润泽流体 RUNZE FLUID

Key Components for Analytical Instrument
Ecological Closed-loop Supplier

Version 1.2

Smart SY-01B Syrinnge Pump

ASCII Code Instruction Manual

南京润泽流体控制设备有限公司
NANJING RUNZE FLUID CONTROL EQUIPMENT CO.,LTD

Note: This manual applies to the RUNZE protocol of the infusion pump. If you are unsure of the protocol currently used by the pump, please first refer to P26 [Query and Switch Protocol].

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Chapter 1 Overview and Precautions

1.1 Company Overview

Nanjing Runze Fluid Control Equipment Co., Ltd., established in 2014, is a high-tech enterprise specializing in the development and manufacturing of fluid accessories, and a supplier of analytical instrument components. Our product range includes syringe pumps, switching valves, high-pressure valves, gas-tight samplers, peristaltic pumps, and tubing connectors. We offer comprehensive services covering the entire industry chain—from product customization, design and R&D, manufacturing, sales, to after-sales support—providing high-quality products and services for fields such as environmental monitoring, biopharmaceuticals, medical equipment, industrial automation, and laboratory instruments.

Since its founding, Runze has obtained ISO9001 certification and has been recognized as a "National High-Tech Enterprise" and a "Private Technology Enterprise in Jiangsu Province." It has also been rated a 5A credit customer by Bank of Nanjing. Through continuous investment in high technology and years of R&D efforts, the company has acquired 48 patents and several software copyrights in the fluid control field, including 8 invention patents, 17 utility model patents, 13 design patents, and 2 software copyrights.

1.2 Product Overview

Thank you for purchasing the Smart SY-01B Syringe Pump from our company. This pump is a fully programmable, open-frame precision liquid delivery module designed for applications ranging from 25 µL to 5 mL. Controlled by an external computer or microprocessor, it supports automated fluid aspiration, dilution, and dispensing. Various distribution valves and syringes can be optionally configured to meet most users' high-precision liquid handling needs. Multiple pumps can also be connected in series for simultaneous use.

The Smart SY-01B Syringe Pump delivers outstanding performance, providing strong support for users' research and applications, and helping them achieve expected results.

1.3 Precautions

The Smart SY-01B Syringe Pump is specifically designed for aspiration and dispensing of liquids within the range of 25 µL to 5 mL. Any other usage is considered improper operation and may cause damage to the pump and affect measurement accuracy.

To enhance user safety awareness, this manual outlines the following warnings:

1.3.1 Notifications and Symbols


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- **Toxic Substances**

  Chemical or biological hazards may be associated with the substances used or the samples processed by the SY-01B. Always be aware of the potential risks related to such materials.

- **Explosion and Fire Hazards**

  Do **not** use the SY-01B to handle flammable or explosive liquids.

- **Mechanical Hazards**

  Caution! Keep fingers away from the syringe slot while the pump is operating to avoid injury.

- **Usage Precautions**

1. The device must be powered on and reset using the /1ZR command before any further instructions can be executed. If any abnormal condition occurs during operation, please reset the device with the /1ZR command.
2. The [z] command simulates piston initialization, but no mechanical action is triggered. This command is useful after an unexpected power outage to regain pump control. After recovery, use [z] to set the current position as the home (zero) position. Pump operation can resume after using [z], but to protect the device, it is recommended to reset the true home position using initialization commands Z<N1,N2,N3> or Y<N1,N2,N3>.
3. Ensure the voltage supplied matches the rated voltage of the device.
4. Use only the original serial cable and power adapter provided with this product.
5. This product supports three communication modes (RS232, RS485, and CAN bus), all of which are non-isolated.
6. If there are any unused ports, seal them tightly using the provided plugs and gaskets to prevent contamination or airflow into the valve, which may affect normal operation.
7. Do not disassemble any product components. Warranty is void if the tamper-proof label is broken.
8. Follow the software operation instructions and communication protocol when operating via software. Do not input unauthorized or fabricated data.
9. When discarding the instrument, please follow relevant regulations for equipment disposal. Waste produced during or after use should be handled in compliance with national environmental protection standards. Do not discard arbitrarily.
10. **Warning**: Improper use of the SY-01B can pose risks to users, property, and the

environment. To ensure safe and correct operation, follow these guidelines:

- Ensure that liquid flows **between the syringe and the valve**; otherwise, the sealing surface may be damaged.
- Power off the device before connecting or disconnecting the pump.

11. When using different syringe models, it is necessary to set different stall current values for proper reset. Refer to the table below for suggested values.

    Note: These are reference values only. If the reset fails due to high internal pressure, increase the current value incrementally (+1) as needed.

Syringe Reset Stall Current Setting	
25μl syringe	/1U200,4R
50μl~1.25mL syringe	/1U200,5R
2.5mL、5mL syringe	/1U200,6R

1.3.2 Electrostatic Discharge (ESD) Precautions

The SY-01B is an electronic device sensitive to electrostatic discharge (ESD). Its components can be damaged by static discharge from clothing or fixed equipment. To prevent pump component failure, effective ESD protection measures must be taken during operation. Examples include, but are not limited to:

- Use of anti-static wrist or ankle straps
- Use of anti-static mats or ESD-protected workbenches
- Applying anti-static floor wax to the working area

Chapter 2 Key Technologies and Functions

2.1 Product Features

- Upgraded syringe mounting fits Runze K/ILS-series syringes interchangeably.
- Integrated encoder system for feedback regulation, improving accuracy
- Enhanced EMC performance: power circuitry includes common-mode interference suppression, self-resetting fuses, and transient voltage suppression diodes, improving overall surge protection
- New rotary DIP switch for address configuration based on switch settings
- New optical encoder disc system for valve positioning, offering three key benefits:

  ① Enhanced resistance to input signal interference

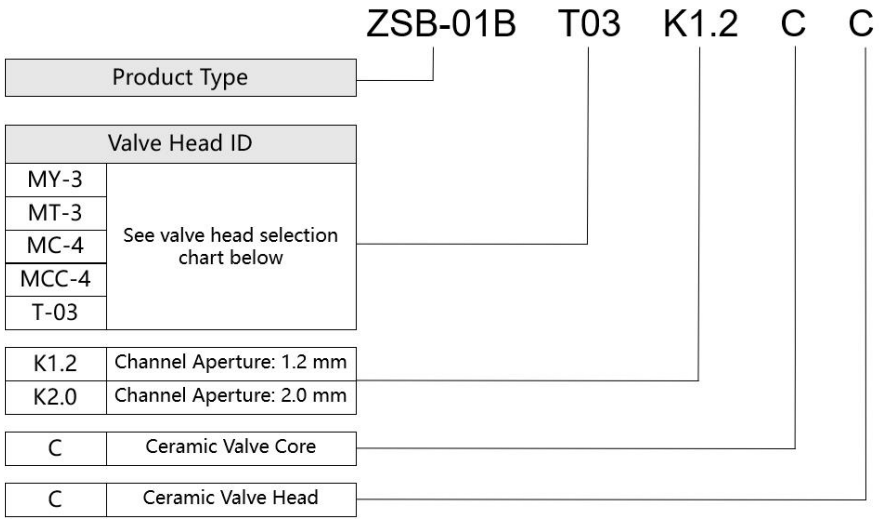
  ② Improved and simplified internal structure and manufacturing process

  ③ Improved error correction during rotational movement
- Ceramic valve core offers excellent wear resistance, high temperature tolerance, corrosion resistance, superior sealing, low friction, and long service life

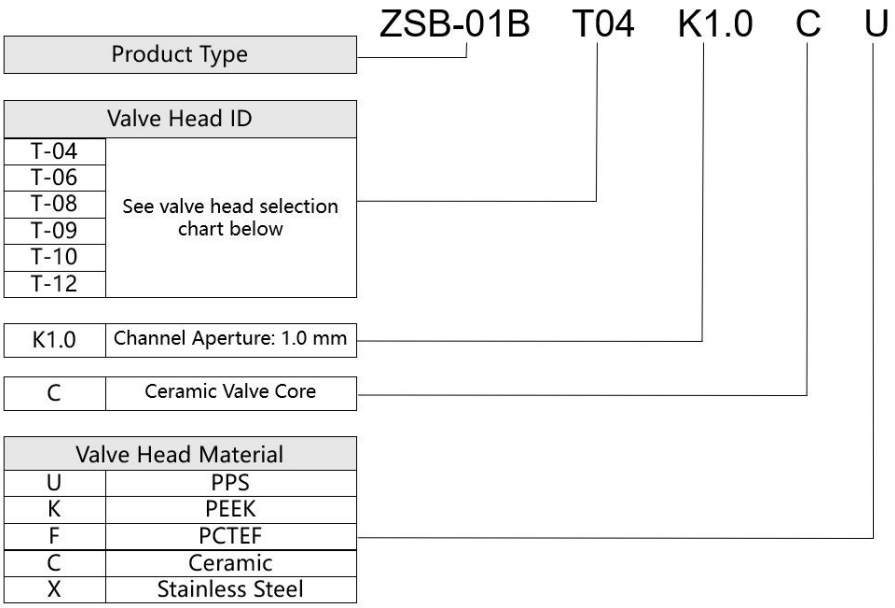
2.2 Model Naming Rules and Selection Guide

2.2.1 Model Parameters

1. Valve head with channel aperture sizes: **1.2 mm / 2.0 mm**



2、Valve head with channel aperture sizes: **1.0 mm**



Example: For a syringe pump configured with a T04 valve head, 1.0 mm flow path aperture, ceramic valve core, and PPS valve head material, the model should be designated as: ZSB-SY01B-T04-K1.0-C-U

Notes:

- Ceramic Valve Head Naming Rules:
- Non-distribution valves are uniformly prefixed with “M”, followed by the number of channels (including the C port) based on flow path configuration.
- Distribution valves are prefixed with “T”, followed by the number of channels (excluding the C port).
- Aperture Specifications:
- Models T-04 / T-06 / T-08 / T-10 / T-12 / (T09) are only available with 1.0 mm through-hole diameters.
- Models MY-3 / MT-3 / MC-4 / MCC-4 / T-03 support selectable through-hole diameters of 1.2 mm or 2.0 mm.
- Material Limitations:
- For the five compact valve heads: MY-3 / MT-3 / MC-4 / MCC-4 / T-03, the valve heads use an integrated ceramic structure and cannot be customized with alternative housing materials.
- 2.2.2 Optional Syringe Models
- Compatible with Runze K30 series syringes (30 mm stroke length).

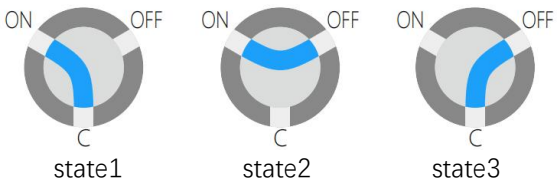
2.2.2 SYRINGE SPECIFICATION

RUNZE K30（Stroke 30mm）

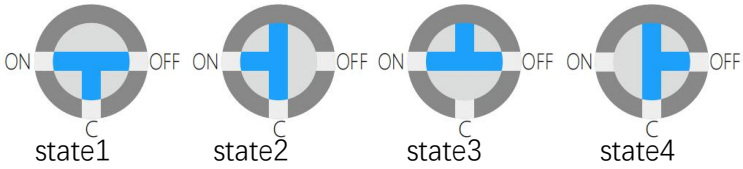
SPECIFICATION

25ul	50ul	125ul	250ul	500μl	1.25ml	2.5ml	5ml

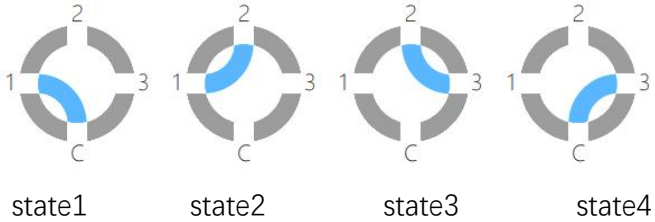
2.2.3 Valve Head



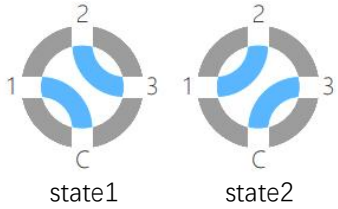
Valve Model: MY-3
Flow Path Control: Non-distribution Valve – Y-type Flow Path
Flow Path States:
- C–ON Connected
- ON–OFF Connected
- C–OFF Connected



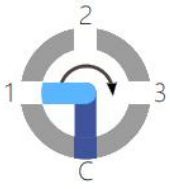
Valve Model: MT-3
Flow Path Control: Non-distribution Valve – T-type Flow Path
Flow Path States:
- C–ON–OFF Connected
- C–ON Connected
- ON–OFF Connected
- C–OFF Connected



Valve Model: MC-4
Flow Path Control: Non-distribution Valve – Single Selection Flow Path
Flow Path States:
- C–1 Connected
- 1–2 Connected
- 2–3 Connected
- C–3 Connected

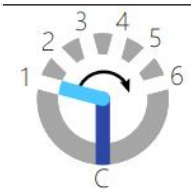


Valve Model: MCC-4
Flow Path Control: Non-distribution Valve – Dual Selection Flow Path
Flow Path States:
- C–1 and 2–3 Connected
- C–3 and 1–2 Connected

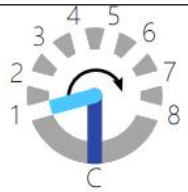


Valve Model: T-03
Flow Path Control: 3-Port Distribution Type Flow Path
(C port selectively connected to ports 1–3)

Valve Model: T-04
Flow Path Control: 4-Port Distribution Type Flow Path
(C port selectively connected to ports 1–4)



Valve Model: T-06
Flow Path Control: 6-Port Distribution Type Flow Path
(C port selectively connected to ports 1–6)



Valve Model: T-08
Flow Path Control: 8-Port Distribution Type Flow Path
(C port selectively connected to ports 1–8)

	**Valve Model: T-10** **Flow Path Control**: 10-Port Distribution Type Flow Path (C port selectively connected to ports 1–10)		**Valve Model: T-12** **Flow Path Control**: 12-Port Distribution Type Flow Path (C port selectively connected to ports 1–15)
	**Valve Model: (Custom) T-09** **Flow Path Control**: 9-Port Distribution Type Flow Path (C port selectively connected to ports 1–9)		

2.3 Technical Specifications

Item	Parameter	
Liquid Volume Accuracy	Error ≤ 1% (rated stroke)	
Liquid Volume Precision	Repeatability error 0.3%–0.5% (rated stroke)	
Rated Stroke (Control Steps)	30mm （12000 steps）	
Linear Speed	450rpm	
Rated Stroke Operation Time	300rpm	
Control Resolution / Minimum Dispensing Precision	0.0333 mm/s-15mm/s	
Drive Mechanism	2s-900s	
Max Piston Drive Force	0.005mm/1步	
Secondary Piston Drive Force	Trapezoidal screw (lead 2 mm)	
Syringe Options (Optional)	≥80N	
Valve Head Types (Optional)	≥40N	
Valve Orifice Diameter	25μl、50μl、125μl、250μl、500μl、1.25ml、2.5ml、5ml	
Valve Switching Time	MY-3、MT-3、MC-4、MCC-4、T-03	T-04、T-06、T-08、T-10、T-09、T12
Wetted Material	1.2mm 、2.0mm	1.0mm
Max Reference Liquid Pressure	≤ 640 ms (between adjacent ports)	
Tubing Interface	Alumina ceramic	
Syringe Interface	0.6 MPa	
Communication Interfaces	1/4-28 UNF internal thread	
Communication Baud Rates	1/4-28 UNF internal thread	
Item	RS232 / RS485 / CAN bus	
Liquid Volume Accuracy	RS232/485：9600bps/19200bps/38400bps/57600bps/115200bps CAN：100kbps/200kbps/500kbps/1Mpbs	
Device Address and Parameter Settings	Communication interface	
Applicable Power Supply	DC24V/3A	
Operating Ambient Temperature	5C°-55C°	

Operating Relative Humidity	< 80%
Dimensions (L × W × H)	142.7*127*45mm
Weight	1.5kg

2.4 Injection Accuracy and Volume Calculation of the Syringe Pump

Example 1: Using a 5 mL syringe (with a 30 mm stroke), the resolution per step is calculated as follows:

- 5 mL = 5000 µL
- 30 mm = 12,000 steps
- 5000 µL12000 steps=0.4167 µL/step\frac{5000 µL}{12000 steps} = 0.4167 µL/step12000 steps5000 µL =0.4167 µL/step

Note: Each step of the syringe pump corresponds to a volume of 0.4167 µL, which is the **minimum resolution** for a 5 mL syringe.

