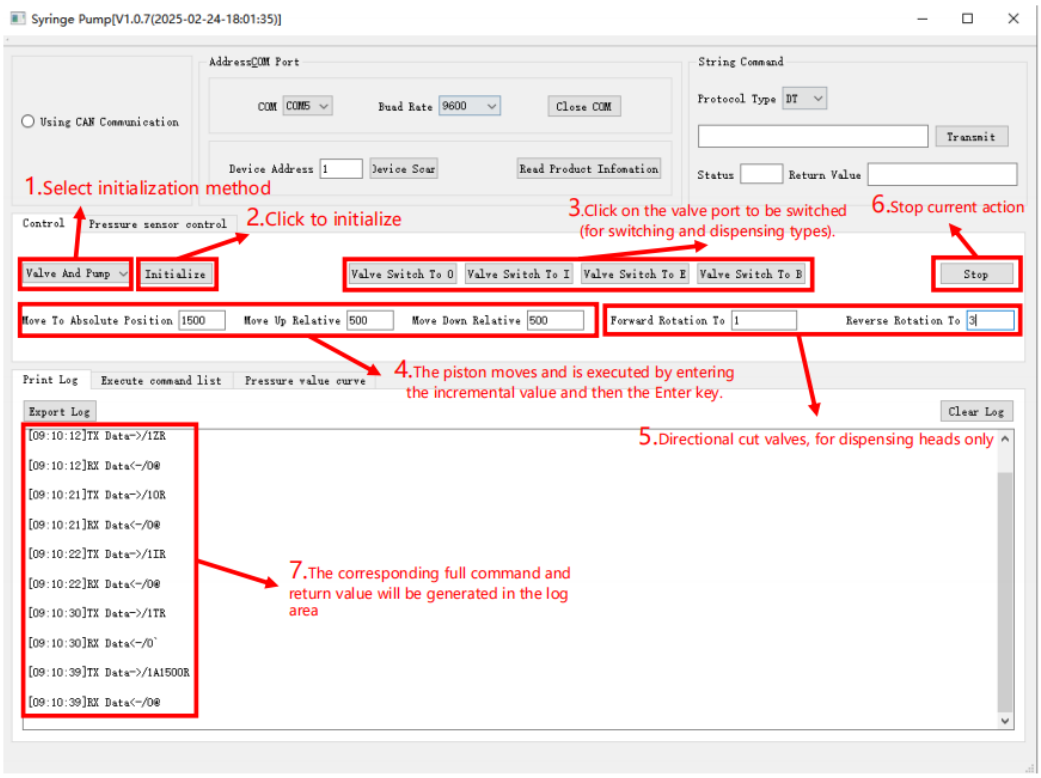
1.Setting will lock current protocol type once protocol type is selected and address is scanned. If it is necessary to change protocol, restart the device.

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 show "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.

