5A33 Series Syringe Pump Operating Manual

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1.0	New	Wu Yi	2023.05.10
1.1	Revise the cover picture to the latest version. Delete Figure 2 B instruction and corresponding schematic. Modify Table 6 status table bit6 to 1. Add 3.3.3.4 solenoid valve description	Wu Yi	2023.05.24
1.2	Revise Figure 2. Add Figures 6, 18, 19 and 20.	Wu Yi	2023.08.09
1.3	Partly revise software instruction section. Modify example errors of six-port valve head and nine-port valve. Updated Figure 18. Revise full-scale standard of CV.	Wu Yi	2023.09.01

Contents

1 Overview

The syringe pump, integrating a glass syringe and a rotary shear valve or solenoid valve with a controller module, is designed to handle high accuracy and precision in liquid handling and switch between different liquid channels, as the liquid channels can be selected and switched according to different applications.

1.1 Syringe Pump Features at-a Glance

- This product is a compact syringe pump with the following features and functions:
- Compact size, with overall dimensions of only 107(D)x127(H)x44(W);
- Lightweight, with an overall weight is less than 1.5kg;
- The resolution is 3000 in standard mode and 24000 in micro-stepping mode;
- Glass syringes options from 50 μL, 100 μL, 250 μL, 500 μL, 1.0 mL, 2.5 mL, 5.0 mL;
- Accuracy <1% at full-stroke, precision ≤ 0.1% CV at full-stroke (Syringes of 1mL and above, deionized water);
- Valve head options from a wide range of valve heads, as described in 1.2.2;
- Wetted materials are corrosion-resistant and mainly made of borosilicate, PCTFE, PTFE, PEI, FFKM;
- RS-232, RS-485 and CAN interface;
- Adjustable operating speed, with a maximum speed of 30mm/1.2s and a minimum speed of 30mm/20min;
- Transmission mechanism utilizing a ball screw with a linear encoder, featuring step-loss detection;
- Easy maintenance: The valve head and syringe offer high and stable accuracy in quantitative liquid handling during the service life. Replacing and maintaining is also straightforward out of the life of these components.

1.2 Terminology Definitions

- Increment: A unit of displacement measurement. Under N0 subdivision, the full stroke is 3000 increments, with each increment corresponding to 0.01 mm.
- Master Control: The client-side controller.
- Device: Syringe pump.
- Backlash: Used to compensate for accumulated mechanical gaps that affect syringe drive, improving the accuracy of the syringe.
- Dead Volume: The distance moved down after the motor stops in the initialization command.
- Bypass Port: Connects the input and output, bypassing the syringe. Aspiration and dispensing operations are prohibited in this state.
- Extra Port: In a 4-port valve, this is the port other than the input, output, and bypass.
- 0x: Hexadecimal indicator.

1.3 Functional Description

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.

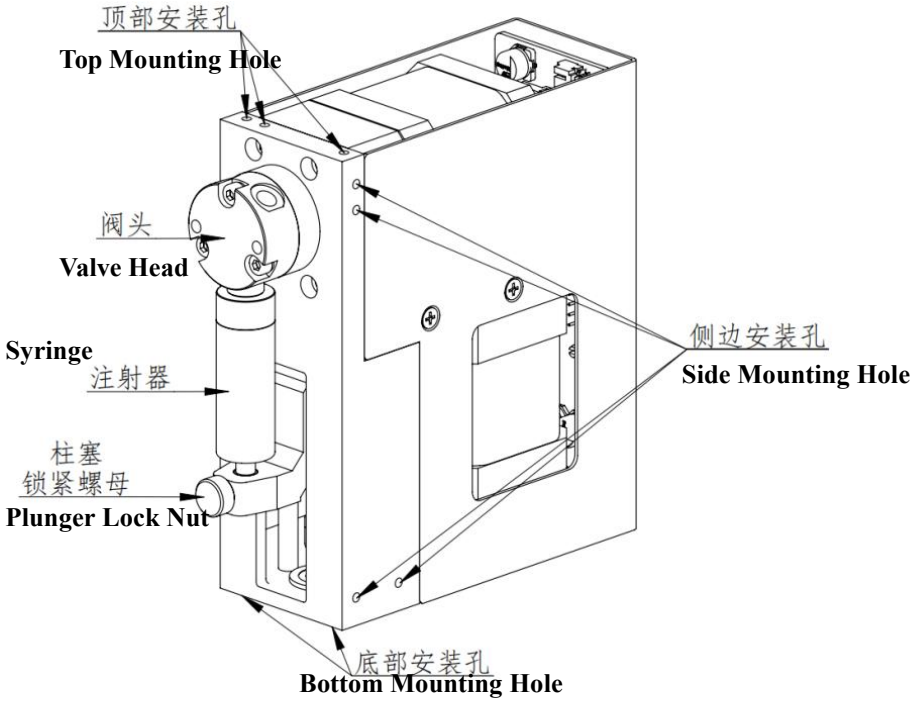


Figure 1 5A33 Series Syringe Pumps

1.3.1 Syringe and syringe drive

The stepper motor, with a linear encoder for step loss detection feedback, first drives the ball screw, and then the ball screw drives the syringe Plunger to reciprocate. The effective stroke of the syringe is 30mm with a resolution of 3000 steps (24000 steps in microstep mode). The base of the syringe plunger is fixed to the nut by a knurled screw. The top of the syringe is connected to the valve head with a 1/4-28 UNF thread.

Applicable syringe sizes: 50 µL, 100 µL, 250 µL, 500 µL, 1.0 mL, 2.5 mL and 5.0 mL.

1.3.2 Valve head and valve head drive

The rotary shear valve head is driven by a stepper motor with encoder for positioning feedback and consists of a stator and a rotor, two of which are driven by a stepper motor to relative rotational motion and connect the syringe port to the respective output ports.

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

The specifications of the applicable valve head are as follows:

Two way non-distribution type solenoid valve head

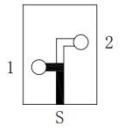
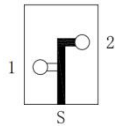
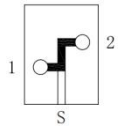
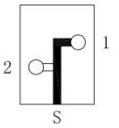
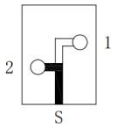
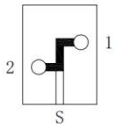
Z Command Reset Example			Y Command Reset Example		
					
Command I Set input port to Port 1	Command O Set output port to Port 2	Command B Port 1 connects To port 2	Command I Set input port to Port 1	Command O Set output port to Port 2	Command B Port 1 connects to port 2

Figure 2 Two way non-distribution type solenoid valve head port description

Three-port distribution type solenoid valve head

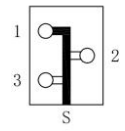
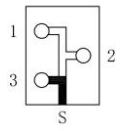
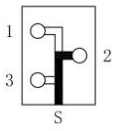
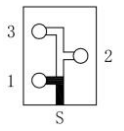
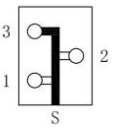
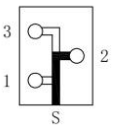
Z Command Reset Example			Y Command Reset Example		
					
Command I<1> Set input port to Port 1	Command O<3> Set output port to Port 3	Command B<2> Port 2 connects to the syringe	Command I<1> Set input port to Port 1	Command O<3> Set output port to Port 3	Command B<2> Port 2 connects to the syringe

Figure 3 Three-port distribution type solenoid head port description

Three-port non-distribution type rotary valve head

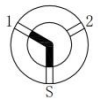
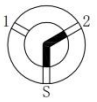
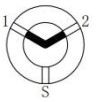
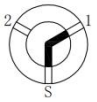
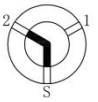
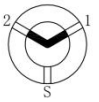
Z Command Reset Example			Y Command Reset Example		
					
Command I Set input port to Port 1	Command O Set output port to Port 2	Command B Port 1 connects to port 2	Command I Set input port to Port 1	Command O Set output port to Port 2	Command B Port 1 connects to port 2

Figure 4 Three-port non-distribution type rotary valve head port description

Four-port non-distribution type rotary valve head

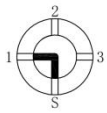
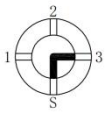
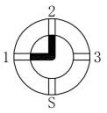
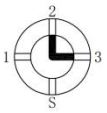
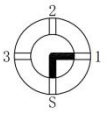
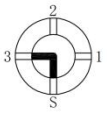
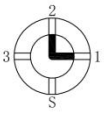
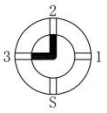
Z Command Reset Example				Y Command Reset Example			
							
Command I Set input port to Port 1	Command O Set output port to Port 3	Command B Port 1 Connects to port 2	Command E Port 2 connects to port 3	Command I Set input port to Port 1	Command O Set output port to Port 3	Command B Port 1 connects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

Figure 5 Four-port non-distribution type rotary valve head port description

Four way double circuit non-distribution type rotary valve head

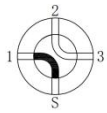
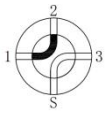
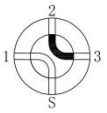
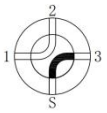
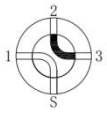
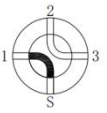
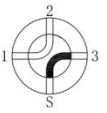
Z Command Reset Example				Y Command Reset Example			
							
Command 1 Port 1 connects to the syringe, Port 2 connects to Port 3	Command E Port 1 connects to Port 2, Port 3 connects to the syringe	Command O Port 1 connects to the syringe, Port 2 connects to Port 3	Command B Port 1 connects to Port 2, Port 3 connects to the syringe	Command 1 Port 1 connects to the syringe, Port 2 connects to Port 3	Command E Port 1 connects to Port 2, Port 3 connects to the syringe	Command O Port 1 connects to the syringe, Port 2 connects to Port 3	Command B Port 1 connects to Port 2, Port 3 connects to the syringe

Figure 6 Four-port dual loop type rotary valve head port description

Three-port distribution type rotary valve head

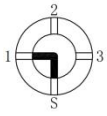
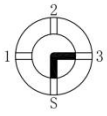
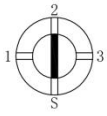
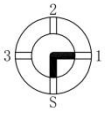
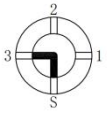
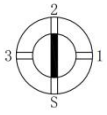
Z Command Reset Example			Y Command Reset Example		
					
Command I<1> Set input port to Port 1	Command O<3> Set output port to Port 3	Command B<2> Port 2 connects to the syringe	Command I<1> Set input port to Port 1	Command O<3> Set output port to Port 3	Command B<2> Port 2 connects to the syringe

Figure 7 Three-port distribution type rotary valve head port description

Four-port distribution type rotary valve head

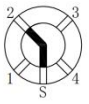
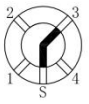
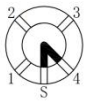
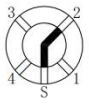
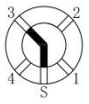
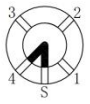
Z Command Reset Example				Y Command Reset Example			
							
I<1> command	I<2> command	O<3> command	O<4> command	I<1> command	I<2> command	O<3> command	O<4> command

Figure 8 Four-port distribution type rotary valve head port description

Six-port distribution type rotary valve head

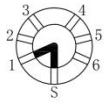
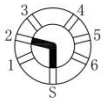
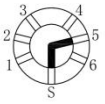
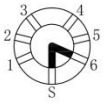
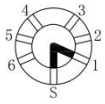
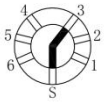
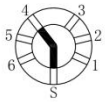
Z Command Reset Example				Y Command Reset Example			
							
I<1> command	I<2> command	O<5> command	O<6> command	I<1> command	I<3> command	O<4> command	O<6> command

Figure 9 Six-port distribution type rotary valve head port description

Nine-port distribution type rotary valve head

Z Command Reset Example				Y Command Reset Example			
							
I<1> command	I<3> command	O<6> command	O<9> command	I<1> command	I<4> command	O<7> command	O<9> command

Figure 10 Nine-port distribution type rotary valve head port description

Twelve-port distribution type rotary valve head

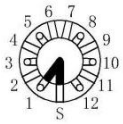
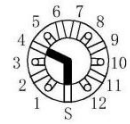
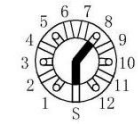
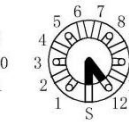
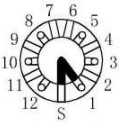
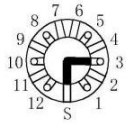
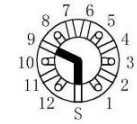
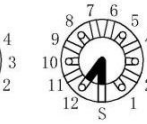
Z Command Reset Example				Y Command Reset Example			
							
I<1> command	I<4> command	O<8> command	O<12> command	I<1> command	I<2> command	O<9> command	O<12> command

Figure 11 Nine-port distribution type rotary valve head port description

1.3.3 Controller

This product holds the microprocessor and circuitry to control the syringe and valve drives.