Example 2: To dispense 3.8 mL of liquid using the syringe pump, calculate the required steps:

- 3.8 mL = 3800 µL
- 3800 µL0.4167 µL/st≈9119\frac{3800 µL}{0.4167 µL/step} ≈ 91190.4167 µL/step3800 µL ≈9119 steps (rounded)
- Therefore, to dispense 3.8 mL, set the syringe pump to **9119 steps**
- **Hexadecimal value**: 9119 (decimal) = **239F** (hexadecimal)

Note: All calculations above are in **decimal**. However, when using debugging tools or writing control code, parameters must be input in **hexadecimal** format.

Chapter 3 Hardware Setting

3.1 Component Installation

3.1.1 Valve Installation

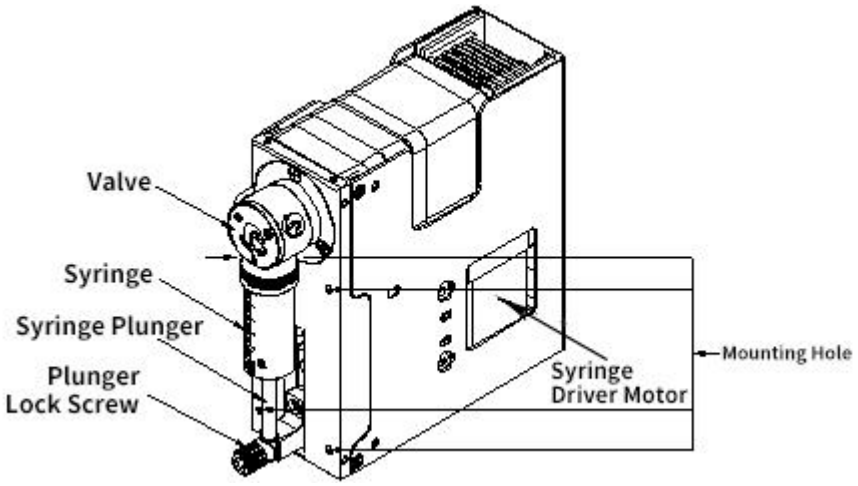
The SY-01B does not support user-replacement of the valve head assembly. If the valve head needs to be replaced, please contact customer service.

3.1.2 Syringe Installation

To install the syringe, follow these steps:

Remove the hand-tightened screw

Follow the steps below as shown in Figure 3-1-2 to install the syringe:



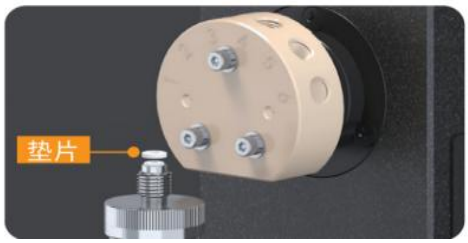
a. Align the syringe’ s threaded port with the installation port and screw it into the valve

b. Keep the plunger bracket and plunger aligned horizontally, then pull the plunger downward

c. Insert the syringe plunger rod through the hole in the plunger bracket

d. Once the holes are aligned, secure them with a screw

Note: **1.** Ensure the hand-tightened screw is fastened securely and the plunger can move freely.



2. For valve heads T-04/T-06/T-08/T-09/T-10/T-12, a gasket must be added to the common port.

3.1.3 Pump Installation

For ease of installation, please refer to Figure 2-4, which shows the dimensions and positions of key mounting holes on the SY-01B outline diagram.

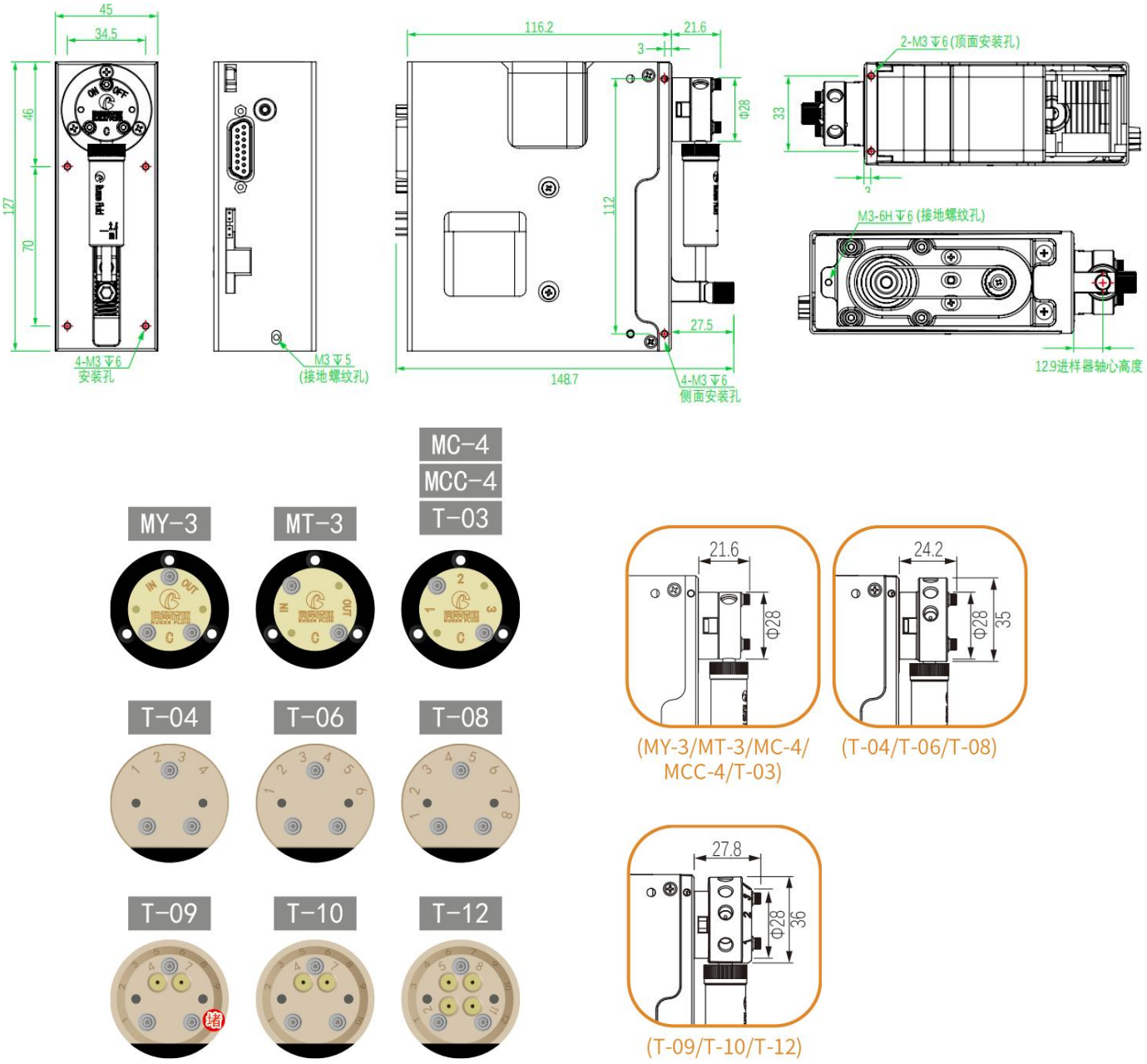


图3-1-3　SY-01B外形缩略图

3.2 Power and Electrical Considerations

SY-01B requires a 24V DC power supply providing at least 1.5A via a DB15 connector. It is recommended to use one power cable for every two pumps to enhance noise resistance — avoid daisy-chaining more than two pumps on a single power line.

3.2.1 Power Supply Selection

A single SY-01B 24V DC power supply must meet the following basic requirements:

- **Output Voltage**: Rated at 24V.

- **Stability**: A high-performance and stable power source is recommended, as voltages below 24V may affect pump performance.
- **Current Rating**: At least 1.5A.
- **Compliance**: Must meet safety standards and EMI/RFI specifications.

3.2.2 Integrated Power Supply

When the power supply serves multiple SY-01B units or other devices, it must meet the total peak current demand of all connected equipment. The power supply and filtering capacitors must collectively support the total peak input current.

If not all pumps are operated simultaneously, the rated power requirement can be reduced accordingly, with the **minimum current rating based on actual testing**.

Inadequate bypass capacitance can lead to voltage fluctuations, transient currents, and reduced component lifespan. Additionally, insufficient filtering capacitance may destabilize otherwise stable power sources, causing load stress, vibration, or component failure. Using a well-designed commercial power supply can effectively prevent these issues.

Wiring Considerations:

- Wiring for SY-01B and its accessories should be as short as possible, with sufficient current capacity.
- Use no less than 20AWG wire unless safety demands otherwise.
- With proper wiring and power, SY-01B units can be daisy-chained.
- For daisy-chaining six units, use 18AWG twisted pairs connected head-to-tail.

For more details on multi-pump systems, refer to Section 2.2 “Cabling”.

To control power to the SY-01B, avoid using relays or contact switches to connect the 24V DC supply directly — the injection pump must not be powered directly from a DC source.

3.2.3 Switching Power Supplies

Carefully verify the minimum load requirements of your switching power supply. Typically, such supplies require a minimum load of 10% of their rated output current.

Note: SY-01B's idle current is less than 10% of its full-load current.

For example, in a daisy-chained system where only one SY-01B runs at low motor speed and others remain in a low-power state, a 24V 5A switching power supply with a minimum load requirement of 50mA may fail to deliver sufficient current. If SY-01B is the only load, the converter's minimum load spec should be ≤50mA. Alternatively, an appropriate external power resistor may be used to meet the minimum load requirement.

3.3 Cable

A single cable can provide both power and communication for one SY-01B unit. Each pump module has a unique address identifier. For more information, refer to the "Address Switch Settings" section later in this chapter. Also see Chapter 3, "Software Communication".

Power requirements are described in Section 3.1, "Power and Electrical Considerations."

Pin	Function	Remarks
1	24vDC	
2	RS-232TxD	Output data
3	RS-232RxD	Input data
4	Reserved	
5	CAN H	CAN H
6	CAN L	CAN L
7	Auxiliary Input #1	TTL Voltage
8	Auxiliary Input #2	TTL Voltage
9	GND	Power and Logic Ground
10	GND	Power and Logic Ground
11	RS-485 A	Data+
12	RS-485 B	Data-
13	Auxiliary Input #1	TTL Voltage
14	Auxiliary Input #2	TTL Voltage
15	Auxiliary Input #3	TTL Voltage

Table 3-3 *DB-15 Connector Pin Assignment*

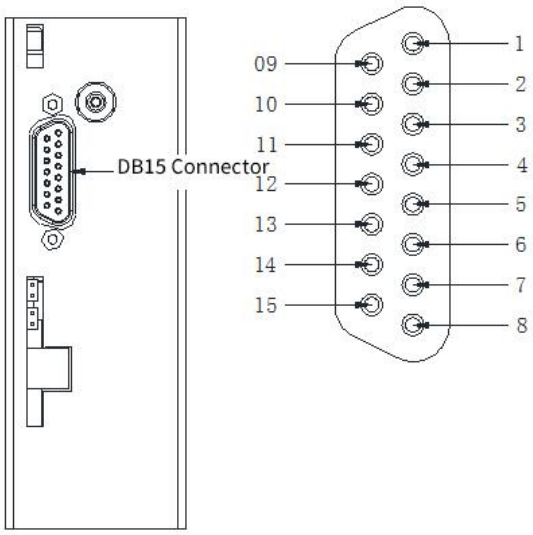
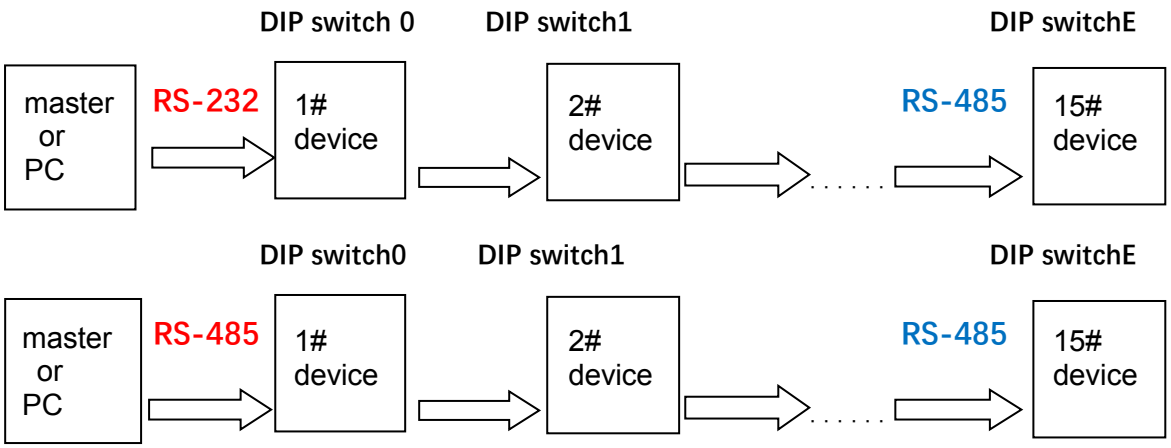


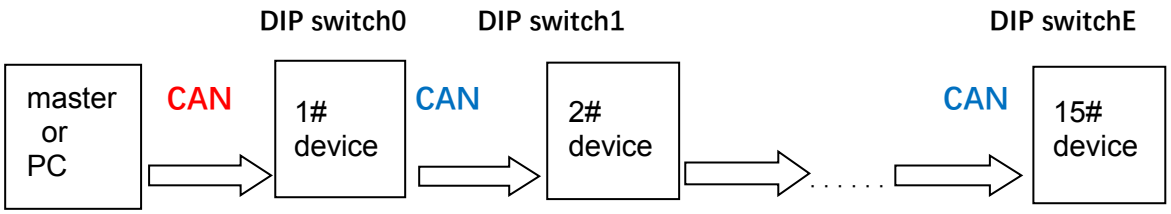
Fig 3-3 *DB-15 Connector Pins*

The diagram shows the pin configuration of the DB-15 connector on the integrated circuit module. This is a male connector and requires a corresponding female connector to mate with it.

3.4 Communication Interface

The computer or controller connects to the SY-01B via RS-232, RS-485, or CAN interface. The SY-01B can automatically detect the communication interface. An example of the wiring connection is shown in the diagram below.

