润泽流体 RUNZE FLUID

Key Components for Analytical Instrument
Ecological Closed-loop Supplier

Version 1.1

Rp-01 Piston Pump Manual

南京润泽流体控制设备有限公司

NANJING RUNZE FLUID CONTROL EQUIPMENT CO.,LTD

Table of Content

Chapter 1 Product Introduction

1.1 Overview

RP-01 series piston pump is a new type of precise pump independently researched and developed by RUNZE company. It is mainly used in biological laboratories. The piston pump has extremely high precision and accuracy of liquid aspirating and dispensing. The pump body is small, compact, easy to install, and convenient to operate. It has been widely used in the fields of medical equipment and laboratory analysis instruments.

The RP-01 piston pump is 6ml in size and has a single-hole, double-hole and solenoid valve double-hole pump head. It is divided into a series with or without drive, with or without encoder, with or without solenoid valve and a series without drive, with or without encoder, with or without solenoid valve, a total of twelve types, as detailed in the product type description.

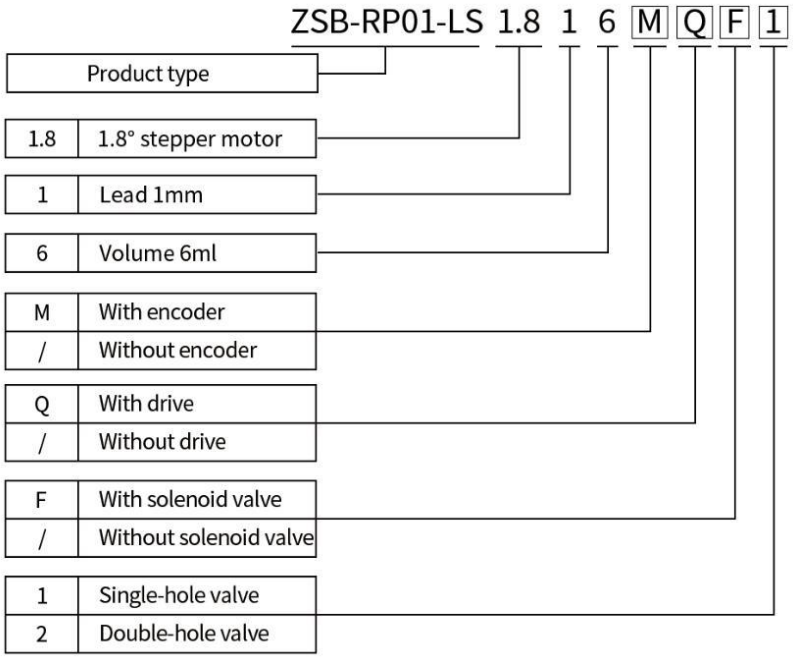
A new optical encoder disc system has been introduced. The advantages are twofold: firstly, it enhances the immunity of the input signal to interference; secondly, it effectively improves the error correction capability during rotation.

1.2 Protocol options

Our products have two protocol options, the first is self-defined protocol, i.e. a total length of 8 bytes, with 0xCC as the frame head and 0xDD as the frame tail; the second is an ASCII protocol (MC12 and MC12M drivers only).

1.3 Naming Rules

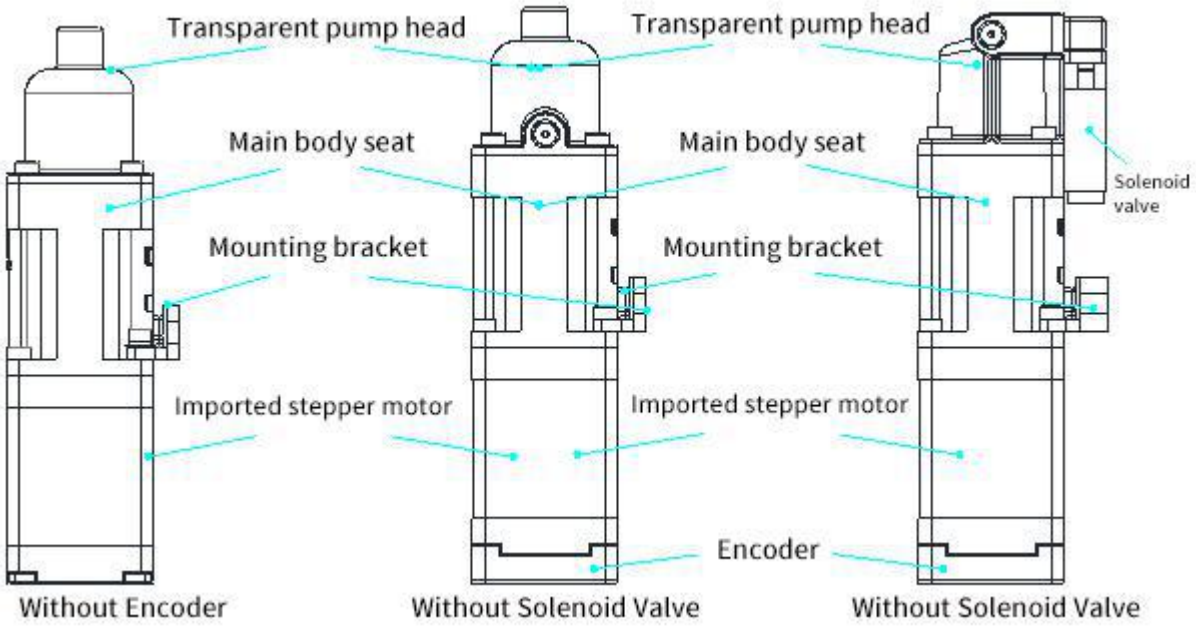
Model parameters are shown as follows:



Product Model Description: 12 models as following:

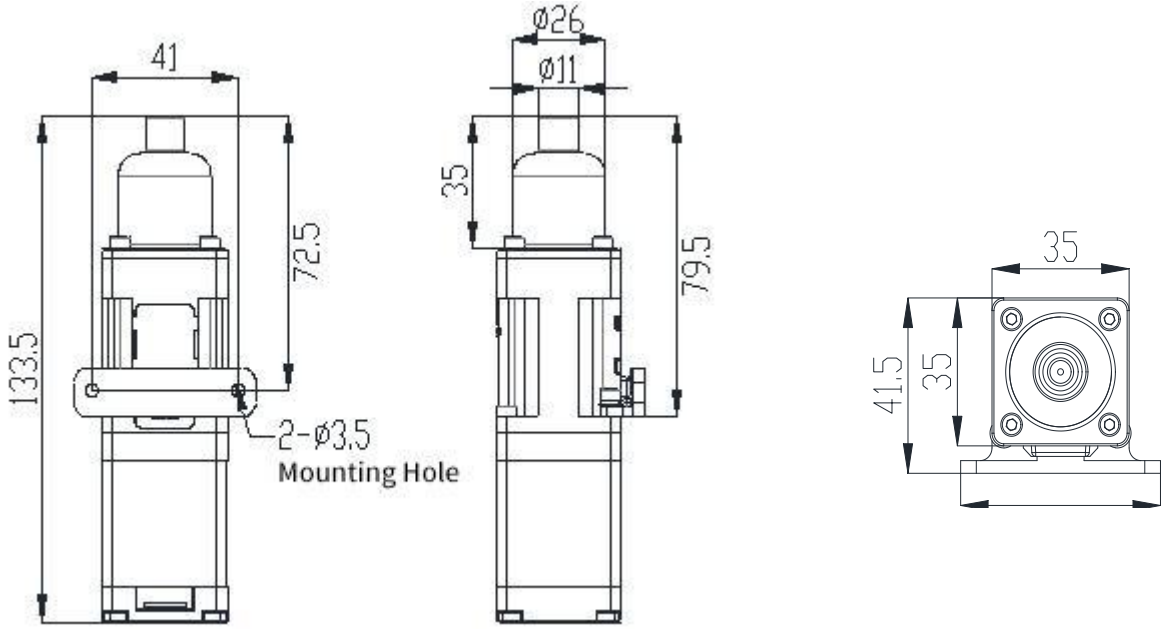
Model	Single/ Double Hole	Volume	Driver	Encoder	Solenoid valve	Optional drive
ZSB-RP01-LS-1.8-1-6-1	Single Hole	6ml	×	×	×	/
ZSB-RP01-LS-1.8-1-6-2	Double Hole	6ml	×	×	×	/
ZSB-RP01-LS-1.8-1-6-F-2	Double Hole	6ml	×	×	√	/
ZSB-RP01-LS-1.8-1-6-M-1	Single Hole	6ml	×	√	×	/
ZSB-RP01-LS-1.8-1-6-M-2	Double Hole	6ml	×	√	×	/
ZSB-RP01-LS-1.8-1-6-M-F-2	Double Hole	6ml	×	√	√	/
ZSB-RP01-LS-1.8-1-6-Q-1	Single Hole	6ml	√	×	×	MC10
ZSB-RP01-LS-1.8-1-6-Q-2	Double Hole	6ml	√	×	×	MC10
ZSB-RP01-LS-1.8-1-6-Q-F-2	Double Hole	6ml	√	×	√	MC10+ MOS
ZSB-RP01-LS-1.8-1-6-M-Q-1	Single Hole	6ml	√	√	×	MC12
ZSB-RP01-LS-1.8-1-6-M-Q-2	Double Hole	6ml	√	√	×	MC12
ZSB-RP01-LS-1.8-1-6-M-Q-F-2	Double Hole	6ml	√	√	√	MC12-M