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

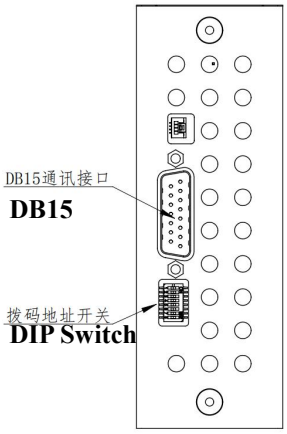


Figure 12 Communication interface and DIP switch of the syringe pump controller

1.3.4 Communication interface

This product can communicate singly or in a multi-pump configuration through an RS-232, RS-485, or CAN interface. For RS-232 and RS-485, baud rates of 9600 and 38400 are supported. For CAN, baud rates of 100K,125K, 250K, 500K, and 1M are supported.

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 Centris pump, see Chapter 2 “Hardware Setup”, and Chapter 3 “Software Communication”.

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

To ensure proper operation, please follow these tips:

- Always set up and mount the pump in an upright position. Failure to do so can cause problems priming the system.
- Always run liquid through the syringe and valve when they are moving. Failure to do so can damage the precision sealing surfaces.
- Always power down the instrument when connecting or disconnecting pumps.

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

2 Hardware Setup

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

- Power and Electrical considerations
- Communications Interfaces
- Address Switch Settings
- Installing Components
- Mounting

2.1 Power and Electrical Considerations

The 5A33 series syringe pumps require a 24V DC power supply rated at least 2.0A , provided through a DB15 connector. It is recommended to use one power cable for every two pumps for EMC safety.

2.2 Communication Interfaces

Each syringe pump has a communication interface through which power can be supplied and the pump communicated. Each syringe pump can be set up with a unique address to identify each pump.

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

Table 1 DA-15 Connector Pin Assignments

Pin	Function	Remark
1	24V DC	Power input ±1%, ≥2A
2	RS-232 TXD	Communication interface
3	RS-232 RXD	Communication interface
4	/	/
5	CAN H	Communication interface
6	CAN L	Communication interface
7	AUXIN1	Auxiliary input 1
8	AUXIN2	Auxiliary input 2

Pin	Function	Remark
9	GND	POWER GROUND
10	GND	POWER GROUND
11	RS-485 A	Communication interface
12	RS-485 B	Communication interface
13	AUXOUT1	Auxiliary output 1
14	AUXOUT2	Auxiliary output 2
15	AUXOUT3	Auxiliary output 3
/	/	/

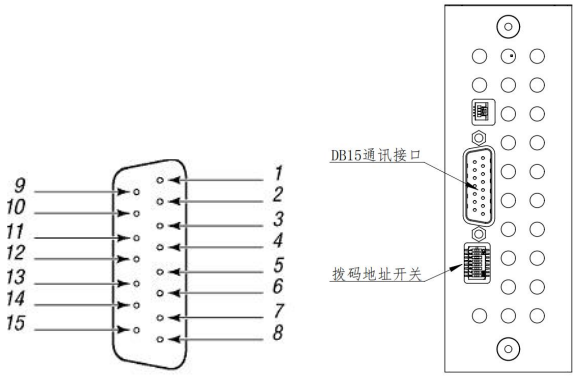


Figure 13 DB15 Connector pin assignments and the positions of the DB15 Connector in syringe pumps

2.3 Control Settings

2.3.1 DIP switch

The DIP switch has 8 bits, (as follows) Figure 13) located at the lower left of the syringe pump rear panel, 4 bits are used to modify the address of each syringe pump for debugging or linkage, and the user can send specific commands to the specified syringe pump to control the pump. The remaining four bits are used to connect the 120-ohm termination resistor for RS-485 or CAN communication. The DIP switch has 16 positions (numbered 0 through F). Fifteen positions (addresses 0 through E) are valid pump addresses by default, while F is the self-test address (refer to Table 2 and Table 3).To set the address, a pair of tweezers or a small screwdriver can be used to switch to the target address.

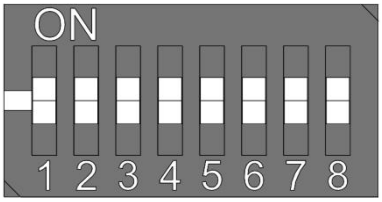


Figure 14 DIP Switches

Table 2 DIP Switch Address Correspondence Table

Number	Function	Description
1	120 ohm CAN termination resistor	ON: Terminated OFF: Disconnected
2	120 Ohm RS485 Termination Resistor	ON: Terminated OFF: Disconnected
3	reservations	The DIP switch address is expressed in a 4-bit binary; bit0 is the lowest bit. After the binary number is converted to a hexadecimal value, +1 is the ID (address value), and the ID range is 1-16. The automatic aging function is enabled after the address is set to 16.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 address value is configured as 6, the corresponding binary value is 5 (0b0101), and the 5-8 bit dialing code is: OFF, ON, OFF, ON.
4	reservations	
5	Address bit3	
6	Address bit2	
7	Address bit1	
8	Address bit0	

Table 3 Switch Address Correspondence Table

Address bit3	Address bit2	Address bit1	Address bit0	dial-up address	Single Device Address		Dual Device Address		Quad Device 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							

2.3.2 Self-Test

The “F” address switch position is used to activate self-test upon power-up. The self-test process includes initialization, valve port switching, and a series of plunger movements at different speeds. If any errors occur during the operation, the syringe pump will stop and provide an alarm message.

Note: Do not allow the syringe pump to run dry multiple times, i.e. without liquid.

2.4 Installation Components

2.4.1 Installing the syringe pump valve head

To install the syringe pump head, follow the steps below, refer to FIG . 14 :

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. Issue the [A3000R] command to run the syringe Plunger to its maximum stroke.
4. Remove the syringe and connection management.
5. Remove the valve head set screws, then remove the valve head from the pump.
6. Install the new head on the front panel so that the rotary valve motor shaft is aligned with the internal holes in the head, the head mounting holes and pins are aligned with the front panel threaded hole screws and pin holes, and the set screws are installed.
7. To assemble the syringe, refer to 2.4.2.

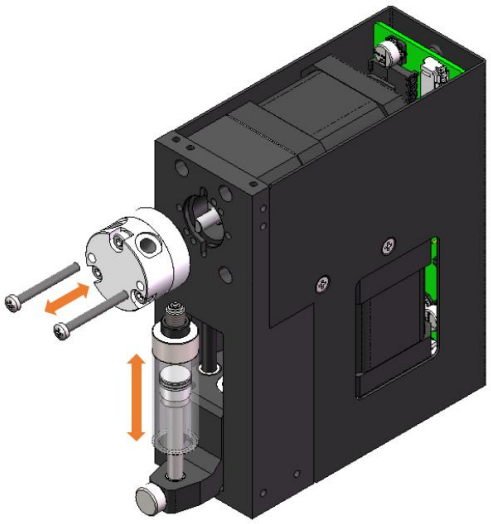


Figure 15 Rotary Head Installation

2.4.2 Installing the syringe

To install the syringe, follow the steps below:

1. Initialize the syringe pump.
2. Loosen the Plunger lock nut about three turns.
3. Lower the Plunger height by sending the command [A3000R].
4. Install the syringe, see Figure 15 :

- 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 the bottom of the Plunger rod fits into the push plate hole.
- Tighten the syringe another 1/8 turn to 1/4 turn.
- Tighten the Plunger lock nut.

5. Reinitialize the pump.

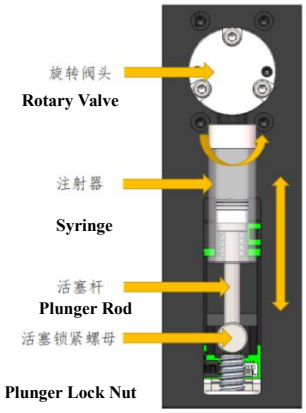


Figure 16 Syringe Installation

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

2.5 Mounting

The 5A33 Series syringe pumps are available in a variety of mounting options to facilitate installation, see Figure 17 and 18.