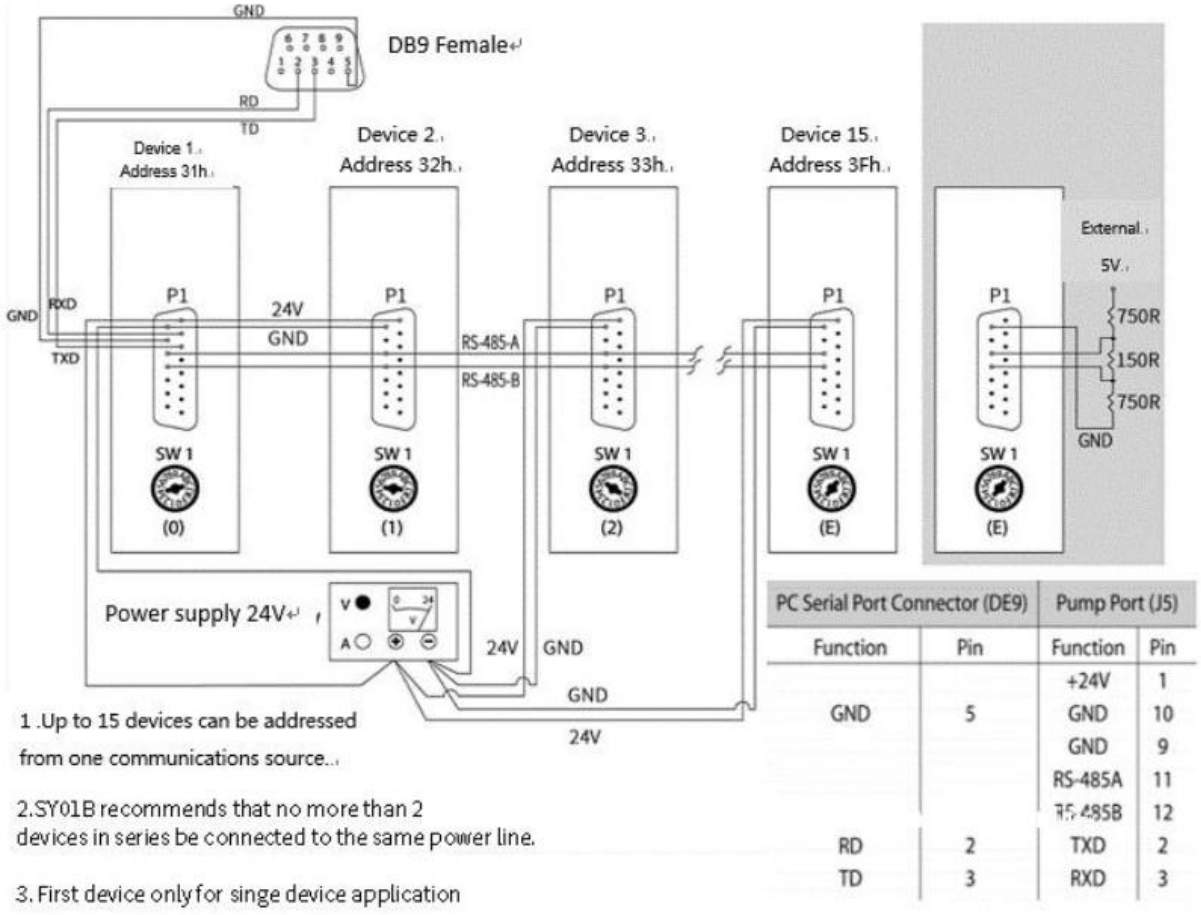




3.4.1 RS232/RS485 Interface

To facilitate connection of devices on the SY-01B RS-485 communication bus, the RS-232 can automatically convert the protocol to RS-485 (commonly referred to as a "multi-point" device).

Note: The RS-232 port lacks hardware handshaking and needs only three wires: receive data, transmit data, and signal ground. In multi-point setups, one controller can manage up to 15 pumps on the same bus. Always verify RS-485 A/B wiring via the diagrams, which also illustrate RS-232/RS-485 connections and external termination setups.



PC Serial Port Connector (DE9)		Pump Port (J5)	
Function	Pin	Function	Pin
		+24V	1
GND	5	GND	10
		GND	9
		RS-485A	11
		RS-485B	12
RD	2	TXD	2
TD	3	RXD	3

Figure 2-2 *RS232 to RS485 Cabling*

3.4.2 CAN Interface

The CAN interface is a two-wire serial system. The bus is driven in a manner similar to RS485. The main difference lies in the protocol.

3.5 Settings and Options

3.5.1 Configuration Commands

The SY-01B firmware allows users to configure the pump in different modes during operation.

The **U command** (refer to Chapter 3 "Software Communication") is used to write configuration information to read-only memory and control the following options:

- **Baud Rate**: For RS-232/RS-485, supported communication baud rates are 9600 (default) and 38400. For CAN, the default is 100K; also supports 125K, 250K, 500K, and 1M baud rates.
- **ROM Auto Mode**: Enables the pump to run command strings stored in ROM.
- **Stall Current**: Allows the pump to set a reset stall current based on syringe size.

3.5.2 Address Switch Settings

The address switch is located near the bottom of the SY-01B circuit board. It is used to assign a unique or specific address to each SY-01B unit in multi-pump configurations, allowing the user to issue commands to a particular pump.

The switch has **16 positions (0 to F)**, with **15 positions (addresses 0 to E)** being valid for pump addressing.

To set the address switch:

Use a small flat-head screwdriver to rotate the switch to the desired address.

Note: Set the address switch *after* powering on the pump. For details on addressing schemes for multi-pump configurations, refer to Chapter 3 "Software Communication".

3.5.3 Self-Test

The **"F"** address switch position activates the SY-01B self-test. The self-test initializes the SY-01B and repeatedly runs reciprocating plunger movements. The self-test cycles through speed codes from 5 to 40 in steps of 5. If an error is detected, the pump stops.

To run a self-test:

Set the address switch to position **"F"**, then power on the pump.

Warning: Keep liquid flow between syringe and valve; failure may damage both.

3.5.4 Input/Output

The SY-01B provides **two auxiliary inputs** and **three auxiliary outputs** via the DB-15 connector. These are TTL-level signals.

Outputs are controlled using the **J command**.

The auxiliary inputs (pins 7 and 8) can be read using the **?13 and ?14** commands. External triggers can be received via the **[H] command**. These commands are further described in Chapter 3 "Software Communication".

Chapter 4 Software Communication

4.1 SY01B Addressing Scheme

As part of the communication protocol, an address for each pump must be specified. The user has the option of addressing a single pump, two pumps (dual device), four pumps (quad device), or all 15 pumps (all devices), depending on the address byte used. Each physical address in the address switch corresponds to a hexadecimal value, as shown in Table 3-1, Hexadecimal Addressing Scheme.

Address (hex)) RS-232/RS-485	Device
30	Master Address (master controller, personal computer, etc.)
31…3F	Addresses single device
41…4F	Addresses two devices at a time (dual device)
51…5D	Addresses four devices at a time (quad device)
5F	Addresses all devices on the bus

For example, an SY01B with address switch set to 0 is addressed as device "31h" in the RS-232 or RS-485 communication protocol, hardware address 1 is addressed as device "32h," and so on.

Table 3-2, Address Switch Settings in Hex (ASCII), shows the different address switch settings for each of these configurations

Note: When using the Pump: Link software to send commands to a device, use the ASCII address values in Table 3-2.

Switch Setting	Single Device		Dual Device		Quad Device		All Devices	
	Hex Address	ASCII Address	Hex Address	ASCII Address	Hex Address	ASCII Address	Address	Value to Send
0	31	1	41	A	51	Q	5F	_
1	32	2						
2	33	3	43	C				
3	34	4						
4	35	5	45	E	55	U		
5	36	6						
6	37	7	47	G				
7	38	8						
8	39	9	49	I	59	Y		
9	3A	:						
A	3B	;	4B	K				
B	3C	<						
C	3D	=	4D	M	5D	]		
D	3E	>						
E	3F	?	4F	O				
F	Self Test							

Table 3-2 *Address Switch Settings in Hex (ASCII)*

The user can communicate with all pumps in the chain by using address "5Fh," for example to initialize all pumps at once. Then each pump can be controlled independently by using addresses "31h" to "3Fh."

Note: Multiple address commands cannot be used to determine device status or to request reports. Each device must be queried separately to gather status or generate a report..

4.2 Communication Protocols

Three communication protocols are available: :

OEM communication protocol

Data Terminal (DT) protocol

CAN protocol

SY01B firmware automatically detects the communication protocol.

The DT protocol can be run via an ASCII data terminal because no sequence numbers or checksums are used. For instructions on using a Microsoft Windows Terminal Emulator, see "Using DT Protocol with Microsoft Windows" in this chapter.

Note: SY01B Systems recommends using the OEM protocol for RS-232 and RS-485 interfaces. It provides increased error checking through the use of checksums and sequence numbers.

Once the SY01B detects either the OEM or DT protocol, it will ignore the other protocol until the next power cycle.

4.2.1 OEM Communication Protocol

OEM communication is a robust protocol that includes automatic recovery from transmission errors.

Parameter	Setting
Character Format	
Baud rate	9600 or 38400
Data bits	8
Parity	None
Stop bit	1
Command Block (see "OEM Protocol Command Block Characters" for details)	
1	STX (^B or 02H)
2	Pump address
3	Sequence number
3+n	Data block (length n)
4+n	ETX (^C or 03H)
5+n	Checksum
Answer Block (see "OEM Protocol Answer Block Characters" for details)	
1	STX (^B or 02H)

2	Master address (0 or 30H)
3	Status code
3+n	Data block (length n)
4+n	ETX (^C or 03H)
5+n	Checksum

Table 3-3 *OEM Commands*

OEM Protocol Command Block Characters

The command block characters in the OEM communication protocol are described below. All characters outside the command block are ignored.

When developing a parsing algorithm, the programmer should key on the STX as the beginning of the answer block and the checksum (character after the ETX) as the end of the answer block.

STX (^B or 02h)

The STX character indicates the beginning of a command

Pump Address

The pump address is a hexadecimal number specific for each pump

Sequence Number/Repeat Flag

The sequence number is a single byte that conveys both a sequence number (legal values: 0 to 7) and a bit-flag indicating that the command block is being repeated due to a communications breakdown. The sequence number is used as an identity stamp for each command block. Since it is only necessary that every message carry a different sequence number from the previous message (except when repeated), the sequence number may be toggled between two different values (e.g., "1" and "2") as each command block is constructed. During normal communication exchanges, the sequence number is ignored. If, however, the repeat flag is set, the pump compares the sequence number with that of the previously received command block to determine if the command should be executed or merely acknowledged without executing.

Note: If the operator chooses not to use this option, the sequence number can be set to a fixed value of 1 (31h).

Data Block (length n)

The data block consists of the data or commands sent to the pump or host (this is an ASCII string). When the pump is responding to a move or [Q] command, the data block length is 0 (i.e., no data string exists).

ETX

The ETX character indicates the end of a command string.

Checksum

The checksum is the last byte of the message string. All bytes (excluding line synchronization and

checksums) are XORed to form an 8-bit checksum. This is appended as the last character of the block. The receiver compares the transmitted value to the computed value. If the two values match, an error free transmission is assumed; otherwise, a transmission error is assumed.

OEM Protocol Answer Block Characters

The answer block characters in the OEM communication protocol are described below.

Only the unique answer block entries are listed in this section. For common commands and answer block commands (characters), see the previous section, "OEM Protocol Command Block Characters."

Master Address

The master address is the address of the host system. This should always be 30h (ASCII value "0").

Status and Error Codes

The status and error codes define pump status and signal error conditions. For a description of status and error codes, see "Error Codes and Pump Status".

4.2.2 Data Terminal (DT) Protocol

The DT protocol can be used easily from any terminal or terminal emulator capable of generating ASCII characters at 9600 baud, 8 bits, and no parity.

Character Format	
Parameter	Setting
Baud rate	9600 or 38400
Data bits	8
Parity	None
Stop bit	1
Command Block (see "DT Protocol Command Block Characters" for details)	
1	Start command (ASCII "/" or 2FH)
2	Pump address
2+n	Data block (length n)
3+n	Carriage Return ([CR] or 0DH)
Answer Block (see "DT Protocol Answer Block Characters" for details)	
1	Start answer (ASCII "/" or 2FH)
2	Master address (ASCII "0" or 30H)
3	Status character
3+n	Data block (length n)
4+n	ETX (03H)
5+n	Carriage return (0DH)
6+n	Line feed (0AH)

Table 3-4 *DT Protocol*

DT Protocol Command Block Characters

The command block characters in the DT communication protocol are described below:

Start Block

The start character indicates the beginning of a message block.

Pump Address

The pump address is an ASCII character specific to each pump.

Data Block (length n)

The data block consists of the ASCII data or commands sent to the pump or host.

End Block

The end character indicates the end of a message block.

DT Protocol Answer Block Characters

The answer block characters comprising the DT communication protocol are described below.

Only unique answer block entries are listed in this section. For information on command and answer block commands (characters), see the previous section, "OEM Protocol Command Block Characters."

Master Address

The master address is the address of the host system. This should always be 30h (ASCII "0").

Status Character

The status and error codes define pump status and signal error conditions. See the description of the [Q] command in "Error Codes and Pump Status."

Data Block

This is the response from all Report commands with the exception of the [Q] command.

Carriage Return (0dh)/Line Feed (0AH to 0CH)

This character terminates the reply block

4.2.3 Using DT Protocol with Microsoft Windows

The SY01B can be controlled in DT protocol mode directly from the Microsoft Windows terminal accessory.

To communicate with the SY01B using Windows , follow these steps:

1 Connect the SY01B to a communications port of the PC.

2 From the Microsoft Program Manager window, start the SerialCommV1.0 application.

3 Select more serial port Settings.

4 Select a baud rate of 9600, 8 data bits, 1 stop bit, no parity, communications port connector (for example,COM1), and no flow control.

5 Click OK and click again to start the serial port

6 Set the pump address switch to 0.

7 Power on the pump.

8 Type /1ZR to initialize the pump.

9 To run the pump, see the commands listed in “Using the SY01B Command Set” in this chapter.

4.2.4 CAN Interface Communication

CAN Controller Area Network is a two-wire, serial communication bus. It eliminates polling sequence that verify task completion. Using CAN, the pump asynchronously report to the maste or host when they have finished the current task

Note: all HMD use CAN controller chips compatible with Philips semiconductor CAN rCAN bus specification, version 2.0. When using the CAN interface, termination resistors (120ohm)are necessary at both ends of the bus.The pump does not provide CAN termination resistors.

4.2.4.1 CAN Messages

CAN messages consist of frames. Each frame has an 11 – bit Message Identifier (MID) and a 4-bit length identifier. The bits: Indlicate to which device on the bus the message is directed

Identify the message type

Show the direction of the message (toor from the master device)

Represent the length of the data block. Data blocks can be from zero to eight bytes in length. Any message that requires more than eight bytes must be sent in a series of multi-frame messages. The receiving unit then assembles the separate frames into one long string.

4.2.4.2 CAN Message Construction

Each message frame begins with the Message ID (MID). The data block (up to 8 bytes in length) follows the MID and length information. The MID makes up three nibbles that are transmitted first in a message frame. The bits are grouped asshown in Figure 3-1, CAN Message Structure"

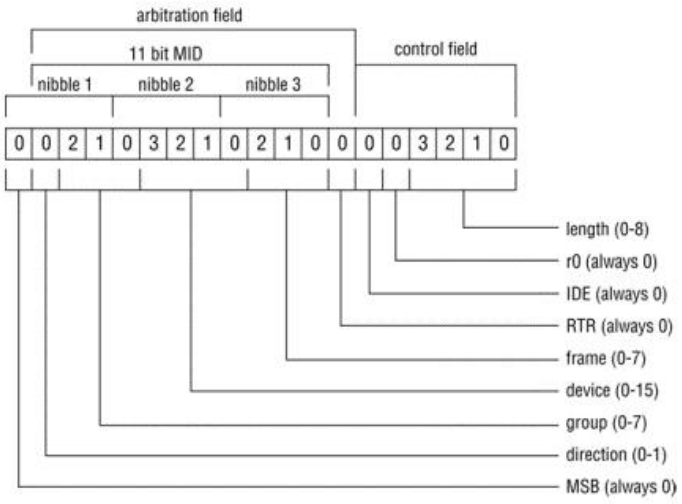


Figure 3-1 CAN Message Structure

Direction

This is the direction bit. It lets the devices on the bus know whether the current message is to or from the master. "O" means that the message is from master to slave; "|" means the message is from the slave to the master.

