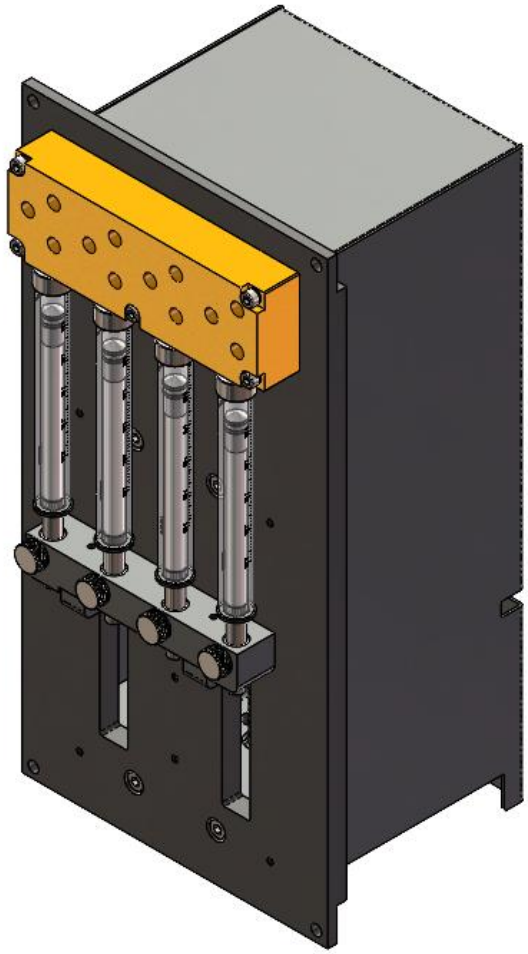
5X66 Series Solenoid Valve Syringe Pump Manual



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Content

1 Getting Started Guide

This product is designed to achieve precise volumetric liquid aspiration and dispensing, as well as switching between different flow path. The pump integrates glass syringes and solenoid valves, and comes with a built-in control module. It offers extremely high accuracy and precision in liquid handling, and users can choose and switch between flow path according to their specific applications. By inputting the corresponding commands, users can easily perform the desired functions.

1.1 Features Overview

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

- Two modes: Standard mode with a resolution of 6000 steps and microstep mode with a resolution of 48000 steps;
- Glass syringes compatible with 100 µL, 250 µL, 500 µL, and 1.0 mL volumes;
- Corrosion-resistant materials in contact with reagents, mainly made of high borosilicate glass, UHMWPE, PEI, FFKM;
- solenoid valve types are compatible with a wide range of options, as described in 1.2.2;
- 2, 4, 6, 8-channel pumps are available;
- Compatible with RS-232, RS-485 and CAN interfaces;
- Adjustable operating speed, with a maximum speed of 6000pps/s and a minimum speed of 5pps/s;
- Transmission mechanism utilizing a ball screw with a linear encoder, featuring step loss detection;
- Easy maintenance: The solenoid valve and syringe offer highly stable and precise liquid handling throughout their lifetime. Replacing and maintaining these components outside their lifetime is also straightforward.

1.2 Functional Description

This product uses a glass syringes and solenoid valves to dispense liquid. Both the glass syringes and the valves are replaceable. Functional descriptions and commands for each major component are provided below.

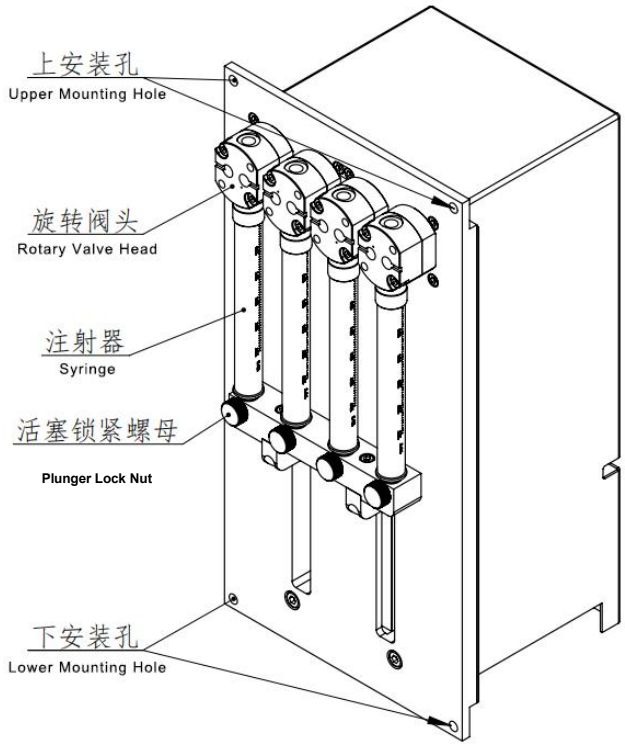


Figure 1 5666 Series Syringe Pumps

1.2.1 Syringe and syringe driver

The syringe is driven back and forth by a stepper motor with ball screw drive, and step loss detection is performed using a linear encoder. The effective stroke of the syringe is 60mm with a resolution of 6000 steps (48000 steps in microstep mode). The base of the syringe plunger is secured to the nut by a knurled screw. The top of the syringe is connected to the solenoid valve with a 1/4-28 UNF thread.

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

1.2.2 Solenoid valve and solenoid valve drive

The valve head is made using a diaphragm-type solenoid valve, which is controlled by the controller to open and close the solenoid valve, connecting the syringe port to each output port.

