润泽流体 RUNZE FLUID

Analysis instrument accessories
Ecological closed loop service provider

Version 1.0

SY-09 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

Thank you very much for choosing our products. Please read and keep this manual carefully before use.

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Chapter1 Product Introduction

1.1 SY-09 Features at-a-Glance

SY-09 syringe pump is a fully programmable, small compact size, high-precision liquid handling micro industrial pump module with stable performance & long service life, developed by RUNZE Company. Controlled by a host controlling system (external computer, microprocessor, PLC, etc.), the clockwise or counterclockwise circular motion of the stepper motor is converted into linear motion through the trapezoidal screw rod, which makes the syringe pump piston move up and down linearly to achieve aspirating and dispensing functions.

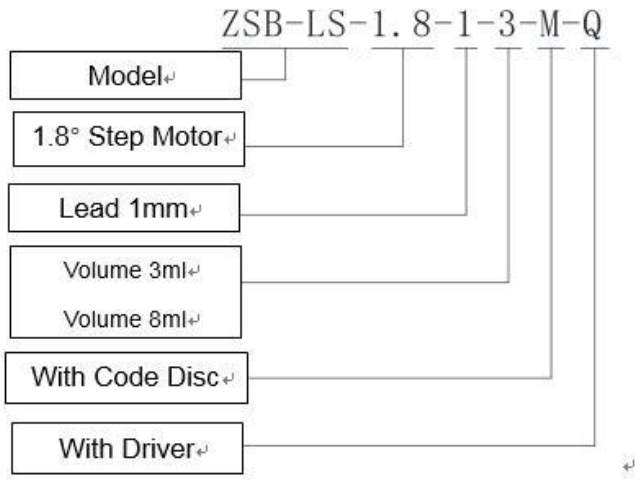
Configuration: 3ml, 8ml

Component: Borosilicate glass syringe, trapezoidal screw, optocoupler, stepper motor, driver

Usage: SY-09 syringe pump is widely used in liquid transferring system with high-precision and high-stability sampling requirements, such as laboratory instrument, medical analysis equipment, chromatographic analyzer, automatic biochemical analyzer, blood analyzer, trace element analyzer, electrolytic analyzer, food & beverages detection and analysis system, water quality on-line analyzer, petroleum detection equipment and biopharmaceutical extraction devices.

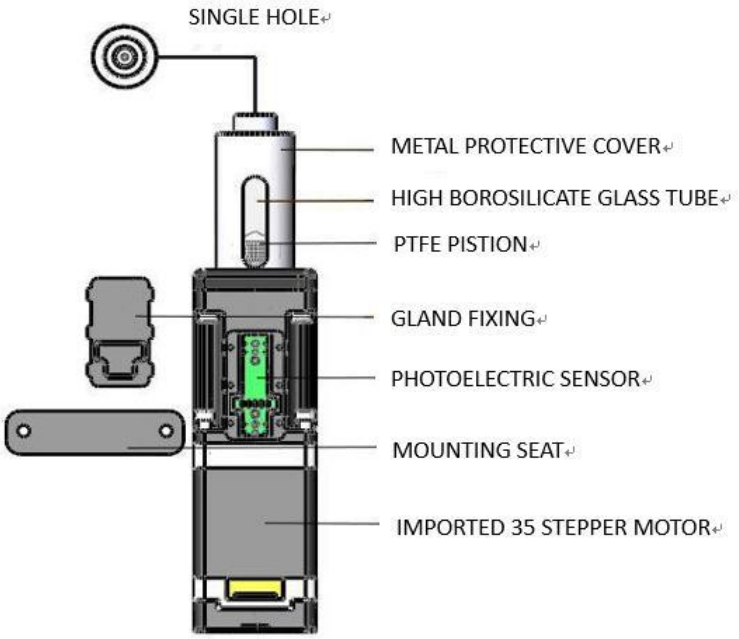
1.2 Naming Rules

Parameters are shown in the model name as below:

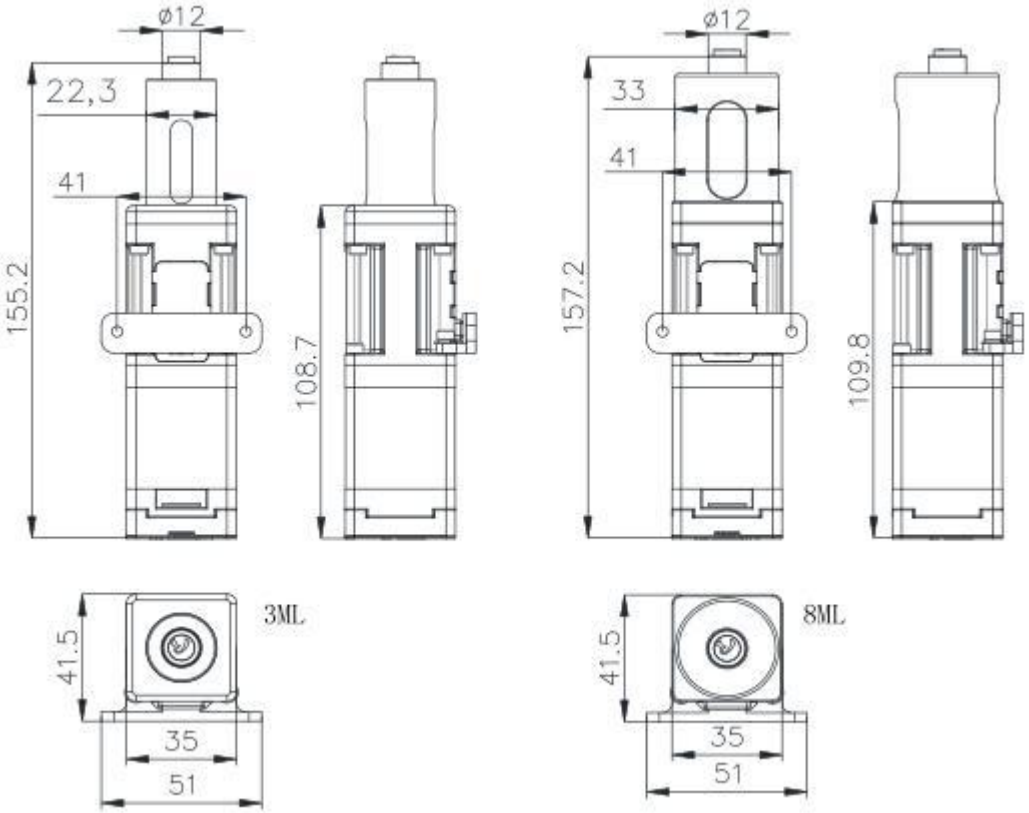


For example: the 3ml syringe pump, with 1.8° stepper motor, single hole, female thread and driver is named ZSB-LS-1.8-1-3-M-Q.