1.4 RP-01 Piston Pump Structure Dimension

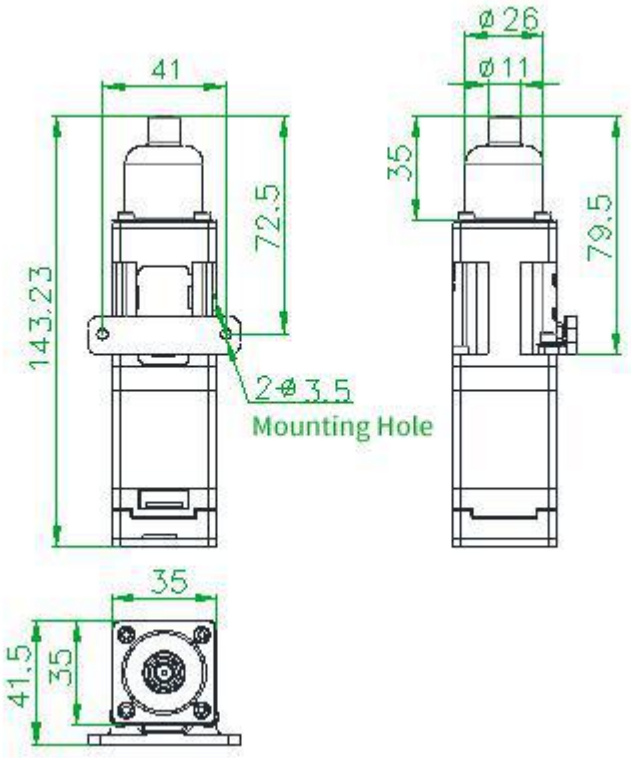


1.5 Basic External Dimensions of Piston Pump (Unit: mm)

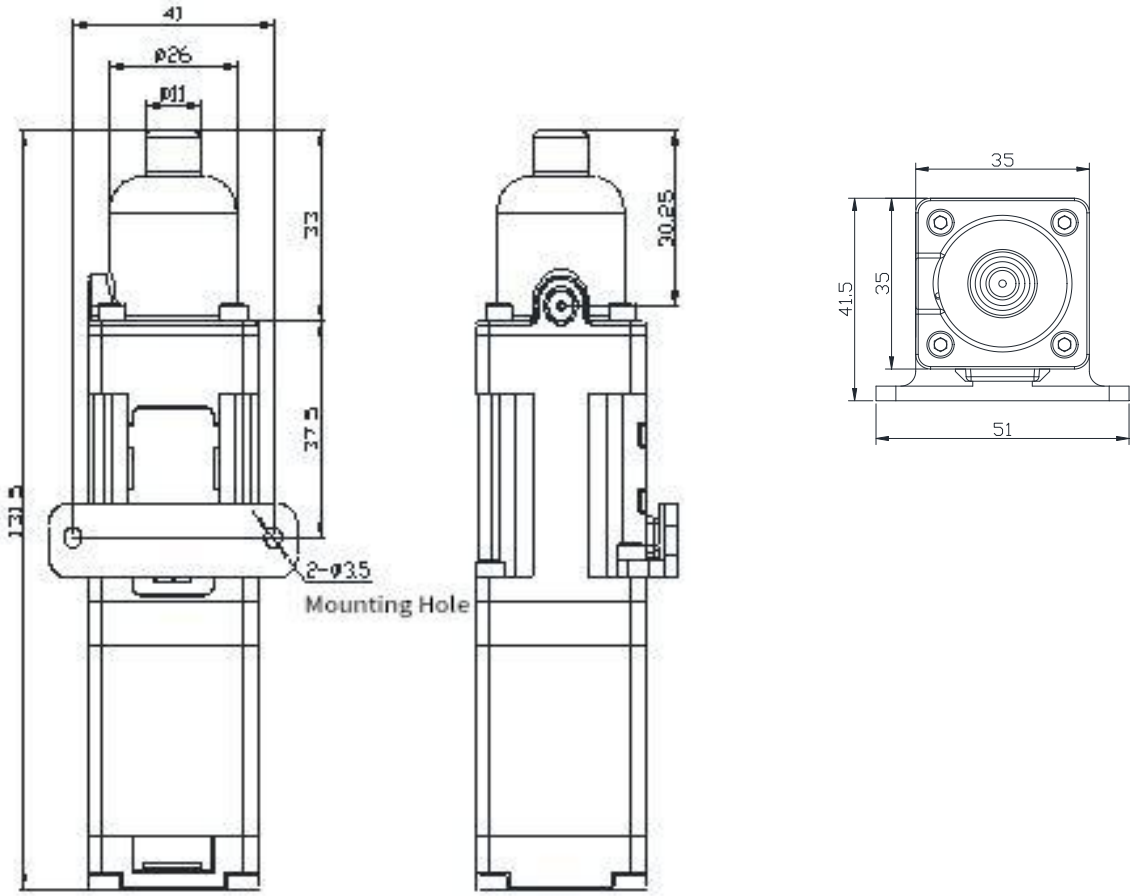
1.5.1 Single-hole Without Solenoid Valve and Encoder



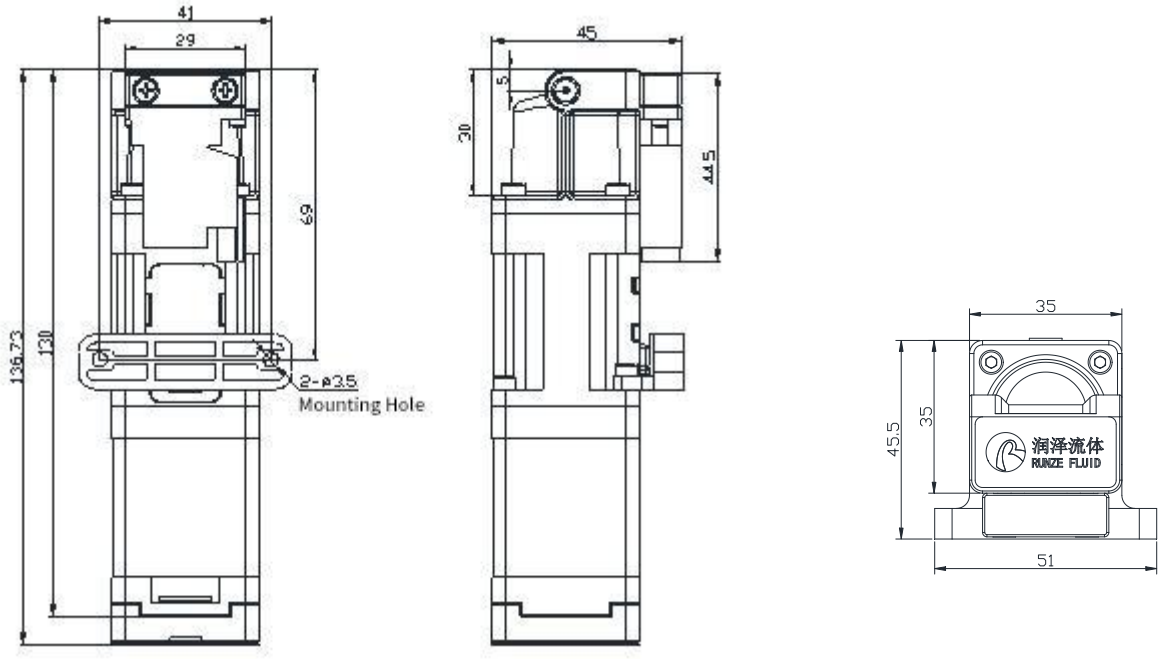
1.5.2 Single-hole with Encoder Without Solenoid Valve



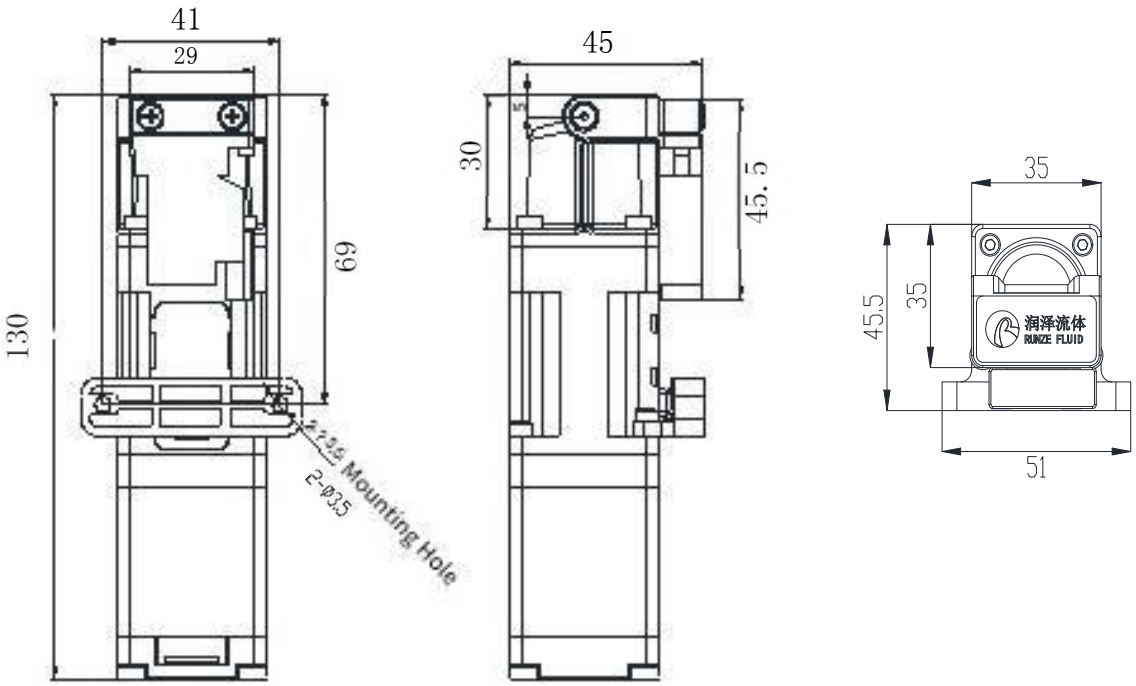
1.5.3 Double-hole Without Solenoid Valve and Encoder



1.5.4 Double-hole with Solenoid Valve and Encoder



1.5.5 Double-hole with Solenoid Valve without Encoder



1.6 Solenoid Valve (If the product does not contain solenoid valve this part can be ignored.)

1.6.1 Solenoid Valve Model type

PVR16-2-1E1-PS DC12V

Specification

Electrical port

2	Normally closed(NC)
Blank	Normally used

Body material

1	PEEK

Rubber material

E	EPDM
F	FKM
K	Kalrez ®

※ Material for rubber diaphragm and sealing gasket

Auxiliary board

blank	Without auxiliary board
1	Under surface M6 x 1
2	Under surface 1/4-28UNF
3	Sde surface M6 x 1
4	Side surface 1/4-28UNF