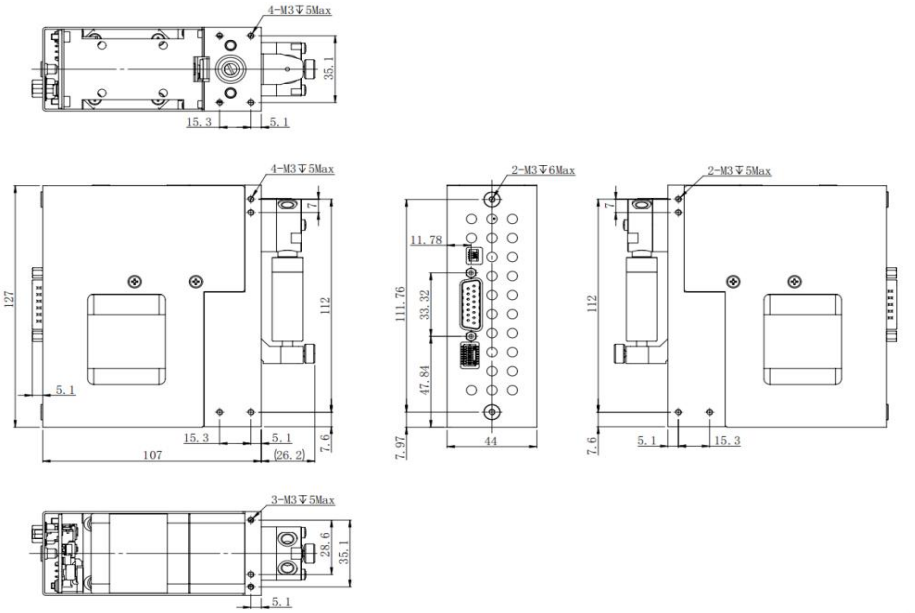


Figure 17 Installation diagram of the 5A33 series syringe pump

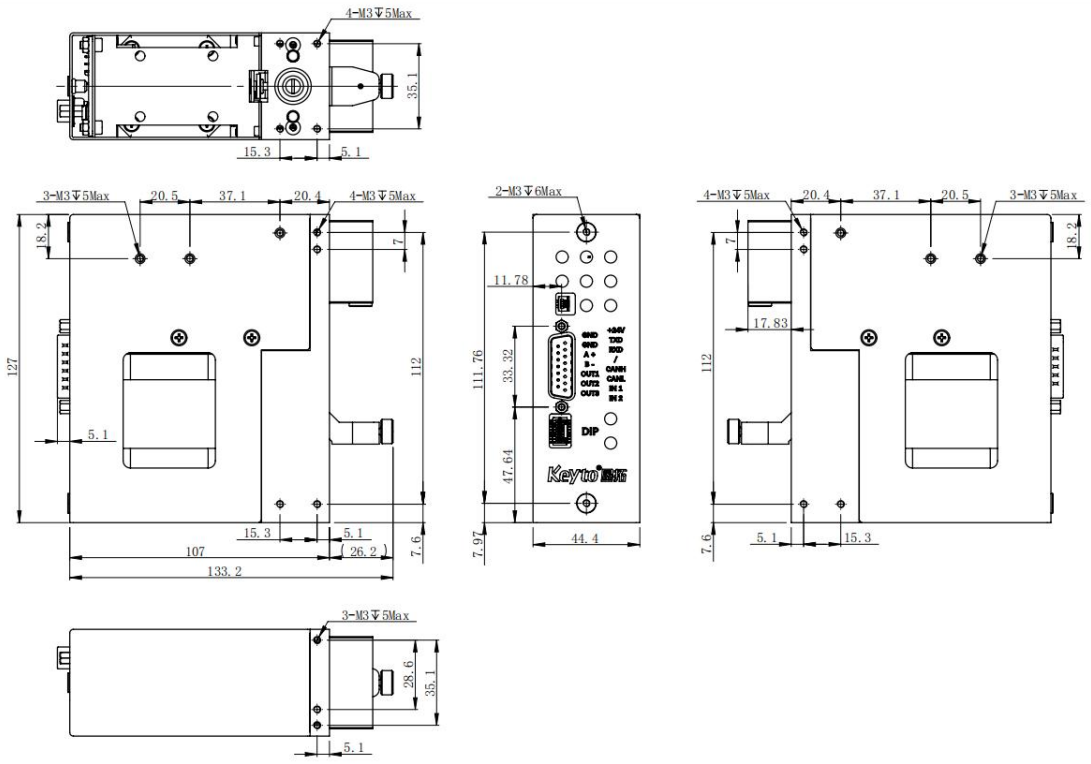


Figure 18 Installation diagram of the 5A33 series syringe pump

3 Software Communication

3.1 Communications Interface

The following methods are supported for communicating with the syringe pump:

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

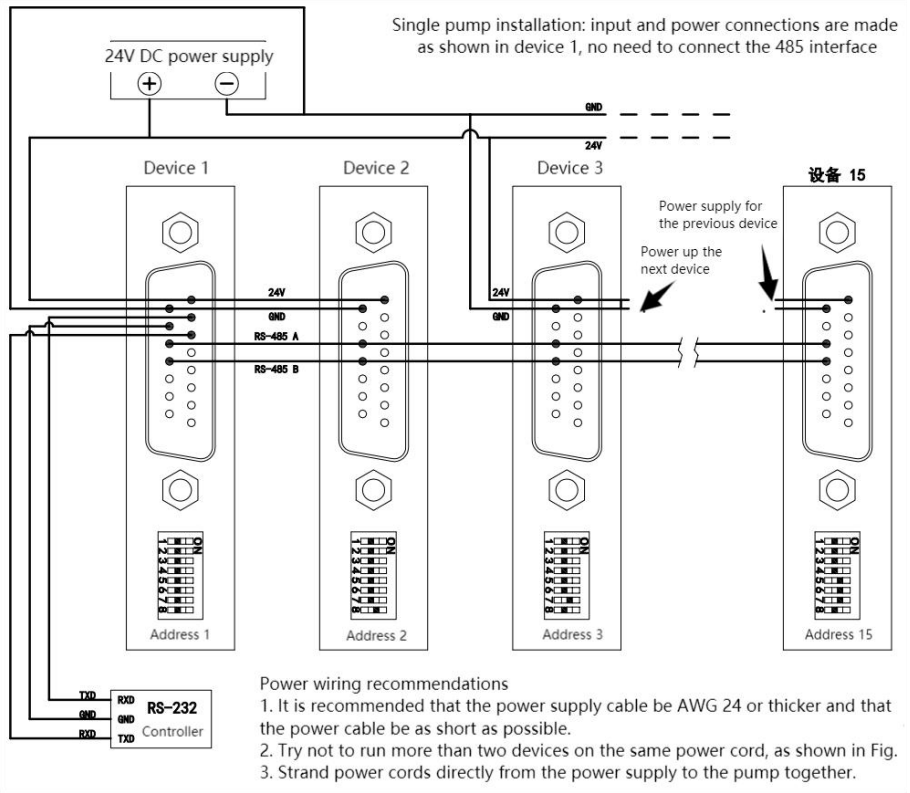
Baud rate:

Serial port: 9600 (default), 38400

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

When selecting a communication interface, prioritize CAN communication (highest reliability and supports networking with multiple devices), followed by RS485 (supports networking with multiple devices), and finally RS232.

3.1.1 RS232 communication and cabling



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

Figure 19 RS232 communication and cabling diagram

3.1.2 RS485 communication and cabling

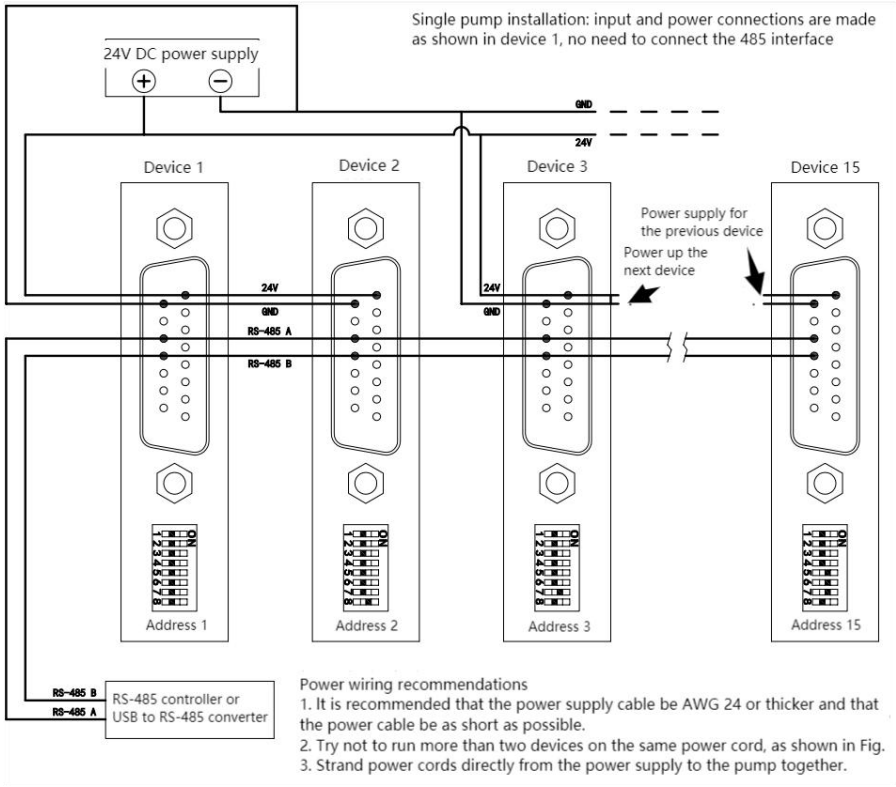


Figure 20 RS485 communication and cabling diagram

3.1.3 CAN communication and power supply wiring

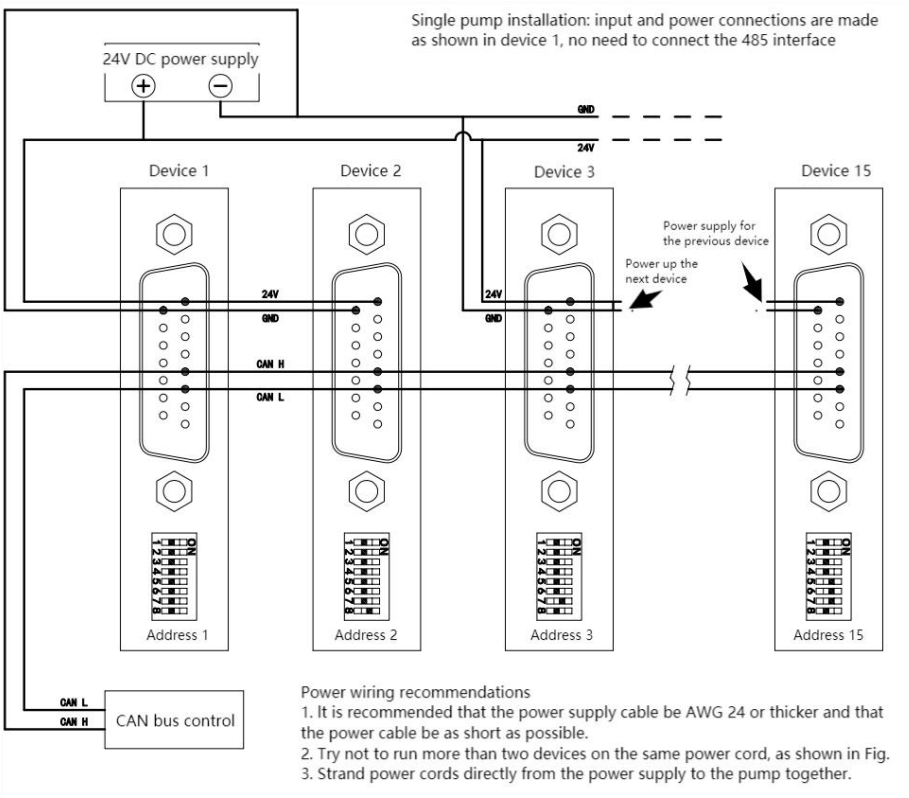


Figure 21 CAN bus communication and power supply wiring diagram

3.2 Communication Protocols

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

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 for 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.

CAN Extended Frame Protocol

This communication protocol is used for CAN communication in a local area network. It utilizes extended frames for communication and uses the pattern of encapsulating the command as an object dictionary with an action using only one frame of data. There is no need to poll the syringe pump status, it will be automatically uploaded after the command is executed. For detailed information, refer to the CAN extended frame protocol.

3.2.1 DT protocol format

Table 4 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 Table 3
2+n	Command string	n			ASCII command strings, see operation commands for details
3+n	End Character	1	Carriage Return [CR]	0x0D	Indicates the end of a command frame

Table 5 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 Table 6
3+n	Data String	n			Return data ASCII string
4+n	End Character	1	Terminator [ETX]	0x03	Indicates the end of a frame of return data
5+n		1	Carriage Return [CR]	0x0D	
6+n		1	Line feed [LF]	0x0A	

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

Table 6 Status table

Status Byte								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.

Table 7 LED light flashing description

Number of flashes	Misdescription	Number of flashes	Misdescription
1	drive failure	2	Valve Zero Optocoupler Error
3	Rotary Cutting Valve Position Optocoupler Error	4	Rotary Cutting Valve Plugging
5	Plunger Zero Optocoupler Error	6	Plunger motor blocking
7	storage error	8	CAN communication error
9	Pressure sensor error		

3.2.2 OEM protocol format

Table 8 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 characters, see Table 3
3	Serial number	1			ASCII characters, see details in Table 10
2+n	Command string	n			ASCII command strings, see Operation Commands for details.
3+n	End Character	1	End-of-Text [ETX]	0x03	Indicates the end of a command frame
4+n	Calibration	1			Heterodyne checksum for the first 3+n command bytes

Table 9 OEM Return Data Protocol Format

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

Table 10 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 of the previous command string. If they are consistent, the internal execution will not be executed and the last error status will be returned. Otherwise, the current command string will be executed normally;This function can be used to resend the command string when communication is abnormal.

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

3.2.3 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.

Table 11 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).

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

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

Frame Type: Types 1, 2, 3, 4, and 6 (3 bits). 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 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 Table 11.