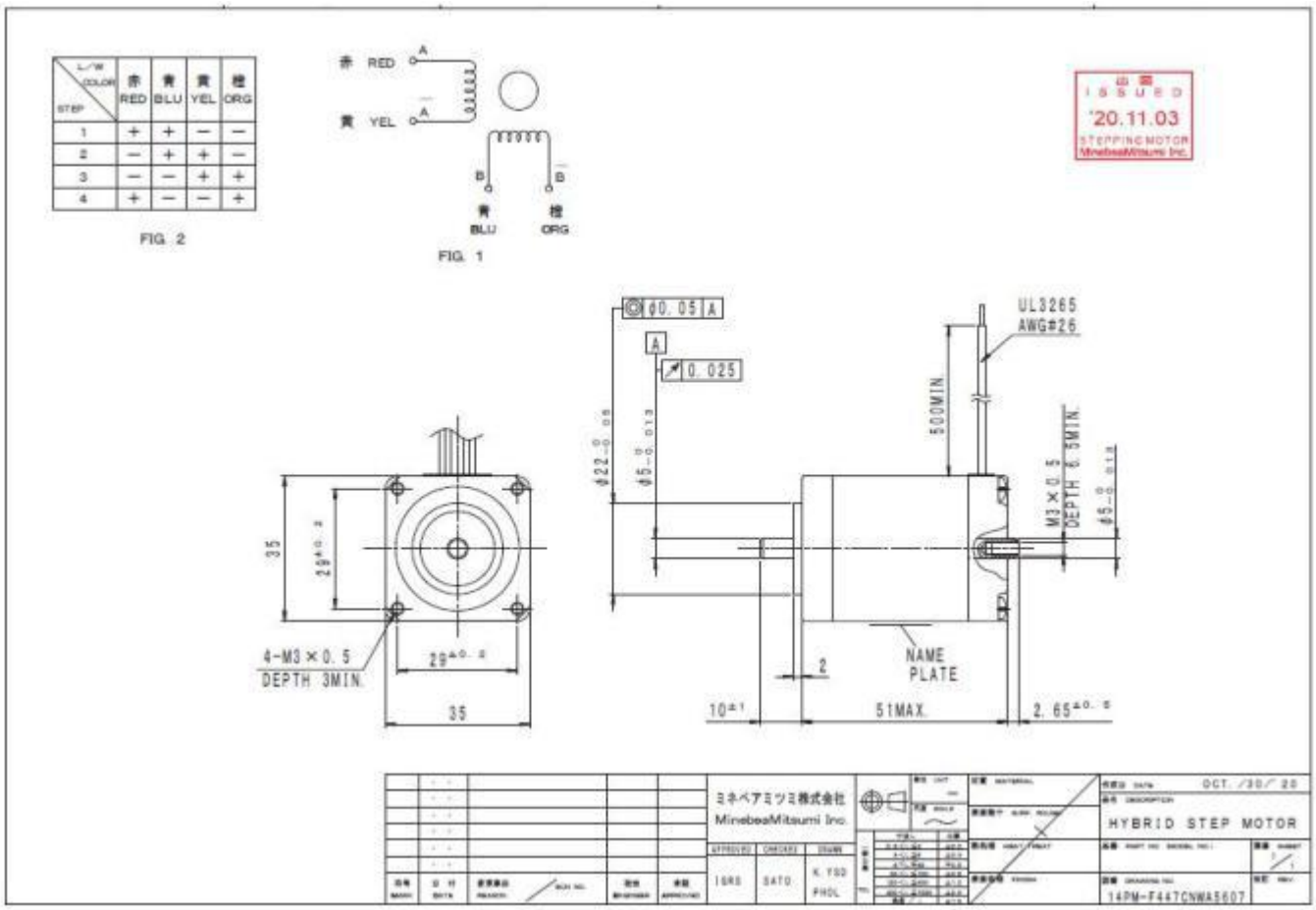
1.3 Structure Diagram



1.4 Dimension without Driver（Unit：mm）



1.5 Manual for NMB 35 Stepper Motor



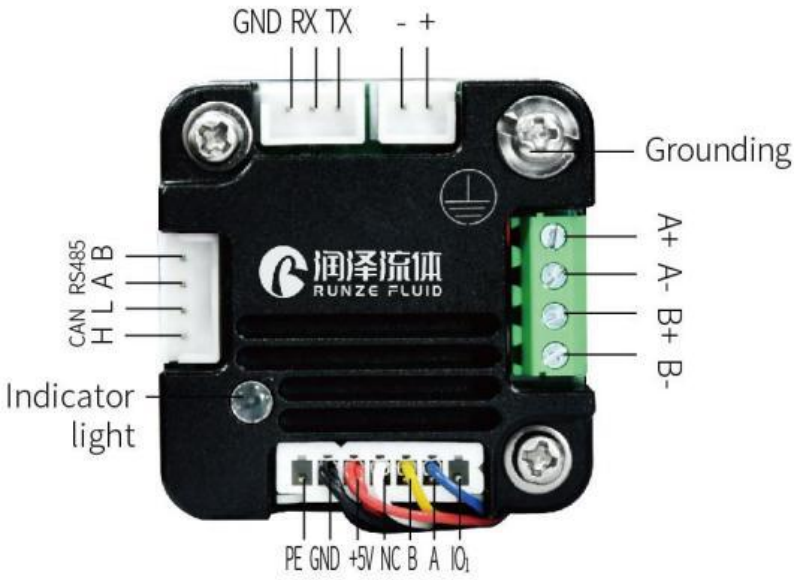
1.6 Basic Parameters

1.6.1 Technical Parameters

Product Function	Description	
Accuracy	≤1% (rated stroke)	
Precision (Repeatability)	0.3%-0.7% (rated stroke)	
Service life	3 million times no leakage (media: water; 1 rated stroke = one time)	
Volume	3 ml	8 ml
Rated stroke (Control steps)	18mm (3600 steps)	19.2mm (3840 steps)
Maximum speed	600rpm	300rpm
Linear speed	0.017~10mm/s	0.017~5mm/s
Running time (Per rated stroke)	1.8~1080s	3.84~1129s
Resolution	0.005mm/0.833μl	0.005mm/2.083μl
Syringe ID	14.55mm	23.03mm
Actuator	Trapezoidal screw (Lead 1mm)	
Wetted material	Borosilicate glass, PTFE piston、PCTFE	
Max. Pressure	Positive 0~0.8Mpa（retention time based on test） Negative 0~0.06Mpa（retention time based on test）	
Channel	Single channel	
Connection	1/4-28UNF	
Communication interface	RS232/RS485	
Baud rate	RS232/RS485：9600bps、38400bps	
Address & Parameter setting	Via communication	
Power supply	DC24V/3A	
Rated power	15W	
Operating temperature	5 ~ 55C°	
Operating humidity	≤80%（relative humidity, non-condensing）	
Dimension (L*W*H)	51*41.5*155.2	51*41.5*157.2
Weight	0.56kg	0.62kg

1.7 Port Definition

Diagram of the driver controller panel



Port definition for driver controller panel:

Port	Description	Port	Description
+	DC24V Positive	A+、A-	Stepper motor Phase A wiring
-	DC24V Negative	B+、B-	Stepper motor Phase B wiring
TX	RS232 Data input	IO1	IO1 Optocoupler signal
RX	RS232 Data output	A	Encoder Phase A
GND	RS232 Grounding	B	Encoder Phase B
H	CAN H	NC	Temporarily not enabled
L	CAN L	+5V	Power positive
A	RS485 A	GND	GND
B	RS485 B	PE	Grounding

Chapter 2 Software Communication

2.1 Address Settings

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 devices), four pumps (quad devices), or all 15 pumps (all devices). Each physical address in the address switch corresponds to a hexadecimal value, as shown in following table, Hexadecimal Addressing Scheme.

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

Table 2-1

For example, set the address switch of a SY09 device to 0, which corresponds to "31H" in the RS-232 or RS-485 communication protocol, hardware address 1 corresponds to "32H", and so on.

Table 2-2, Address Switch Settings in Hex (ASCII code), shows the different address switch settings of each of device.

Note: When using the pump: link software to send commands to a device, using the ASCII address values in Table 2-2.

Switch Setting	Single Device		Dual Device		Quad Device		Fifteen 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							

Figure 2-2 Address Switch Settings in Hex (ASCII)

The user can communicate with all pumps in the chain by using address 5F, for example, to initialize all pumps at once. After that, you can switch address 31 to 3F to realize the independent operation of a single pump.