The specifications of the applicable solenoid valve types are as follows:

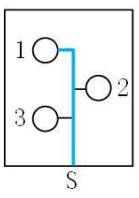
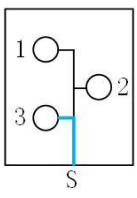
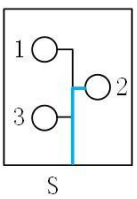
Z command or Y command reset example		
		
I<1> Command Port 1 is the Input	O<3> Command Port 3 is the Output	B<2> command 2-port pass syringe

Figure 2 solenoid valve specifications

1.2.3 Controllers

This product includes a controller with a microprocessor and circuits to control the operation of the glass syringe and valve head. It also features a DB15 communication interface for power supply and communication, as well as a DIP switch to manage the address.

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

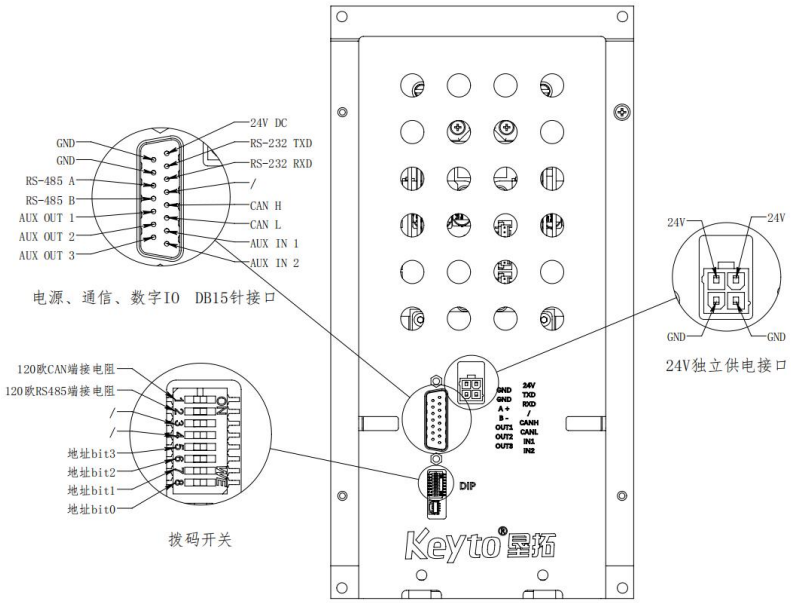


Figure 3 Communication interface and DIP switch of the syringe pump controller

1.2.4 Communication interface

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

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

1.3 Operation Tips

For complete information on setting up the syringe pump, please refer to Chapter 2, "dware Settings," 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 install the syringe pump in an upright position to avoid poor startup.
- Ensure that there is liquid flowing through the syringe and valve head while they are in operation to prevent damage to the sealing.

◆ Always turn off the power when connecting or disconnecting the pump.

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

2 Hardware Settings

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

- Hardware Interface
- Control Settings
- Component Installation
- Complete System Installation

2.1 Hardware Interface

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

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

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

Table 1 DB15 interface pin definitions

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

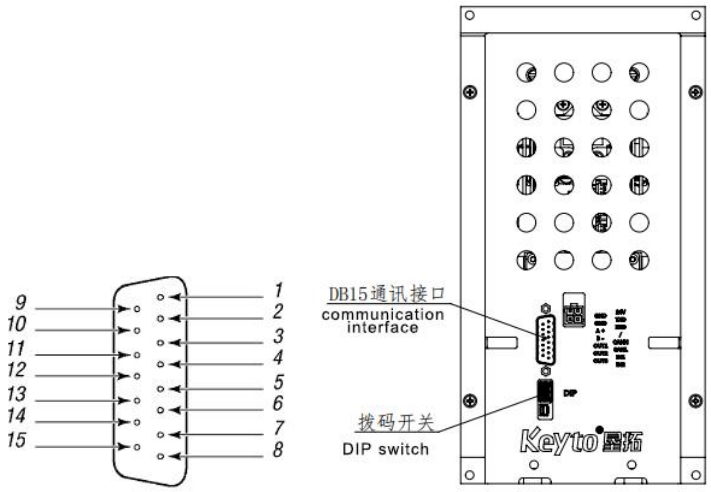


Figure 4 DB15 Pin Indication and Syringe Pump DB15 Position Indication

2.2 Control Settings

2.2.1 DIP switch

The DIP switch has 8 bits (as shown in the figure below, Figure 5) and is located on the lower left side of the rear panel of the syringe pump. Four bits are used to modify the address of each syringe pump for debugging or interlocking purposes. Users can send specific commands to the designated syringe pump to control its operation. The remaining four bits are used to short the 120-ohm termination resistor for RS-485 or CAN communication. The DIP switch has 16 positions (numbered 0 to F). Fifteen addresses (addresses 0 to E) can be set, while F is the self-check address (refer to Table 1 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 5 Address Setting DIP Switch

Table 2 DIP Switch Address Correspondence Table

Number	Function	clarification
1	120 Ohm CAN Termination Resistor	ON: Connected OFF: Disconnected
2	120 Ohm RS485 Termination Resistor	ON: Connected OFF: Disconnected
3	Reserved	The DIP switch address is represented by a 4-bit binary number, with bit 0 being the least significant bit. The ID (address value) is obtained by converting the binary number to a hexadecimal value and adding 1. The ID range is from 1
4	Reserved	
5	Address bit3	
6	Address bit2	

7	Address bit1	to 16. When the address is set to 16, automatic aging is enabled. For each bit of the DIP switch, an upward position represents ON (1), and a downward position represents OFF (0).
8	Address bit0	