Table 12 CAN general frame commands

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

4	Terminate command execution, same as T command

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

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

Type 6, Report/Response Frame: This frame can be used to allow the syringe pump to report information about itself, the same as the ? command, just use this frame to send the parameters of the ? command, the report command is shown in the table below:

Table 13 CAN report/answer frame commands

Command	Description
0	Report absolute syringe position
1	Report the encoder position of the syringe
3	Reporting Valve Ports
4	Report the maximum speed of the syringe
6	Reporting of syringe start-up speed
7	Report syringe stopping speed
10	Report command buffer status, 0: buffer empty, 1: buffer with commands
12	Report the syringe backlash set by the K command
13	Report the status of auxiliary input 1, 0:low, 1:high
14	Report 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 switches
18	Report the number of valve switches since the last report
19	Report whether the pump has been initialized
20	Report controller unique number
23	Report firmware version
24	Report the syringe dead volume set by the k command
25	Report the syringe acceleration set by the L command
28	Report the segmentation mode set by the N command
29	Report current motion status
30-34	Report command strings in non-volatile memory
76	Report syringe pump configuration

When the syringe pump receives a command, completes a command, or executes an error, it will use the same frame type as the command to send a response frame to the host. The first two bytes of the response frame are status bytes, and the first byte is 0x20, such as Error codes in Table 6; the second byte is fixed to 0x60, and the rest are characters in the ASCII format of the response; all messages of frame type 1 and 2 are acknowledged with a blank message with a data length of zero;

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

3.2.4 Explanation of the execution of the command

- Except for reporting and query commands, all other commands must end with the R command.
- Single commands and command strings can be executed sequentially, such as /1ZIA800R\r. The syringe pump at address 1 is initialized first, then switches the valve to the input channel, and then moves the syringe to the 800 increment position;
- 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 the command is executed, the syringe pump will enter the busy state. It will not exit the busy state until the execution of the command string is completed or a stop command (T command) is received. The status can be queried through the query Q command;
- Prior to controlling movement, the syringe pump must be initialized using the initialization command.

3.3 Operating Commands

3.3.1 Syringe pump configuration commands

3.3.1.1 <N>[n] Set syringe step division

Table 14 Syringe step division settings

Command	Parameters	Parameter Range	Default Value	Description
N	n	0	0	All position and velocity-related parameters is in half-steps
		1		All position-related parameters is in micro-steps, and velocity-related parameters are in half-steps.
		2		All position and velocity-related parameters is in micro-steps

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

3.3.1.2 <K>[n] Set syringe backlash

Table 15 Syringe backlash settings

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.

Setting the compensates for the backlash in the syringe drive structure and improves liquid handling accuracy. This parameter returns to the default value after the syringe pump resets and restarts.

3.3.1.3 <k>[n] Set syringe dead volume

Table 16 Syringe dead volume Setting

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.

With the default initialization, the Plunger moves upward until it contacts the top of the syringe, causing the motor to stop initializing after it is out of step. The Plunger then moves down and up, leaving a small gap (dead volume) between the syringe tip seal and the top of the Plunger. This small gap is designed to keep from hitting the top of the Plunger every time the syringe moves to the zero position of the syringe. This avoids affecting the life of the Plunger and the syringe.

Note: It is not recommended that the k command parameter be set to a range of less than 10, if not for special circumstances, as it is susceptible to damage to the Plunger or syringe after running.

3.3.1.4 <U>[n] Syringe pump configuration

Table 17 syringe pump configuration

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

		54		Set CAN baud rate to 1M
		57		Set the CAN baud rate to 125K

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

3.3.2 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 optocoupler is in the triggered state, the plunger will move in the liquid aspiration direction until the 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.

NOTE: To avoid damaging the Plunger and syringe when resetting small displacement syringes, use a different drive force when resetting.

Table 18 Recommended Syringe Initialization Forces

Syringe Displacement	Drag force
1.0mL and above	All drag force
250uL, 500uL	One half of the drag force
50uL, 100uL	One-third of the drag force

3.3.2.1 <Z>[n1],[n2],[n3] Clockwise initialization of valve and plunger

Table 19 Clockwise Initialization Plunger and Valve

Command	Parameters	Parameter Range	Default Value	Description
Z	n1	0	0	Full Drive Force and Initialize plunger at default speed
		1		two-third driving force and Initialize plunger at default speed
		2		One-third driving force and Initialize plunger at default speed
		10-40		Full Driving force and Initialize the plunger with speed code [n1] speed, the list of speed codes is shown in Table 35
	n2	0	0	Set the initialized valve input port to Port 1
		1-X		Set the initialization valve input number, X is the maximum number for the valve port
	n3	0	0	Setting the initialization valve output port X;
		1-X		Set initialization valve output number, X for the maximum number of valve port;

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

3.3.2.2 <Y>[n1],[n2],[n3] Counterclockwise initialization of valve and plunger

Table 20 Counterclockwise Initialization Plunger and Valve

Command	Parameters	Parameter Range	Default Value	Description
Y	n1	0	0	Full the initialized valve input port and Initialize plunger at default speed
		1		Full Drive Force and Initialize plunger at default speed
		2		two-third driving force and Initialize plunger at default speed
		10-40		One-third driving force and Initialize plunger at default speed
	n2	0	0	Set the initialization valve input port to Port 1
		1-X		Set the initialization valve input number, X is the maximum number for the valve port
	n3	0	0	Setting the initialization valve output port X;
		1-X		Set initialization valve output number, X for the maximum number of valve port;

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

3.3.2.3 <W>[n1] Initialize plunger only

Table 21 Initialize Plunger Only

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

3.3.2.4 <w>[n1],[n2] Initialize valve only

Table 22 Initialize valve only

Command	Parameters	Parameter Range	Default Value	Description
w	n1	1-X	1	Set the initialization valve port number, X for the maximum valve port number;
	n2	0	0	Initialize the valve clockwise
		1		Initialize the valve counterclockwise

3.3.2.5 <z>[n] Analog plunger initialization

Table 23 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
		0-3000		When setting the syringe subdivision to N0, n is set to the plunger position and the plunger operation error is cleared.
		0-24000		When setting the syringe subdivision to N1 or N2, n is set to the plunger position and clears the plunger operation error.

This command is mainly used when a plunger movement operation needs to be performed after an error is reported by the syringe.

NOTE: Improper use of this command will cause the Plunger to run out of travel, risking damage to

the syringe pump.

3.3.3 Valve control commands

3.3.3.1 <I>[n] Switching valve to the input port/Switch valve clockwise

Table 24 Switching valve to the input port/Switch valve clockwise

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

If the valve is not initialized before using this command, it will initialize the valve and switch to the set port in clockwise direction.

3.3.3.2 <O>[n] Switching valve to output port/Switch valve counterclockwise

Table 25 Switching valve to output port/Switch valve counterclockwise

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

If the valve is not initialized before using this command, the valve will be initialized and switch to the set port in counterclockwise direction.

3.3.3.3 <B>[n] Switching valve to the bypass port/Optimal path switching valve

Table 26 Switching valve to the bypass port/Optimal path switching valve

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

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

3.3.3.4 <E>[n] Switching valves to additional ports/Optimal path switching valve

Table 27 Switching valves to additional ports/Optimal path switching valve

Command	Parameters	Parameter Range	Default Value	Description
E	n	None		Optimal path to switch valve to other ports
		1-X		If the rotary cut valve head is the optimal path to move the valve to n-port, if the solenoid valve head is independent control of each solenoid valve switch

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

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

3.3.4 Syringe control commands

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

3.3.4.1 <A>[n] Move Plunger to absolute position

Table Table 28 Moving the Plunger to the Absolute Position

command	parameters	Parameter range	default value	descriptive
A	n	0-3000	0	When setting the syringe subdivision to N0
		0-24000		When setting the syringe subdivision to N1 or N2

3.3.4.2 <a>[n] Move Plunger to absolute position (return is idle)

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

3.3.4.3 <P>[n] Relative position aspiration

Table 29 Relative Position Aspiration

command	parameters	Parameter range	default value	descriptive
P	n	0-3000	0	When setting the syringe subdivision to N0
		0-24000		When setting the syringe subdivision to N1 or N2

3.3.4.4 <p>[n] Relative position aspiration (return is idle)

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

3.3.4.5 <D>[n] Relative position dispense

Table 30 Relative Position Drain

command	parameters	Parameter range	default value	descriptive
D	n	0-3000	0	When setting the syringe subdivision to N0
		0-24000		When setting the syringe subdivision to N1 or N2

3.3.4.6 <d>[n] Relative position drain (return is idle)

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

3.3.5 Syringe parameter setting command

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

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

3.3.5.1 <L>[n] Set acceleration

Table 31 Acceleration

Command	Parameter	Parameter range	Default value	Description
L	n	1-20	7	Set acceleration to n*2500 increments per square second

3.3.5.2 <v>[n] Set the startup speed

Table 32 Set the startup speed

Command	Parameter	Parameter range	Default value	Description
V	n	50-1000	900	Set the syringe startup speed to n increments per second

3.3.5.3 <V>[n] Set the maximum speed

Table 33 Set the maximum speed

Command	Parameter	Parameter range	Default value	Description
v	n	5-6000	1400	Set the maximum speed of the syringe to increments per second

Note: When the syringe pump's outlet is connected to a longer or narrower tubing, a certain amount of back pressure may be generated due to flow resistance caused by changes in diameter and along the tubing's length. This back pressure is directly proportional to flow rate, inversely proportional to tubing diameter, and directly proportional to tube length. Therefore, the pump's dispensing speed should not be too high to prevent the internal hydraulic pressure of the syringe from exceeding the valve's pressure tolerance. The specific speed limit can be set based on actual fluid path test results.

3.3.5.4 <S>[n] Set the maximum speed (table lookup method)

Table 34 Set the maximum speed (table lookup method)

Command	Parameter	Parameter range	Default value	Description
S	n	0-40	11	Set the maximum speed to speed code [n], see Table 35

Table 35 Speed code table

Speed code	Speed (increments per second)	Seconds / Full stroke (N0 or N1)	Seconds / Full stroke (N2)
0	6000	1.25	8.25
1	5600	1.30	8.80
2	5000	1.39	9.79
3	4400	1.52	11.1
4	3800	1.71	12.8
5	3200	1.97	15.1
6	2600	2.37	18.5

7	2200	2.77	21.9
8	2000	3.03	24.0
9	1800	3.36	26.7
10	1600	3.77	30.0
11	1400	4.30	34.3
12	1200	5.00	40.0
13	1000	6.00	48.0
14	800	7.50	60.0
15	600	10.00	80.0
16	400	15.00	120
17	200	30.00	240
18	190	31.58	253
19	180	33.33	267
20	170	35.29	282
21	160	37.50	300
22	150	40.00	320
23	140	42.86	343
24	130	46.15	369
25	120	50.00	400
26	110	54.55	436
27	100	60.00	480
28	90	66.67	533
29	80	75.00	600
30	70	85.71	686
31	60	100.00	800
32	50	120.00	960
33	40	150.00	1200
34	30	200.00	1600
35	20	300.00	2400
36	18	333.33	2667
37	16	375.00	3000
38	14	428.57	3429
39	12	500.00	4000
40	10	600.00	4800

3.3.5.5 <c>[n] Set stop speed

Table 36 Set stop speed

Command	Parameter	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.

3.3.6 System control commands

3.3.6.1 <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.