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

2.2 Communication Protocols

Two communication protocols are available: :

- OEM communication protocol
- Data Terminal (DT) protocol

2.2.1 Data Terminal (OEM) Protocol

SY-09 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: SY-09 system 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 SY-09 detects either the OEM or DT protocol, it will ignore the other protocols until the next power cycle.

OEM Communication Protocol

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

As shown in Table 3-2, each setting of the OEM protocol is described in detail.

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 3-2 OEM Command

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 focus 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 these 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".

2.2.2 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 rate, 8 bits, and no parity.

Parameter	Setting
Character Format	
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	Newline(0Ah)

Table 3-2-2 DT Protocol

DT Protocol Command Block Characters

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

STX

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 more information about commands and response 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

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)/Newline (0AH to 0CH)

This character terminates the feedback block.

2.2.3 Using DT Protocol with Microsoft Windows

The communication protocol of SY09 can be directly set to DT protocol mode through Windows terminal.

To communicate with the SY09 using Windows , follow these steps:：

1．Connect the SY09 to the communication port of PC.

2．Start the SerialCommV1.3.0 application on the PC.

3．Select more serial port settings.

4．Select the communication port (such as COM1), the baud rate is 9600, 8 data bits, 1 stop bit, no parity, no flow control

5．Click OK and then click to open 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 SY09 Command Set" in this chapter.

2.3 Using the SY09 Command Set

2.3.1 Precautions for Command Execution

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
- The pump can accept a single command or string.

  For example:

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

  – A multi-command string such as [IA6000OA0R] moves the plunger to position 6000, 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.
- Once a command is executed, new commands are not accepted until the sequence is completed. Exceptions to this rule include T Terminate Command and Report command.
- 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. This instruction is not executed regardless of the error.
- The syringe should not run dry, otherwise it will damage the plunger seal.
- Keep your hand away from the narrow slit in the syringe during pump operation to avoid injury.