Table 3 Address Setting Mapping Table

Address bit3	Address bit2	Address bit1	Address bit0	Dial code address	Single pump control address		2 pump control address		4 pump control address		All devices	
					HEX	ASCII	HEX	ASCII	HEX	ASCII	HEX	ASCII
OFF	OFF	OFF	OFF	0	0x31	1	0x41	A	0x51	Q	0x5F	_
OFF	OFF	OFF	ON	1	0x32	2						
OFF	OFF	ON	OFF	2	0x33	3	0x43	C				
OFF	OFF	ON	ON	3	0x34	4						
OFF	ON	OFF	OFF	4	0x35	5	0x45	E	0x55	U		
OFF	ON	OFF	ON	5	0x36	6						
OFF	ON	ON	OFF	6	0x37	7	0x47	G				
OFF	ON	ON	ON	7	0x38	8						
ON	OFF	OFF	OFF	8	0x39	9	0x49	I	0x59	Y		
ON	OFF	OFF	ON	9	0x3A	.						
ON	OFF	ON	OFF	A	0x3B	.	0x4B	K				
ON	OFF	ON	ON	B	0x3C	<						
ON	ON	OFF	OFF	C	0x3D	=	0x4D	M	0x5D	]		
ON	ON	OFF	ON	D	0x3E	>						
ON	ON	ON	OFF	E	0x3F	?	0x4F	O				
ON	ON	ON	ON	F	Automatic power-on self-test							

2.2.2 Self-check

When the DIP address is set to "F", the syringe pump will run a self-test program upon power-up. The self-test process includes initialization, valve port switching, and a series of plunger movements at different speeds. If any errors occur during the operation, the syringe pump will stop and provide an alarm message.

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

2.3 Component Installation

2.3.1 Installing the syringe

To install the syringe, follow these steps:

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

◆ Screw the syringe into the valve head until the top of the syringe is in contact with the bottom hole of the valve head threads.

◆ Pull down the syringe plunger rod until it aligns with the bottom hole of the pusher plate.

◆ Tighten the syringe by rotating it 1/8 to 1/4 turn.

◆ Tighten the plunger lock nut.

5. Reinitialize the pump.

2.4 Complete System Installation

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

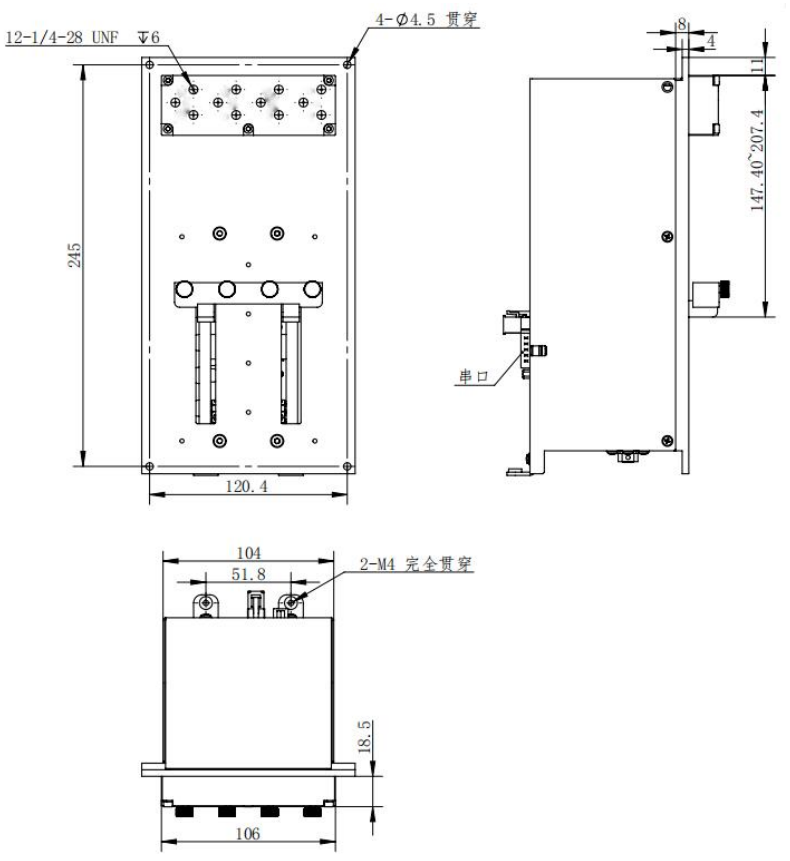


Figure 6 5666 Series Syringe Pump 2D Drawing

3 Software Communication

3.1 Communications Interface

The syringe pump supports the following communication interfaces:

- RS232
- RS485
- CAN (standard frame)

Baud rate:

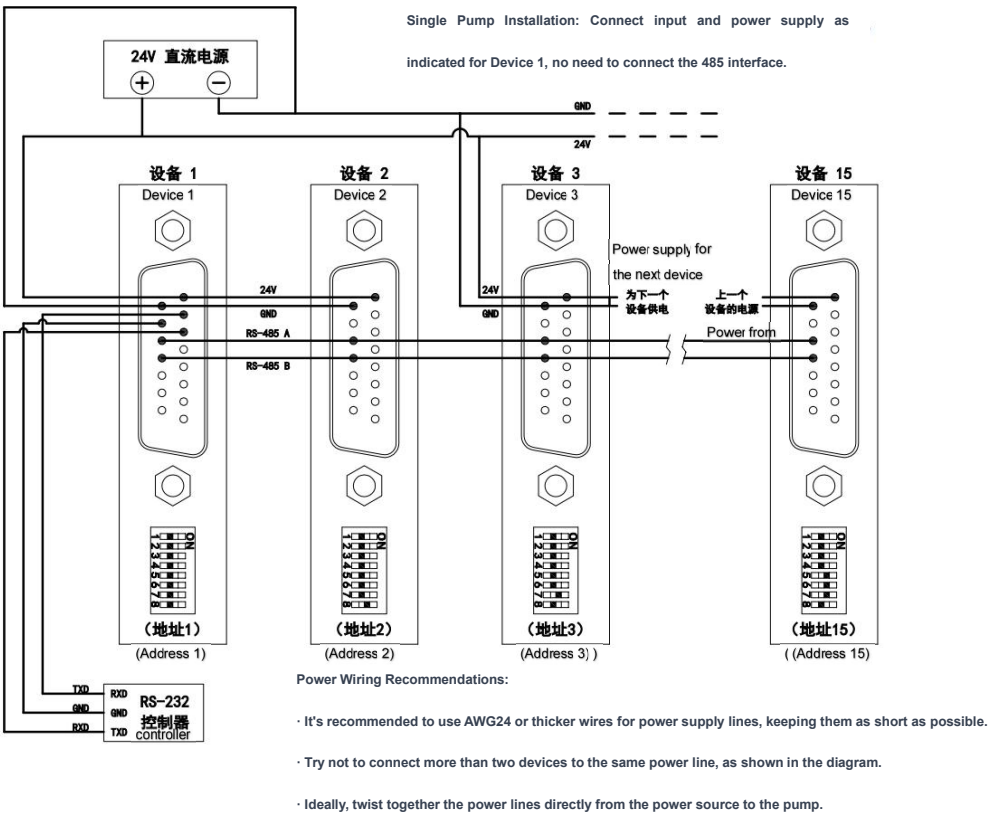
Serial port: 9600 (default), 38400

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

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

Refer to the wiring schematic for each communication method. Figure 7, Figure 8 and Figure 9.

3.1.1 RS232 communication and power supply wiring



Syringe Pump DB15 Male Pin Definition		DB9 Female Pin Definition	
Definition	Pin Number	Definition	Pin Number
TXD	2	TXD	2