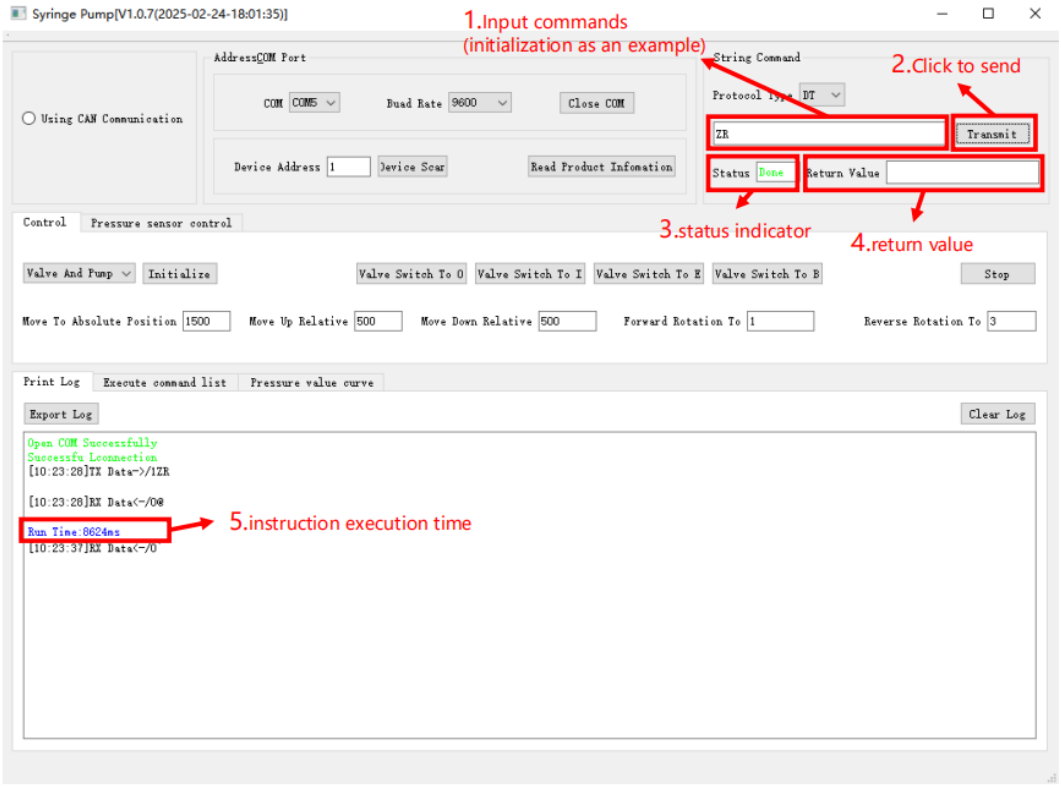
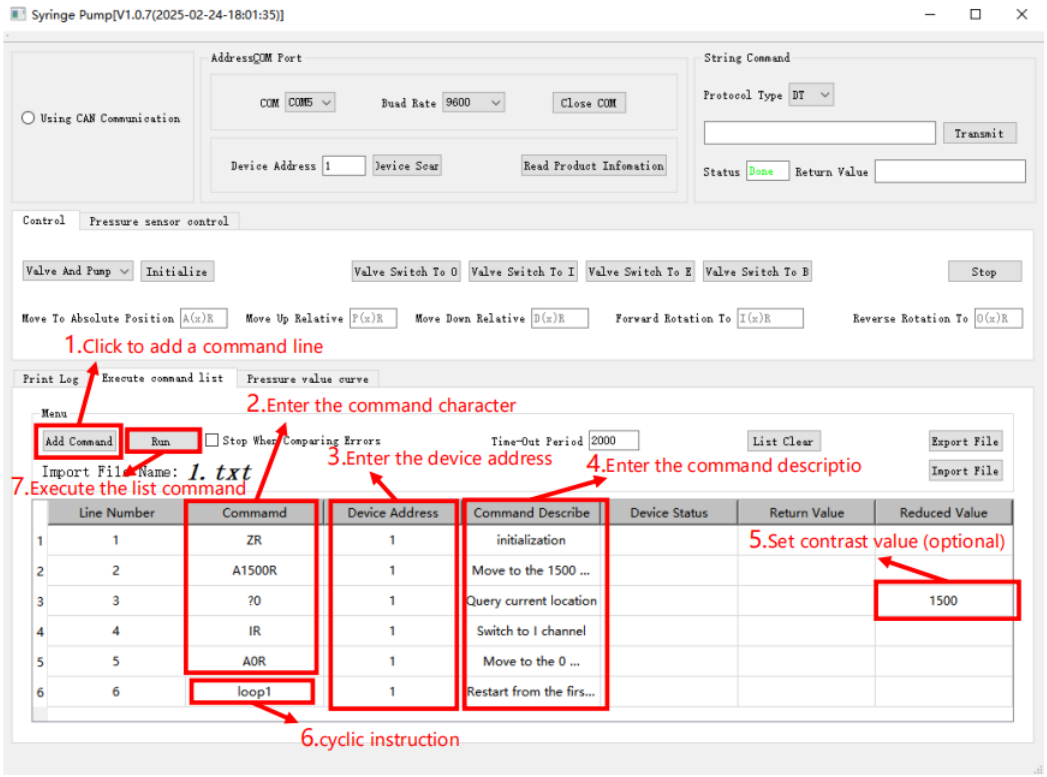


Table Execution

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, you need to query the current running 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 port baud rate to 9600	Send	/1U41R[CR]	/ start-stop character; 1 device address; U41 set the serial port baud rate to 9600; 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
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; !

	Receive	/0`[ETX][CR][LF]	reset restart; 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
Store Z at the position of command string 0 in the non-volatile memory	Send	/1s0ZR[CR]	/start-stop character; 1 device address; s0Z store Z at the position of command string 0 in the non-volatile memory; 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
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	Send	/1N0ZIV600 A300R[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

increments

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 37 31 30 36 03 61	02 Frame Header; 30 Host PC Address; 60 idle status; 32 33 31 32 32 37 31 30 36(231227106); 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 Start 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 a 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).
	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 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).
	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). 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).
	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). 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 (s0ZR).
	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	The frame ID direction is 1, group number

			33 31 32 32 37	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.