3.3.6.2 <X> Repeat the last action command string

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

3.3.6.3 <G>[n] Loop execution of a command or command string

Table 37 Loop execution of a command or command string

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

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

3.3.6.4 <g> Start tag for loop execution of a command or command string

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

3.3.6.5 <M>[n] Delay execution

Table 38 Delay execution

Command	Parameter	Parameter range	Default value	Description
M	n	0-30000		Delay execution time (milliseconds)

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

3.3.6.6 <H>[n] Interrupt execution

Table 39 Interrupt execution

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

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

3.3.6.7 <T> Terminate command

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

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

3.3.6.8 <J>[n] Auxiliary output control

Table 40 Auxiliary output control

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

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

3.3.6.9 <!> 3.3.6.9 Reset command

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

3.3.7 Non-volatile memory command

3.3.7.1 <s>[n] Store command string to non-volatile memory

Table 41 Store command string to non-volatile storage

Command	Parameter	Parameter	Default	Description

		range	value	
s	n	0-14		Store the command string to the location of command string n in non-volatile memory

The user can store the command string into non-volatile memory by putting the s command at the beginning of the command string, and each command string can be up to 128 bytes, which can be accessed by the ? command to query the command string stored into non-volatile memory, see Table 45;

For example, the s1ZgIA3000BA0G10R command string, i.e., the ZgIA3000BA0G10R command is stored at the location of command string 1 in the non-volatile memory.

3.3.7.2 <e>[n] Execute a command string in non-volatile memory

Table 42 Execute a command string in non-volatile memory

Command	Parameter	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, i.e., to allow automatic operation of the command string in non-volatile memory mode, where the command string is executed at the DIP switch address (see Table 3).

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

3.3.7.3 <>>n1,n2 Set user data

Table 43 Set user data

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

3.3.7.4 <<>[n] Read user data

Table 44 Read user data

Command	Parameter	Parameter range	Default value	Description
<	n1	0-15	0	Position index in non-volatile memory

3.3.8 Query the command

3.3.8.1 <?>[n] Report syringe pump information

Table 45 Report syringe pump information

Command	Parameter	Parameter range	Default value	Description
?	n	0	0	Report absolute syringe position
		1		Report syringe startup speed

		2		Report maximum syringe speed
		3		Report syringe stop speed
		4		Report the encoder position of the syringe
		6		Report valve port
		10		Report command cache status, 0: cache is empty, 1: cache has commands
		12		Report the syringe backlash set by the K command
		13		Reports the status of auxiliary input 1, 0: low, 1: high
		14		Reports the status of auxiliary input 2, 0: low, 1: high
		15		Report the number of times of syringe initializations
		16		Report the number of times of plunger movements
		17		Report the number of times of valve switching
		18		Report the number of times of valve switching since the last report
		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

3.3.8.2 <F> Report the status of the command buffer

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

3.3.8.3 <%> Report the number of times of valve switching since the last report

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

3.3.8.4 <#> Report board unique number

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

3.3.8.5 <&> Report firmware version

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

3.3.8.6 <Q> Report Status

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

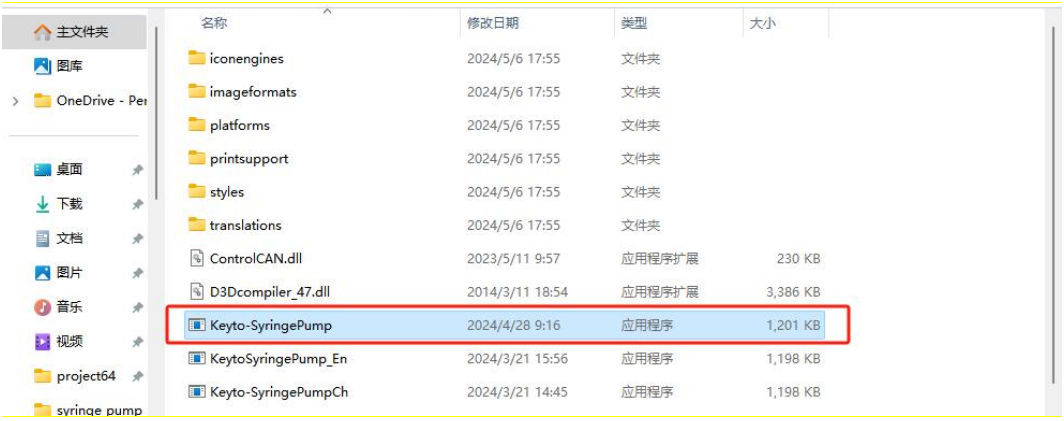
3.3.8.7 <Q>Report Status

And? Similar to the 29 command, report the current status of the PSP, as shown in Table 6.

3.4 Upper Computer Test Software

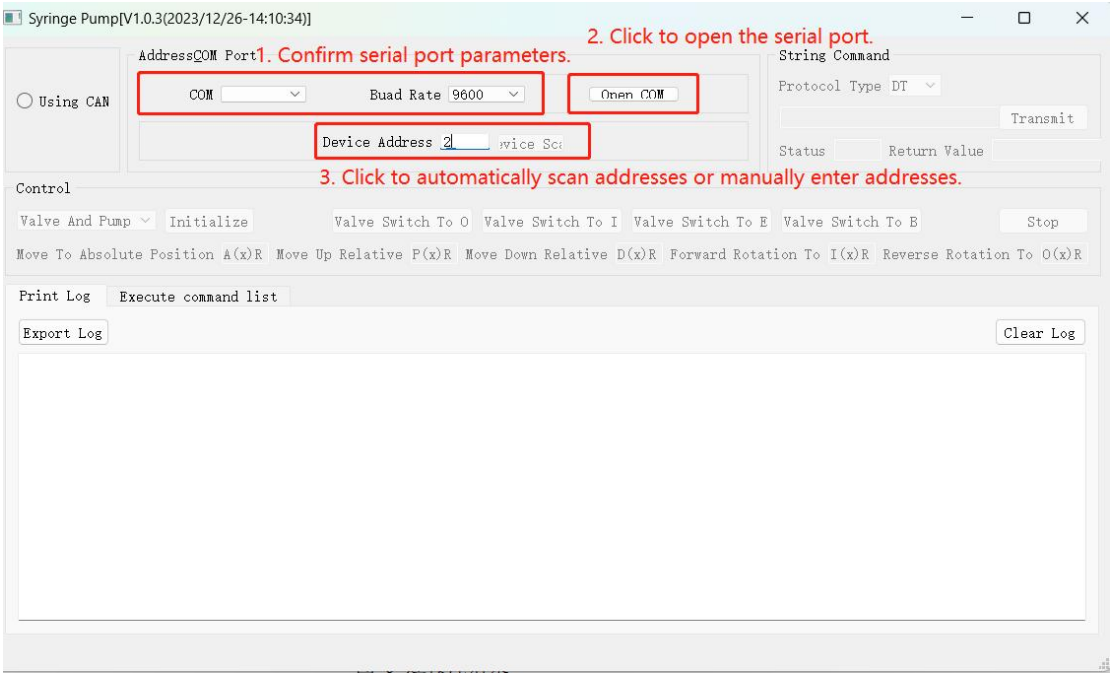
3.4.1 Open the upper computer test software

First of all, the device is connected to the line according to the hardware settings in Chapter 2 and powered on, then open the Keyto-SyringePump.exe test software:



3.4.2 Serial port, baud rate selection

Select the corresponding port number, select 9600 baud rate (factory default 9600), click "Open Serial Port" button to open the serial port.



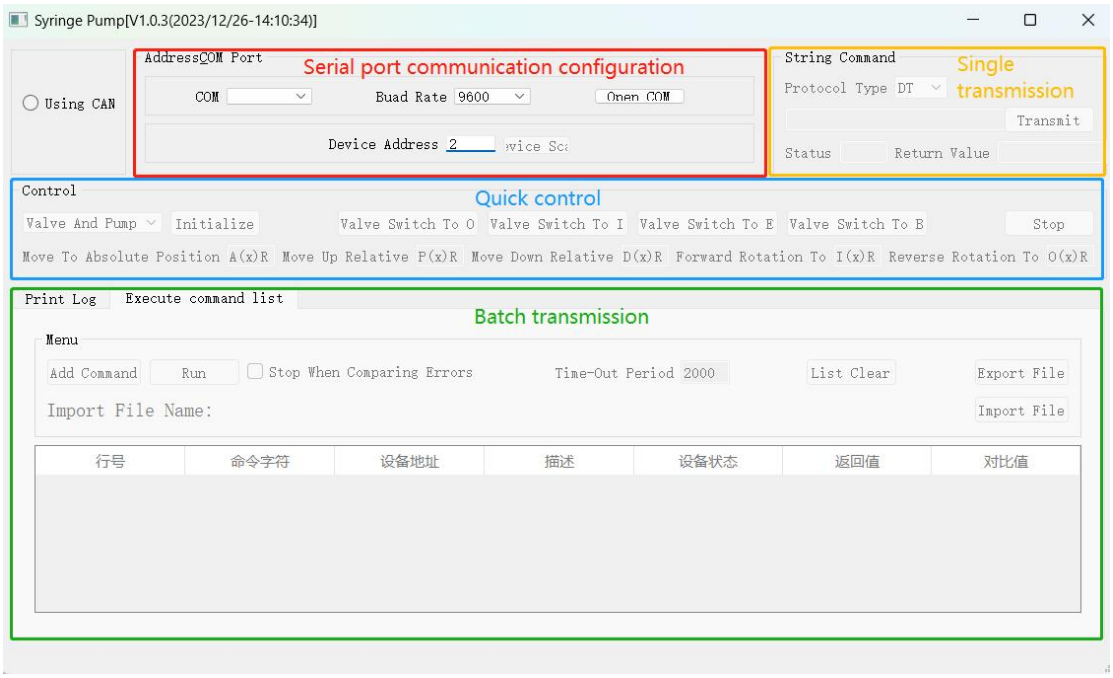
3.4.3 Protocol selection, scanning devices

Click the drop-down button at the protocol type, you can select DT or OEM protocol, click the Auto Scan button after you finish the selection, the default address of the device is 1, the address bar will be automatically filled with the scanned address after the scanning is completed,

note that only after the address is scanned can you perform the subsequent operations.

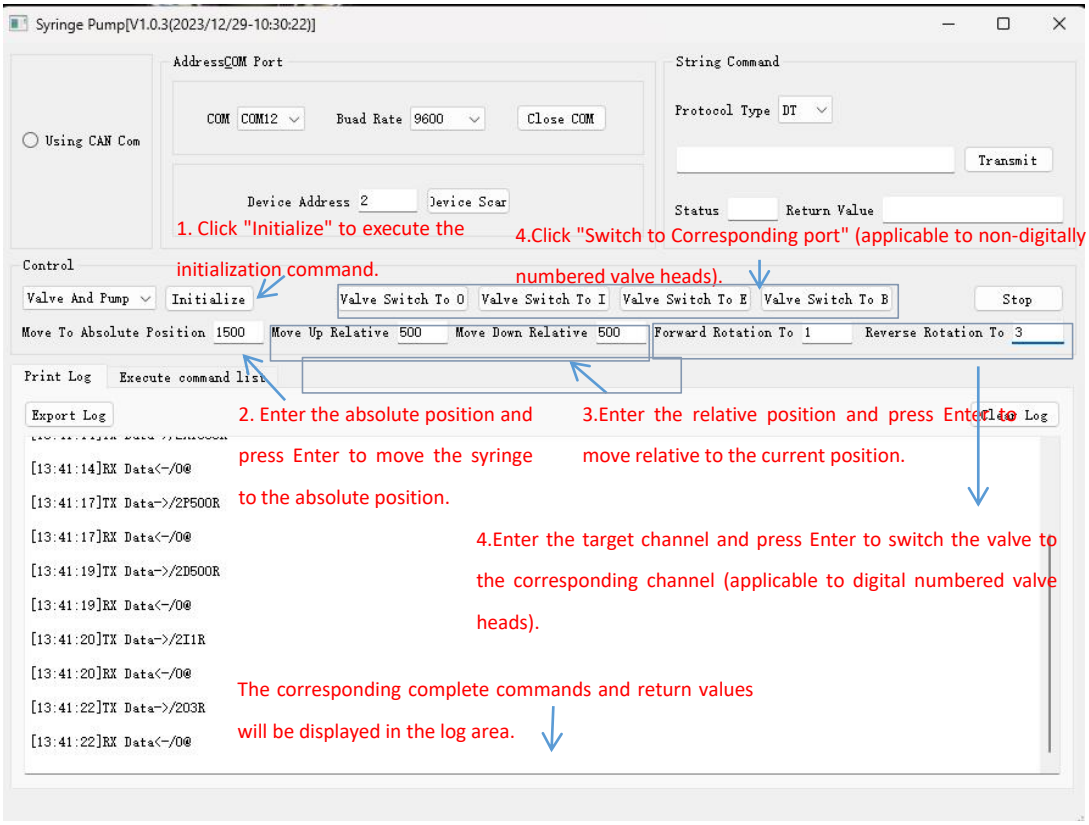
Note: 1. After selecting the protocol type and scanning the address, the setting will lock the current protocol type, if you need to change the protocol, you need to reboot the device.