RXD	3	RXD	3
GND	10	GND	5

Figure 7 RS232 communication and power supply wiring diagram

3.1.2 RS485 communication and power supply wiring

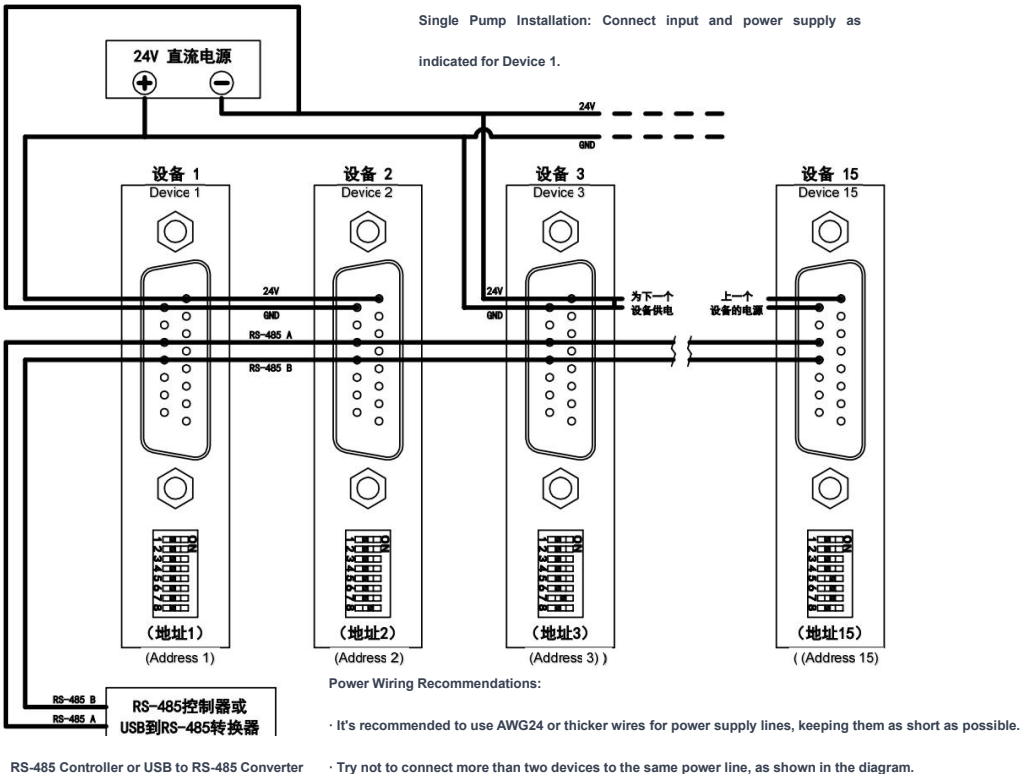


Figure 8 RS485 communication and power supply wiring diagram

3.1.3 CAN bus communication and power supply wiring

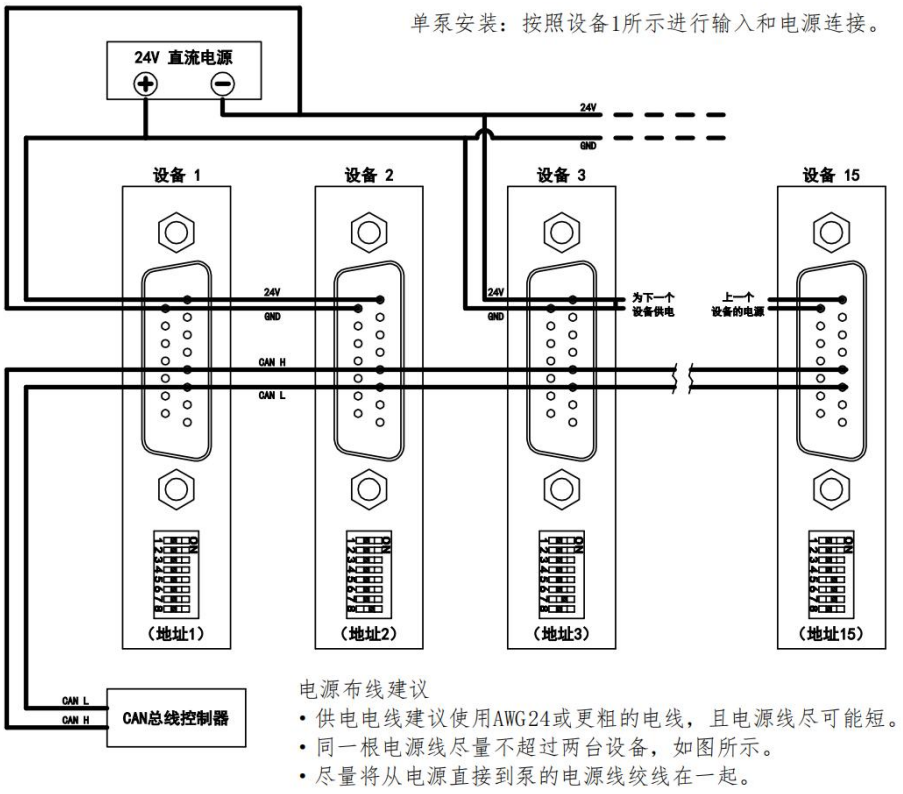


Figure 9 CAN bus communication and power supply wiring diagram

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.

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.

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	End-of-Text [ETX]	0x03	Indicates the end of a frame of return data
5+n		1	Carriage return [CR]	0x0D	
6+n		1	Line break [LF]	0x0A	

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

Table 6 Status Table

Status bytes								Error Code	Description
bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0		
0	1	x	0	0	0	0	0	0	No errors

0	1	x	0	0	0	0	1	1	Initialization error
0	1	x	0	0	0	1	0	2	Invalid command
0	1	x	0	0	0	1	1	3	Invalid operand
0	1	x	0	0	1	0	0	4	Invalid command sequence
0	1	x	0	0	1	1	0	6	Non-volatile memory error
0	1	x	0	0	1	1	1	7	Device not initialized
0	1	x	0	1	0	0	1	9	Plunger overload
0	1	x	0	1	0	1	0	10	Rotary shear valve overload
0	1	x	0	1	0	1	1	11	Plunger motion not allowed
0	1	x	0	1	1	0	0	12	Internal error
0	1	x	0	1	1	1	1	15	Command cache overflow

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

Table 7 Description of LED Blinking

Blink Count	Description	Blink Count	Description
1	Driver Fault	2	Valve Zero Position Optocoupler Position
3	Rotary Valve Position Optocoupler Error	4	Optocoupler Error
5	Piston Zero Position Optocoupler Error	6	Rotary Valve Jammed
7	Storage Error	8	Piston Motor Jammed
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 character, see Control Address in Table 3
3	Serial number	1			ASCII characters, see details in Table 9
2+n	Command	n			ASCII command strings, see Operation

	string				Commands
3+n	End Character	1	End-of-Text [ETX]	0x03	Indicates the end of a frame of return data
4+n	Calibration	1			XOR checksum of the preceding 3+n command bytes

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 of a frame of return data
2	Host Address	1	0	0x30	Fixed host address
3	Status	1			Current device status, see Table 6
3+n	Data String	n			Return data ASCII string
4+n	End Character	1	End-of-Text [ETX]	0x03	Indicates the end of a frame of return data
5+n	Calibration	1			XOR checksum of the preceding 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 with the previous command string. If they match, the internal execution is skipped, and the previous error status is returned. Otherwise, the current command string is executed normally. This feature can be used to resend command strings in case of communication abnormalities.

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

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 10 CAN standard frame message ID construction

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

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

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

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

Frame Type: Types 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 11 CAN General Frame Commands

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

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

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

Type 6, Report/Response Frame: This frame is used to report information from the syringe pump, similar to the ? command. Only the parameters of the ? command need to be sent in this frame, for example, sending the ASCII character "15" will report the initialization count of the syringe pump.

When the syringe pump receives a command, completes a command, or encounters an execution error, it sends a response frame to the host using the same frame type as the corresponding command. The first two bytes of the response frame represent the status, where the

first byte is 0x20 plus the error code from Table 6, and the second byte is fixed at 0x60. The remaining bytes contain the response in ASCII format. All messages of frame types 1 and 2 use a blank message with a data length of zero for acknowledgment.

During power-up, the syringe pump initiates a startup request by sending a request message every 100 milliseconds. The ID of the message has direction 1, group number 1, device class address according to the DIP switch settings (refer to Table 3), frame type 2, and message length 0. The syringe pump only stops sending request messages and starts accepting commands after receiving confirmation of the startup request from the host. The ID of the host's confirmation startup request message has direction 0, group number 1, device address 0, frame type 0, message length 2. The first byte represents the target syringe pump's DIP switch address (see Table 3) + 0x20, and the second byte represents the address assigned by the host to the syringe pump + 0x20. The address assigned by the host can be different from the syringe pump's own DIP switch address (see Table 3) and can be any number from 0 to 15.

3.2.4 Command execution commends

◆ Except for reporting and query commands, all other commands must end with the R command.

◆ Individual commands and command strings can be executed sequentially. For example, "/1ZIA800R\r" will initialize the syringe pump at address 1, switch the valve to the input channel, and then move the syringe to a position 800 increments away.

◆ The syringe pump can receive command strings of up to 255 bytes in length. If a command or command string sent does not end with the R command, it will be stored in the cache without execution.

◆ Once a command is executed, the syringe pump enters a busy state until the command string is completed or a stop command (T command) is received to exit the busy state. The status can be queried using the Q command.

◆ Prior to controlling movement, the syringe pump must be initialized using the initialization command.

3.3 Command

3.3.1 Syringe pump configuration command

3.3.1.1 <N>[n] Set syringe subdivision

Table 13 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 step division to N2 allows for finer control of syringe movement. This parameter returns to the default value after the syringe pump is reset.

3.3.1.2 <K>[n] Set syringe backlash

Table 14 Setting Syringe Backlash

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 dispensing accuracy. This parameter returns to the default value after the syringe pump is reset.