Wiring Specification

PL	L-shaped plug
PS	Straight plug

※ Wire Length

Voltage

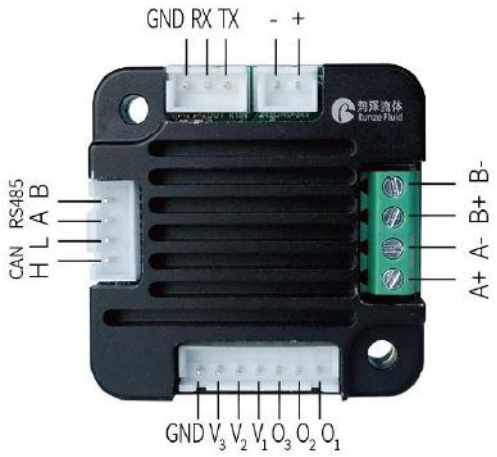
DC12V	DC12V
DC24V	DC24V

1.6.2 Solenoid Valve Electrical Specifications

PVR16-1E-PSDC24V		
Electrical Specifications	Operating voltage range	24V±10%
	Starting current	154mA
	Steady current	42mA
	Start-up power consumption	3.7W
	Stable current consumption	Below 1W
	Permissible circuit leakage current	4mA
	Insulation resistance	100M Ω MIN
	Indicator light	Red LED
	Anti-surge measure	Surge Absorber Diodes

1.7 Optional Drive Port Definitions

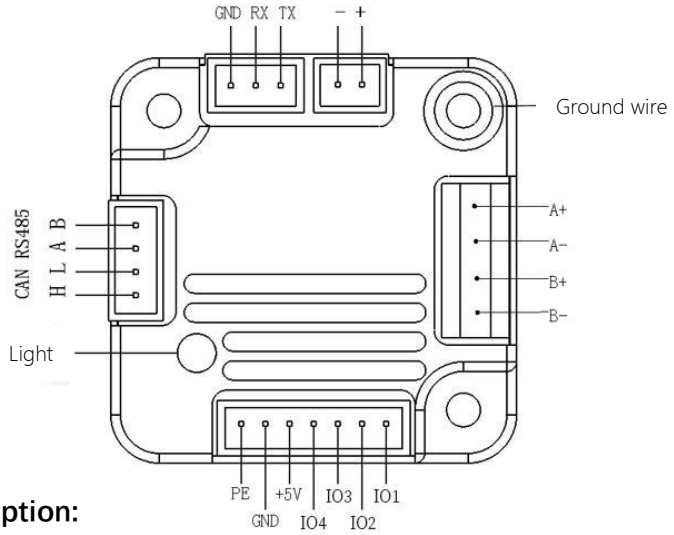
1.7.1 MC10 Driver



Driver Board Port Description:

Port name	Feature	Port name	Feature
+	DC24V Positive	A+、A-	Stepper motor phase A wiring
-	DC24V Negative	B+、B-	Stepper motor phase A wiring
TX	RS232 Data input	O_1	IO1 Optocoupler signal
RX	RS232 Data output	O_2	IO2 Optocoupler signal
GND	RS232 GND	O_3	IO3 Optocoupler signal
H	CAN Communication H	V_1	V1 Positive
L	CAN Communication L	V_2	V2 Positive
A	RS485 Communication A	V_3	V3 Positive
B	RS485 Communication B	GND	Power supply GND

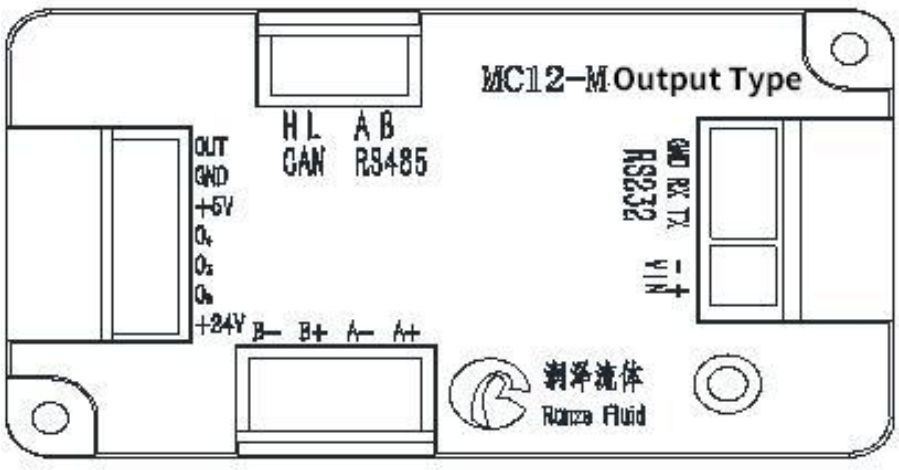
1.7.2 MC12 Driver



Driver Board Port Description:

Port name	Feature	Port name	Feature
+	DC24V Positive	A+、A-	Stepper motor phase A wiring
-	DC24V Negative	B+、B-	Stepper motor phase A wiring
TX	RS232 Data input	IO_1	NC
RX	RS232 Data output	IO_2	Encoder phase A
GND	RS232 GND	IO_3	Encoder phase B
H	CAN Communication H	IO_4	IO4 Optocoupler signal
L	CAN Communication L	+5V	Power positive
A	RS485 Communication A	GND	Power supply GND
B	RS485 Communication B	PE	Power ground wire

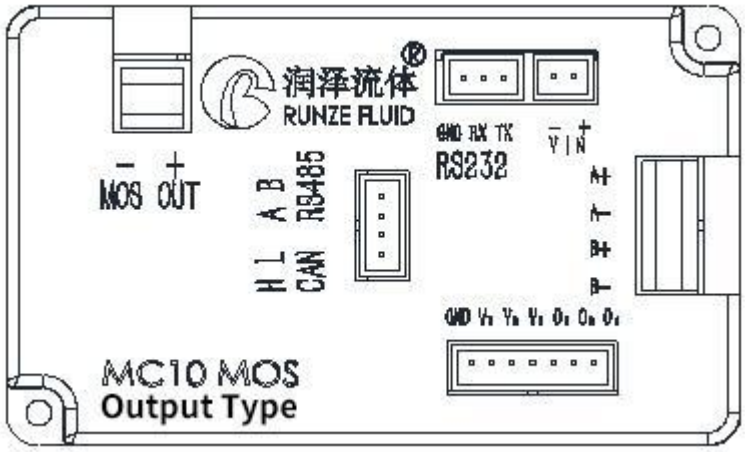
1.7.3 MC12M Driver



Driver Board Port Description:

Port name	Feature	Port name	Feature
+	DC24V Positive	A+、A-	Stepper motor phase A wiring
-	DC24V Negative	B+、B-	Stepper motor phase A wiring
TX	RS232 Data input	+24V	Solenoid valve Positive polarity
RX	RS232 Data output	IO_2	Encoder phase A
GND	RS232 GND	IO_3	Encoder phase B
H	CAN Communication H	IO_4	IO4 Optocoupler signal
L	CAN Communication L	+5V	Power positive
A	RS485 Communication A	GND	Power supply GND
B	RS485 Communication B	OUT	Solenoid negative

1.7.4 MC10+MOS



Driver Board Port Description:

Port name	Feature	Port name	Feature
+	DC24V Positive	A+、A-	Stepper motor phase A wiring
-	DC24V Negative	B+、B-	Stepper motor phase A wiring
TX	RS232 Data input	IO_1	IO1 Optocoupler signal
RX	RS232 Data output	IO_2	IO2 Optocoupler signal
GND	RS232 Ground wire	IO_3	IO3 Optocoupler signal
H	CAN Communication H	V_1	V1 Power positive
L	CAN Communication L	V_2	V2 Power positive
A	RS485 Communication A	V_3	V3 Power positive
B	RS485 Communication B	GND	Power supply GND
MOS OUT +	Solenoid valve power supply positive	MOS OUT -	Solenoid valve power supply Negative

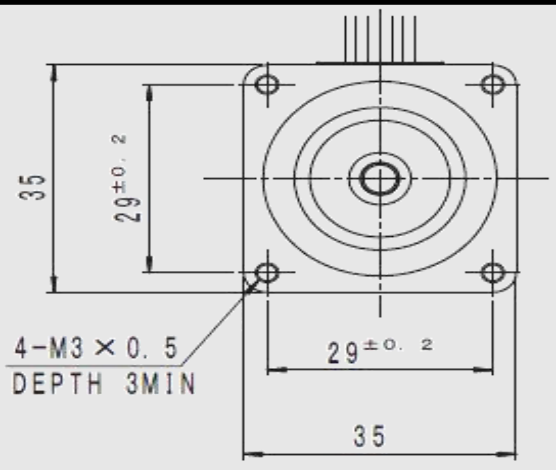
1.8 Reset Optocoupler Electrical Specifications

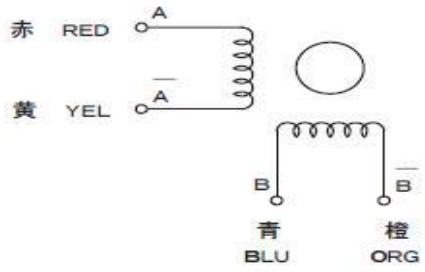
Electrical Specifications	Input Diode(E)	
	Input Diode Power Dissipation	75mW
	Input Diode Forward D.C. Current	20mA
	Input Diode Forward D.C. Voltage	1.2(Typ)
	High and Low Level Output Voltage	
	Vcc	5V
	VOH	
	VOL	
	IF	20mA

1.9 Encoder Electrical Specifications

参数	Sym.	Min.	Typ.	Max.	Units	Notes
Supply current	I_{cc}		2.2	5.0	mA	
High Level Output Voltage	V_{oh}	2.4			V	I_{oh}=-0.2mA
Low Level Output Voltage	V_{ol}			0.4	V	I_{oL}=8.0mA
Rise time	t_r		500		ns	C_L=25pF, R_L=2.7kΩ
Fall time	t_f		100		ns	C_L=25pF, R_L=2.7kΩ
Operating voltage	V			5V	V	

1.10 Description of 35 Stepper Motor

35 Stepper Motor	
Dimensions	

Wiring Method	 FIG. 1	
Electrical Parameters	Maximum Power	10.8W
	Step Angle	1.8°
	Rated Voltage	3.6V
	Rated Current	1.5A
	Holding Torque	350mNm
	Resistance	2.4Ω±0.24Ω
	Inductance	3.6mH REF
	Braking Torque	12mNm
	Rotational Inertia	43g-cm²
	Insulation	100M Ω MIN
	Maximum Temperature	80C° MAX
	Insulation Class	B
Current Setting	The output current is set to be equal to or slightly less than the rated current of the motor.	