2. If you cannot scan the address, please refer to the Q&A 2 for troubleshooting.



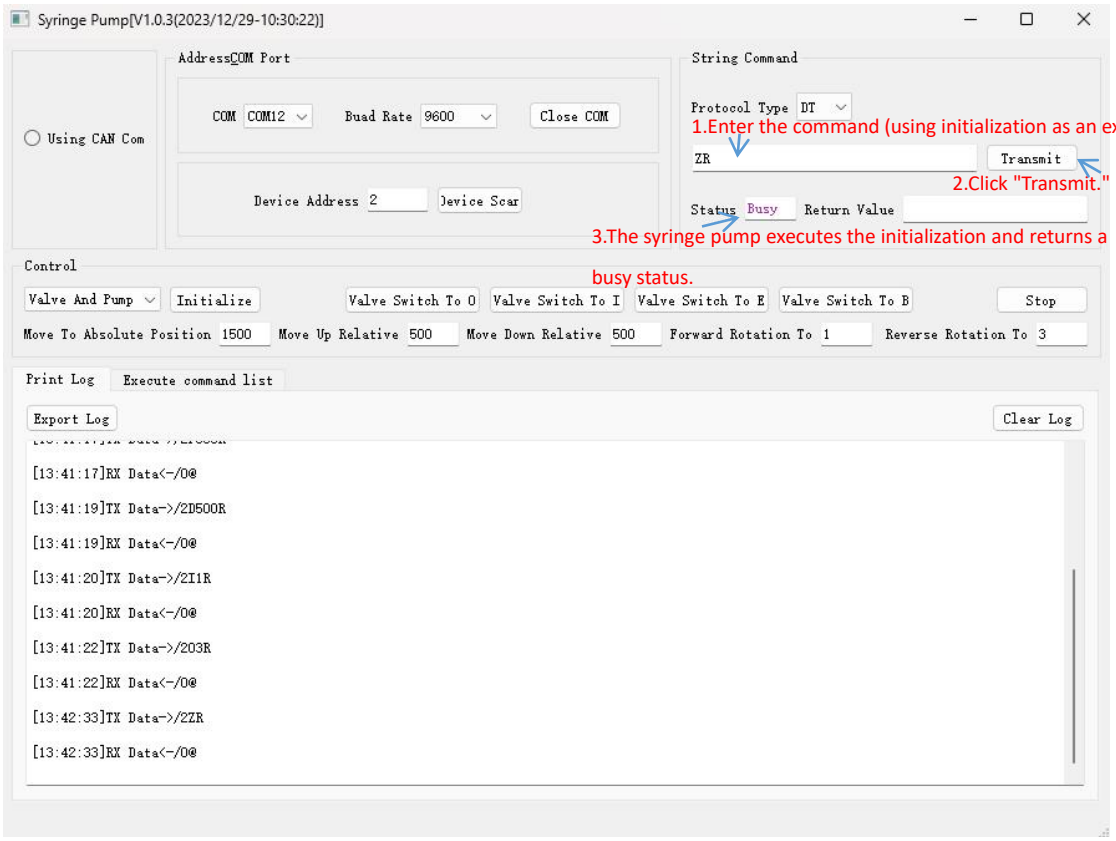
3.4.4 Quick control

Simple control of the pump can be achieved at the quick control bar by clicking on a button or by entering the value, as shown in the figure below.



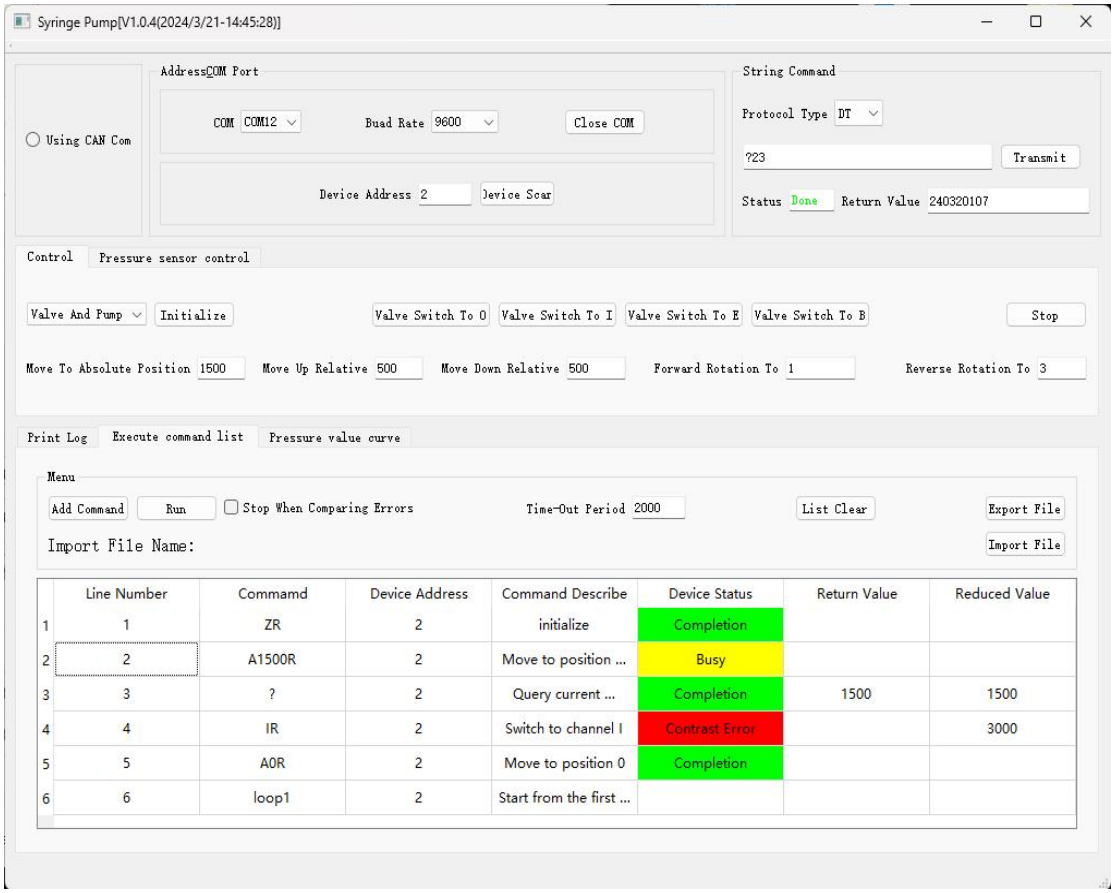
3.4.5 Manually issued

All commands for the syringe pump can be issued manually in this area. When the DT protocol is selected, only the ASCII command string needs to be entered, and the host computer will automatically convert to the full DT protocol command to be issued. The status bar will show the current status of the pump, Busy if it is in motion, and Finished if the motion is completed. If the command sent is a query command, the host computer will display the parsed return value at the return value. When OEM is selected, it also only needs to input ASCII command string, and the upper computer will convert it into a complete OEM protocol command and send it out. The specific command sent out can be viewed in the log area, and the execution time of the command will be displayed in the log area after the command execution is completed.



3.4.6 List execution

You can edit the simple process in the list execution column. After the process is finished editing and clicking Auto Run, the upper computer will start issuing the first command and poll the current status when it finishes issuing, and continue issuing the next command when the status becomes idle, and the upper computer will report the error and stop issuing the subsequent commands when there is an error in the process running or the command is abnormal.



3.5 Application Examples

Before sending the motion command, it is necessary to query the current running state with the Q command, and the motion command is sent only when it is the idle state, and the state returned by other non-Q commands can not be used for the identification of the running or idle state of the device, and can only be used for exception handling.

The following example device serial port address is 1 (CAN address is 0).

3.5.1 DT protocol

3.5.1.1 Execute a single command action

Function	Direction	Data	Description
Set the serial port baud rate to 9600	Send	/1U41R [CR]	/start character;1 device address; U41 set serial port baud rate to 9600; R execute command; [CR] carriage return character
	Receive	/0`[ETX][CR][LF]	/start character; 0 host address; `state idle; [ETX] terminator, [CR] carriage return; [LF] line feed
Initialization	Send	/1ZR[CR]	/start character;1 device address; Z initialization instruction; R execute command; [CR] carriage return character
	Receive	/0@[etx][cr][lf]	/start character; 0 host address; @status busy; [ETX] termination character, [CR] carriage return character; [LF] line feed character
Switching Valve to Input Port	Send	/1IR[CR]	/start character;1 device address; I switch valve to input port command; R execute command; [CR]

			carriage return character
	Receive	/0@[etx][cr][lf]	/start character; 0 host address; @status busy; [ETX] termination character, [CR] carriage return character; [LF] line feed character
Plunger movement to absolute position 300 increments	Send	/1A300R[CR]	/start character;1 device address; A300 Plunger moves to absolute position 300 increments; R execute command; [CR] carriage return character
	Receive	/0@[etx][cr][lf]	/start character; 0 host address; @status busy; [ETX] termination character, [CR] carriage return character; [LF] line feed character
Setting the maximum speed to 3000 increments/second	Send	/1V3000R[CR]	/start character;1 device address; V3000 sets the maximum speed to 3000 increments per second; R executes the command; [CR] carriage return character
	Receive	/0`[ETX][CR][LF]	/start character; 0 host address; `state idle; [ETX] terminator, [CR] carriage return; [LF] line feed
Reset and restart	Send	/1!R[CR]	/start character;1 device address; ! Reset reboot; R Execute command; [CR] Carriage return character
	Receive	/0`[ETX][CR][LF]	/start character; 0 host address; `state idle; [ETX] terminator, [CR] carriage return; [LF] line feed
Store Z at command string location 0 in non-volatile memory	Send	/1s0ZR[CR]	/start character;1 device address; s0Z stores Z at position 0 of the command string in non-volatile memory; R executes the command; [CR] carriage return character
	Receive	/0@[etx][cr][lf]	/start character; 0 host address; @status busy; [ETX] termination character, [CR] carriage return character; [LF] line feed character
Query Firmware Version Number	Send	/1?23[CR]	/start character;1 device address; ?23 query firmware version number; [CR] carriage return character
	Receive	/0`231227106 [etx][cr][lf]	/start character; 0 host address; `status idle; 231227106 firmware version number code; [ETX] terminator, [CR] carriage return character; [LF] line feed character

3.5.1.2 Execute multiple command actions

Function	Direction	Data	Description
Set the subdivision to N0, then initialize, then switch the valve to the input port, then set the speed to 600 increments per second, and finally the Plunger moves to the absolute position of 300	Send	/1N0ZIV600A300R Carriage Return [CR]	/start character;1 device address; N0 sets subdivision; Z initializes; I switches valve to input port; V600 sets speed to 600 increments per second; A300 Plunger moves to absolute position 300; [CR] carriage return character
	Receive	/0@[etx][cr][lf]	/start character; 0 host address; @status busy; [ETX] termination character, [CR] carriage return character; [LF] line feed character