2.3.2 Pump Configuration Commands

SY-09 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, baud rate, gastight syringe reset stall current and device address.

N <n> Set Micro-step Mode Off/On

The [N] command enables or disables subdivisions (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/sec2.
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/sec2. Maximum cutoff frequency limited to 750 half-steps/sec; maximum on- the-fly set velocity limited to 750 half-steps/sec.
2	Subdivision mode /Micro-step mode: All positions set and reported in micro-steps; all speed settings in micro-steps/sec and all slopes in micro-steps/sec2.

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 (100 is the default),

and <n> = 0---6400 in fine positioning mode (800 is the default).

When the syringe drive motor to reverse 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 dispensing 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
200	Set the syringe reset stall current
300	Set device address

Table 3-5 Write Pump Configuration Command Values

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

2.4 Initialization

2.4.1 Initialization

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

The [k] command sets the number of increments that the plunger driver 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 modes (50 is the default)

n = 0···6400 in fine positioning and micro-step modes (400 is the default)

Under default initializations, the plunger moves upward until it contacts the top of the syringe, causing a forced stop. The plunger then moves downward, 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 [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

– WR

2.4.2 Initialization Command

W <n1> Initialize Plunger Drive

The [W] command initializes the plunger drive only (commonly used for valve-less pumps). Because the valve cannot be initialized, only plunger force and/or speed can be set. The default initialization speed is 1400 pulses per second.

n 1 = Set initialization plunger force/speed

The parameters are described below.

W Parameter	Value	Description
<n>	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.

2.4.3 z Simulation of the Plunger Initialization

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

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 to set the current position to 0, and the

pump must be reinitialized using the [W] commands to set the true zero position to protect the device.

2.5 Operating Commands

2.5.1 Plunger Movement Commands

A <n> Absolute Position

The [A] command moves the plunger to the absolute position <n>, where<n> = 0…7200/7680 in standard mode and 0…57600/61440 in fine positioning and micro-steps mode.

Command	<n> Parameter Value	Description
A	0-7200/7680	Absolute position in half increments (N=0)
	0-57600/61440	Absolute position in micro-steps (N=1)
	0-57600/61440	Absolute position in micro-steps (N=2)

For example:

– [A300R] moves the syringe plunger to position 300.

– [A6000R] moves the syringe plunger 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 plunger down the number of increments commanded. The new absolute position is the previous position plus <n>, where

<n> = 0…7200/7680 in standard mode and

<n> = 0…57600/61440 in fine positioning and micro-steps mode

Command	<n> Parameter Value	Description
P	0-7200/7680	Relative position in half increments (N=0)
	0-57600/61440	Relative position in micro-steps (N=1)
	0-57600/61440	Relative position in micro-steps (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 7200/7680.

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> 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…7200/7680 in standard mode and

<n> = 0…57600/61440 in fine positioning and micro-steps mode

Command	<n> Parameter Value	Description
D	0-7200/7680	Relative position in half increments (N=0)
	0-57600/61440	Relative position in micro-steps (N=1)
	0-57600/61440	Relative position in micro-steps (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.

2.5.2 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 dispensing 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 micro-steps 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/sec² are listed below.

Slope Code	Pulses/sec ² (KHz)	Slope Code	Pulses/sec² (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 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	1400	Set top speed in pulses/sec.

Note: According to the different specifications of the syringe, the value can be adjusted, 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.

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	130	46.15	369
25	120	50.00	400
26	110	54.55	436
27	100	60.00	480

28	90	66.67	533
29	80	75.00	600
30	70	85.71	686
31	60	100.00	800
32	50	120.00	960
33	40	150.00	1200
34	30	200.00	1600
35	20	300.00	2400
36	18	333.33	2667
37	16	375.00	3000
38	14	428.00	3429
39	12	500.00	4000
40	10	600.00	4800

Note: To achieve maximum stroke time of 24 minutes for N=0, N=1 or 192 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 dispensing move. During aspiration, [c] = [v]

2.5.3 Control Commands

R Execute Command

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

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 3-5, 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

Table 3-5 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 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 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 remaining string command.

J <n>External Control Output

The [J] command sets the TTL output lines.

The syntax for this command is:

[J<n>]

where <n> = 0…7 (0 is the default)

DB15 provides three external control 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

U200 Set Reset Stall Current

[U200] command sets the reset stall current

[U200<n>] where <n> = 1…31

U300<n> Set Device Address

[U300] command sets device address. This instruction cannot be queried after setting the address.