1.11 Basic Parameters of RP-01 Piston pump

Product Features	Description		
Accuracy	≤1% (100% rated stroke)		
Precision (Repeatability)	0.3%~0.7% (100% stroke)		
Service life	3 million times no leakage (media: water; 1 rated stroke=one time)		
Initial position detection	Photoelectric detects original piston position		
Pump head	Single-hole	L-shaped Double-hole	Double-hole with valve
Dead Volume	1.45ml	1.387ml	1.716ml
Volume	**6ml**		
Rated stroke (control steps) Self-defined Protocol	19.1mm （3820 steps）		

Rated stroke (control steps) ASC II Protocol	19.1mm（7640steps）	
Maximum speed	500rpm	
Linear speed	0.017~8.33mm/s	
Running time (per rated stroke)	2.2s(500rpm) ~1146s(1rpm)	
Resolution (Self-defined Protocol)	0.005mm/1.5707μl	
Resolution (ASC II Protocol)	0.0025mm/ 0.7853μl	
Cylinder ID	20mm	
Actuator	Lead Screw（lead 1mm）	
Wetted material	PC, Ceramics, PTFE	PC, Ceramics, PTFE, PEEK, EPDM, FKM
Maximum pressure	Positive air pressure 0~0.8Mpa (retention time 1min) Negative air pressure 0~0.06Mpa (retention time 1min)	-0.075~0.2(COM→NC、NO)
Connection	1/4-28UNF female thread	
Power supply	DC24V/1.5A	
Operating temperature	5~55C°	
Operating humidity	< 80%	
Dimensions (length*width*height)	51*45.5*136.73mm (with solenoid valve and encoder)	
Weight	0.462kg (with solenoid valve and encoder)	

Table 1-1 Technical Parameters

Dead volume diagram

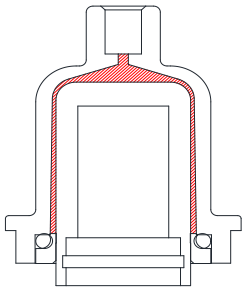


Figure 1-5-1 Single-hole

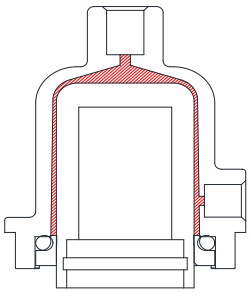
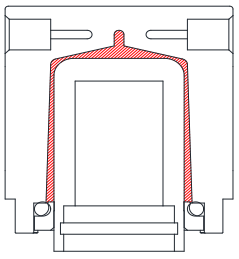


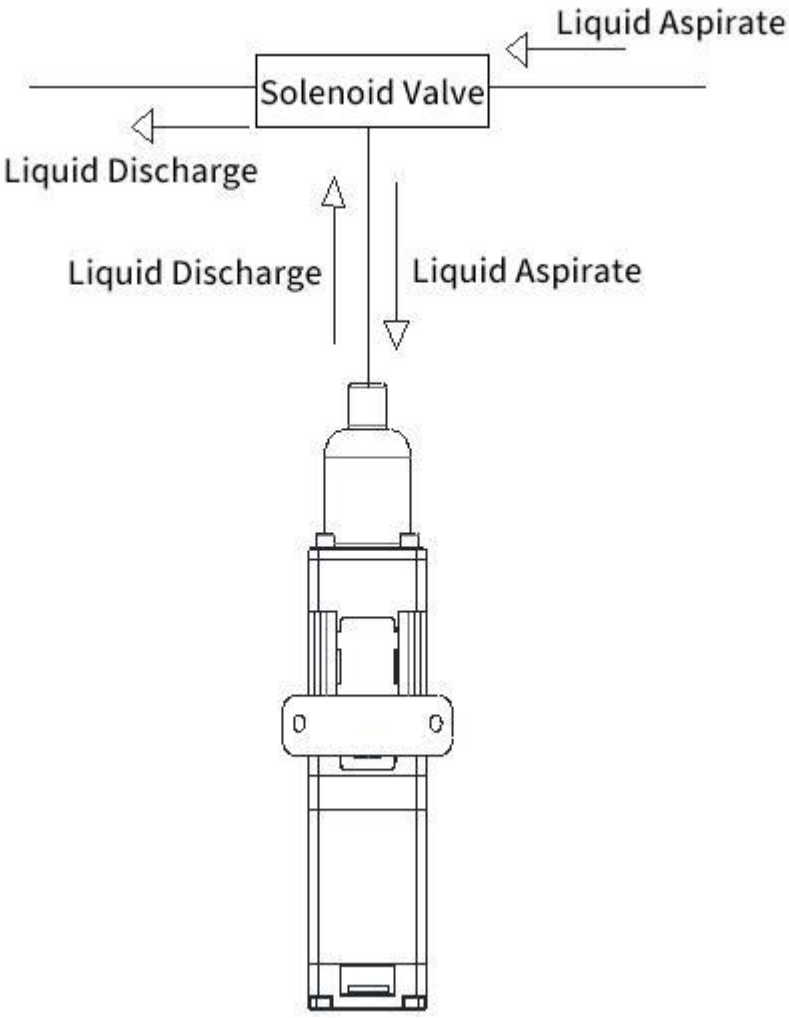
Figure 1-5-2 L-shaped Double-hole



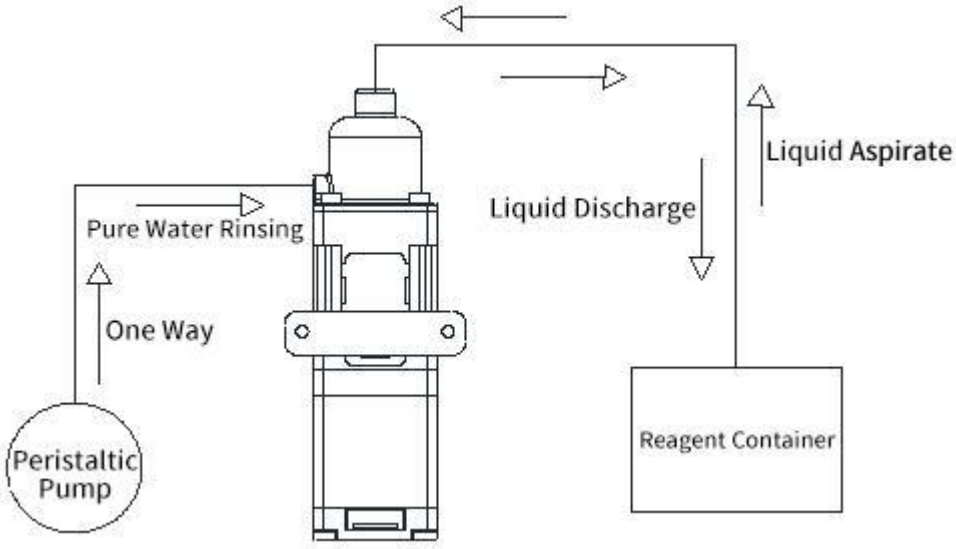
1-5-3 Double-hole with valve

1.12 Typical Applications for Pump Heads

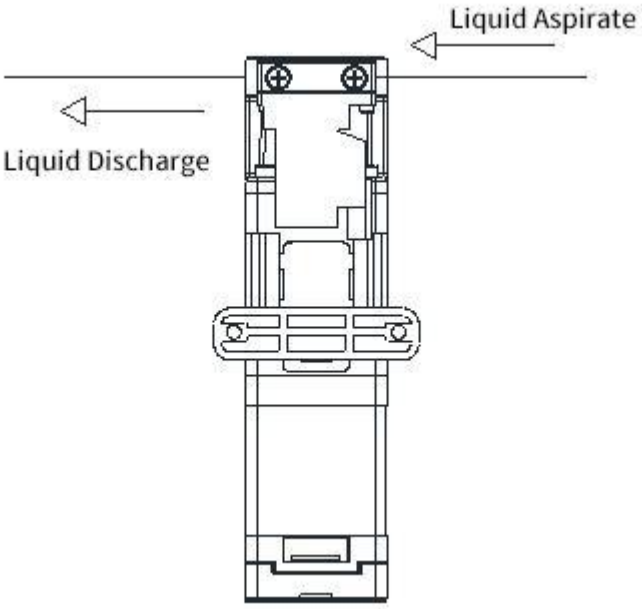
1.12.1 Single-hole Pump Head



1.12.2 L-shaped hole pump head



1.12.3 Double- hole pump head with solenoid valve



Chapter 2 Instruction of Piston Pump Control Code

2.1 Instruction of MC10 Driver Control Code

2.1.1 Overview

The data transmission between the piston pump and the Upper (Computer, MCU, PLC, etc.) adopts serial communication (RS232, RS485, CAN bus). Description of the communication format are as following: the communication adopts asynchronous serial communication, and the sum check with two bytes (2Byte) is adopted by the command & data frame. Commands & data in communication must be in hexadecimal. Parameters are stored in little-endian mode.

Other Instruction: Communication Interface: RS232, RS485, CAN bus;

Communication Mode: two-way asynchronous, master-slave mode;

Baud Rate: RS232&RS485: 9600bps, 19200bps, 38400bps,57600bps, 115200bps;

CAN: 100K, 200K, 500K, 1M;

Data Bits: 8 Bit;

Parity Check: no check;

Response time: <1 second after receiving the command

2.1.2 Installation and Debugging

1.Install the debugging tools, please refer to 《Debugging tools instructions》for details

2. Instructions for use, please refer to 《Drive Quick Use Guide》for details

2.1.3 Communication Protocols

2.1.3.1 Command format

A: Pump Parameter Setting Command

B: Pump Parameter Query Command

C: Pump Action Command

2.1.3.2 Factory Command format (Send 8 bytes, return 8 bytes)

Factory commands need to be used with V0.8 debugging tools when RS232 and RS485 are used separately. For details, see *Quick Use Guide.*

Byte send:

B0	B1	B2	B3,B4 B5,B6	B7	B8	B9	B10	B11	B12	B13
FH (Frame Header)	Address code	Function code	Pass word	Function Parameter				EOF (End of frame)	CUCUM (Cumulative sum)	
STX	ADDR	FUNC	PWD	1-8 bit	9-16 bit	17-24 bit	25-32bit	ETX	Low byte	High byte

The 1st byte STX : Frame header （0xCC）

The 2nd byte ADDR : Slave address（0x00 ~ 0xFF）

The 3rd byte FUNC : Function code

The 4th -7th byte : Factory command code

The 8th -11th byte : Parameters corresponding to the function code

The 12th byte ETX : End of frame（0xDD）

The 13th, 14thbyte : Cumulative sum check code from byte 1 to 12

Byte return:

B0	B1	B2	B3	B4	B5	B6	B7
FH (Frame header)	Address code	Status code	Status Parameter		EOF (End of frame)	CUCUM (Cumulative sum)	
STX	ADDR	STATUS	1-8 Bit	9-16 Bit	ETX	Low byte	High byte

The 1st byte STX : Frame header （0xCC）

The 2nd byte ADDR : Slave address（0x00 ~ 0xFF）

The 3rd byte STATUS : Status code

The 4th -5th byte : Parameters corresponding to the status code

The 6th byte ETX : End of frame（0xDD）

The 7th, 8th byte : Cumulative sum check code from byte 1 to 6

A: Pump Parameter Setting Command (Factory Command)

Command B2	Specification	Operation Command B3B4 Range	Parameter Specification
0x00	Set device address	0x0000 ~ 0x00FF	0x0000 ~ 0x00FF (0 ~ 255)
0x01	Set RS232 baud rate	0x0000 ~ 0x0004	Totally 5 baud rates, the factory default is 9600bps B3B4=0x0000 9600bps B3B4=0x0001 19200bps B3B4=0x0002 38400bps B3B4=0x0003 57600bps B3B4=0x0004 115200bp
0x02	Set RS485 baud rate	0x0000 ~ 0x0004	

0x03	Set CAN baud rate	0x0000 ~ 0x0003	Totally 4 baud rates: the factory default value is 100K B3B4=0x0000 100Kbps B3B4=0x0001 200Kbps B3B4=0x0002 500Kbps B3B4=0x0003 1Mbps
0x05	Set subdivision	0x0000 ~ 0x0008	Value Range: 0000-0008 B3B4= 0x0000 full subdivision B3B4=0x0001 subdivision 2 B3B4=0x0002 subdivision 4 B3B4=0x0003 subdivision 8 B3B4=0x0004 subdivision 16 B3B4=0x0005 subdivision 32 B3B4=0x0006 subdivision 64 B3B4=0x0007 subdivision 128 B3B4=0x0008 subdivision 256
0x07	Set maximum speed	0x0001 ~ 0x01F4	The value indicating the maximum speed of the current device can be set to 500rpm, but according to the actual device situation.
0x0E	Set automatic reset after power-on	0x0000 ~ 0x0001	B3B4=0x0000 do not automatically reset after power-on B3B4=0x0001 Automatically reset after power-on
0x10	Set the destination address of CAN	0x0000 ~ 0x00FF	Address：0 ~ 255
0xFC	Lock the set parameters	B3=0xFF B4=0xEE B5=0xBB B6=0xAA	The parameters are all 0x0000
0xFF	Restore factory settings	B3=0xFF B4=0xEE B5=0xBB B6=0xAA	The parameters are all 0x0000

2.1.3.3 Common Command Format (Send 8 bytes, return 8 bytes)

Byte send:

B0	B1	B2	B3	B4	B5	B6	B7
FH (Frame header)	Address code	Function code	Status Parameter		EOF (End of frame)	CUCUM (Cumulative sum)	
STX	ADDR	FUNC	1-8 Bit	9-16 Bit	ETX	Low byte	High byte

The 1st byte STX : Frame header （0xCC）

The 2nd byte ADDR : Slave address（0x00 ~ 0xFF）

The 3rd byte FUNC : Function code

The 4th , 5th byte : Parameters corresponding to the function code

The 6th byte ETX : End of frame（0xDD）

The 7th, 8th byte : Cumulative sum check code from byte 1 to 6

Byte return:

B0	B1	B2	B3	B4	B5	B6	B7
FH (Frame header)	Address code	Status code	Status Parameter		EOF (End of frame)	CUCUM (Cumulative sum)	
STX	ADDR	FUNC	1-8 Bit	9-16 Bit	ETX	Low byte	High byte

The 1st byte STX : Frame header （0xCC）

The 2nd byte ADDR : Slave address（0x00 ~ 0xFF）

The 3rd byte STATUS : Status code

The 4th, 5th byte : Parameters corresponding to the status code

The 6th byte ETX : End of frame （0xDD）

The 7th, 8th byte : Cumulative sum check code from byte 1 to 6

B: Pump Parameter Query Command (Common Command)

Command B2	Specification	Parameters B3、B4	Response Parameters B3、B4
0x20	Query address	0x0000	0x0000 ~ 0x00FF(0 ~ 255)
0x21	Query RS232 baud rate	0x0000	Totally five baud rates: Factory default: 9600bps. B3B4=0x0000 9600bps. B3B4=0x0001 19200bps. B3B4=0x0002 38400bps. B3B4=0x0003 57600bps. B3B4=0x0004 115200bps.
0x22	Query RS485 baud rate	0x0000	
0x23	Query CAN baud rate	0x0000	Totally four baud rates: Factory default: 100Kps. B3B4=0x0000 100Kps B3B4=0x0001 200Kps B3B4=0x0002 500Kps B3B4=0x0003 1Mps
0x25	Query subdivision	0x0000	Value Range: 0000-0008 B3B4= 0x0000 full subdivision B3B4=0x0001 subdivision 2 B3B4=0x0002 subdivision 4 B3B4=0x0003 subdivision 8 B3B4=0x0004 subdivision 16 B3B4=0x0005 subdivision 32 B3B4=0x0006 subdivision 64 B3B4=0x0007 subdivision 128 B3B4=0x0008 subdivision 256
0x27	Query Max. Speed	0x0000	0x0000 ~ 0x01F4(0 ~ 500rpm)

0x30	Query CAN destination address	0x0000	B3=0xXX （B4=0x00) The value range of XX is 00 ~ FF, and the default is 00
0x3F	Query current firmware version	0x0000	B3B4 software version number, hexadecimal representation
0xEF	Query current firmware subversion	0x0000	B3B4 software subversion number, hexadecimal representation
0x4A	Query motor status	0x0000	B3B4=0x0000
0x60 *	I03 output high	0x0001	* Enabled only in piston pumps with solenoid valve and driver (MC10+MOS/MC12M driver) *
0x61 *	I03 output low	0x0001	
0x66	Query current location	0x0000	B3=0x00 B4=0x00 The piston pump stops working due to external reasons or sudden power failure during pump operation. We can use command to query the current position of the motor and display the distance between the current position and home position (number of steps), If we use the 0x66 command to query, in receiving command, B3=0x3E B4=0x0A, 2622 as the decimal number, indicates that the distance between the current position and home position is 2622 steps, so as to calculate the aspirating or dispensing volume of liquid.
0x67	Clear location	0x0000	B3=0x00 B4=0x00 The piston pump will continue to run for a short period of time after sudden power failure in the running state. The actual running number of steps is higher than the original ideal number of steps. If power on again, it will reset automatically (or send the command 0x45 to reset), the reset position of the motor is not the home position. We need to run position reset command 0x67, then use 0x66 command to query current position, In receiving command, B3=0x00, B4=0x00 indicates that the current position is the home position.
0x68	Query the running direction of the piston	0x0000	B3=0x00 B4=0x00 query the running status of the motor. In receiving command, B3=0x00 B4=0x00 indicates that the motor rotates in CCW, the piston moves downwards, and the piston pump aspirates liquid; B3=0x01 B4=0x00 indicates that the motor rotates in clockwise, the piston moves upwards and the piston pump dispenses liquid.

C: Pump Action Command (Common Command)

Command (B2)	Specification	Parameters B3、B4	Response Parameters B3、B4
0x42	Run in CW (clockwise)	Running steps	The value of B3&B4 ⩾0. When the number of steps corresponding to the B3&B4 parameter is greater than the steps from the motor to the position of reset optocoupler, the motor will stop at the position of reset optocoupler. When the number of steps is less than the steps from the motor to the position of reset optocoupler, the motor will rotate according to the set steps
0x4D	Run in CCW (counterclockwise)	Running steps	The maximum value of B3B4 is based on the piston pump capacity: The single step resolution of 6ml piston pump is 1.5707ul, and the maximum number of steps is 6ml÷1.571ul≈3820, the corresponding hexadecimal number is 0x0EEC, then the value range of B3B4 is 0x0001 ~ 0x0EEC
0x45	Reset	0x0000	B3=0x00 B4=0x00 the piston will stop at the position of the reset optocoupler.
0x4B	Set dynamic speed (It will fail when power-off, and if not set, it will be the default speed.)	Rotational Speed	The value range of B3B4 is 0x0001 ~ 0x01F4 The motor rotational speed is 1 ~ 500rpm Note: When the speed is 1 revolution, the subdivision must be 256 subdivisions
0x49	Forced Stop	0x0000	B3B4 remaining steps

Status list

Code B2	Description
0x00	Normal status
0x01	Frame error
0x02	Parameter error
0x03	Optocoupler error
0x04	Motor Busy
0x05	Motor Stall
0x06	Unknown position
0xFE	Task pending (command received to execute)
0xFF	Unknown error

Note: In RS485 communication, when sending an action command, the B2 byte receives FE means the command is received and is being executed

The code B2 in the response command indicates the current motor running status. Only when

B2=0x00, the motor runs normally. Other parameters are shown in the above table and different abnormal status are shown respectively. In principle, the 0x4A command should be sent to query the motor status after the motor runs. Only when the B2 parameter in the response command is 00, other commands can be executed correctly.

2.2 Instruction of MC12 Driver Control Code (Self-defined protocols)

2.2.1 Overview

The data transmission between the piston pump and the host controlling system (Computer, MCU, PLC, etc.) adopts serial communication (RS232, RS485, CAN bus). Description of the communication format are as following: the communication adopts asynchronous serial communication, and the sum check with two bytes (2Byte) is adopted by the command & data frame. Commands & data in communication must be in hexadecimal. Parameters are stored in little-endian mode.