Note: Peer-to-peer messaging is not supported.

Group

This is the group number (0 - 7). Each type device on the CAN bus has a group assignment. HMD is assigned to group 2. The group number "1" is reserved for the boot request procedure.

Device

This is the address of the module in the particular group. Each group can have up to 16 devices. The address value is 0 - 15.

Frame

This lets the device know what type of message is coming. See "CAN Frame Types" in this chapter.

RTR

This bit is not used in HMD CAN implementation and should always be set to 0.

IDE

This will always be set to O for standard format frames.

r0

Reserved bit. set to 0.

Length

This is the length of the data block in the message. Data blocks can be from zero to eight bytes in length.

CAN Frame Types

The frame types allow each device to know what type of command is coming in and enables faster processing of commands. Pumps respond to the frame types described below:

Action Frames, Type 1

This frame type is used for action commands, such as Initialization commands, Movement commands, Valve commands, or to set pump operating parameters. All "task-type" commands are sent in this type message frame. When multi-frame messages are used to send an action command, this frame is the end message sent to the pump.

Common Commands, Type 2

This frame type is used for commands that are common to every device on the bus. The frame type is set to 2 and the command is a single ASCII character in the data block. The sinqle ASCII character is described below.

Command	Command
0	Reset mode. This resets the pump and beqins the boot request procedure.
1	Start loaded command. Just like sending an [R] command after a string has been loaded.
2	Clear loaded command. This clears out the command buffer.
3	Repeat last command. This command does the same thing as the (X] command,
4	Stop action immediately. This acts like a [T] command.

Multi-Frame Start Message, Type 3

This frame type lets the pump know that the next message will be longer than the 8-byte maximum for each frame. Subsequent frames will follow to complete the message.

Multi-Frame Data, Type 4

This frame type is used to identify a frame in the middle of a multi-frame message. The last frame of a multi-frame message for action commands must be type 1. The last frame of a multi-frame message response from the pump for report commands will be type 6.

Note: There is no type 5 frame.

Report/Answer Commands, Type 6

This frame type is used to get information back from the pump. It is similar in operation to the query commands (i.e., (?]) used in the OEM and DT protocols. The report command is one byte long and consists of one or more ASCII characters in the data block. Report commands in ASCII format are:

Command	Command
0	Report absolute plunger position
1	Report start speed
2	Report top speed
3	Report cutoff speed
6	Report current valve position
10	Report buffer status
12	Report pump backlash increment
13	Report status of input #1
14	Report status of input #2
15	Report the number of pump initializations
16	Report the number of plunger movements
17	Report the number of valve movements
18	Report the number of valve movements since last report
23	Report current software version
24	Report the number of reset offset steps
29	Report device status
76	Report pump configuration
200	Verify conf file
201	Query log
202	Query the serial number

203	Query encoder values
300-314	Query program strings in s0-s14
*	Query voltage
<	Report user data

When the pump responds to a query, the first two bytes of the data block are the status bytes. The first byte contains an error code (same error codes used with he RS-232 and RS-485 protocols) added to Ox20h. The second byte contains the value Ox60h and is not used. The remaining six bytes are for the response in ASCII. If the pump is only reporting Current status, the message is only two bytes long. If the reply consists of more than six bytes, multi-frame messages are used.

CAN Data Block

The data block tells the pump what to do. Pump commands are sent in ASCII just like in RS-232 or RS-485. For command strings that are more than eight bytes in length, multi-frame messages are used. This permits long program strings to be sent as with the other communications interfaces (remember that the SY-01C buffer size is 255 characters).

Handling of Pump Boot Requests

When the pump is first powered up or receives a system reset command (frametype 2, command 0), the pump notifies the host of this condition by sending a boot request message at 100 millisecond intervals until it receives a proper response. The group number is 1 for the boot request message. The frame type is 2 when the pump sends messages to the host, and the frame type must be 0 when the host replies to the boot request.

Example 1. The pump is set to address 0

Pump sends:

Direction	Group	Device	Frame	RTR	Length
1	001	0000	010	0	0000

Host acknowledges ;

Direction	Group	Device	Frame	RTR	Length	Node ID	Slave ID
0	001	0000	000	0	0010	0010 0000	001 00000

Host acknowledges the boot request with:

Direction	0	Host to slave
Group	1	Boot request response group
Device	0	Always 0 in boot response
Frame	0	Boot request response frame
RTR	0	Always 0
Length	2	Two data bytes in return message
Node ID		Node ID (2) +Pump Address (6)　00h must respond with Group & Address

Slave ID		Same as Node ID 20 in hex 00h

Example 2. The pump is set to address 6

Pump sends:

Direction	Group	Device	Frame	RTR	Length
1	001	0110	010	0	0000

Host acknowledges:

Direction	Group	Device	Frame	RTR	Length	Node ID	Slave ID
0	001	0000	000	0	0010	0010 0110	0010 0110

Host acknowledges the boot request with:

Direction	0	Host to slave
Group	1	Boot request response group
Device	0	Always 0 in boot response
Frame	0	Boot request response frame
RTR	0	Always 0
Length	2	Two data bytes in return message
Node ID		Node ID (2) +Pump Address (6) “&” 26 in hex
Slave ID		Slave ID same as Node ID 26 in hex

The pump will save the Node ID to use for message filter Group ID.

Note: The slave ID does not have to be the same as the node ID. The pump can be assigned any number between 0 and Ox7F (127) for the slave ID.

CAN Host and Pump Exchanges

When a slave pump receives a command, finishes a command, encounters an error condition, or responds to a query, it sends an answer frame to the host using the same frame type as the command it belongs to. The answer frame format is device dependent. Generally, it will have the following format:

<MID><DLC><Answer>

<MID>

11-bit message identifier. The direction bit is 1. The group number and the frame type are the same as received. Device ID is the slave message ID assigned by the host.

<DLC>

4-bit data length code

<Answer>

Data bytes block. The first byte of the data block is always the status byte, which is an error code (same error codes used with the RS232 and RS485 protocols) added to Ox20h. The second byte is always Ox60h.

The remaining bytes contain the response in ASCII format. If the reply consists of more than six bytes, the multi-frame messages are used.

Note: Only one command of a given frame type can be in progress at any one time; e.g., after issuing a command to a slave pump with frame type = 1, the master must wait for the answer with frame type = 1 before issuing the next command with frame type = 1. If the user insists on sending the command, a command overload status results. Several commands with different frame types can be in progress at the same time; e.g., an action command and a query command. Following are typical exchanges between the host and slave for action commands, multi-frame commands, common commands, and query commands.

Action Command

The host commands (ZR] to a pump, and the pump is set to address 0

Host sends:

0	XXXXXXX	001	0	0010	ZR
Direction	Slave ID	Frame Type	RTR	DLC	Data bytes

Pump acknowledges:

0	XXXXXXX	001	0	0010
Direction	Slave ID	Frame Type	RTR	DLC

After executing the command, pump reports status:

0	XXXXXXX	001	0	0010	<20h><60h>
Direction	Slave ID	Frame Type	RTR	DLC	Data bytes

Note: The mixed formats ASCII and hexadecimal are used in the data bytes block. The hexadecimal number is bracketed (<>). The rest of the fields are displayed in binary format.

Multi-Frame Command

The host commands [Z2S5gIA30000gHD300G10G5R] to a pump, and the pump is set to address 0.

Host sends:

0	XXXXXXX	011	0	1000	Z2S5gIA3
Direction	Slave ID	Frame Type	RTR	DLC	Data bytes
0	XXXXXXX	100	0	1000	000OgHD3
Direction	Slave ID	Frame Type	RTR	DLC	Data bytes
0	XXXXXXX	001	0	1000	00G10G5R
Direction	Slave ID	Frame Type	RTR	DLC	Data bytes

Pump acknowledges:

1	XXXXXXX	001	0	0000
Direction	Slave ID	Frame Type	RTR	DLC

After executing the command, pump reports status:

1	XXXXXXX	001	0	0010	<20h><60h>
Direction	Slave ID	Frame Type	RTR	DLC	Data bytes

Note: For multi-frame commands, the pump only acknowledges the last frame.

Common Command

After the host has sent command [A1000A0] to the pump, it sends command 1 of frame type 2 to a pump and makes the pump move. The pump is set to address 0.

Host sends:

0	010	0000	010	0	0001	1
Direction	Slave ID	Frame Type	RTR	DLC	Data bytes	Direction

Pump acknowledges:

1	XXXXXXX	002	0	0000
Direction	Slave ID	Frame Type	RTR	DLC

After executing the command, pump reports status:

1	XXXXXXX	002	0	0010	<20h><60h>
Direction	Slave ID	Frame Type	RTR	DLC	Data bytes

Query Command

The host commands 29 of frame type 6 to a pump, and the pump is set to address 1

Host sends:

0	XXXXXXX	110	0	0010	29
Direction	Slave ID	Frame Type	RTR	DLC	Data bytes

Pump acknowledges:

1	XXXXXXX	110	0	0010	<20h><60h>
Direction	Slave ID	Frame Type	RTR	DLC	

Note: For query commands, no acknowledge frame is needed

Report Command

The host commands 23 of frame type 6 to a pump, and the pump is set to address 1

0	XXXXXXX	110	0	0010	23
Direction	Slave ID	Frame Type	RTR	DLC	Data bytes

Pump reports：

1	XXXXXXX	011	0	1000	<20h><60h><727920>
Direction	Slave ID	Frame Type	RTR	DLC	
1	XXXXXXX	110	0	0110	<20h>Rev<20h>A
Direction	Slave ID	Frame Type	RTR	DLC	Data bytes

Note: For multi-frame replies, the starting frame is type 3, the middle frame is type 4 and the last frame

is type 6.

Note: In this example, the returned data has been actualised.

4.3 Using the SY01B Command Set

4.3.1 Command Execution Guidelines

To use the commands properly, keep the following in mind:

◆ All commands, except Report commands and most Control commands, must be followed by an [R] (Execute) comman

◆ Single or multiple command strings can be sent to the pump.

For example:

– A single command such as [A6000R] moves the plunger to position 6000.

– A multi-command string such as [IA6000OA0R] moves the valve to the input position, moves the plunger to position 6000, turns the valve to the output position, and finally returns the plunger to position 0.

◆ The pump’ s command buffer holds a maximum of 255 characters. If a command is sent without the [R] (Execution) command, it is placed into the buffer without being executed. If a second command is sent before the first command is executed, the second command overwrites the first command (i.e., the first command string is erased).

◆ Once a command is executed, new commands are not accepted until the sequence is completed. Exceptions to this rule include interruptible (see “T Terminate Command” in this chapter) and Report commands.

◆ When a command is sent, the pump answers immediately. If an invalid command has been sent in a command string, or there was an invalid parameter in the command, the pump reports an error immediately. In the case of a [Q] (Query) command, the error is read back to the host computer.

◆ Always run liquid through the syringe and valve when issuing a Move command. Failure to do so may damage the valve and syringe seal.

◆ Keep fingers out of the syringe slot while the pump is running. Failure to do so can result in injury.

4.3.2 Pump Configuration Commands

SY01B pumps are preconfigured at the factory to the default settings. The firmware, however, allows the user to configure the pump to meet his or her specific requirements. Configuration options available to the user include resolution, backlash, valve type, and baud rate.

N <n> Set Microstep Mode Off/On

The [N] command enables or disables microstepping (fine positioning).

The syntax for this command is:

[N<n>]

where <n> = 0 or 1 (0 is the default)

Value of <n>	Description
0	Normal mode: All positions set and reported in half-steps; all speedsettings in half-steps/sec and all slopes in half-steps/sec 2.
1	Fine positioning mode: All positions set and reported in micro-steps; all speed settings in half-steps/sec and all slopes in half-steps/sec 2 . Maximum cutoff frequency limited to 750 half-steps/sec; maximum on- the-fly set velocity limited to 750 half-steps/sec.。
2	Micro-step mode: All positions set and reported in micro-steps; all speed settings in micro-steps/sec and all slopes in micro-steps/sec 2 .

K<n> Backlash Increments

The [K] command sets the number of backlash increments.

The syntax for this command is

[K<n>]

where <n> = 0---800 in full step mode

and <n> = 0---1600 in fine positioning mode

When the syringe drive motor reverses direction, the carriage will not move until the backlash due to mechanical play within the system is compensated. To provide this compensation, during aspirating, the plunger moves down additional increments, then backs up the set number of backlash increments.

This ensures that the plunger is in the correct position to begin a dispense move.

> Set User Data Command

The [>] command loads a byte of user data into non-volatile memory:

[> <n1>, <n2>], where: <n1> is 0..15 (location in non-volatile memory) and

<n2> is 0..255 (data to load into non-volatile memory).

U<n> Write Pump Configuration to Non-Volatile Memory

The [U] command is used to write configuration information to the non-volatile memory. The pumps are configured during the manufacturing process but can be reconfigured at any time with the following [U] commands

Value<n>	Description
30	Set Non-Volatile Memory Auto Mode
31	Clear Non-Volatile Memory Auto Mode
41	Set RS-232/RS-485 Baud rate to 9600
47	Set RS-232/RS-485 Baud rate to 38400

U200	Set the stall current of the syringe pump (1-31)

Figure 3-5 Write Pump Configuration Command Values

Note: [U] commands take effect upon the pump's next power-up.

4.4 Initialization

4.4.1 Initialization Forces

Initialization moves the plunger to the top of travel, then backs off a user-specified number of increments (see k command) and sets this as position 0. Also, the input and output positions of the valve are assigned depending on the initialization command. All other command parameters are reset to default values.

The top of the syringe is recognized when upward movement of the plunger causes an overload condition.

The force at which the plunger presses against the top of the syringe can be controlled via a parameter after the Initialization command (possible values are 0, 1 and 2).

Table 3-6 lists the recommended initialization force for each type of syringe.

Caution! To retain the integrity of the seal on smaller syringes, use a lower initialization force than that for larger syringes. The default initialization speed is 500 Hz.

Syringes	Force
1.0 mL and larger	Full
250，500μl	Half
50，100μl	Third

Figure 3-6 *Recommended Initialization Forces by Syringe*

k <n> Syringe Dead Volume Command / Offset Steps after Reset

The [k] command sets the number of increments that the plunger drive is offset from the top of travel. This is to minimize dead volume.

The syntax for this command is:

[k<n>]

where:

n = the offset in increments from top of travel

n = 0…800 in full step mode

n = 0…6400 in fine positioning and microstep modes

Under default initializations, the plunger moves upward until it contacts the top of the syringe, causing a forced stall initialization. The plunger then moves downward and upward, leaving a small gap between the syringe seal and the top of the plunger. This small gap was designed so that the Teflon seal does not hit the

top of the plunger each time the syringe moves to the "home" position. This maximizes the life of the syringe seal.

The [k] command must be followed by the Initialization command [Z], [Y], or[W]. Each time the unit is powered down, the "k" value will return to the default condition.

For example, to offset 10 increments away from the top of travel, send the following commands:

– k10R

– ZR

4.4.2 Initialization Commands

Z <n1, n2, n3> Initialize Plunger and Valve Drive (CW Polarity)

The [Z] command initializes the plunger drive and homes the valve in a clockwise direction. Valve ports are numbered 1..X, starting in a clockwise direction at the first port after the syringe port. The default initialization speed is 500 pulses per second.(In the SY01B system, the process of suction is initialized in input port, and the dispensing is initialized in output port)

n 1 = Set initialization plunger force/speed

n 2 = Set initialization input port

n 3 = Set initialization output port

The parameters are described below:

Z Parameter	Value	Description
<n1>	0	Initializes at full plunger force and at default initialization speed (default)
	1	Initializes at half plunger force and at default initialization speed
	2	nitializes at one-third plunger force and at default initialization speed
	10…40	Initializes at full force and at speed code <n 1 >. See command <S> for a list of speed codes.
<n2>	0	Sets initialization input port to port 1 (default)
	1…X	Sets initialization input port for distribution valves, where X is the number of ports on the valve.
<n3>	0	Sets initialization output port to port X (default), where X is the number of ports on the valve.
	1…X	Sets initialization output port for distribution valves, where X is the number of ports on the valve.