3.3.1.3 <k>[n] Set syringe dead volume

Table 15 Setting Syringe Dead Volume

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

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

3.3.1.4 <U>[n] Syringe pump configuration

Table 15 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 command

Initialization can be configured according to different commands and parameters initialization process valve rotation direction, syringe plunger movement speed and driving force; initial valve and plunger, first initialize the valve, then switch to the output port, if the current plunger zero position optocoupler is in the trigger state, the plunger moves in the direction of aspiration until the plunger zero position optocoupler does not trigger when it stops, then the plunger moves in the direction of dispense until the top of the glass tube apex Then stop when the plunger moves twice the distance set by the k command in the aspiration direction, and finally cut the valve to the output port, and the plunger moves the distance set by the k command in the dispense direction, and finally set the current position to zero, and initialization is completed; if it is only initializing the plunger, the operation of the valve is omitted in the steps of initializing the plunger and the valve; if it is only initializing the valve, the valve is initialized in the specified direction and switch to the specified port.

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

3.3.2.1 <Z>[n] Open input port and initialize plunger

Table 17 Open the Input Port and Initialize the plunger

Command	Parameters	Parameter range	Default value	Description
Z	n	0	0	Initialize plunger at default speed
		10-40		Initialize the plunger with speed code [n] speed, the list of speed codes is shown in Table 30

With this command, all channels open only the valves of the input ports, in the plunger initialization;

3.3.2.2 <Y>[n] Open output port valve and initialize valve and plunger

Table 18 Opening Output Port Valves and Initializing Valves and plungers

command	parameters	Parameter range	default value	Description
Y	n	0	0	Initialize plunger at default speed
		10-40		Initialized with speed code [n] speed, the list of speed codes is shown in Table 30

With this command, all channels open only the valves of the output ports, in the plunger initialization;

3.3.2.3 <W>[n] Initialize plunger only

Table 19 Initialize plunger Only

Command	Parameters	Parameter Range	Default Value	Description
W	n	0	0	Initialize the plunger at the default speed
		10-40		Initialize the plunger with the speed code [n] speed, see Table 30

3.3.2.4 <x>[n1] Percentage of motor power when initializing the plunger

Table 20 Percentage of motor power when initializing plunger

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

3.3.2.5 <z>[n] Analog plunger initialization

Table 21 Analog plunger Initialization

Command	Parameters	Parameter Range	Default Value	Description
z	n	not have		Set the encoder position to the plunger position and clear any plunger running errors
		0-6000		When setting the syringe subdivision to N0, n is set to the plunger position and the plunger operation error is cleared.
		0-4800		When setting the syringe subdivision to N1 or N2, n is set to the plunger position and clears the plunger operation error.

This command 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 exceed its stroke, risking damage to the syringe pump.

3.3.3 Valve control command

3.3.3.1 <I> Switch valve to input port

Use this command to open only the input port valves for all channels;

3.3.3.2 <O> Switch valve to output port

With this command, only the output port valves are opened for all channels;

3.3.3.3 <B>[n] Switch Valve to Bypass Port

Table 22 Switching Valve to the Bypass Port

Command	Parameter	Parameter range	Default value	Description
B	n	None		Open only bypass port valves for all channels
				Individually controlled valves for each channel

<B>[n] instruction controls I, B, and O ports of all channels independently, each channel occupies one digit, 0 means only input port valves are o, 1 means only output port valves are opened, and 2 means only additional port valves are opened;

For example, with the B0121 command, channel one opens the output port valve, channel two opens the additional port valve only, channel three opens the output port valve only, and channel four opens the input port valve only.

3.3.3.4 <E>[n] Individually controlled valves for each port

The <E>[n] instruction controls all valves independently, with each channel occupying one digit, and each digit binary representing the on/off switching of each valve for that channel;

For example, with the E0137 command, all valves in ports 1-3 of channel one are open, all valves in ports 2-3 of channel two are open, channel three opens only the valves in port 3, and all valves in channel four are closed.

For example, with the E2546 command, all valves in ports 1-2 of channel one are open, only the valve in port 1 of channel two is open, the valves in ports 1 and 3 of channel three are open, and only the valve in channel 2 of channel four is open.

3.3.4 Syringe control command

The units of the syringe control commands are all increments, with full travel in 6,000 increments when the syringe subdivision is set to N0, and 48,000 increments when it is set to N1 or N2.

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

Table Table 23 Moving the plunger to the Absolute Position

command	parameters	Parameter range	default value	Description
A	n	0-6000	0	When setting the syringe subdivision to N0

		0-48000		When setting the syringe subdivision to N1 or N2

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

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

3.3.4.3 <P>[n] Relative position aspiration

Table 24 Relative position aspiration

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

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

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

3.3.4.5 <D>[n] Relative position dispense

Table 25 Relative Position dispense

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

3.3.4.6 <d>[n] Relative position dispense (return to idle)

Same function as the D command, except that when using the d command, the queried state is idle;

3.3.5 Syringe parameter setting command

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

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

3.3.5.1 <L>[n] Set acceleration

Table 26 Setting the acceleration

Command	Parameters	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 startup speed

Table 27 Set the start-up speed

Command	Parameters	Parameter Range	Default Value	Description
V	n	50-1000	900	Set the syringe start speed to n increments per second

3.3.5.3 <V>[n] Set the maximum speed

Table 28 Setting the maximum speed

Command	Parameters	Parameter Range	Default Value	Description
v	n	5-6000	900	Set the maximum speed of the syringe to increments per second

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

Table 29 Set the maximum speed (table lookup method)

Command	Parameter	Parameter range	Default value	Description
S	n	0-40	14	Set the maximum speed to speed code [n], see Table 30

Table 30 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 31 Set the stop speed

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

The stop speed setting is valid only when dispensing, and the stop speed is equal to the start speed when aspiration.