Communication Interface: RS232, RS485, CAN bus;

Communication Mode: two-way asynchronous, master-slave mode;

Baud Rate: RS232&RS485: 9600bps, 19200bps, 38400bps,57600bps, 115200bps;

CAN: 100K, 200K, 500K, 1M;

Data Bits: 8 Bit;

Parity Check: no check;

Response Time: <1 second after receiving the command

2.2.2 Installation and Debugging

- Install the debugging tools, please refer to *Debugging tools instructions* for details
- Instructions for use, please refer to *Driver Quick Use Guide* for details

2.2.3 Communication Protocols

2.2.3.1 Command Format

A: Pump Parameter Query Command

B: Pump Action Command

C: Pump Parameter Setting Command

2.2.3.2 Common Command format (Send 8 bytes, return 8 bytes)

Byte send:

B0	B1	B2	B3	B4	B5	B6	B7
FH (Frame header)	Address code	Function code	Status Parameter		EOF (End of frame)	CUCUM (Cumulative sum)	
STX	ADDR	FUNC	1-8 Bit	9-16 Bit	ETX	Low byte	High byte

The 1st byte STX : Frame header （0xCC）

The 2nd byte ADDR : Slave address（0x00 ~ 0x7F）

Multicast address（0x80 ~ 0xFE）Broadcast address（0xFF）

The 3rd byte FUNC : Function code

The 4th , 5th byte : Parameters corresponding to the function code

The 6th byte ETX : End of frame（0xDD）

The 7th , 8th byte : Cumulative sum check code from byte 1 to 6

Byte return:

B0	B1	B2	B3	B4	B5	B6	B7
FH (Frame header)	Ad dress code	Status code	Status Parameter		EOF (End of frame)	CUCUM (Cumulative sum)	
STX	ADDR	STATUS	1-8 Bit	9-16 Bit	ETX	Low byte	High byte

The 1st byte STX : Frame header （0xCC）

The 2nd byte ADDR : Slave address（0x00 ~ 0x7F）

Multicast address（0x80 ~ 0xFE）Broadcast address（0xFF）

The 3rd byte STATUS : Status code

The 4th, 5th byte : Parameters corresponding to the status code

The 6th byte ETX : End of frame（0xDD）

The 7th, 8th byte : Cumulative sum check code from byte 1 to 6

A: Pump Parameter Query Command (Common Command) （B2 ~ B4）

Command B2	Specification	Response Parameters B3、B4
0x20	Query address	The value of address is 0x0000 ~ 0x007F and the default value is 00.
0x21	Query RS232 baud rate	There are five baud rates: factory default is 9600bps. B3B4=0x0000: 9600bps. B3B4=0x0001: 19200bps. B3B4=0x0002: 38400bps. B3B4=0x0003: 57600bps. B3B4=0x0004: 115200bps.
0x22	Query RS485 baud rate	

0x23	Query CAN baud rate	Corresponding CAN baud rate: B3B4=0x0000 100Kps B3B4=0x0001 200Kps B3B4=0x0002 500Kps B3B4=0x0003 1Mps
0x25	Query subdivision	Corresponding subdivision: B3B4=0x0001 subdivision 2 B3B4=0x0002 subdivision 4 B3B4=0x0003 subdivision 8 B3B4=0x0004 subdivision 16 B3B4=0x0005 subdivision 32
0x27	Query Max. Speed	Maximum speed range is 0x0000 ~ 0x01F4.
0x30	Query CAN destination address	B3B4=0x0000
0x3E	Query current channel position	B3B4=0x0000
0x3F	Query current firmware version	B3=0x01 B4=0x1E, as an example, indicates that the version is V1.30, See the version No. on the label for details.
0x4A	Query motor status	B3B4=0x0000
0x66	Query piston position	B3B4=0x0000 After the pump finished running, we can use commands to query the current position of the motor, which displays the current distance between the motor &the home position (number of steps)
0x67	Synchronize piston position	B3B4=0x0000 When the piston pump is suddenly powered off during operation, the pump will continue to run for a short period of time, at which time the number of steps will be out of wrong, the number of steps to reach the reset position is not the home position when the power is turned on again. At this time, we need to run the position reset command 0x67, and then send 0x66 command to query current position, it means current position is the home position when B3=0x00 B4=0x00 received.
0x70	Query multicast channel 1 address	B3B4=0x0000
0x71	Query multicast channel 2 address	B3B4=0x0000
0x72	Query multicast channel 3 address	B3B4=0x0000
0x73	Query multicast channel 4 address	B3B4=0x0000

B: Pump Action Command（Common Command）(B2～B4)

Command (B2)	Specification	Parameters B3、B4	Response Parameters B3、B4
0x42	Run in CW (clockwise)	Operating parameters	The value of B3&B4 ≥0. When the number of steps corresponding to the B3&B4 parameter is greater than the maximum stroke steps, the motor will not run, and B3=02, B4=00 will return; when the number of steps is less than the Max. stroke steps, the devices will rotate according to the set steps
0x4D	Run in CCW (counterclockwise)	Operating parameters	The maximum value of B3B4 is based on the piston pump capacity: The single step resolution of 6ml piston pump is 1.5707ul, and the maximum number of steps in rotation is 6ml÷1.5707ul≈3819.95, 3820 steps after rounding, and the corresponding hexadecimal value is 0x0EEC, so the value range of B3B4 is 0x0001 ~ 0x0EEC
0x45	Reset	0x0000	B3=0x00 B4=0x00 The action of reset after power on is the same as 0x4F result. The reset will go directly to the home position on other cases.
0x4F	Forced to reset	0x0000	B3=0x00 B4=0x00 When the syringe runs to the home position, the number of locked-rotor steps runs to the top through resetting which causes forced resetting. Then the piston will go back for a certain number of offset steps, leaving a little gap between the top of the piston and the syringe which greatly improve the service life of the piston seal.
0x4B	Set dynamic speed (It will fail when power-off, and if not set, it will be the default speed.)	Operating parameters	The value range of B3&B4 is 0x0001 ~ 0x01F4 Motor rotate speed is 1 ~ 500
0x4E	Syringe to the absolute position	Operating parameters	The value range of B3&B4 is 0x0000 ~ 0x0EEC, indicates any position between the stroke of the syringe
0x49	Forced to stop	0x0000	B3=0x00 B4=0x00
0x60 *	I03 Output high	0x0001	* Available only in piston pumps with solenoid valve and drive (MC10+MOS/MC12M drive) *
0x61 *	I03 Output low	0x0001	

Status list

Status (B2)	Description of the response frame (B2) status
0x00	Normal status
0x01	Frame error
0x02	Parameter error
0x03	Optocoupler error
0x04	Motor busy
0x05	Motor stalled
0x06	Unknown position
0x07	Command rejected
0x08	Illegal location
0xFE	Task is running
0xFF	Unknown error

Note: In RS485 communication, when sending an action command, the B2 byte receives FE means the command is received and is being executed.

The code B2 in the response command indicates the current running status of the motor, only when B2=0x00, the motor runs normally, and the other parameters are as shown in the above table, which means different abnormal status respectively. In principle, the 0X4A command should be sent to query the motor status when the motor finishes operation. Only when the B2=0x00, other commands can be sent and execute correctly.

2.2.3.3 Factory Command Format (send 14 bytes, return 8 bytes)

Factory commands need to be used with V0.8 debugging tools when RS232 or RS485 are used separately. See *Quick Use Guide* in details.

Byte send:

B0	B1	B2	B3,B4 B5,B6	B7	B8	B9	B10	B11	B12	B13
FH (frame header)	Address code	Function code	Pass word	Function Parameter				EOF (End of frame)	CUCUM (Cumulative sum)	
STX	ADDR	FUNC	PWD	1-8 bit	9-16 bit	17-24 bit	25-32 bit	ETX	Low byte	High byte

The 1st byte STX : Frame header (0xCC)

The 2nd byte ADDR : Slave address (0x00 ~ 0x7F)

Multicast address (0x80 ~ 0xFE) Broadcast address (0xFF)

The 3rd byte FUNC : Function code

The 4th -7th byte : Factory command format

The 8th -11th byte : Parameters corresponding to the function code

The 12th byte ETX : End of frame（0xDD）

The 13th, 14th byte : Cumulative sum check code from byte 1 to 12

Byte return:

B0	B1	B2	B3	B4	B5	B6	B7
FH (frame header)	Address code	Status code	Status Parameter		EOF (End of frame)	CUCUM (Cumulative sum)	
STX	ADDR	STATUS	1-8 Bit	9-16 Bit	ETX	Low byte	High byte

The 1st byte STX : Frame header （0xCC）

The 2nd byte ADDR : Slave address（0x00 ~ 0x7F）

Multicast address（0x80 ~ 0xFE）Broadcast address（0xFF）

The 3rd byte FUNC : Function code

The 4th -5th byte : Parameters corresponding to the function code

The 6th byte ETX : End of frame（0xDD）

The 7th, 8th byte : Cumulative sum check code from byte 1 to 6

C: Pump Parameter Command Setting （Factory Command）

Command B2	Abbreviation	Password B3 B4 B5 B6	Parameter Specification B7 B8 B9 B10
0x00	Set device address	B3=0xFF B4=0xEE B5=0xBB B6=0xAA	B7=0xXX (B8=0x00 B9=0x00 B10=0x00) The value range of XX is 00 ~ 7F, default value is 00
0x01	Set RS232 baud rate	B3=0xFF B4=0xEE B5=0xBB B6=0xAA	Totally 5 baud rates, the factory default is 9600bps B7=0x0000 9600bps B7=0x0001 19200bps B7=0x0002 38400bps B7=0x0003 57600bps B7=0x0004 115200bp
0x02	Set RS485 baud rate	B3=0xFF B4=0xEE B5=0xBB B6=0xAA	
0x03	Set CAN baud rate	B3=0xFF B4=0xEE B5=0xBB B6=0xAA	Totally 4 baud rates: the factory default value is 100K B7=0x0000: 100Kbps B7=0x0001: 200Kbps B7=0x0002: 500Kbps B7=0x0003: 1Mbps
0x05	Set subdivision	B3=0xFF B4=0xEE B5=0xBB B6=0xAA	Totally 5 subdivisions: the factory default is subdivision 8

			B7=0x0001 subdivision 2 B7=0x0002 subdivision 4 B7=0x0003 subdivision 8 B7=0x0004 subdivision 16 B7=0x0005 subdivision 32
0x07	Set maximum speed	B3=0xFF B4=0xEE B5=0xBB B6=0xAA	Indicates that the value of the maximum speed of the current device can be set to 500rpm
0x0E	Set automatic reset after power-on	B3=0xFF B4=0xEE B5=0xBB B6=0xAA	B3B4=0x0000 do not automatically reset after power-on B3B4=0x0001 Automatically reset after power-on
0x10	Set the destination address of CAN	B3=0xFF B4=0xEE B5=0xBB B6=0xAA	B7=0xXX (B8=0x00 B9=0x00 B10=0x00) The value range of XX is 00 ~ FF, default value is 00
0x50	Set the multicast channel 1 address	B3=0xFF B4=0xEE B5=0xBB B6=0xAA	B7=0xXX (B8=0x00 B9=0x00 B10=0x00) The value range of XX is 80 ~ FE, default value is 00
0x51	Set the multicast channel 2 address	B3=0xFF B4=0xEE B5=0xBB B6=0xAA	B7=0xXX (B8=0x00 B9=0x00 B10=0x00) The value range of XX is 80 ~ FE, default value is 00
0x52	Set the multicast channel 3 address	B3=0xFF B4=0xEE B5=0xBB B6=0xAA	B7=0xXX (B8=0x00 B9=0x00 B10=0x00) The value range of XX is 80 ~ FE, default value is 00
0x53	Set the multicast channel 4 address	B3=0xFF B4=0xEE B5=0xBB B6=0xAA	B7=0xXX (B8=0x00 B9=0x00 B10=0x00) The value range of XX is 80 ~ FE, default value is 00