Y＜n1、n2、n3 > Initialize Plunger and Valve Drive (CCW Polarity)

The [Y] command initializes the plunger drive and homes the valve in a counter-clockwise direction. Valve ports are numbered 1..X in a counter-clockwise direction starting with the first port after the syringe port. The default initialization speed is 500 pulses per second.

n 1 = Set initialization plunger force/speed

n 2 = Set initialization input port

n 3 = Set initialization output port

The parameters are described below.

Y Parameter	Value	Description
<n1>	0	Initializes at full plunger force and at default initialization speed (default)
	1	Initializes at half plunger force and at default initialization speed
	2	Initializes at one-third plunger force and at default initialization speed
	10…40	Initializes at full force and at speed code <n 1 >. See command <S> for a list of speed codes.
<n2>	0	Sets initialization input port to port 1 (default)
	1…X	Sets initialization input port for distribution valves, where X is the number of ports on the valve.
<n3>	0	Sets initialization output port to port X (default), where X is the number of ports on the valve.
	1…X	Sets initialization output port for distribution valves, where X is the number of ports on the valve.

W <n1> Initialize Plunger Drive

The [W] command initializes the plunger drive only (commonly used for valveless pumps). Because the valve is not initialized, only plunger force and/or speed can be set.The default initialization speed is 4000 pulses per second.

n 1 = Set initialization plunger force/speed

The parameters are described below.

W Parameter	Value	Description
<n1>	0	Initializes at full plunger force and at default initialization speed (default)
	1	Initializes at half plunger force and at default initialization speed
	2	Initializes at one-third plunger force and at default initialization speed.
	10…40	Initializes at full force and at speed code <n 1 >. See command <S> for a list of speed codes.

w<n1, n2> Initialize Valve Drive

The [w] command initializes the valve drive only. Because the plunger is not initialized, only the initialization port can be set.

n 1 = Set port

n 2 = Set valve homing and port numbering direction

The parameters are described below.

w Parameter	value	Description
<n1>	1…X	Set initialization port, where X is the number of ports on the valve

<n2>	0	Valve homes in a *clockwise* direction; valve ports numbered in a *clockwise* direction.
	1	Valve homes in a *counterclockwise* direction; valve ports numbered in a counterclockwise direction.

z Simulated Plunger Initialization

The [z] command simulates an initialization of the plunger drive, however, no mechanical initialization occurs. The current position of the plunger is set as the zero (home) position.

This command can be used after a plunger overload error, to regain control of the pump. After recovering from the overload condition using the [z] command, the pump must be reinitialized using the Z<n 1 , n 2 , n 3 > or Y<n 1 , n 2 ,n 3 > commands to set the true home position.

Caution! Incorrect use of this command can damage the device.

4.5 Operating Commands

4.5.1 Valve Commands

Valve commands position the input and output channels to the specified ports. Similar valve commands cause different actions depending on whether you are using non-distribution valves or distribution valves.

With non-distribution valves, any combination of two valve ports, including or excluding the syringe port, may be used. With distribution valves, the syringe port is a common port, always included as one of the two valve ports in use.

The initialization command (Z, Y, or w) determines:

the direction in which the valve homes during initialization (clockwise or counterclockwise)

the direction in which the ports are numbered, starting with the syringe port (clockwise or counterclockwise)

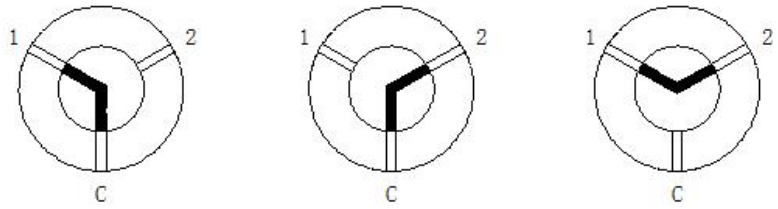
After initialization, the direction in which the valve moves is specific to the valve type and command.

With non-distribution valves, the I, O, B, or E command specifies the combination of valve ports to be connected. The valve moves following the shortest path available.

For example, in Figure 3-2, if the 3-port non-distribution valve has been initialized with the [Z] command, the ports will be numbered as shown in the top diagram (clockwise). Issuing an [O] command aligns the syringe port with port 2, as shown.

Figure 3-2 Valve Position Examples for 3-Port Non-Distribution Valves

3-Port Valve
Z Initialization Command Examples
Port sequence is clockwise from Syringe port （C）



I Valve Command
Input to port 1

0 Valve Command
Output to port 2

B Valve Command
Bypass to Input & Output

With distribution valves, the direction in which the valve moves is determined by the valve command. It will not necessarily follow the shortest path.

- The [I] command moves the valve in a clockwise direction.
- The [O] command moves the valve in a counterclockwise direction.

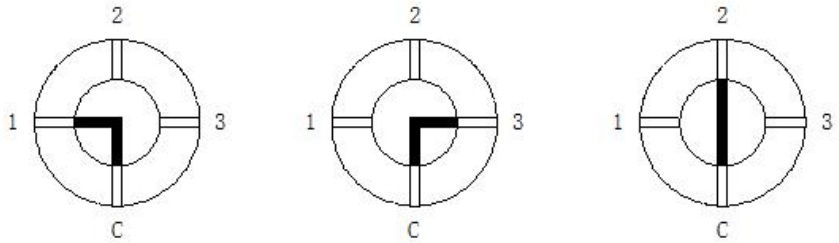
Note: Use of [I] and [O] in distribution valves is by convention, and does not pertain to input or output characteristics

Because the syringe port is always a common port, in distribution valves, the [B] (Bypass) and [E] (Extra) commands are meaningless. However, the commands are available, to provide backward compatibility with earlier versions of firmware.

For example, in Figure 3-3, if the 3-port distribution valve has been initialized with the [Y] command, the ports will be numbered as shown in the bottom diagram (counterclockwise). Issuing an [O<3>] command will align the syringe port with port 3, as shown.

Figure3-3 Valve Position Examples for 3-Port Distribution Valves

3-Port Distribution Valve
Z Initialization Command Examples
Port sequence is clockwise from Syringe port (C)

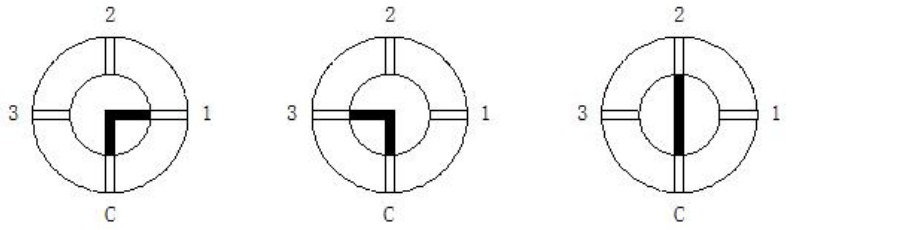


Set I<1> Command
Input (I) on port 1

Set O<3> Command
Output (O) on port 3

Extra<E>postion Command
Connect port C and 2

3-Port Distribution Valve
Y Initialization Command Examples
Port sequence is counter-clockwise from Syringe port (C)



Set I<1> Command Input（I）on port 1 | Set O<3> Command Output（O）on port 3 | Extra<E>postion Command Connect port C and 2

Following are more detailed descriptions of the various valve commands and what they do.

I Move Valve to Input Position (Non-distribution Valves)

The [I] command moves the valve to the input port set by the initialization command, following the shortest path.

I < n> Move Valve Clockwise to Port n (Distribution Valves)

The [I<n>] command sets the valve position to port [n], moving in a clockwise direction. This command is independent of input or output characteristics.

O Move Valve to Output Position (Non-distribution Valves)

The [O] command moves the valve to the output port set by the initialization command, following the shortest path.

O <n> Move Valve Counterclockwise to Port n (Distribution Valves)

The [O<n>] command sets the valve position to port [n], moving in a counter-clockwise direction. This command is independent of input or output characteristics.

B Move Valve to Bypass (Non-distribution Valves)

The [B] command connects the input and output positions, bypassing the syringe. The valve moves following the shortest path.

E Move Valve to Extra Position (4-Port Non-distribution Valve)

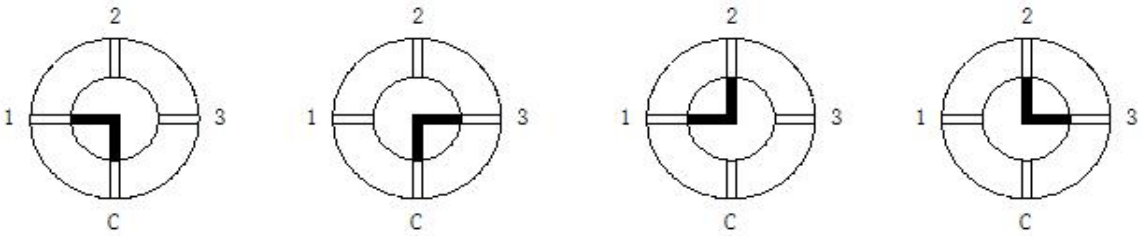
The [E] command connects the extra position in the 4-port valve, bypassing the syringe. The valve moves following the shortest path.

Note: The [B] and [E] commands are useful when flushing fluid lines. If a Valve command is issued to a valveless pump, the command is ignored.

Caution! When the valve is in the Bypass position, the syringe plunger will not move. Sending a Plunger Movement command causes an error 11 (plunger move not allowed)

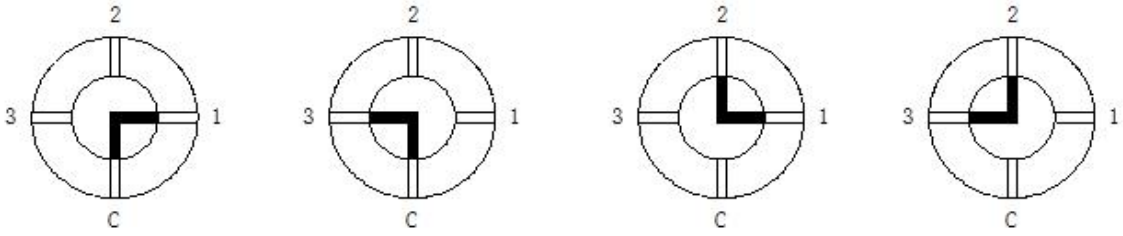
Figure3-4 Valve Position Examples for 4-Port Non-Distribution Valves

4 Port-Valve
Z Initialization Command Examples
Port squence is clockwise from Syringe(C) Port



Sets I command Input（I）on port 1 | Sets 0 command Output (0) on port 3 | Bypass(B)command Connects ports 1 & 2 | Extral(E)position command Connects ports 2 & 3

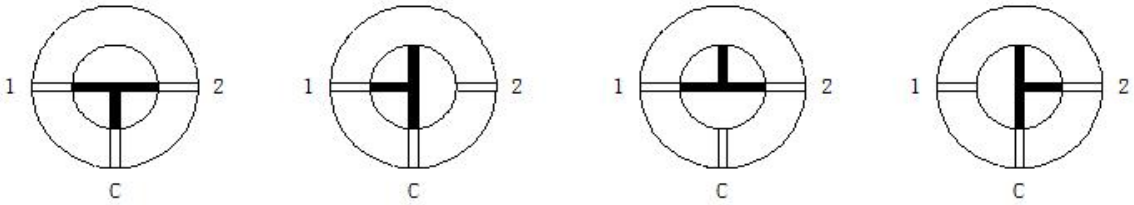
4 Port-Valve
Y Initialization Command Examples
Port squence is counter-clockwise from Syringe(C) Port



Sets I command Input（I）on port 1 | Sets 0 command Output (0) on port 3 | Bypass(B)command connects ports 1 & 2 | Extral(E)position command connects ports 2 & 3

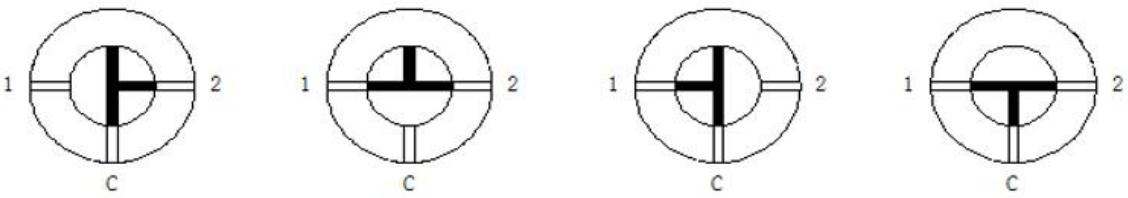
Figure 3-5 Valve Position Examples for T Valves (Distribution)

T-Valve
Z Initialization Command Examples
Port sequence is clockwise from Syringe (C) port



Sets I command Input(I)on port1&2 | Bypass(B)command connects port1 | Extral(E)command connects port1&2 | Sets 0 command Output(0)on port 2

T-Valve
Y Initialization Command Examples
Port sequence is counter-clockwise from Syringe (C) port



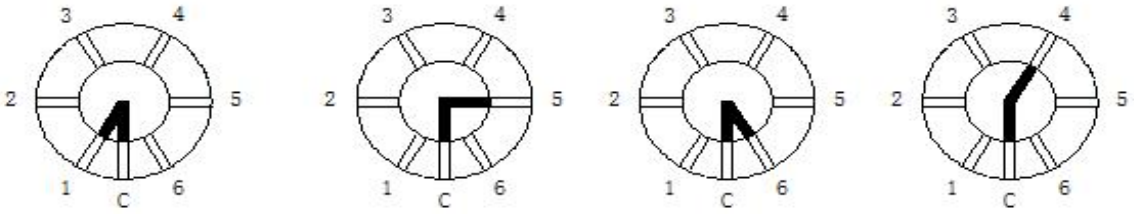
Sets I command | Bypass(B)command | Extral(E)command | Sets 0 command

Input(I)on port 2 connects port1&2 connects port1 Output(0)on port 1&2

Note: For M02 T-type valve head, it is forbidden to use the piston movement command ([A], [a], [P], [p], [D], [d]) to move the pistion when the valve head is switched to I3!!!(Pay attention)

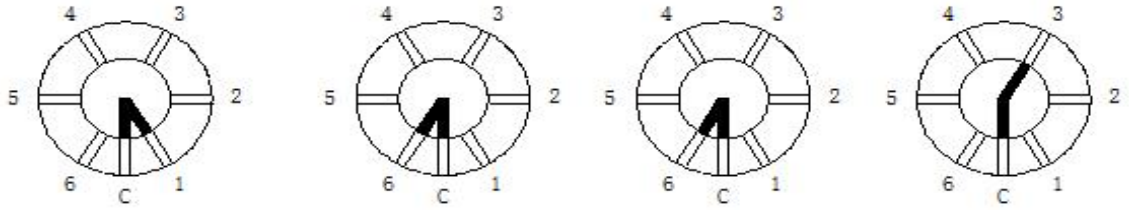
Figure3-6 Valve Position Examples for 6-Port Distribution Valves

6-Port Distribution Valves
Z Initialization Command Examples
Port sequence is clockwise from Syringe (C) port



I<1>Command Input on port 1(default) | I<5>Command Input on port 5 | O<6>Command Output on port 6(default) | O<4>Command Output on port 4