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

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

1. The starting speed shall always be less than or equal to the maximum speed.

2. The maximum speed shall always be greater than or equal to the starting and cut-off speeds.

3. The stop speed shall always be less than or equal to the maximum speed and greater than or equal to the starting speed.

3.3.6 System control command

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

3.3.6.3 <G>[n] Cyclic execution of commands or command strings

Table 32 Cyclic Execution of Commands or Command Strings

Command	Parameter	Parameter Range	Default Value	Description
G	n	0-48000		Number of times to execute the command or command string in a loop

Cycle through commands or command strings as many times as specified, and when the cycle count is 0, it keeps cycling through.

3.3.6.4 <g> Loop execution starting marker for command or command string

Cyclic execution of the command or the start mark of the command string, for example, send ZgIA300BA0G5R command string, the syringe pump first with the default parameters into the initialization of the valve and plunger, and then execute the cyclic command string IA300BA0 five times, that is, first switch the valve to the input port, then move the plunger to the position of 300 increments (aspiration), then switch the valve to the additional port, then move the plunger to the position of 0 increments (dispense), and so on five times.

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

3.3.6.5 <M>[n] Delayed execution

Table Table 33 Delayed execution

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

This command can be used between the move plunger command and the switch valve port command. When the move plunger is finished, it delays for a certain time before switching the valve port to reduce the pressure fluctuation; if the R command is received during the delay, it can terminate the delay process and continue to execute the subsequent command string.

3.3.6.6 <H>[n] Interrupt execution

Table 34 Interrupt execution

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

As shown in the command description, it can interrupt the execution of the command string and continue the execution when the R command or the falling edge signal of the auxiliary input is received. This command will not interrupt the execution of the action command, but only terminate the execution of the delay command, so it is routinely nested in the command string and executed separately only for interrupting the execution of the delay command.

3.3.6.7 <T> Terminate command

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

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

3.3.6.8 <J>[n] Auxiliary output control

Table 35 Auxiliary Output Control

Command	Parameters	Parameter Range	Default Value	Description
J	n	0	0	Low output of auxiliary output 3, low output of auxiliary output 2, low output of auxiliary output 1
		1		Low output of auxiliary output 3, low output of auxiliary

				output 2, high output of auxiliary output 1
		2		Low output of auxiliary output 3, high output of auxiliary output 2, low output of auxiliary output 1
		3		Auxiliary output 3 output is low, auxiliary output 2 output is high, auxiliary output 1 output is high
		4		High output of auxiliary output 3, low output of auxiliary output 2, low output of auxiliary output 1
		5		High output of auxiliary output 3, low output of auxiliary output 2, high output of auxiliary output 1
		6		High output of auxiliary output 3, high output of auxiliary output 2, low output of auxiliary output 1
		7		High output of auxiliary output 3, high output of auxiliary output 2, high output of auxiliary output 1

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

3.3.6.9 <! > Reboot Command

When the syringe pump configuration has been modified with the U command, the reset reboot command can be used to cause the syringe pump to reboot to allow the configuration to take effect.

3.3.7 Non-volatile storage command

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

Table 36 Storing Command Strings to Non-Volatile Storage

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

The user can store the command string into non-volatile memory by putting the s command at the beginning of the command string, and each command string can be up to 128 bytes, which can be accessed by the ? command to query the command string stored into non-volatile memory, see Table 43 ; the

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

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

Table 37 Executing Command Strings in Non-Volatile Memory

Command	Parameters	Parameter Range	Default Value	Description
e	n	0-14		Execute command string in non-volatile memory

Execute the command string stored in non-volatile memory by the s command. Another way

of executing the command string in non-volatile memory is to configure the syringe pump U30, i.e., to enable 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 40 Set User Data

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

3.3.7.4 <<>[n] Read user data

Table 41 Reading User Data

Command	Parameters	Parameter Range	Default Value	Description
<	n1	0-15	0	Location indexing in non-volatile memory

3.3.8 Query command

3.3.8.1 <? >[n] Report syringe pump information

Table 40 Report Syringe Pump Information

Command	Parameters	Parameter Range	Default Value	Description
What is it?	n	0	0	Report absolute syringe position
		1		Report syringe start-up speed
		2		Report maximum syringe speed
		3		Report syringe stop speed
		4		Report the encoder position of the syringe
		6		Report valve port
		10		Report command cache status, 0: cache is empty, 1: cache has commands
		12		Report the syringe backlash set by the K command
		13		Reports the status of auxiliary input 1, 0: low, 1: high
		14		Reports the status of auxiliary input 2, 0: low, 1: high
		15		Report the number of syringe initializations
		16		Report the number of plunger movements
		17		Report the number of valve switching
		18		Report the number of valve switches since the last report

		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 cache

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

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

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

3.3.8.4 <#> Report board unique number

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

3.3.8.5 <&> Report firmware version

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

3.3.8.6 <Q> Report Status

As with the ?29 command, the current syringe pump status is reported, see Table 6 .