Example: Use the 0x50/51/52/53 command to set the multicast address (this example only uses the three commands 0x50/51/52)

Use three sets RP01 piston pumps with the same software version. In the RS485 communication mode, set their addresses to 00, 01, 02 and make a mark. Firstly, set parameter 0x81 of RP01 multicast channel 1 address marked as 00 to 81 by the command 0x50, set parameter 0x83 of multicast channel 3 address to 83 by command 0x52; Set parameter 0x81 of the multicast channel 1 address of RP01 marked as 01 to 81 by command 0x50, and the parameter 0x82 of multicast channel 2 address is set to 82 by command 0x51. Set parameter 0x82 of the multicast channel 2 address of RP01 marked as 02 to 82 by command 0x51, and the parameter 0x83 of multicast channel 3 address to 83 by command 0x52 (See the table below for details)

Device / Items	Device 1 (Address 0)	Device 2 (Address 1)	Device 3 (Address 2)
multicast address	81	81	
		82	82
	83		83
broadcast address	FF	FF	FF

After the setting is completed, connect the three devices in parallel to the serial debugging tool, and use our debugging tool MotorTest V0.8 for debugging. In MotorTest V0.8, set the address to 0x81, the command to 0x4D and the parameter to 0xC8, click to send and then the pistons of device 1 and device 2 will have pumping action; Set the address to 0x82 ,the command to 0x4D and the parameter to 0xC8, click to send and then the pistons of device 2 and device 3 will have pumping action; Set the address to 0x83, the command to 0x4D and the parameter to 0xC8, click send and then the pistons of device 1 and device 3 will have pumping action; Set the address to 0xFF, the command to 0x4D, and the parameter to 0xC8 , click to send and then the pistons 1, 2, and 3 will all have pumping action.

The newly added command to set the multicast address meets the needs of customer groups to a great extent and makes it easier for customers to selects the equipment they want to control, and can complete the work requirements more efficiently and quickly during use.

2.3 Instruction of MC12 Drive Control Code (ASC II Protocols)

2.3.1 Address Setting

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 below

Address (hex)	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

Table 1-1

For example, an RP-01 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 1-2, 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 2-2.

SWITCH SETTING	Single Device		Dual Device		Quad Device		15 Devices	
	Hex Address	ASCII Address	Hex Address	ASCII Address	Hex Address	ASCII Address	Hex Address	ASCII Address
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 1-2 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 "31" to "3F."

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.

2.3.2Communication Protocols

Two communication protocols are available: :

OEM communication protocols

Data Terminal (DT) protocol

2.3.2.1 Data Terminal (OEM) protocol

RP-01 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: RP-01 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 RP-01detects either the OEM or DT protocol, it will ignore the other protocol until the next power cycle.

OEM Communication Protocol

OEM communication is a robust protocol that includes automatic recovery from transmission errors. Table 3-2, OEM Protocol describes each setting within the OEM communication protocol.

Parameter	Setting
Character Format	
Baud rate	9600 或 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 3-2, 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 (standard 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 ASC II 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 matched, 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".

2.3.2.2 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.

Parameter	Setting
Character Format	
Baud rate	9600 或 38400
Data bits	8
Parity	None
Stop bit	1
Command Block (see "DT Protocol Command Block Characters" for details)	
1	Start command (ASC II "/" 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 3-2-2 DT protocols

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 ASC II 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 (ASC II "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

2.3.3 Using DT Protocol with Microsoft Windows

The RP-01 can be controlled in DT protocol mode directly from the Microsoft Windows terminal accessory.

To communicate with the RP-01 using Windows, follow these steps:

1 Connect the RP-01 to a communications port of the PC.

2 From the Microsoft Program Manager window, start the SerialCommV1.3.0 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 /1WR to initialize the pump.

9 To run the pump, see the commands listed in "Using the RP-01 Command Set" in this chapter.

2.4 Using the RP-01 Command Set

2.4.1 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) command.

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

For example:

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

A multi-command string such as [IA6000OA0R] moves the piston to position 6000, returns the piston 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

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. 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.

2.4.2 Pump Configuration Commands

Rp-01 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 Micro step Mode Off/On

The [N] command enables or disables micro stepping (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 speed settings in half-steps/sec and all slopes in half-steps/sec.
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. 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..7640 in full step mode (100 is the default),

and <n> = 0···61120 in fine positioning mode (800 is the default).

When the piston pump 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 piston moves down additional increments, then backs up the set number of backlash increments.

This ensures that the piston 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

<n>值	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
200	Setting the piston pump reset blocking current
300	Set device address

Figure 3-5 Pump Configuration Command Values

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

2.5 Initialization Forces

2.5.1 Initialization

k<n> the offset in increments after reset

The [k] command sets the number of increments that the piston 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…7640 (50 is the default)

n = 0…640 in fine positioning and micro step modes (400 is the default)

Under default initializations, the piston moves upward until it contacts the top of the piston, causing a forced stall initialization. The piston then moves downward and upward, leaving a small gap between the syringe and the top of the piston. This small gap was designed so that the sealing ring does not hit the top of the piston each time the piston moves to the “home” position. This maximizes the life of the piston seal.

The [k] command must be followed by the Initialization command [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

2.5.2 Initialization Commands

W <n1> Initialize Piston and Driver

The [W] command initializes the piston (normally valveless pump) drive. As the valve has not been initialized, only piston force and speed can be set. The default initialization speed is 1400 pulses per second.

n 1 = Set initialization piston force/speed

The parameters are described below:

W Parameter	Value	Description
<n>	0	Initializes at full piston force and at default initialization speed (default)
	1	Initializes at half piston force and at default initialization speed
	2	Initializes at one-third piston 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.

2.5.3 Z Simulated Piston Initialization

The [z] command simulates initialization of the piston, however, no mechanical initialization occurs.

This command can be used to regain control of the pump after an unexpected power failure of the equipment. Use the [Z] command after recovering from power failure to set the current position to position 0. You can continue to control the pump operation after using the [Z] command, but to protect the device, it is recommended to use the initialization command [W] to reset the true 0 position.

2.6 Operating Commands

2.5.1 Piston Movement Commands

A <n> Absolute Position

The [A] command moves the piston to absolute position <n>

Where

<n> = 0..61120 in fine positioning and micro step mode.

Command	<n> Parameter Value	Description
A	0-7640	Absolute position in half increments (N=0)
	0-61120	Absolute position in micro steps (N=1)
	0-61120	Absolute position in micro steps (N=2)

For example:

– [A300R] moves the piston to position 300.

– [A6000R] moves the piston to position 6000.

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 piston down the number of increments commanded. The new absolute position is the previous position plus <n>,

where

<n> = 0..7640 in standard mode and

<n> = 0..61120 in fine positioning and micro step mode.

Command	<n> Parameter Value	Description
P	0-7640	Relative position in half increments (N=0)
	0-61120	Relative position in micro steps (N=1)
	0-61120	Relative position in micro steps (N=2)

For example:

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

The [P] command will return error 3 (invalid operand) if the final piston position is greater than 61120.

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 piston upward the number of increments commanded. The new absolute position is the previous position minus <n>,

where

<n> = 0..7640 in standard mode and

<n> = 0..61120 in fine positioning and micro step mode.

Command	<n> Parameter Value	Description
D	0-7640	Relative position in half increments (N=0)
	0-61120	Relative position in micro steps (N=1)
	0-61120	Relative position in micro steps (N=2)

For example:

The piston is at position 3000. [D300] will move the piston 300 increments to an absolute position 2700.

The [D] command will return error 3 (invalid operand) if the final piston 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.

2.6.2 Set Commands (Speed and Acceleration)

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

- **Ramping Up.** Piston movement begins with the start speed and accelerates with the programmed slope to the constant or top speed.
- **Constant or Top Speed.** The piston moves at the constant or top speed. Piston speed can be programmed in Hz (half-increments/second) or in preprogrammed Set Speeds. The actual time the piston travels is dependent on the ramping up and down. If the piston move is short, it may never reach top speed.
- **Ramping Down**. The piston will decelerate based on the programmed slope. To enhance fluid separation, the Cutoff command ([c]) can be used to define the end speed of the piston 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 piston move, the firmware calculates how many increments the piston must travel during each phase in order to move the total number of increments commanded. If the piston is moving at a rate less than 900 Hz, the pump automatically micro steps to reduce the pulsation.

The top speed can be changed on the fly (while the piston 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],cut off speed [c].

Changing Speed on the Fly

Speed changes can be made while the syringe piston 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 Piston 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 piston 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 piston 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)	Slope Code	Pulses/sec 2 (KHz)
1	2500	11	27500
2	5000	12	30000
3	7500	13	32500
4	10000	14	35000
5	12500	15	37500
6	15000	16	40000

7	17500	17	42500
8	20000	18	45000
9	22500	19	47500
10	25000	20	50000

v <n> Set Start Speed

The [v] command sets the speed at which the piston begins its movement, in pulses/sec. The piston 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	1400	Set top speed in pulses/sec.

S <n> Set Speed

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

Command	<n> Parameter Value	Default Value	Description
S	0-40	14	Set piston drive speed in pulses/sec.