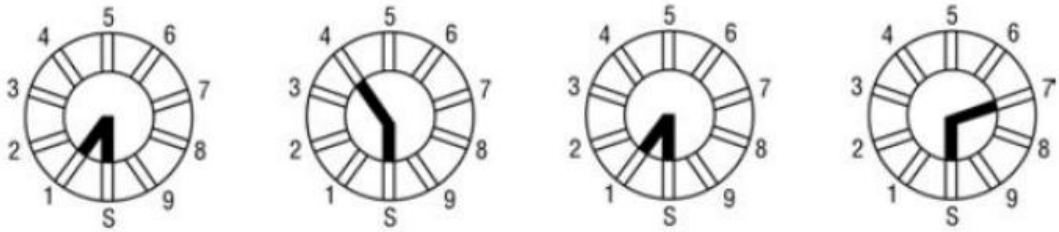
6-Port Distribution Valves
Y Initialization Command Examples
Port sequence is counter-clockwise from Syringe(C)



I<1>Command Input on port1(default) | I<6>Command Input on port 6 | O<6>Command Output on port 6 (default) | O<3>Command Output on port 3

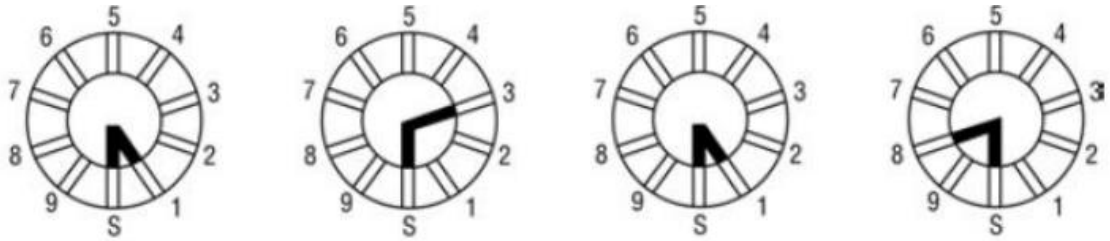
Figure3-7 Valve Position Examples for 9-Port Distribution Valves

9-Port Distribution Valves
Z Initialization Command Examples
Port sequence is clockwise from Syringe (C) port



I<1>Command Input on port 1(default) | I<4>Command Input on port 4 | O<1>Command Output on port1(default) | O<7>Command Output on port 7

9-Port Distribution Valves
Y Initialization Command Examples
Port sequence is counter-clockwise from Syringe(C)



I<1>Command	I<3>Command	O<1>Command	O<8>Command
Input on port 1(default)	Input on port 3	Output on port1(default)	Output on port8

4.5.2 Plunger Movement Commands

A <n> Absolute Position

The [A] command moves the plunger to the absolute position <n>, where<n> = 0..12000 in standard mode and 0..96000 in fine positioning and microstep mode.

Command	<n> Parameter Value	Description
A	0-12000	Absolute position in half increments (N=0)
	0-96000	Absolute position in microsteps (N=1)
	0-96000	Absolute position in microsteps (N=2)

For example:

– [A300] moves the syringe plunger to position 300.

– [A12000] moves the syringe plunger to position 12000.

a <n> Absolute Position (Not Busy)

This is the same as the [A] command, except that the status bit within the reply string indicates that the pump is not busy.

P <n> Relative Pickup

The [P] command moves the plunger down the number of increments commanded. The new absolute position is the previous position plus <n>, where

<n> = 0..12000 in standard mode and

<n> = 0..96000 in fine positioning and microstep mode.

Command	<n> Parameter Value	Description
P	0-12000	Relative position in half increments (N=0)
	0-96000	Relative position in microsteps (N=1)
	0-96000	Relative position in microsteps (N=2)

For example:

The syringe plunger is at position 0. [P300] moves the plunger down 300 increments. [P600] moves the plunger down an additional 600 increments to an absolute position of 900.

The [P] command will return error 3 (invalid operand) if the final plunger position is greater than 12000.

p <n> Relative Pickup (Not Busy)

This is the same as the [P] command, except that the status bit of the reply string indicates that the pump is not busy..

D <n> / d <n> Relative Dispense

The [D] command moves the plunger upward the number of increments commanded. The new absolute

position is the previous position minus <n>,where

<n> = 0..12000 in standard mode and

<n> = 0..96000 in fine positioning and microstep mode.

Command	<n> Parameter Value	Description
D	0-12000	Relative position in half increments (N=0)
	0-96000	Relative position in microsteps (N=1)
	0-96000	Relative position in microsteps (N=2)

For example:

The syringe plunger is at position 3000. [D300] will move the plunger up 300 increments to an absolute position of 2700.

The [D] command will return error 3 (invalid operand) if the final plunger position would be less than 0.

d <n> Relative Dispense (Not Busy)

This is the same as the [D] command, except that the status bit of the reply string indicates that the pump is not busy.

4.5.3 Set Commands (Speed and Acceleration)

Set commands are used to control the speed of the plunger. Plunger movement is divided into three phases:

- **Ramping Up.** Plunger movement begins with the start speed and accelerates with the programmed slope to the constant or top speed.
- **Constant or Top Speed.** The plunger moves at the constant or top speed. Plunger speed can be programmed in Hz (half-increments/second) or in preprogrammed Set Speeds. The actual time the plunger travels is dependent on the ramping up and down. If the plunger move is short, it may never reach top speed.
- **Ramping Down**. The plunger will decelerate based on the programmed slope. To enhance fluid breakoff, the Cutoff command ([c]) can be used to define the end speed of the plunger just before it stops.

Note: The Cutoff command is only active in a dispense move. During aspiration the move will end at the start speed [v].

For each plunger move, the firmware calculates how many increments the plunger must travel during each phase in order to move the total number of increments commanded. If the plunger is moving at a rate less than 900 Hz, the pump automatically microsteps to reduce the pulsation.

The top speed can be changed on the fly (while the plunger is moving) using the [v] command, providing the top speed is less than or equal to the start speed. Ramps are not included in on-the-fly speed changes; therefore, large speed changes (100 Hz to 1000 Hz) are not recommended.

Note: Unless the top speed is less than or equal to the start or cutoff speed, always program the pump in order of the move: start speed [v], top speed [V],cutoff speed [c].

Changing Speed on the Fly

Speed changes can be made while the syringe plunger is moving. This is called "changing speed on the fly."

Speeds can be decreased or increased between 1 and 12000Hz (i.e., in the fine positioning region)

To change speed on the fly:

1. Issue speed commands with identical start and top speeds (e.g., [v100V100]), followed by a Plunger Move command. Ramping is not allowed in on-the-fly changes.
2. Issue a new top speed in the range 5 to 750 (e.g. [V600]) while the plunger is moving, to change the speed on the fly.

Note: *When the move completes, speed values revert to original values (i.e.,value sent on-the-fly is temporary).*

L <n> Set Slope

During the beginning and end of a move, the plunger speed ramps up and down respectively. The ramp is programmed using the Slope command. It is calculated as <n> x 2.5 pulses/sec 2 . The syntax for this command is:

[L<n>]

where <n> = 1..20 (14 is the default)

In normal or fine positioning modes (N0, N1) pulses are in half steps. In micro-step mode (N2) pulses are in micro-steps.

The corresponding slopes in pulses/sec 2 are listed below.

Slope Code	Pulses/sec 2 (KHz)
1	2500
2	5000
3	7500
4	10000
5	12500
6	15000
7	17500
8	20000
9	22500
10	25000
11	27500
12	30000
13	32500
14	35000

15	37500
16	40000
17	42500
18	45000
19	47500
20	50000

v <n> Set Start Speed

The [v] command sets the speed at which the plunger begins its movement, in pulses/sec. The plunger will then ramp up (slope) to the top speed. The start speed should always be less than the top speed

Command	<n> Parameter Value	Default Value	Description
v	1-1000	900	Set start speed in pulses/sec.

V <n> Set Top Speed

The [V] command sets the top speed in pulses/second. This command may be sent while a command string is already executing. (See section on Changing Speed on the Fly, earlier in this chapter.)

Command	<n> Parameter Value	Default Value	Description
V	1-6000	4000	Set top speed in pulses/sec.

Note: According to the different specifications of the syringe, the value can be adjusted to 12000, but we can only guarantee that 1-6000 will run perfectly on the syringe we provide. For the speed set higher than V6000, Users must determine the appropriate speeds for their actual applications.

S <n> Set Speed

The [S] command sets a predefined top plunger speed, in pulses/sec. As <n> increases, the plunger speed decreases.

Command	<n> Parameter Value	Default Value	Description
S	0-40	11	Set plunger drive speed in pulses/sec.

These speed settings do not cover the full range of speeds the plunger can travel. They are commonly used speeds provided for the convenience of the user. All times are approximate and will vary with different ramp speeds and cutoffs. For information on determining timing for specific applications, see Appendix B, "Plunger Information"."

The [S] command sets top speed without changing start speed, slope, and cutoff speed, except under the following conditions:

- If the start speed is higher than the (new) top speed, start speed is changed to equal the top speed.
- If the cutoff speed is higher than the (new) top speed, cutoff speed is changed to equal the top speed.

Speed codes, the Hz (pulses/second) equivalent, and seconds per stroke are listed below.

Seconds/stroke values are based on default ramping

Speed Code	Value (pulses/sec)	Seconds/stroke (N=0, N=1)	Seconds/stroke (N=2)
0	6000	2	16
1	5600	2.2	17.6
2	5000	2.5	20
3	4400	2.7	21.6
4	3800	3.1	24.8
5	3200	3.8	30.4
6	2600	4.1	32.8
7	2200	5.5	44
8	2000	6	48
9	1800	6.7	53.6
10	1600	7.5	60
11	1400	8.5	68
12	1200	10	80
13	1000	12	96
14	800	15	120
15	600	20	160
16	400	30	240
17	200	60	480
18	190	63	504
19	180	67	536
20	170	72	576
21	160	75	600
22	150	80	640
23	140	87	696
24	130	93	744
25	120	101	808
26	110	108	864
27	100	120	960
28	90	135	1080
29	80	150	1200
30	70	171	1368
31	60	204	1632
32	50	240	1920
33	40	300	2400
34	30	408	3264
35	20	600	4800
36	18	660	5280
37	16	750	6000
38	14	870	6960
39	12	1008	8064

40	10	1200	9600

Note: To achieve maximum stroke time 200 minutes for N=0, N=1 or 1600 minutes for N=2, At this time, the [S] speed code is not available, and the [V1] instruction is required for programming.

c <n> Cutoff Speed in Pulses/Second

The [c] command sets the speed at which the plunger ends its movement, in pulses/sec. The plunger will ramp down (slope) from the peak speed. The [c] command overwrites the [C] command.

Command	<n> Parameter Value	Default Value	Description
c	1-5400	900	Set cutoff speed in half-steps/sec (N=0,N=1)
	1-1500	900	Set cutoff speed in micro-steps/sec (N=2)

Note: [c] is only valid in a dispense move. During aspiration, [c] = [v]

4.5.4 Interaction of Set Commands

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

[v]≤[c]≤[V]

1. Start Speed should always be less than or equal to Top Speed. Changing the Start Speed will change the Cutoff Speed if Cutoff Speed is less than the Start Speed set. If the Start Speed [v] is greater than the Top Speed, the Start Speed will be set equal to the Top Speed.

2. Top Speed should always be greater than or equal to the Start Speed and Cutoff Speed. Changing the Top Speed will modify the Cutoff Speed and Start Speed if they were improper, but will not modify the stored Start Speed. For instance, values of 750, 100 and 1200 will cause the pump to run simply at the top speed of 100.

3. Cutoff Speed [c] should always be less than or equal to Top Speed [V] and greater than or equal to Start Speed [v]. Changing the Cutoff Speed will not modify the Start Speed or Top Speed. However, if Cutoff Speed is greater than Top Speed it will be ignored and the Cutoff Speed will be set equal to the Top Speed. And if the Cutoff Speed is set less than Start Speed, it will be ignored and the Cutoff Speed will be set equal to the Start Speed.

4.5.5 Control Commands

R Execute Command or Program String

The [R] command tells the pump to execute a new or previously loaded but unexecuted command string. This command will also cause the resumption of a halted (“H”) or terminated (“T”) command string.

Commands containing [R] at the end of the string will execute immediately. If the command or program string is sent without the [R], it is placed in the command buffer.

Sending the [R] alone will execute the last unexecuted command in the buffer. Sending another [R] will not repeat the program string (i.e., the string has been executed.

X Execute the Last Command or Program String

The [X] command repeats the last executed command or program string.

G <n> Repeat Command Sequence

This command repeats a command or program string the specified number of times. If a GR or a G0R is sent, the sequence is repeated until a Terminate command [T] is issued. The G command can be used to nest up to 10 loops and can be repeated up to 48,000 times.

The syntax for this command is:

[G<n>]

where <n> = 0..48000

For example, [A3000A0G10R] moves the syringe plunger to position 3000 then back to position 0. This sequence is repeated 10 times.

g Mark the Start of a Repeat Sequence

The [g] command is used in conjunction with the [G] command. The [g] command marks the beginning of a repeat sequence (loop) that occurs within a program string (i.e., the entire string is not repeated). Both the [g] and [G] commands can be used to nest up to 10 loops.

Table 3-7, Example Program String, shows the various segments of the command string [A0gP50gP100D100G10G5R].

Command Segment	Description
A0	Move plunger to position 0
g	Outer loop start.
P50	Move plunger down 50 increments.
g	Inner loop start.
P100	Move plunger down 100 increments
D100	Move plunger up 100 increments.
G10	Inner loop, repeat 10 times.
G5	Outer loop, repeat 5 times
R	Execute command string

Figure3-7 Example Program String

M <n> Delay Command Execution

The [M] command delays execution of a command in milliseconds to the closest multiple of five. This command is typically used to allow time for liquid in the syringe and tubing to stop oscillating, thereby enhancing precision. The syntax for this command is:

[M<n>]

where <n> = 0..30,000 milliseconds (5 is the default)

H <n> Halt Command Execution

The [H] command is used within a program string to halt execution of the string. To resume execution, an [R] command or TTL signal must be sent.

The syntax for this command is:

[H<n>]

where <n> = 0..2

Two TTL inputs are available, input 1 (P11 pin 7) and input 2 (P11 pin 8). They control execution as follows:

<n> = 0 Waits for [R] or either input 1 or 2 to go low

<n> = 1 Waits for [R] or input 1 to go low

<n> = 2 Waits for [R] or input 2 to go low

Note: If the value of <n> is not specified, <n> defaults to 0.

The status of the TTL input lines can also be read by using [?13]and [?14].

These commands are described in "Report Commands" later in this chapter

T Terminate Command

The [T] command terminates plunger moves in progress ([A], [[a], [P], [p], [D] and [d]) , control loops, and delays [M].

Note: The [T] command will not terminate Valve Move commands. The [T] command will terminate both single commands and program strings. If a program string is terminated before completion, the [R] (Execution) command will resume the program string. If the command was terminated due to a problem or error, the pump must be reinitialized.

Caution! When a plunger move is terminated, lost increments may result. Reinitialization is recommended following termination.

For "H" command and "T" command: In the string containing "H" command, the execution of the string will stop when the execution command encouters the "H" command, and the "R" command should be sent to execute the following instructions of the "H" command. When the subsequent instructions are executed, sending the "R" command will re-execute this instruction containing the "H" command; For a command that is being executed, sending the "T" command will terminate the movement being executed, and then send "R" command will re-execute the remaining string command.

J <n> Auxiliary Outputs

The [J] command sets the TTL output lines.