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 Section 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 60 Ω.
		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 NO 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

Although the maintenance intervals may vary depending on different applications, it is recommended to perform the corresponding maintenance and care according to the following cycles in order to maintain the optimal performance of the syringe pump.

5.1 Daily Maintenance

To ensure the normal operation of the syringe pump, perform the following tasks daily:

- Check for any leaks in the pump and correct any potential malfunctions.
- Wipe clean any spilled fluids on the pump and its surroundings.
- Thoroughly flush the pump (including the syringe) with distilled or deionized water after each use and when the pump is not in use.

Note: It is not allowed to run the syringe pump multiple times without any liquid (dry run).

5.2 Weekly Maintenance

It is necessary to clean the deposits, such as salts, along the fluid path of the syringe pump on a weekly basis to inhibit bacterial growth. You can use any of the following cleaning solutions:

- Diluted cleaning solution
- Weak acids and bases
- 10% bleach

The cleaning process for the above solutions will be described in the following sections.

Cleaning Procedure With Diluted Cleaning Solution

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

- Fill the pump with the diluted cleaning solution and let the solution stay in the pump for 30 minutes.

- After 30 minutes, empty all the liquid from the syringe and tubing into the waste container.
- Aspiration and dispense at least 10 times with full distilled or deionized water in a pump.
- The flow path needs to be filled with distilled or deionized water when storing the pump.

Note: The cleaning solution refers to a reagent or neutral solution that has similar solubility with the application medium.

Cleaning Procedure With Weak Acid And Weak Base Solution

To clean the pump with a weak acid and weak base solution, follow these steps:

- Fill the pump with 0.1 mol/L NaOH and allow the solution to remain in the pump for 10 minutes.
- Flush the pump with distilled or deionized water.
- Fill the pump with 0.1 mol/L Hcl and allow the solution to remain in the pump for 10 minutes.
- After 10 minutes, empty all the liquid from the syringe and tubing into the waste container.
- Aspiration and dispense at least 10 times with distilled or deionized water in a full pump.
- The flow path needs to be filled with distilled or deionized water when storing the pump.

Cleaning Procedure With 10% Bleach Solution

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

- Configuration of 10% bleach (1 times bleach and 9 times water)
- Fill the pump with 10% bleach and allow the solution to remain in the pump for 30 minutes.
- After 30 minutes, empty all the liquid from the syringe and tubing into the waste container.
- Aspiration and dispense at least 10 times with distilled or deionized water in a full pump.
- The flow path needs to be filled with distilled or deionized water when storing the pump.

5.3 Regular Maintenance

The tubing, syringe seal, and valve head need regular maintenance. Determine whether replacement is required based on the following conditions:

- Poor precision or repeatability accuracy
- Bubbles appear when the glass tube when it is filled with liquid
- Liquid leakage

If any of these phenomena occur and it is not possible to determine which component is responsible, it is easier to identify and more economical to replace the components in the following order:

- Input and output tubing
- Plunger seals (or glass syringes)
- Valve head

The frequency of replacement will depend on the number of uses, the fluid to which the flow path

is exposed, and the maintenance of the instrument.

Quality Control Assurance

Regularly inspect the accuracy and CV of the syringe pump. It is recommended to use an analytical balance with a accuracy of 0.01mg to calibrate the accuracy of the syringe pump through gravimetric analysis. The calibration of the syringe can be done by comparing the weight of the target liquid with the actual dispensed liquid weight.

To determine the accuracy and CV, it is recommended to run the measurement data at least 20 times repeatedly. The accuracy, average value, standard deviation and coefficient of variation are then calculated (see formulas below). The calculation needs to take into account the specific gravity of water, which is directly related to the room temperature, generally 0.99707 at room temperature of 25° C. In addition, the liquid may also be adsorbed in the tip of the pipeline when dispensing, in order to prevent the inaccurate measurement caused by the liquid sticking to the tip of the pipeline, it is necessary to add a small amount of surfactant in the water (for example, 0.01% concentration of Fluorad®).

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

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

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

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

Replacement of Dispensing Tubing Or Reagent Tubing

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

- Remove the old tubing fitting and use the corresponding threaded wrench to gently loosen the fitting and remove the tubing.
- Install the new tubing by screwing the fitting into the valve head and finger tightening.
- Set the upper torque limit of thread wrench 1.5~3kgf-cm and use thread wrench to tighten the pipe joint.

Syringe Replacement

To replace the syringe, refer to section 2.3.1 for Installation of Syringe.

Replace Syringe Pump Valve Head

To replace the syringe pump valve head, refer to section 2.3.2 for Installation of Syringe Valve Head.

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.