These speed settings do not cover the full range of speeds the piston 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, "Piston 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	1.25	8.25
1	5600	1.30	8.80
2	5000	1.39	9.79
3	4400	1.52	11.1
4	3800	1.71	12.8
5	3200	1.97	15.1
6	2600	2.37	18.5
7	2200	2.77	21.9
8	2000	3.03	24.0
9	1800	3.36	26.7
10	1600	3.77	30.0
11	1400	4.30	34.3
12	1200	5.00	40.0
13	1000	6.00	48.0
14	800	7.50	60.0
15	600	10.00	80.0
16	400	15.00	120
17	200	30.00	240
18	190	31.58	253
19	180	33.33	267
20	170	35.29	282
21	160	37.50	300
22	150	40.00	320
23	140	42.86	343
24	13	46.15	369
25	120	50.00	400
26	110	54.55	436
27	100	60.00	480
28	90	66.67	533
29	80	75.00	600
30	70	85.71	686
31	60	100.00	800
32	50	120.00	960

33	40	150.00	1200
34	30	200.00	1600
35	20	300.00	2400
36	18	333.33	2667
37	16	375.00	3000
38	14	428.00	3429
39	12	500.00	4000
40	10	600.00	4800

Note: To achieve maximum stroke time of 80 minutes for N=0, N=1 or 640 minutes for N=2, In this case, the [S] speed code cannot be used and command [V1] for programming.

c <n> Cutoff Speed

The [c] command sets the speed at which the piston ends its movement, in pulses/sec. The piston 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]

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

Figure3-5 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 piston pump 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

T Terminate Command

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

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 encounters 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 string command.

U200 Set reset blocking current

The [U200] command sets the piston pump blocking current.

[U200, <n>] where <n> = 1...31

U300<n> Sets the device address

The [U300] command sets the address of the device, which cannot be queried after the address is set

[U300, <n>] where <n> = 1...15

J <n> Auxiliary Outputs

The syntax for this command is:

[J<n>]

where <n> = 0..15 (0 is the default)

0, 2, 4, 6, 8, 10, 12, 14 are the default state, the solenoid valve is closed (NO port open)

1, 3, 5, 7, 9, 11, 13, 15 are open state of the solenoid valve (NO)

2.6.4 Non-Volatile Memory (EEPROM) Commands

The non-volatile memory in the RP01 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)
W	Initializes pump
S1	Sets pump speed
g	Marks start of loop
A3000	Turns piston to position 3000
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 standalone 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.

2.6.5 Report Commands

Report commands do not require an [R] command.

? Report Absolute Plunger Position

The [?] command reports the absolute position of the piston in half-steps[N0] or in micro steps [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 piston encoder position in increments.

? 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.

? 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 piston moves. This value cannot be reset.

? 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 micro steps (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 micro step).

? 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 piston 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.

2.7 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).

2.7.1 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.

2.7.2 Error Codes

Error codes describe problem conditions that may be detected in the RP01 (not 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 piston pump overloads, until they are cleared by the Initialization command. On a piston overload, the device will not execute another 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 RP01 Systems 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 RP01 Systems Technical Services.
9 (09h)	Piston Overload. This error occurs when movement of the syringe piston 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.
11 (0Bh)	Piston movement is not allowed. The piston movement command is not allowed when the remaining value of the piston is less than the value that will be sent.
12 (0Ch)	Internal fault. If this error occurs, please call RP01 Systems Technical Services.
14 (0Eh)	A/D converter failure. This error occurs when the A/D converter is faulty. If this error occurs, please call RP01 Systems Technical Services.

15 （0Fh）	Command overflow. This error occurs when an action command is sent before completing the current operation. The command in the buffer must be executed before any other further commands can be executed.

2.7.3 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

The “Plunger Overload” (errors 9). If the pump returns piston 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]). 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	or 1	Number	Error
0 1 X 0 0 0 0 0	40H	60H	64	96	0	Error
0 1 X 0 0 0 0 1	41H	61H	65	97	1	No Error
0 1 X 0 0 0 1 0	42H	62H	66	98	2	Initialization
0 1 X 0 0 0 1 1	43H	63H	67	99	3	Invalid Command
0 1 X 0 0 1 1 0	46H	66H	70	102	6	Invalid Operand
0 1 X 0 0 1 1 1	47H	67H	71	103	7	EEPROM Failure
0 1 X 0 1 0 0 1	49H	9H	73	105	9	Device not Initialized
0 1 X 0 1 0 1 1	4BH	6BH	75	107	11	Piston Overload
0 1 X 0 1 1 0 0	4CH	6CH	76	108	12	Pump Overload
0 1 X 0 1 1 1 0	4EH	6EH	78	110	14	Pump Move Not Allowed
0 1 X 0 0 0 0 0	4FH	6FH	79	111	15	Internal Failure

Error Reporting Examples	
[A7000R]	Do not move the piston and reports a "No Error" status; when queried ([Q] command), returns error. A second try returns error 3 (67)
[P6000P600R]	Moves to absolute position 6000, then stops. A [Q] command returns an error.
[t2000R]	Returns an invalid command error immediately. The pump status is "Not Busy"
[A6000t2000R]	Returns an invalid command error immediately. The pump is "Not Busy."

A Communication Commands

Command Type	Command	Valid/Invalid
Initialization	W	Valid
Initialization	z	Valid
Piston Movement	A, a, P, p, D, d	Valid
Set	S, V, v, c, L, K, k	Valid
Command for micro step-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 micro stepping or fine positioning mode
	1 = fine positioning mode on	
	2 = micro step 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 blocking current (1-31, default 5)	
	300 = Set device address (1-15, default 1)	
K	0..31 in full step mode (default 12)	Sets number of backlash increments.
	0..248 in fine positioning mode (default 96)	

B.2 Initialization Commands

Command	Values of <n>	Description
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	

z		Simulates initialization and sets the current position of the plunger as the home position
k	0..80 in standard mode (50 default)	Set 0 gap (blocking increments after reset)
	0..640 in fine positioning or micro step mode (400 default)	

B.3 Piston Movement Commands/Status Bit Reports

Command	Value of <n>	Description	Status
A <n>	0-7640 0-61120 in fine positioning or micro step mode	[A]bsolute Position	Busy
a <n>	0-7640 0-61120 in fine positioning or micro step mode	[a]bsolute Position	Ready
P <n>	0-7640 0-61120 in fine positioning or micro step mode	Relative [P]ickup	Busy
p <n>	0-7640 0-61120 in fine positioning or micro step mode	Relative [p]ickup	Ready
D <n>	0-7640, 0-61120 in fine positioning or micro step mode	Relative [D]ispense	Busy
d <n>	0-7640 0-61120 in fine positioning or micro step mode	Relative [d]ispense	Ready

B.4 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.5 Report Commands

Command	Description
Q	Query, Status and Error Bytes
?	Report absolute piston position
?1	Report start speed
?2	Report top speed
?3	Report cutoff speed
?4	Report actual position of piston
?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 piston movements
? 20or#	Report firmware checksum
? 23or&	Report firmware version
? 24	Report zero gap increments
?29	Same as Q (query, status and error bytes)
?76	Report pump configuration
*	Report supply voltage
< <n>	Report user data (0..15)

B.6 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	Piston overload
0 1 X 0 1 0 1 1	4Bh	6Bh	75	107	11	Pump 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

2.8 MC12M Commands

Note: The commands are compatible with MC12.

2.9 MC10+MOS Commands

Note: The commands are compatible with MC10.

Caution.

1. The code and parameters of all the above commands are adopting the small-end mode. Small end mode storage, data low bit is stored in the address low bit, data high bit is stored in the address high bit.

2, when the piston pump suddenly powered off during operation, the moment of power failure piston pump will continue to run for a short period of time, the number of running steps will deviate, and then power on again to run to the reset position is not zero, you need to run command 0x67 the position to zero, this command helps to reduce the error, generally used after the reset command.

Chapter 3 Common Problems and Solutions

No.	Problem	Possible Reason	Solutions
1	Not working when powered on	Working voltage is not within the qualified range.	Detect whether there is deviation between the actual pin voltage and the rated voltage.
		The connection is loose or broken.	Manually check whether the contact is good, or check the circuit with a multi-meter.
2	Unable to aspirate liquid or not fully	The tube is not tightly sealed.	Check whether the joint is tight.
		Tube is blocked,	Clean and unblock the tube
		Aspirating valve or dispensing valve is blocked by debris.	Clear valve debris.
3	Have bubbles	Air leakage in the tube.	Look for leaks and rule them out
		The inlet and outlet tube joints are not tightly sealed.	Replace the ferrule and tighten the pipe joint.
		Sealing ferrule is damaged.	Replace the sealing ferrule
		Excessive change in liquid pipe diameter	The diameter of the fluid path should be as consistent as possible
4	The pump stuck	Optocoupler is not triggered.	Check the optocoupler wiring (refer to the optocoupler wiring method).
		Optocoupler is burned out.	Replace the optocoupler.
		The motor wire is connected inversely.	Swap any phase of the motor wire.
5	The motor overheated	Driving voltage is too large.	Adjust voltage.
		Driving current is too large,	Adjust current.
		Holding current is too large,	Holding current≤50% of rated current
6	Abnormal sound of pump operation	Motor running speed is too high or too low.	Adjust the motor speed to a suitable value.
		There are crystals in the pump head.	Cleaning steps are required after the machine runs or before it starts
7	Poor Accuracy	The tube is not sealed tightly.	Check whether the joint is tight.
		There are bubbles in the tube.	Refer to the solutions of the Problem 3.

Product Safety Precautions：

For the personal safety of you and other users, please read the safety precautions carefully.

This manual uses the following symbols and please fully understand the meaning of the following symbols before continuing to read.

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

Symbol Description

	You must operate according to the warning, and the specific warning or caution information is described in the triangle.		The actions must be prohibited and the specific prohibited content is depicted in the circle.
	Important instructions or actions that must be performed.		

 Caution			
	Please turn off the power when it is idle for a long time or the whole machine is being repaired, otherwise it may cause fire or electric shock.		Do not place it in damp, dusty, oily or close to heating equipment, otherwise it will cause the product loose efficacy, or even malfunction, fire or electric shock.
	Please ensure that the voltage matches the standard voltage of the instrument.		If there are vacant holes that are not needed, please use matching plugs and gaskets to plug them tightly to prevent impurities and airflow from entering the pump body and affecting normal use.

Warning			
	**Do not disassemble.** Do not disassemble, repair or modify the product without permission, and there are no warranties when the tamper label is torn.		**Avoid using in humid environment.** Moisture may cause electric shock.
	**Cut off the power when abnormal.** If there is any abnormality, cut off the power immediately. Otherwise, it may cause fire or electric shock.		**Pay attention to protection when using corrosive fluids.** It must be used strictly in accordance with the applicable medium in the specification, and protection must be paid attention to when corrosive fluids are used.
	**Do not discard casually.** Disposal of wastes should be handled according to related regulations, and the user should not discard it casually.		

Chapter 4 Technical Service

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