The syntax for this command is:

[J<n>]

where <n> = 0..7 (0 is the default)

SY01B provides three TTL outputs on P11 (pins 13, 14, and 15) that correspond to outputs 1, 2, and 3. They are controlled as shown in the following table:

Command	Output 1 (pin 13)	Output 2 (pin 14)	Output 3 (pin 15)
J0	0	0	0
J1	1	0	0
J2	0	1	0
J3	1	1	0
J4	0	0	1
J5	1	0	1
J6	0	1	1
J7	1	1	1

0 = low; for example, Gnd

1 = high; for example, +5V DC

4.5.6 Non-Volatile Memory (EEPROM) Commands

The non-volatile memory in the SY01B can store a program string thus providing the user with the option of computer-free operation. The pump can be configured to run stored programs using the U<30> command. See "Pump Configuration Commands" earlier in this chapter.

s < n > Load Program String into Non-Volatile Memory

The [s] command is placed at the beginning of a program string to load the string into the non-volatile memory. The syntax for this command is:

[s<n>]

where <n> = 0..14

Up to 15 program strings (numbered 0 through 14) can be loaded into the non-volatile memory. Each string can use up to 128 characters.

For example, [IA3000OA0R] requires 10 bytes.

Example Program String: [s8ZS1gIA3000OA0GR]]

Command Segment	Description
s8	Loads string into program 8 of non-volatile memory (Addressswitch position 8)
Z	Initializes pump
S1	Sets plunger speed
g	Marks start of loop
I	Turns valve to input position
A3000	Moves plunger to position 3000
O	Turns valve to output position

A0	Moves plunger to position 0
G	Endlessly repeats loop
R	Executes command string

e < n > Execute Non-Volatile Memory Program String

Non-volatile memory command strings are executed by sending an [e] command. The executing program string can be terminated using the [T] command.

[e<n>]

where <n> = 0..14 (the string number)

Note: An Initialization command should always be included in the non-volatile memory command string if the pump will be used in standalone mode.

U30 Set Run from Non-Volatile Memory Auto Mode

The [U30] command sets the "Run from Non-Volatile Memory Auto Mode" flag in the non-volatile memory and begins operating the pump in stand alone mode. The pump will run one of 15 command strings <n> as selected by the address switch,

where <n> = 0..E

U31 Clear Run From Non-Volatile Memory

The [U31] command clears the "Run from Non-Volatile Memory Auto Mode" flag in the EEPROM and begins operating in the default mode.

Linking Program Strings in the Non-Volatile Memory

Non-volatile memory program strings can be linked by ending one program string with an [e] command that refers to a second program string.

Example Program Strings:

[slZgIA3000OA0G5e2R]

[s2gIA3000OgHD300G10GR]

The first string loads an initialization and prime sequence into program 1 of the non-volatile memory (address switch position 1). It then links to string 2 in the non-volatile memory.

The second string loads an aspirate and dispense sequence into program 2 of the non-volatile memory. The second non-volatile memory program string fills the syringe, then performs 10 dispenses of 300 increments each. The dispenses are triggered by an [R] command. This string is repeated endlessly until the pump is powered down.

On power-up the pump will automatically initialize, prime and perform the multiple dispenses until it is again powered down.

4.5.7 Report Commands

Report commands do not require an [R] command.

? Report Absolute Plunger Position

The [?] command reports the absolute position of the plunger in half-steps[N0] or in microsteps [N1, N2].

?1 Report Start Speed

The [?1] command reports the start speed in pulses/sec [1...1000]

?2 Report Top Speed

The [?2] command reports the top speed in pulses/sec [1....12000]

?3 Report Cutoff Speed

The [?3] command reports the cutoff speed in pulses/sec [1....5400]

?4 Report Actual Position of Plunger

The [?4] command reports the plunger encoder position in increments.

?6 Report Valve Position

The [?6] command reports the valve position in mnemonics (i = input, o =output, e = extra, and b = bypass for non-distribution valves.

For distribution valves, the [?6] command reports ASCII values 1..X, where X is the number of distribution valve ports.

?10 or F Report Command Buffer Status

The [?10] or [F] command reports the command buffer status. If the buffer is empty, the pump returns status code 0. If the buffer is not empty, the pump returns a 1. If a program string is sent to the pump without an [R] command, the string is loaded into the buffer and the buffer status becomes 1. An [R] command will then execute the command stored in the buffer.

0 = empty

1 = commands in buffer

?12 Report Number of Backlash Increments

The [?12] command reports the number of backlash increments as set by the "K" command.

?13 Report Status of Auxiliary Input #1 (P11, Pin 7)

0 = low

1 = high

?14 Report Status of Auxiliary Input #2 (P11, Pin 8)

0 = low

1 = high

? 15 Report Number of Pump Initializations

Command [?15] reports the number of pump initializations. This value cannot be reset.

? 16 Report Number of Plunger Movements

Command [?16] reports the number of plunger moves. This value cannot be reset.

? 17 Report Number of Valve Movements

Command [?17] reports the number of valve movements. This value cannot be reset

? 18 or % Report Number of Valve Movements (Since Last Report)

The [?18] or [%] command reports the number of valve movements since the last [?18] or [%] command.

? 24 Report the Zero Gap increments

The [?24] command reports the value set by the "k" command. The value reported is in half steps (N=0) or in microsteps (N=1, N=2).

? 25 Report Slope Code Setting

The [?25] command reports the slope code setting as set by the "L" command.

? 28 Report Current Mode

The [?28] command reports the current mode as set by the "N" command (normal, fine positioning, or microstep).

? 29 or Q Report the Device Status

The [?29] command reports device status (error code).

? 76 Report Pump Configuration

The [?76] command reports pump configuration in ASCII text.

? 200 Verify conf file

[?200]

? 201 Query log

[?201]log is used to record the current device status, The log can be queried only when there is an error again, normally, the log is 0.

? 202 Query sequence number

[?202] can be used to query the sequence number of the current device, and the sequence number of each device is unique.

?203 Query encoder

[?203]value=n/(2*200)*920 n:The value of the plunger from the zero point

? 300-? 314 Query the program string of s0-s14

[?300] Query the program string written in s0

*** Report Voltage**

The [*] command reports the value of the device power supply. The value is multiplied by 10. For example, if V = 24.0 VDC, the * command reports 240

< Report User Data

The [<] command returns the value of user data stored in the EEPROM. The

value <n> is between 0 and 15; 0 is the default.

4.6 Error Codes and Pump Status

The [Q] command is used for serial communications and reports error codes and pump status (ready or busy). The user should send a [Q] command before sending a program string or individual command to ensure that the pump has completed the previous command successfully.

Note: [Q] is the only valid method for obtaining pump status in serial mode.

Note: [Q] command (the status byte) provides two items of information: Pump status (bit 5) and error code (bits 0-3).

4.6.1 Status Bit

Bit 5 is the status bit. It indicates when the pump is busy or not busy. The designations for bit 5 are listed below.

Status Bit 5	Description
X = 1	Pump is ready to accept new commands.
X= 0	Pump is busy and will only accept Report and Terminate commands.

In response to uppercase Move commands ([A], [P] and [D]), the [Q] command reports that the pump is busy. In response to lowercase Move commands ([a], [p]and [d]), the [Q] command reports that the pump is not busy. Additionally,commands addressed to multiple pumps at once cannot be used to obtain pump status; pumps must be queried separately.

Note: Although the answer block for other commands contains a status bit, it should not be used for determining pump status. A [Q] command is the only valid method to determine if the pump is busy. The error information in the status byte of the answer block is always valid.

4.6.2 Error Codes

Error codes describe problem conditions that may be detected in the SY01B (excluding error code 0). Error codes are returned in the least significant four bits of the status byte. If an error occurs, the pump stops executing commands, clears the command buffer, and inserts the error code into the status byte.

Some errors continue to appear, such as syringe overloads, until they are cleared by the Initialization command. On a plunger overload, the device will not execute another valve or syringe Move command until it is reinitialized. The last error has precedence in the status byte. For example, if a command overflow occurs, an error 15 results. If the next command causes an error #3, the status byte reflects the error #3 (invalid

operand)

Error Code	Description
0 (00H)	Error Free Condition.
1 (01H)	Initialization error. This error occurs when the pump fails to initialize.Check for blockages and loose connections before attempting to reinitialize. The pump will not accept commands until it has been successfully initialized. This error can only be cleared by successfully initializing the pump.
2 (02H)	Invalid Command. This error occurs when an unrecognized command is issued. Correct the command and operation will continue normally
3 (03H)	Invalid Operand. This error occurs when an invalid parameter (<n>) is given with a command. Correct the parameter and pump operation will continue normally
6 (06H)	EEPROM Failure. This error occurs when the EEPROM is faulty. If you receive this error, please call Runze Technical Service.
7 (07H)	Device Not Initialized. This error occurs when the pump is not initialized. To clear the error, initialize the pump.
8 (08H)	Internal failure. If this error occurs, please call Runze Technical Services.
9 (09H)	Plunger Overload. This error occurs when movement of the syringe plunger is blocked by excessive backpressure. The pump must be reinitialized before normal operation can resume. This error can only be cleared by reinitializing the pump.
10 (0AH)	Valve Overload. This error occurs when the valve drive loses increments by blockage or excess backpressure. The pump must be reinitialized before normal operation can resume. Sending another Valve command reinitializes the valve and sets it to the correct location. Continual valve overload errors are an indication the valve should be replaced.
11 (0BH)	Plunger Move Not Allowed. When the valve is in the bypass or throughput position, Plunger Movement commands are not allowed.
12 (0CH)	Internal failure. If this error occurs, please call Runze Technical Services.
14 (0EH)	A/D converter failure. This error occurs when the internal A/D converter is faulty. If this error occurs, please call Runze Technical Services.
15 (0FH)	Command Overflow. This error occurs when action commands are sent to the pump before it has completed the current action. Commands in the buffer must be executed before more commands can be sent.

Figure 3-8 *Error Codes*

4.6.3 Error Types

The pump handles errors differently, depending on the error type. There are four error types, which are described below.,

Immediate Errors

These include "Invalid Command" (error 2), "Invalid Operand" (error 3). After the command is sent, the answer block immediately returns an error. Once a valid command is sent, the pump will continue to function normally. Since the [Q] command is a valid command, the pump will not return an error. In this case,

the [Q] command is not required.

Note: There is no need to reinitialize the pump following this error type.

Initialization Errors

These include "Initialization errors" (error 1) and "Device not Initialized" (error 7). If the pump fails to initialize or if an Initialization command has not been sent, subsequent commands will not be executed.

To ensure that the pump initializes successfully, send a [Q] command after the Initialization command.

- If the [Q] command indicates both a successful initialization and that the pump is ready, subsequent Move commands can be sent.
- If the [Q] command indicates the pump has not initialized, the pump must be reinitialized until the [Q] command indicates successful initialization.
- If initialization is not successful, a "Device Not Initialized" error is returned as soon as the next Move command is sent. A successful reinitialization must be executed before subsequent commands can be sent.

Overload Errors

These include the "Plunger Overload" and "Valve Overload" errors (errors 9 and 10). If the pump returns either a plunger or valve overload, the pump must be reinitialized before continuing. If another command is sent without reinitializing the pump, another overload error will be returned when the next Move command is issued. The [Q] command clears the error; however, if a successful initialization has not occurred, an initialization error is returned.

Command Overflow Error

This is error 15, and it occurs if a Move command, Set command (except [V]), or Valve command is sent while the plunger is moving. The pump ignores the command and issues an error 15. The [Q] command allows the controller to determine when the command is complete and the pump is ready to accept new commands.

Note: There is no need to reinitialize the pump following this error type.

Report commands, Control commands, and the Top Speed command [V] will not return an error 15. Report and Control commands are considered valid commands during a Move. Because the pump can change speed while the plunger is moving in the 1-12000 pulses/sec range, the [V] commands will not return a "Command Overflow" error.

Caution! All errors reported by the pump should be captured by the user software and the physical cause corrected before continuing operation. Failure to do so may result in damage to the pump or adversely affected pump performance,and void the warranty.

Status Byte	Hex # if Bit 5 =		Dec # if Bit 5 =		Error Code	
7 6 5 4 3 2 1 0	0	or 1	0	or1	Number	Error
0 1 X 0 0 0 0 0	40H	60H	64	96	0	No Error
0 1 X 0 0 0 0 1	41H	61H	65	97	1	Initialization
0 1 X 0 0 0 1 0	42H	62H	66	98	2	Invalid Command
0 1 X 0 0 0 1 1	43H	63H	67	99	3	Invalid Operand
0 1 X 0 0 1 1 0	46H	66H	70	102	6	EEPROM Failure
0 1 X 0 0 1 1 1	47H	67H	71	103	7	Device not Initialized
0 1 X 0 1 0 0 1	49H	69H	73	105	9	Plunger Overload
0 1 X 0 1 0 1 0	4AH	6AH	74	106	10	Valve Overload
0 1 X 0 1 0 1 1	4BH	6BH	75	107	11	Plunger Move Not Allowed
0 1 X 0 1 1 0 0	4CH	6CH	76	108	12	Internal Failure
0 1 X 0 1 1 1 0	4EH	6EH	78	110	14	A/D converter failure
0 1 X 0 0 0 0 0	4FH	6FH	79	111	15	Command Overflow

Error Reporting Examples	
[A7000R]	Does not move the plunger and reports a “No Error” status; when queried ([Q] command), returns error. A second try returns error 3 (67)
[P12000P600R]	Moves to position 6000, then stops. A [Q] command returns an error.
[t2000R]	Returns an invalid command error immediately. The pump status is “Not Busy”
[A12000t2000R]	Returns an invalid command error immediately. The pump is “Not Busy.”
Valve in Bypass [A1000R]	Returns an error immediately; when queried ([Q] command),does not return an error.

Chapter 5 Setting Up the SY01B for Application

The SY01B is capable of providing precision pumping in a wide variety of liquid handling systems. The interplay of fluid viscosity, aspiration and dispense speeds, and system geometry (syringe size, tubing inner diameter, and valve inner diameter) determine the behavior of the SY01B in a particular application. Following is a description of the hardware, fluid, and pump control parameters to be evaluated and optimized in managing these interdependencies for optimal pump performance.

5.1 Glossary

air gap

A small volume of air at the end of the output tubing or sandwiched between two fluids in the pump system tubing. Air gaps may be created by aspirating air (programmed air gaps) or by the spring action of the fluid system (inertial air gaps).

Aspirate/Dispense Tubing

Connects the valve output port (1/4-28 thread fitting) to a sample source and destination. To ensure good breakoff, aspirate/dispense tubing tends to have a smaller I.D. than reagent tubing, and a necked-down or tapered end.

Backlash

Mechanical play in the syringe drive created by accumulated mechanical clearances.

Backpressure

The pressure which must be exceeded to move fluid through tubing. Backpressure is created by a combination of fluid inertia and friction.

Breakoff

Describes how the last droplet of fluid exits the end of the output tubing following a dispense. Rapid or sharp breakoff means that the droplet exits cleanly with high inertia.

Breakup

Undesired air gaps created by overly rapid aspiration.

Carryover

Contamination of a volume of fluid by residual fluid from a previous aspiration or dispense. Carryover

causes variability in final volume and concentration.

Cavitation

Formation of air bubbles due to rapid pressure changes. Often caused by aspirating fluid into the syringe too quickly.

Dilution effect

Reduction in sample or reagent concentration, caused by contact with system fluid or residual fluid from a previous aspiration or dispense.

I.D. (“inner diameter”)

Diameter of the constraining wall of a fluid path.

Priming

Completely filling the pump tubing and syringe with bubble-free fluid to allow sustained, reproducible pumping action. The air in an unprimed line acts as a spring, adversely affecting accuracy and precision.

Reagent Tube

Connects the valve input port (1/4-28 thread fitting) to a reagent source. Reagent tubing is used to fill the pump syringe; it tends to have a larger I.D. than aspirate/dispense tubing, and a blunt-cut end which extends into the reagent.

System Fluid

A fluid used to prime the pump system that does not act as sample or reagent. Typically the system fluid is deionized water or a wash buffer and is isolated from sample or reagent fluid by an air gap to avoid intermixing.

Syringe Speed Profile

Typically, the syringe plunger begins moving slowly, then ramps up to top speed. This allows the plunger to start moving gradually, without overloading the motor, and still provide maximum flowrate. The syringe plunger stops by ramping down in speed. This results in the most reproducible fluid breakoff for accurate dispensing.