3.5.2 OEM agreement

3.5.2.1 Execute a single command action

Function	Direction	Data	Description
Set the serial port baud rate to 9600	Send	02 31 30 55 34 31 52 03 02	02 frame header; 31 device address; 30 sequence number; 55 34 31 (U41); 52 (R); 03 frame end; 02 heterodyne check
	Receive	02 30 60 03 51	02 frame header; 30 host address; 60 idle state; 03 frame end; 51 heterodyne check
Initialization	Send	02 31 30 5A 52 03 08	02 Frame header; 31 Device address; 30 Sequence number; 5A (Z); 52 (R); 03 End of frame; 08 Alter checksum
	Receive	02 30 40 03 71	02 Frame header; 30 Host address; 40 Busy status; 03

			Frame end; 71 Heterodyne check
Switching Valve to Input Port	Send	02 31 30 49 52 03 1B	02 Frame header; 31 Device address; 30 Sequence number; 49 (I); 52 (R); 03 Frame ender; 1B heterodyne checksum
	Receive	02 30 40 03 71	02 Frame header; 30 Host address; 40 Busy status; 03 Frame end; 71 Heterodyne check
Plunger movement to absolute position 300 increments	Send	02 31 30 41 33 30 30 52 03 20	02 Frame header; 31 Device address; 30 Sequence number; 41 33 30 30 (A300); 52 (R); 03 Frame tail; 20 Alias checksum
	Receive	02 30 40 03 71	02 Frame header; 30 Host address; 40 Busy status; 03 Frame end; 71 Heterodyne check
Setting the maximum speed to 3000 increments/second	Send	02 31 30 56 33 30 30 30 30 52 03 07	02 Frame header; 31 Device address; 30 Sequence number; 56 33 30 30 30 30 (V3000); 52 (R); 03 Frame ender; 07 Heterodyne checksum
	Receive	02 30 60 03 51	02 frame header; 30 host address; 60 idle state; 03 frame end; 51 heterodyne check
Reset and restart	Send	02 31 30 21 52 03 73	02 frame header; 31 device address; 30 sequence number; 21 (!) ; 52 (R); 03 frame end; 73 heterodyne check
	Receive	02 30 60 03 51	02 frame header; 30 host address; 60 idle state; 03 frame end; 51 heterodyne check
Store Z at command string location 0 in non-volatile memory	Send	02 31 30 73 30 5A 52 03 4B	02 frame header; 31 device address; 30 sequence number; 73 30 5A 52 (s0ZR); 03 frame end; 4B heterodyne checksum
	Receive	02 30 40 03 51	02 frame header; 30 host address; 40 busy status; 03 frame end; 51 heterodyne check
Query Firmware Version Number	Send	02 31 30 3F 32 33 03 3E	02 Frame header; 31 Device address; 30 Sequence number; 3F 32 33 (?23); 03 Frame tail; 3E heterodyne checksum
	Receive	02 30 60 32 33 31 32 32 37 31 30 36 03 61	02 frame header; 30 host address; 60 idle state; 32 33 31 32 32 37 31 30 36 (231227106); 03 frame end; 61 heterodyne checksum

3.5.2.2 Execute multiple command actions

Function	Direction	Data	Description
Set the subdivision to N0, then initialize, then switch the valve to the input port, then set the speed to 600 increments per second, and finally the Plunger moves to the absolute position of 300	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 sequence number; 4E 30 5A 49 56 36 30 30 41 33 30 30 52 (N0ZIV600A300R); 03 frame tail; 2D heterosync checksum
	Receive	02 30 40 03 51	02 frame header; 30 host address; 40 busy status; 03 frame end; 51 heterodyne check

3.5.3 CAN standard frame protocol

3.5.3.1 Host acknowledges startup request

Function	Direction	Data	Description	Function
request a connection	Receive	0x0482	not have	The syringe pump sends a start request to the host at fixed intervals.
establish a connection	Send	0x0080	20 20	20 Device address (dialed address + 0x20); 20 Assigned address (assigned address + 0x20)

Example of a frame ID description:

orientations	organize	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			
The ID is the frame ID when sending the connection establishment, the sending direction is from host to slave, so the direction is bit 0; the group number of the 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;										

3.5.3.2 Execute a single command action

Function	orientations	Frame ID	Frame data (HEX)	Description
Set the serial port baud rate to 9600	Send	0x0101	55 34 31 52	Frame ID direction 0, group number 2, device address 0, frame type 1 (001 0000 0001); frame data 55 34 31 52 (U41R)
	Receive	0x0501	not have	Immediately returned with frame ID direction 1, group number 2, device address 0, frame type 1 (101 0000 0001)
	Receive	0x0501	60 00	Returned after completion of movement, frame ID direction is 1, group number is 2, device address is 0, frame type is 1 (101 0000 0001); frame data 20 status without error; 60 fixed return, no real meaning
Initialization	Send	0x0101	5A 52	Frame ID direction 0, group number 2, device address 0, frame type 1 (001 0000 0001); frame data 5A 52 (ZR)
	Receive	0x0501	not have	Immediately returned with frame ID direction 1, group number 2, device address 0, frame type 1 (101 0000 0001)
	Receive	0x0501	60 00	Returned after completion of movement, frame ID direction is 1, group number is 2, device address is 0, frame type is 1 (101 0000 0001); frame data 20 status without error; 60 fixed return, no real meaning
Switching Valve to Input Port	Send	0x0101	49 52	Frame ID direction 0, group number 2, device address 0, frame type 1 (001 0000 0001); frame data 49 52 (IR)
	Receive	0x0501	not have	Immediately returned with frame ID direction 1, group number 2, device address 0, frame type 1 (101 0000 0001)
	Receive	0x0501	60 00	Returned after completion of movement, frame ID direction is 1, group number is 2, device address is 0, frame type is 1 (101 0000 0001); frame data 20 status without error; 60 fixed return, no real meaning
Plunger movement to absolute position 300 increments	Send	0x0101	41 33 30 30 52	Frame ID direction 0, group number 2, device address 0, frame type 1 (001 0000 0001); frame data 41 33 30 30 52 (A300R)
	Receive	0x0501	not have	Immediately returned, 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	60 00	Returned after completion of movement, frame ID direction is 1, group number is 2, device address is 0, frame type is 1 (101 0000 0001); frame data 20 status without error; 60 fixed return, no real meaning
Setting the maximum speed to 3000 increments/second	Send	0x0101	56 33 30 30 30 30 52	Frame ID direction 0, group number 2, device address 0, frame type 1 (001 0000 0001); frame data 56 33 30 30 30 30 52 (V3000R)
	Receive	0x0501	not have	Immediately returned with frame ID direction 1, group number 2, device address 0, frame type 1 (101 0000 0001)

	Receive	0x0501	60 00	Returned after completion of movement, frame ID direction is 1, group number is 2, device address is 0, frame type is 1 (101 0000 0001); frame data 20 status without error; 60 fixed return, no real meaning
Reset and restart	Send	0x0101	21 52	Frame ID direction 0, group number 2, device address 0, frame type 1 (001 0000 0001); frame data 21 52 (!R)
	Receive	0x0501	not have	Immediately returned with frame ID direction 1, group number 2, device address 0, frame type 1 (101 0000 0001)
	Receive	0x0501	60 00	Returned after completion of movement, frame ID direction is 1, group number is 2, device address is 0, frame type is 1 (101 0000 0001); frame data 20 status without error; 60 fixed return, no real meaning
Store Z at command string location 0 in non-volatile memory	Send	0x0101	56 33 30 30 30 52	Frame ID direction 0, group number 2, device address 0, frame type 1 (001 0000 0001); frame data 73 30 5A 52 (s0ZR)
	Receive	0x0501	not have	Immediately returned with frame ID direction 1, group number 2, device address 0, frame type 1 (101 0000 0001)
	Receive	0x0501	60 00	Returned after completion of movement, frame ID direction is 1, group number is 2, device address is 0, frame type is 1 (101 0000 0001); frame data 20 status without error; 60 fixed return, no real meaning
Query Firmware Version Number	Send	0x0106	32 33	Frame ID direction 0, group number 2, device address 0, frame type 6 (001 0000 0110); frame data 32 33 (23)
	Receive	0x0503	60 00 32 33 31 32 32 37	Frame ID direction 1, group number 2, device address 0, frame type 3 (101 0000 0011); frame data 20 status no error; 60 fixed return, no real; 32 33 31 32 32 37 (231227)
	Receive	0x0506	31 30 36	Returned after completion of movement with frame ID direction 1, group number 2, device address 0, frame type 1 (101 0000 0110); frame data 31 30 36 (106)

3.5.3.3 Execute multiple command actions

Function	Direction	Frame ID	Frame data (HEX)	Description
Set the subdivision to N0, then initialize, then switch the valve to the input port, then set the speed to 600 increments per second, and finally the Plunger moves to the absolute position of 300	Send	0x0103	4E 30 5A 49 56 36 30 30	Frame ID direction 0, group number 2, device address 0, frame type 3 (001 0000 0011); frame data 4E 30 5A 49 56 36 30 30 (N0ZIV600)
	Send	0x0104	4D 31 30 30 30 30 41 33 30	Frame ID direction 0, group number 2, device address 0, frame type 3 (001 0000 0100); frame data 4D 31 30 30 30 30 41 33 30 (M1000A30)
	Send	0x0101	30 52	Frame ID direction 0, group number 2, device address 0, frame type 3 (001 0000 0001); frame data 30 52 (0R)
	Receive	0x0501	not have	Immediately returned with frame ID direction 1, group number 2, device address 0, frame type 1 (101 0000 0001)
	Receive	0x0501	60 00	Returned after completion of movement, frame ID direction is 1, group number is 2, device address is 0, frame type is 1 (101 0000 0001); frame data 20 status without error; 60 fixed return, no real meaning

4 Q&A

Note: The following descriptions are troubleshooting methods that arise when performed in a compliant operating environment and under rated operating conditions.

	Q	A
1	Why doesn't the syringe pump LED blink on and off after powering on the pump?	Poor contact of power cable at B15 plug, use a multimeter to test whether DB15 and cable are conductive, confirm whether DB15 plug is loose, and confirm whether 24V and ground at power supply are well connected.
		Power supply short circuit, need to confirm the DB15 plug and power supply at the 24V output and ground is short-circuited
		Incorrect cable connection, refer to section 2.2, check cable connection
2	Why can't I establish communication with the syringe pump?	Incorrect baud rate, default baud rate for syringe pump serial port is 9600, CAN baud rate is 100k
		Incorrect cable connection, refer to section 2.2, check cable connection
		Serial tools are not compatible, replace other manufacturers of serial cables, adapters, serial communication assistant
		Incorrect address, refer to section 2.3.1 to check the current device address
		Command format is not correct, check the command format, refer to section 3.4 Application Examples
		Protocol lockout, commands for other protocols have been sent during power up and are inconsistent with the currently used protocol, try powering down or resetting and restarting, then send the required protocol commands again
3	Why is communication with the syringe pump unstable?	Communication line is noisy, please make sure the communication line is as short as possible, separate the communication cable from the high-current cable, and keep the termination resistance between CAN and RS485 phases at 60Ω.
		Unstable communication mode, using slower baud rate for communication, using one question and one answer communication mode, more than 10ms interval between serial commands, using retransmission mechanism to ensure the reliability of communication
4	Which communication method is recommended?	Recommended use of CAN standard frame communication mode, the device movement is completed or abnormal commands will be actively reported, waiting for the completion of the device movement can be sent to the next movement command, the movement process can be used to query the command.
		Serial port is recommended to use the OEM protocol, it is recommended to use a one-question-one-answer method, after receiving the answer, the next frame can be sent, the interval between sending and receiving is at least 10ms, the current status can be queried by Q or ?29 in the process of the movement, when the status is changed from busy to idle, the next movement command can be sent.
5	How do you determine movement completion? /Can motion completion be reported to the flag bit?	When using serial communication, query the status of the device through Q or ?29 instruction, when the status changes from busy to idle, the current movement is completed and the next movement instruction can be issued
		When using CAN communication, when the movement is completed, the device will automatically report a frame of movement completion flag, when the flag is reported, it means that the current movement is complete, and the next movement instruction can be issued.