3.4 Application Examples

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

3.4.1 DT protocol

3.4.1.1 Execute a single command action

Host	ASCII commands	HEX command	Description

computer			
Send	/1ZR carriage return [CR]	2F 31 5A 52 0D	Send clockwise initialize valve and plunger command
Receiving	/0@End-of-Text[ETX] carriage return[CR] line feed[LF]	2F 30 40 03 0D 0A	Received answer data with busy status
Send	/1QR carriage return [CR]	2F 31 51 52 0D	Query operation status
Receiving	/0` End-of-Text [ETX] carriage return [CR] line feed [LF]	2F 30 60 03 0D	Query to current running status idle

3.4.1.2 Execute multiple command actions

Host computer	ASCII commands	HEX command	Description
Send	/1ZIA300BA0R carriage return [CR]	2F 31 5A 49 41 33 30 30 42 41 30 52 0D	(a) The syringe pump initializes the valve and plunger clockwise, then switches the valve to the input port, then moves the plunger to 300 increments, then switches the valve to the additional port, then moves the plunger to 0 increments;
Receiving	/0@End-of-Text[ETX] carriage return[CR] line feed[LF]	2F 30 40 03 0D 0A	Received answer data with busy status

3.4.2 OEM agreement

3.4.2.1 Execute a single command action

Host computer	HEX command	Description
Send	02 31 30 5A 52 03 08	Send non-repeating clockwise initialization valve and plunger commands
Receiving	02 30 40 03 71	Received answer data with busy status
Send	02 31 30 51 52 03 03	Query operation status
Receiving	02 30 60 03 51	Query to current running status idle
Send	02 31 38 5A 52 03 00	Send repeated clockwise initialization valve and plunger commands
Receiving	02 30 60 03 51	Return to the current running state idle, not repeatedly executed because the instruction number is the same as the previous one

3.4.2.2 Execute multiple command actions

Host computer	HEX command	Description
Send	02 31 30 5A 49 41 33 30 30 42 41 30 52 03 00	sending a non-repeating command string, the syringe pump initializes the valve and plunger clockwise, then switches the valve to the input port, then moves the plunger to 300 increments, then switches the valve to the additional port, then moves the plunger to 0 increments;

Receiving	02 30 40 03 71	Received answer data with busy status

3.4.3 CAN standard frame protocol

3.4.3.1 Host acknowledges start request

Host computer	CAN_ID	CAN data (HEX)	Description
Receiving	0x0482	None	The syringe pump sends a start request to the host at 100 ms intervals
Send	0x0080	20 20	The host acknowledges the start request and assigns an address of 0 to the syringe pump

3.4.3.2 Execute a single command action

Host computer	CAN_ID	CAN data (HEX)	Description
Send	0x0101	5A 52	Host sends clockwise initialize valve and plunger commands
Receiving	0x0501	None	The syringe pump immediately responds to the received command string
Receiving	0x0501	20 60	Active idle status data is sent after the syringe pump movement is completed

3.4.3.3 Execute multiple command actions

Host computer	CAN_ID	CAN data (HEX)	Description
Send	0x0103	5A 49 41 33 30 30 42 41	Send the first frame of data 'ZIA300BA' with type 3
Send	0x0104	30 49 41 33 30 30 4F 41	Send second frame of data '0IA300OA' with type 4
Send	0x0101	30 52	Send the last frame of data '0R' with type 1
Receiving	0x0501	None	The syringe pump immediately responds to the received command string
Receiving	0x0501	20 60	Active idle status data is sent after the syringe pump movement is completed

Throughout the movement, the syringe pump first initializes the valve and plunger clockwise, then switches the valve to the input port, then moves the plunger to the 300 increment, then switches the valve to the extra port, then moves the plunger to the 0 increment; then switches the valve to the input port, then moves the plunger to the 300 increment position, then switches the valve to the output port, and finally moves the plunger to the 0 increment position.

4 Maintenance and Care

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

4.1 Daily Maintenance

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

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

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

4.2 Weekly Maintenance

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

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

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

4.2.1 Cleaning procedure with diluted cleaning solution

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

1. Fill the pump with the diluted cleaning solution and let the solution stay in the pump for 30 minutes.
2. After 30 minutes, empty all the liquid from the syringe and tubing into the waste container.
3. Aspiration and dispense at least 10 times with full distilled or deionized water in a pump.
4. The flow path needs to be filled with distilled or deionized water when storing the pump.

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

4.2.2 Cleaning procedure with weak acid and weak alkali solution

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

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

4.2.3 Cleaning procedure with 10% bleach solution

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

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

4.3 Regular Maintenance

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

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

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

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

The frequency of replacement will depend on the number of uses, the fluid to which the flow path is exposed, and the maintenance of the instrument.

4.3.1 Quality control assurance

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

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

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

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

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

Here:

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

$Vol_{expected}$: the expected dispensed volume

n: number of fluid dispensing

X: the result of a single test

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

4.3.2 Replacement of dispensing tubing or reagent tubing

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

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

4.3.3 Syringe replacement

To replace the syringe, refer to section 2.3.1 for syringe installation.

5 Safety Precautions

For your personal safety and the safety of other users, please read the safety precautions carefully. This manual uses the following symbols. Please fully understand the meanings represented by these symbols before continuing to read.

 **Warning**	Contents marked with this symbol are related to the safe use of the product and personal safety of the user. They must be strictly followed as instructed; otherwise, it may result in product damage or endanger the user's safety.
 **Attention**	Contents marked with this symbol are areas that users must pay attention to. Failure to do so may cause product damage or other losses.

 **Attention**	When the device is idle for a long time or during the entire machine maintenance, please turn off the power to prevent fire or electric shock.
	Do not place it in damp, dusty, greasy areas, or near heat-generating equipment, as it may cause product failure, malfunctions, fire, or electric shock.
	If there are unused ports for a long time, please plug them with the provided stoppers to prevent magazine and airflow from entering the valve body, which may affect normal operation.
	Avoid using in a humid environment as moisture can cause electric shock.
	In case of any abnormal situation, immediately disconnect the power. Failure to do so may cause fire or electric shock.
	When using corrosive fluids, pay attention to protection and strictly follow the applicable medium specified in the specification sheet. Protective measures must be taken when using corrosive fluids.
 **Warning**	It is prohibited to plug or unplug any power cords or communication cables while they are energized, as it may cause communication or other failures.
	It is prohibited to disassemble, repair, or modify the product without authorization, as it may result in the inability to use it properly.
	It is prohibited to use this product to handle flammable or highly flammable liquids.

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