Start Speed (v)

The speed at which the syringe plunger starts moving.

Top Speed (V)

The maximum speed at which the syringe plunger moves.

Cutoff Speed (c)

The speed of the syringe plunger just before stopping.

Slope (L)

Acceleration (deceleration) of the syringe plunger between start speed, top speed, and cutoff speed.

Volume Calculation

The volume aspirated or dispensed when the syringe plunger moves a specified number of increments depending on the syringe size. To determine the number of increments required to aspirate or dispense a given volume, use the following formula:

# of increments = ((pump resolution) x volume)/ syringe size

For example, to aspirate 100 µL using an SY01B pump with 1 mL syringe, move the plunger as follows:

# of increments = (12000 increments x 100 µL)/ (1 mL x 1000 µL/mL) = 1200 increments

5.2 Optimizing SY01B Performance

Caution! Run the pump only in the upright position. Do not move the pump valve or syringe plunger without first wetting or priming the pump.For command details, see Chapter 3, "Software Communication".

To optimize SY01B performance, follow these steps:

1. Select syringe size.

Determine your volume and flowrate requirements. Select a syringe that accommodates the smallest and largest volumes to be dispensed without refill, as well as the desired flowrate (see Table 4-1, Flowrate Ranges). While smaller syringes allow better accuracy and precision, a larger syringe allows more aliquots when multiple aspirations or multiple dispenses are required, and they allow better breakoff and longer seal life.

2. Select tubing.

In tubing selection, the general rule is that smaller syringes work best with smaller I.D. tubing and larger syringes with larger I.D. tubing. The M01-M05 SY-01B valve has an internal I.D. of 1.5mm, the M06. M10. M12 valve has an internal I.D. of 1.2mm.

3. Make pump connections.

Connect power and communications cables to the pump, install syringe and tubing. Place the end of the input tubing in a reservoir of particle-free fluid; place the end of the output tubing in a waste reservoir.

4. Check communications to the pump.

– Open the Pump:Link program to the SY01B menu (full page), or use your own communications program.

–Send the command [?29] to read the pump’ s current status. Successful communication will return to the “Ready” status.

Possible errors:

–No response. Check for loose or incorrectly connected cables, or connection to the wrong computer COM port. Retry.

5. Initialize pump and set initialization speed

The following information assumes that your input tubing connects to the right valve port. If your input tubing connects to the left valve port, exchange [Y] for all instances of [Z] in the following commands.

– Send the command [ZR] to initialize the pump. Successful initialization will move the syringe plunger to the position "0" (fully dispensed) and return the "Ready" status.

Possible errors:

– Error 1 (initialization error). Check for tubing blockage and reinitialize. If you are using very narrow I.D. tubing or pumping a viscous fluid, the initialization speed may need to be reduced.

– This is accomplished (only if using a 1 mL or larger syringe) by sending the command [Z16R] (initializes at full-force, reduced speed). Repeat with decreasing initialization speed (increase "Z_" value) until the pump

successfully initializes.

6. Prime the syringe

– Send the command [IA12000OA0R] to pull fluid through the valve input position and into the syringe.

– Inspect the pump tubing and syringe for bubbles and re-prime until all bubbles are completely gone.

If bubbles remain after several priming strokes, disassemble the syringe and clean it with alcohol. Also check to ensure the fittings are tight and the syringe is tight within the Teflon fitting.

– Re-prime.

Possible errors:

– Error 9 (plunger overload). See step 8.

7. Check aspirate/dispense.

Send the command [IA12000OA0R] to aspirate a full syringe stroke (12000 increments) from input and dispense it to output. Successful execution will move the syringe plunger to position "12000" then back to "0," then it will return a "Ready" status.

Possible errors:

– Error 9 (plunger overload). The stepper motor is unable to move the syringe plunger, probably because of excessive backpressure caused by excessive flowrate, narrow tubing I.D., or valve or tubing blockage. Note whether the error occurred during aspiration or dispensing. To differentiate between blockage and flowrate limitation, reduce syringe plunger speed by sending the command [S12IA3000OA0R]. Repeat with decreasing plunger speed (increase "S_" value) until the pump aspirates and dispenses successfully.

8. Set start speed and top speed.

The SY01B plunger speed can be controlled from 1.2 seconds per stroke to 160 minutes per stroke (top speed) using the [S] or [V] commands. (The [V] command allows a slightly larger speed range.) As a general

rule, aspiration should be slow (to avoid cavitation) and dispense fast (to promote breakoff). Since cavitation and breakoff will affect both accuracy and precision, speed settings may be optimized separately for aspiration and dispense.

Using aspirate/dispense commands, set start speed [v] and top speed [V] to meet application throughput goals.

– Send the command [v50IA12000OA0R]. Repeat with increasing start speed (increase "v_" value) to find the maximum value.

– Send the command [v_V_IA12000OA0R] to set top speed equal to start speed (x). Repeat with increasing top speed (increase "V_" value) to the maximum value that does not overload the plunger or cause cavitation.

Now optimize start speed and top speed for dispensing using a similar approach.

9. Set cutoff speed and slope

Using aspirate/dispense commands, set slope [L] and cutoff speed [c] to attain reproducible breakoff. Note that cutoff speed controls only dispensing.To optimize the slope, send the command [v_V_L14IA12000OA0R]. Repeat with modified slope ("L_" value) to achieve the overall time suited to your application without plunger overload.

To optimize the cutoff speed, start with the maximum cutoff speed allowed for your application (the lower of 2700 Hz or the top speed). Send the command [c_A12000OA0R] and monitor the dispense for plunger overload or any splattering of the fluid dispensed outside of the dispense vessel. If any of these conditions occur, lower the cutoff speed until the pump can dispense the fluid with clean breakoff.

Another condition that affects breakoff is the formation of inertial air gaps. This is seen as a small air gap inside the tubing at the tip. This occurs to a greater extent on larger reagent syringes, and it enhances the breakoff of liquid from the tip of the tubing. If an inertial air gap is not desired in the application, lowering the cutoff speed and/or the top speed will remove the inertial air gap. However, this may not give a clean breakoff of the fluid.

Increasing the cutoff speed and ramp (slope) may also improve the fluid breakoff. Smaller I.D. tubing may improve breakoff, especially for smaller syringes.

Note: It may not be possible to achieve good fluid breakoff under any circumstance, especially with syringes smaller than 500 µL or with some fluids.

5.3 Helpful Hints

To maintain pump performance, keep the following in mind when operating the SY-01B:

- Wipe up all spills immediately.

- Pumping cold fluids may cause leaks, the result of differing coefficients of expansion of Teflon and glass. Leaks may occur when pumping fluids that are at or below 15°C (61°F).
- To reduce the amount of carryover, a ratio of three parts reagent to one part sample is recommended.
- Replace the valves and syringe seals as needed. (Interval may vary depending on the application.)

Chapter 6 Common Problems & Solutions

Fault	Reason	Troubleshooting method
Not working when powered on	The working voltage is not in the acceptable range	Check whether the actual voltage deviates from the rated voltage
	The connection is loose or disconnected	Manually check whether the connection is good, or check the line with a multimeter
Unable to aspirate	The aspirating pipe is blocked by by debris	Clear the debris

Chapter 7 Quick Command

A Communication Commands

Command Type	Command	Valid/Invalid
Initialization	Z, Y, W	Valid
Initialization	z	Valid
Plunger Movement	A, a, P, p, D, d	Valid
Valve	I, O, B	Valid
Valve	E	Valid
Set	S, V, v, c, L, K, k	Valid
Command for microstep-enabled firmware	N	Valid
Control	G, g, M, H	Valid
Control	X	Valid
Control	R	Valid
Control	T	Valid
Control	Clear loaded command	Valid
Control	J, s, e, U	Valid
Report	?0 through ?314	Valid
Report	F	Valid
Report	&	Valid
Report	Q	Valid
Report	#	Valid
Report	%	Valid
Report	*	Valid

B Command Quick Reference

B.1 Pump Configuration Commands

Command	Values of <n>	Description
N	0 = fine positioning mode off	Enables or disables microstepping or fine positioning mode
	1 = fine positioning mode on	
	2 = microstep mode on	

U	30 = Set Non-Volatile Memory Auto Mode	Writes configuration information to non-volatile memory
	31 = Clear Non-Volatile Memory Mode	
	41 = Set RS baud rate to 9600	
	47 = Set RS baud rate to 38400	
	200= Set piston reset stall current (1-31, default 5)	
	300= Set device address (1-15, default 1)	
K	0…800 in full step mode (default 12)	Sets number of backlash increments.
	0…6400 in fine positioning mode (default 96)	

B.2 Initialization Commands

Command	Values of <n>	Description
Z	<n1>	Initializes the plunger drive and homes the valve in a clockwise direction
	0 = initializes at full plunger force	
	1 = initializes at half plunger force	
	2 = initializes at one-third plunger force	
	10–40 = initializes at the defined speed	
	<n2>	Sets initialization input port
	0 =Set initialization input port to Port 1	
	1 x =Set initialization input port for distribution valves, where X is the number of ports on the valve	
	<n3>	Sets initialization output port
	0 =Set initialization output port to Port X	
	1 x = Set initialization output port for distribution valves, where X is the number of ports on the valve	
Y	<n1>	Initializes the plunger drive and homes the valve in a counterclockwise direction.
	0 =initializes at full plunger force	
	1 = initializes at half plunger force	
	2 = initializes at one-third plunger force	
	10–40 = initializes at the defined speed	
	<n2>	Sets initialization input ports
	0 =Set initialization input port to Port 1	
	1 x =Set initialization input port for distribution valves, where X is the number of ports on the valve	
	<n3>	Sets initialization output port
	0 =Set initialization output port to Port X	
	1 x =Set initialization output port for distribution valves, where X is the number of ports on the valve	
W	<n1>	Initializes the plunger drive only (commonly used for valveless pumps).
	0 = initializes at full plunger force	
	1 =initializes at half plunger force	
	2 =initializes at one-third plunger force	
	10–40 =initializes at the defined speed	
w	<n1> 1…x =Set initialization port where X is the number of ports on the valve	Initializes the valve drive only
	<n2>0 =Valve homes in a clockwise direction; valve	nitializes the valve drive only.

	ports numbered in a clockwise direction.	
	1 =Valve homes in a counterclockwise direction; valve ports numbered in a counterclockwise direction.	
z		Simulates initialization andsets the current position of the plunger as the home position
k	0···800 in standard mode (50 default)	Set zero gap (increments)
	0···6400 in fine positioning or microstep mode (	

B.3 Valve Commands

Command	Description
I	Moves valve to input position
O	Moves valve to output position
B	Moves valve to bypass position
E	Moves valve to extra position

B.4 Plunger Movement Commands/Status Bit Reports

Command	Value of <n>	Description	Status
A <n>	0-12000, 0-96,000 in fine positioning or microstep mode	[A] bsolute Position	Busy
a <n>	0-12000, 0-96,000 in fine positioning or microstep mode	[a] bsolute Position	Ready
P <n>	0-12000, 0-96,000 in fine positioning or microstep mode	Relative [P]ickup	Busy
p <n>	0-12000, 0-96,000 in fine positioning or microstep mode	Relative [p]ickup	Ready
D <n>	0-12000, 0-96,000 in fine positioning or microstep mode	Relative [D]ispense	Busy
d <n>	0-12000, 0-96,000 in fine positioning or microstep mode	Relative [d]ispense	Ready

B.5 Non-Volatile Memory (EEPROM) Commands

Description	Value of <n>	Description
s <n>	0..14	Loads command string in Non-Volatile Memory
e <n>	0..14	Executes Non-Volatile Memory command string
U31		Clears “Run from Non-Volatile Memory” flag.
U30		Sets “Run from Non-Volatile Memory” flag

B.6 Report Commands

Command	Description
Q	Query, Status and Error Bytes

?	Report absolute plunger position
?1	Report start speed
?2	Report top speed
?3	Report cutoff speed
?4	Report actual position of plunger
?6	Report valve position
?10 or F	Report command buffer status
? 12	Report number of backlash increments
? 13	Report status of input #1 (P11, Pin7)
? 14	Report status of input #2 (P11, Pin 8)
? 15	Report number of pump initializations
? 16	Report number of plunger movements
? 17	Report number of valve movements
? 18or %	Report number of valve movements (since last report)
? 20 or #	Report firmware checksum
? 23 or &	Report software version
? 24	Report zero gap increments
?29	Same as Q (query, status and error bytes)
?76	Report pump configuration
?200	Report conf file checksum
?201	Report log
?202	Report serial number
?203	Report encoder
?300-?314	Report the program written to the non-volatile memory
*	Report supply voltage
< <n>	Report user data (0..15)

B.7 Error Codes and Status Byte

Status Byte	Hex # if Bit 5 =		Dec # if Bit 5 =		Error Code	
7 6 5 4 3 2 1 0	0	or 1	0	or 1	Number	Description
0 1 X 0 0 0 0 0	40H	60H	64	96	0	No error
0 1 X 0 0 0 0 1	41H	61H	65	97	1	Initialization
0 1 X 0 0 0 1 0	42H	62H	66	98	2	Invalid command
0 1 X 0 0 0 1 1	43H	63H	67	99	3	Invalid operand
0 1 X 0 0 1 1 0	46H	66H	70	102	6	EEPROM failure
0 1 X 0 0 1 1 1	47H	67H	71	103	7	Device not initialized
0 1 X 0 1 0 0 1	49H	69H	73	105	9	Plunger overload
0 1 X 0 1 0 1 0	4AH	6AH	74	106	10	Valve overload

0 1 X 0 1 0 1 1	4BH	6BH	75	107	11	Plunger move not allowed
0 1 X 0 1 1 0 0	4CH	6CH	76	108	12	Internal failure
0 1 X 0 1 1 1 0	4EH	6EH	78	110	14	A/D converter failure
0 1 X 0 1 1 1 1	4FH	6FH	79	111	15	Command overflow

C Switching Protocol

SY08 has two protocols, RUNZE and ASCII protocol. If you need to switch protocols, you can refer to the following steps (both need to be powered off after switching)

1. Burn-in Protocol

- If the default programmed command is the ASC II command, it will query the following return code

  Send→ 91 EB 07 00 00 00 00 00 00 D5 28 FF F8

  Receive← 91 EB 0A 01 00 02 C4 47 0B 00

  0A parameter definition: 0A stands for ASC II

- If the default programmed command is the RUNZE command, it will query the following return code

  Send→ 91 EB 07 00 00 00 00 00 00 D5 28 FF F8

  Receive← 91 EB 02 01 00 63 D7 F6 AB 00

  02 parameter definition: 02 stands for RUZNE

2. Switching protocol (must use RS232 port to switch the address, and must be powered off after switching)

- If RUNZE command is required, the following code can be used to switch the address

  Set the address to 0x0802 (RUNZE)

  Send→ 91 EB 03 00 00 02 08 00 00 0C 0A 69 69

  Receive← 91 EB 00 01 00 0D 5A 8A 40 00

  The values queried after the setting are as follows.

  Send→ 91 EB 07 00 00 00 00 00 00 D5 28 FF F8

  Receive← 91 EB 02 01 00 63 D7 F6 AB 00

- If ASC II command is required, the following code can be used to switch the address

  Send→ 91 EB 03 00 00 0A 08 00 00 6D 19 D8 C9

  Receive← 91 EB 00 01 00 0D 5A 8A 40 00

  The values queried after the setting are as follows.

  Send→ 91 EB 07 00 00 00 00 00 00 D5 28 FF F8

Receive← 91 EB 0A 01 00 02 C4 47 0B 00

Chapter 8 Version Description

Version	Description	Release Date
V1.0	Initial Version	2024.11.14
V1.3	Added note: Gasket required for valve head installation	2025.3.15
V1.4	PSU material changed to PPS material	2025.4.16

Chapter 9Technical Services

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