6	Which parameters can be saved by power down/how to save the set parameters by power down?	Non-volatile stored parameters, restarting the device after the setup is completed, or sending a reset restart command, will automatically save the parameter, no separate save command. Mainly contains the following commands: U, s, >	
		Syringe parameter setting commands: L, v, V, S, and c commands are set, the default values will be restored after initializing the syringe pump or resetting and restarting.	
7	What if I want to use the N2 subdivision mode to control syringe pump suction and discharge, but I want the initialization speed to be the same as the N0 subdivision mode?	Use a combination of commands to achieve this function, such as "N0ZN2R" as the initialization command, the function of this instruction is to set the syringe pump to N0 subdivision mode, then initialize it with the default parameters, and then set it to N2 subdivision mode; similarly, as long as the length of the byte is not more than 255, it is possible to combine other functions together.	
8	What if the device reports an error?	Record the status and current execution process of the device when reporting an error. If the following solutions do not provide effective help, please contact us. Some of the status trigger scenarios and solution measures	
		Error Code 1	Initialization error. This error occurs when the pump cannot be initialized or fails to initialize; please check whether the Plunger is stuck by foreign objects, if there is no abnormality, please try to re-initialize it
		Error Code 2	Invalid command, this error occurs when an unrecognized command is issued; for the command format and usage, please refer to section 3.2 Communication Protocols and 3.4 Application Examples.
		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, this error occurs when using "s" and "e" commands with incorrect command structure, please check the command format.
		Error Code 6	This error will occur when the EEPROM fails, if this error occurs, please reboot and try, if still abnormal, please contact our company.
		Error Code 7	Device not initialized This error occurs when the pump is not initialized. To clear this error, initialize the pump
		Error Code 9	Plunger overload, this error occurs when the syringe plunger is excessively impeded, check for clogged lines, use initialization to clear this error
		Error Code 10	Valve overload, this error occurs when the valve is unable to move due to blockage or excessive obstruction, use the initialization valve to clear this error
		Error Code 11	Plunger is not allowed to move, this error occurs when sending a Plunger movement command when the valve is not connected to the syringe, please check the current channel position
		Error Code 12	Internal error, when this error occurs, please contact our company
		Error Code 15	Command overflow, this error will occur when sending motion commands during syringe pump motion, please send the next motion command after the current motion is complete

5 Maintenance

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

5.1 Routine Maintenance

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

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

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

5.2 Weekly Maintenance

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

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

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

5.2.1 Diluted cleaning solution cleaning process

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

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

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

5.2.2 Weak acids and weak bases cleaning process

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

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

5.2.3 10% Bleach Cleaning Process

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

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

5.3 Periodic Maintenance

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

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

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

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

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

5.3.1 Quality control assurance

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

To determine precision and repeatability, at least 20 replicate runs of assay data are recommended. Precision, mean, standard deviation and coefficient of variation are then calculated (see formulas below).The specific gravity of water needs to be taken into account when calculating, and the specific gravity of water is directly related to temperature. Generally, the specific gravity of water is 0.99707 at a room temperature of 25℃.In addition, the liquid may adsorb at the tip of the line during discharge, and in order to prevent measurement errors caused by the liquid sticking to the tip of the line, a small amount of surfactant (e.g., 0.01% concentration of Fluorad®) needs to be added to the water.

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

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

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

Here:

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

$Vol_{expected}$：The expected volume of liquid to be dispensed;

n：discharge times;

X：single test results;

$\overline{X}$：the mean of all the results.

5.3.2 Replace the dispensing line or reagent line

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

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

5.3.3 Replace the valve head of the syringe pump

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

5.3.4 Replace the syringe

To replace the syringe, refer to 2.4.2.

Appendix A ASCII Code Table

Bin	Oct	Dec	Hex	Abbreviations/characters	Explain
0000 0000	0	0	0x00	NUL(null)	blank character
0000 0001	1	1	0x01	SOH (start of headline)	The title begins
0000 0010	2	2	0x02	STX (start of text)	Beginning of the text
0000 0011	3	3	0x03	ETX (end of text)	end of main text
0000 0100	4	4	0x04	EOT (end of transmission)	End of transmission
0000 0101	5	5	0x05	ENQ (enquiry)	requesting
0000 0110	6	6	0x06	ACK (acknowledge)	Notification received
0000 0111	7	7	0x07	BEL (bell)	beep
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)	line feed (computing)
0000 1011	13	11	0x0B	VT (vertical tab)	vertical tab
0000 1100	14	12	0x0C	FF (NP form feed, new page)	page feed key
0000 1101	15	13	0x0D	CR (carriage return)	carriage return
0000 1110	16	14	0x0E	SO (shift out)	No need to switch.
0000 1111	17	15	0x0F	SI (shift in)	Enable switching
0001 0000	20	16	0x10	DLE (data link escape)	data link escape
0001 0001	21	17	0x11	DC1 (device control 1)	Equipment control 1
0001 0010	22	18	0x12	DC2 (device control 2)	Equipment control 2
0001 0011	23	19	0x13	DC3 (device control 3)	Equipment control 3
0001 0100	24	20	0x14	DC4 (device control 4)	Equipment control 4
0001 0101	25	21	0x15	NAK (negative acknowledge)	Rejection
0001 0110	26	22	0x16	SYN (synchronous idle)	synchronous idle
0001 0111	27	23	0x17	ETB (end of trans. block)	END TRANSFER BLOCK
0001 1000	30	24	0x18	CAN (cancel)	abolish
0001 1001	31	25	0x19	EM (end of medium)	End of media
0001 1010	32	26	0x1A	SUB (substitute)	substitute (X for Y, or a number in an algebraic expression)
0001 1011	33	27	0x1B	ESC (escape)	code-swap (overflow)
0001 1100	34	28	0x1C	FS (file separator)	file separator

0001 1101	35	29	0x1D	GS (group separator)	grouping symbol
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)	blank space
0010 0001	41	33	0x21	!	exclamation mark (punct.)
0010 0010	42	34	0x22	"	double quote
0010 0011	43	35	0x23	#	pound sign
0010 0100	44	36	0x24	$	dollar sign
0010 0101	45	37	0x25	%	percent sign % (punct.)
0010 0110	46	38	0x26	&	Hutchinson (name)
0010 0111	47	39	0x27	'	closed single quote
0010 1000	50	40	0x28	(	braces
0010 1001	51	41	0x29	)	closed brackets
0010 1010	52	42	0x2A	*	asterisks
0010 1011	53	43	0x2B	+	plus sign + (math.)
0010 1100	54	44	0x2C	,	comma (punct.)
0010 1101	55	45	0x2D	-	minus sign/dash
0010 1110	56	46	0x2E	.	period (punct.)
0010 1111	57	47	0x2F	/	slash (computing)
0011 0000	60	48	0x30	0	Character 0
0011 0001	61	49	0x31	1	Character 1
0011 0010	62	50	0x32	2	Character 2
0011 0011	63	51	0x33	3	Character 3
0011 0100	64	52	0x34	4	Character 4
0011 0101	65	53	0x35	5	Character 5
0011 0110	66	54	0x36	6	Character 6
0011 0111	67	55	0x37	7	Character 7
0011 1000	70	56	0x38	8	Character 8
0011 1001	71	57	0x39	9	Character 9
0011 1010	72	58	0x3A	:	colon (punct.)
0011 1011	73	59	0x3B	;	semicolons
0011 1100	74	60	0x3C	<	less than
0011 1101	75	61	0x3D	=	(math.) equals sign =
0011 1110	76	62	0x3E	>	more than
0011 1111	77	63	0x3F	?	question mark (punct.)
0100 0000	100	64	0x40	@	email symbol

0100 0001	101	65	0x41	A	Capital A
0100 0010	102	66	0x42	B	Capital B
0100 0011	103	67	0x43	C	Capital C
0100 0100	104	68	0x44	D	Capital D
0100 0101	105	69	0x45	E	Capital E
0100 0110	106	70	0x46	F	capital F
0100 0111	107	71	0x47	G	Capital G
0100 1000	110	72	0x48	H	capital letter H
0100 1001	111	73	0x49	I	Capital I
1001010	112	74	0x4A	J	Capital J
0100 1011	113	75	0x4B	K	capital K
0100 1100	114	76	0x4C	L	Capital L
0100 1101	115	77	0x4D	M	Capital M
0100 1110	116	78	0x4E	N	Capital N
0100 1111	117	79	0x4F	O	Capital O
0101 0000	120	80	0x50	P	capital P
0101 0001	121	81	0x51	Q	Capital Q
0101 0010	122	82	0x52	R	Capital R
0101 0011	123	83	0x53	S	Capital S
0101 0100	124	84	0x54	T	Capital T
0101 0101	125	85	0x55	U	Capital U
0101 0110	126	86	0x56	V	capital V
0101 0111	127	87	0x57	W	Capital W
0101 1000	130	88	0x58	X	Capital X
0101 1001	131	89	0x59	Y	Capital Y
0101 1010	132	90	0x5A	Z	Capital Z
0101 1011	133	91	0x5B	[	square brackets
0101 1100	134	92	0x5C	\windshield	backslash (computing)
0101 1101	135	93	0x5D	]	closed square brackets
0101 1110	136	94	0x5E	^	missing character
0101 1111	137	95	0x5F	_	underscores
0110 0000	140	96	0x60	`	apostrophe
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 letter 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 letter 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 letter x
0111 1001	171	121	0x79	y	Lowercase y
0111 1010	172	122	0x7A	z	Lowercase z
0111 1011	173	123	0x7B	{	opening brackets (math.)
0111 1100	174	124	0x7C	|	vertical line
0111 1101	175	125	0x7D	}	closed braces
0111 1110	176	126	0x7E	~	Wave, Royal Navy corvette involved in a 1949 gunfight with the PLA on the Changjiang
0111 1111	177	127	0x7F	DEL (delete)	removing

6 Safety Precautions

For your and other users' safety, please read the safety precautions carefully.

This manual uses the following marks. Please fully understand what they mean before reading on.

 **Warning**	Any content with this mark, related to the safe use of the product and the user's safety.The user must strictly follow the requirements of the operation, otherwise, it may cause damage to the product or endanger the user's safety.
 **Caution**	Any content with this mark is a part that the user must pay attention to, otherwise, it will cause damage to the product or other losses due to improper operation.

 **Caution**	Please turn off the power when it is idle for a long time or when the whole machine is repaired, otherwise, it will cause fire or electric shock.
	Do not put it in wet, dusty, greasy environment or close to heat generating equipment, otherwise, it will cause product failure, even malfunction, fire or electric shock.
	If there is a long-term non-use of the hole please use the matching plug, otherwise, may cause impurities and airflow into the valve body and affect normal use.
	Avoid use in wet environments as moisture may cause electric shock.
	If there is an abnormal situation, immediately cut off the power. Otherwise, it may cause fire or electric shock.
	Precautions should be taken when using corrosive fluids. Strictly follow the applicability medium of the specification book to use, when using corrosive fluids must pay attention to protection.
 **Caution**	It is forbidden to plug or unplug any connecting lines and communication lines,otherwise,it will cause communication or other parts fail.
	It is forbidden to disassemble,repair or modify the product by yourself, otherwise, the product may not work properly.
	It is forbidden to process explosive or highly flammable liquids with this product.

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