[U300, <n>] where <n>=1…15

2.5.4 Non-Volatile Memory (EEPROM)

The non-volatile memory in the SY09 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 to 14) can be loaded into the non-volatile memory. Each string can use up to 128 characters.

For example, [A3000A0R] requires 8 bytes.

Example Program String: [s8WS1gA3000A0GR]

Command Segment	Description
s8	Loads string into program 8 of non-volatile memory (Address switch position 8)
W	Initializes pump
S1	Sets plunger speed
g	Marks start of loop
A3000	Moves plunger 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 to Run in Non-Volatile Memory Auto Mode

The [U30] command sets the "Run in 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>.

where <n> = 0···E

U31 Clear Running in Non-Volatile Memory

The [U31] command clears the "Run in Non-Volatile Memory Auto Mode" flag in the E^2PROM 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:

[s1WgA3000A0G5e2R]

[s2gA3000gHD300G10GR]

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.

2.5.5 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 micro-steps [N1, N2].

? 1 Report Start Speed

The [?1] command reports the start speed in pulses/sec [50…1000]

? 2 Report Top Speed

The [?2] command reports the top speed in pulses/sec [5…12000]

? 3 Report Cutoff Speed

The [?3] command reports the cutoff speed in pulses/sec [50…5400]

? 4 Report Actual Position of Plunger

The [?4] command reports the plunger 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.

?13 Report Status of Auxiliary Input #1（DB15, Pin 7）

= low

= high

?14 Report Status of Auxiliary Input #2 (DB15, Pin 8)

= low

= 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.

? 24 Report the steps to reset the stall /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-steps).

? 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] Query conf file checksum, and the same specification of the product checksum must be exactly the same.

? 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

*** Query 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.

2.6 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).

2.6.1 Report Command

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.

2.6.2 Error Codes

Error codes describe problem conditions that may be detected in the SY-09 (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 SY09 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 SY09 Systems 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.
11 (0Bh)	Plunger Move Not Allowed. When the remaining value of the plunger is less than the value to be sent, the Plunger Movement commands are not allowed.
12 (0Ch)	Internal failure. If this error occurs, please call SY-09 Systems 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 SY09 Systems 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.

2.6.3 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

It means the "Plunger Overload" error (errors 9). If the pump returns a plunger 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 Errors

This is error 15, and it occurs if a Move command or Set command (except [V]) 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.

Note: 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	Status Byte
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	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 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)
[P6000P600R]	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"
[A6000t2000R]	Returns an invalid command error immediately. The pump status is "Not Busy."

A Communication Commands

Command Type	Command	Valid/Invalid
Initialization	W	Valid
Initialization	Z	Valid
Plunger Movement	A, a, P, p, D, d	Valid
Set	S, V, v, c, L, K, k	Valid
Command for Firmware micro-steps operation	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 stall current (1-31, default 5)	
	300= Set device address (1-15, default 1)	
K	0···.800 in full step mode (default 100)	Sets number of backlash increments.
	0...6400 in fine positioning mode (default 800)	

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…800 in standard mode (50 default)	Set zero gap (stall steps after reset)
	0…6400 in fine positioning or micro-step mode (400 default)	

B.3 Plunger Movement Commands / Status Bit Report

Command	Value of <n>	Description	Status
A <n>	0-7200/7680, 0-57600/61400 in fine positioning or micro-step mode	[A] Absolute Position	Busy
a <n>	0-7200/7680, 0-57600/61400 in fine positioning or micro-step mode	[a]Absolute Position	Ready
P <n>	0-7200/7680, 0-57600/61400 in fine positioning or micro-step mode	Relative [P]pickup	Busy
p <n>	0-7200/7680, 0-57600/61400 in fine positioning or micro-step mode	Relative [p]pickup	Ready
D <n>	0-7200/7680, 0-57600/61400 in fine positioning or micro-step mode	Relative [D]dispense	Busy
d <n>	0-7200/7680, 0-57600/61400 in fine positioning or micro-step mode	Relative [d]dispense	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 Command

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
?10 或 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
?20 或#	Report firmware checksum
?23 或&	Report firmware version
?24	Report number of backlash 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	Status Byte
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	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 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

Chapter 3 Technical Service

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