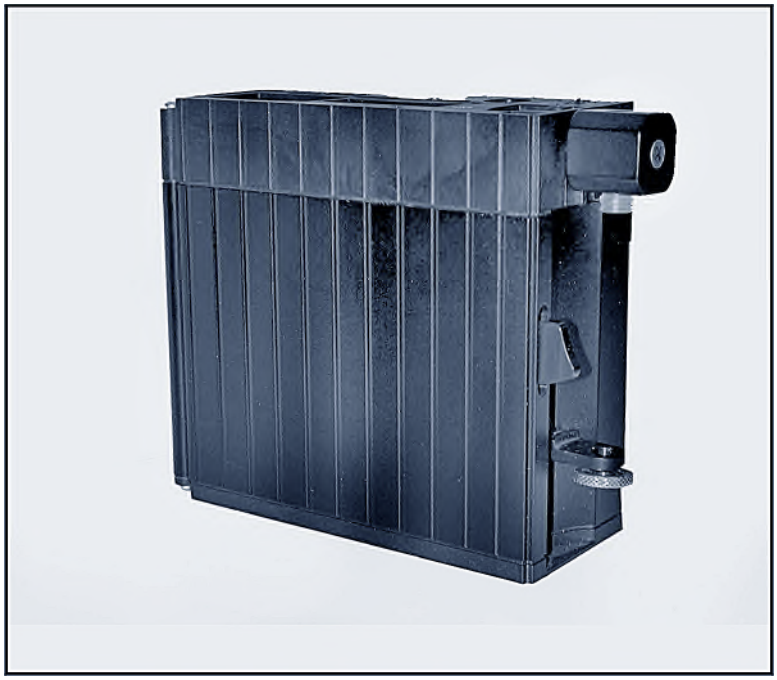
MICROLAB® PSD/3



User Guide

Part Number 7443-01 (Rev. A)

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HAMILTON

THE MEASURE OF EXCELLENCE℠

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Chapter 1 Introduction to the Hamilton PSD/3

Accurate and Precise
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Designed specifically for Original Equipment Manufacturers (OEMs), the compact PSD/3 performs all liquid handling operations including dispensing, serial dispensing and diluting. Operating on 24VDC, the PSD/3 can be used as a single syringe pump or connected together in series from a single serial port to form a bank of up to sixteen modules.

Accurate and Precise

A powder coated extruded aluminum housing provides a rigid platform for system components resulting in a reduction of overall system hysteresis. This combined with a self lubricating, wear compensating lead nut/screw and backlash eliminating firmware provide unsurpassed syringe plunger positioning. Achieve accuracy of better than 99% and precision of better than 99.8%. Each PSD/3 is provided with a N. I. S. T. traceable performance test report performed on that module, assuring outstanding accuracy and precision.

Easy Valve Replacement

The PSD/3 is available with or without a valve drive. The valve drive option allows easy replacement of Hamilton Company's inert HVI valves with a simple snap-in or snap-out movement. No tools are required.

Wide Selection of Syringes Available

A wide selection of Hamilton syringes are available for use with the PSD/3, from 5 µl to 12.5 ml.

Inert Fluid Path

The fluid contact surfaces of the PSD/3 are chemically inert materials, such as, PTFE, FEP, CTFE, and glass.

Auto-addressing

Auto-addressing is a standard feature on the PSD/3 when using Protocol 1/ RNO. Up to 16 modules can be auto addressed in a daisy chain.

Communication Protocols

Each module has a built-in RS232 connection allowing the use of either of Hamilton Company's communication protocols:

Protocol 1/RNO+ syntax
DIN Protocol/BDZ+ syntax

One TTL/IO port is available to signal or trigger an external device.

Clean Mounting

Pre-tapped mounting holes are located on the top and bottom of each module.

Turnkey System

For a total quality turnkey system, The PSD/3 can be combined with other Hamilton syringe and/or valve drives in a daisy chain from one serial port.

Chapter 2
PSD/3 Performance Specifications

Fluid Delivery Resolution

PSD/3 resolution:

Table 2-1. PSD/3 Syringe drive resolution

PSD3 Half Height Syringe Drive Resolution	
Software Resolution Mode	Increments for Full Stroke (30 mm)
Standard/Half (Default)	1000
Standard/Full	2000
High/Half	15,000
High Full	30,000

Fluid Delivery Accuracy and Precision (with Syringe)

The PSD/3 accuracy and precision:

Table 2-2. PSD3 accuracy and precision

PSD3 Half Height Accuracy & Precision (with Syringe)				
Syringe Size (ul)	Percent Stroke	Accuracy (±)	Precision	Balance[3]
5	10% ≤ Stroke < 20%	2.0%	2.0%	6
	20% ≤ Stroke < 40%	1.0%	1.0%	
	Stroke ≥ 40%	1.0%	0.5%	
12.5	8% ≤ Stroke < 20%	3.0%	1.0%	6
	20% ≤ Stroke < 80%	1.0%	0.4%	
	Stroke ≥ 80%	1.0%	0.2%	
25	20% ≤ Stroke < 40%	2.0%	2.0%	5
	40% ≤ Stroke < 80%	1.0%	1.0%	
	Stroke ≥ 80%	1.0%	0.5%	
50	10% ≤ Stroke < 20	2.0%	2.0%	5
	20% ≤ Stroke < 40%	1.0%	1.0%	
	Stroke ≥ 40%	1.0%	0.5%	
125	5% ≤ Stroke < 10%	1.6%	1.6%	5
	10% ≤ Stroke < 40%	1.0%	0.8%	
	Stroke ≥ 40%	1.0%	0.2%	

PSD3 Half Height Accuracy & Precision (with Syringe) (Continued)				
250	5% ≤ Stroke < 10%	1.2%	0.8%	5
	10% ≤ Stroke < 30	1.2%	0.5%	
	Stroke ≥ 30%	1.0%	0.2%	
500	1% ≤ Stroke < 5%	3.0%	2.0%	5
	5% ≤Stroke < 30%	1.2%	0.5%	
	Stroke ≥ 30%	1.0%	0.2%	
1.25 & larger	1% ≤ Stroke < 5%	3.0%	1.5%	5
	5% ≤ Stroke < 30%	1.2%	0.5%	
	Stroke ≥ 30%	1.0%	0.2%	

1) Reference Temperature: 21.5 ± 2.5^{O}C
2) Default Back-off & Return Steps are used.
3) Balance sensitivity requirement is given in terms of decimal places on a gram scale.

Fluid Delivery Speed

Syringe speeds range from 0.5 to 3600 seconds over a full stroke of 30 mm. The syringe speed is defined as the approximate time it takes the syringe plunger to travel full stroke.

Valve Drive Performance

Valve Drive Resolution

The valve drive resolution (minimum move increment) is 15 degrees.

Chapter 3
PSD/3 Set Up

PSD/3 Typical Layout

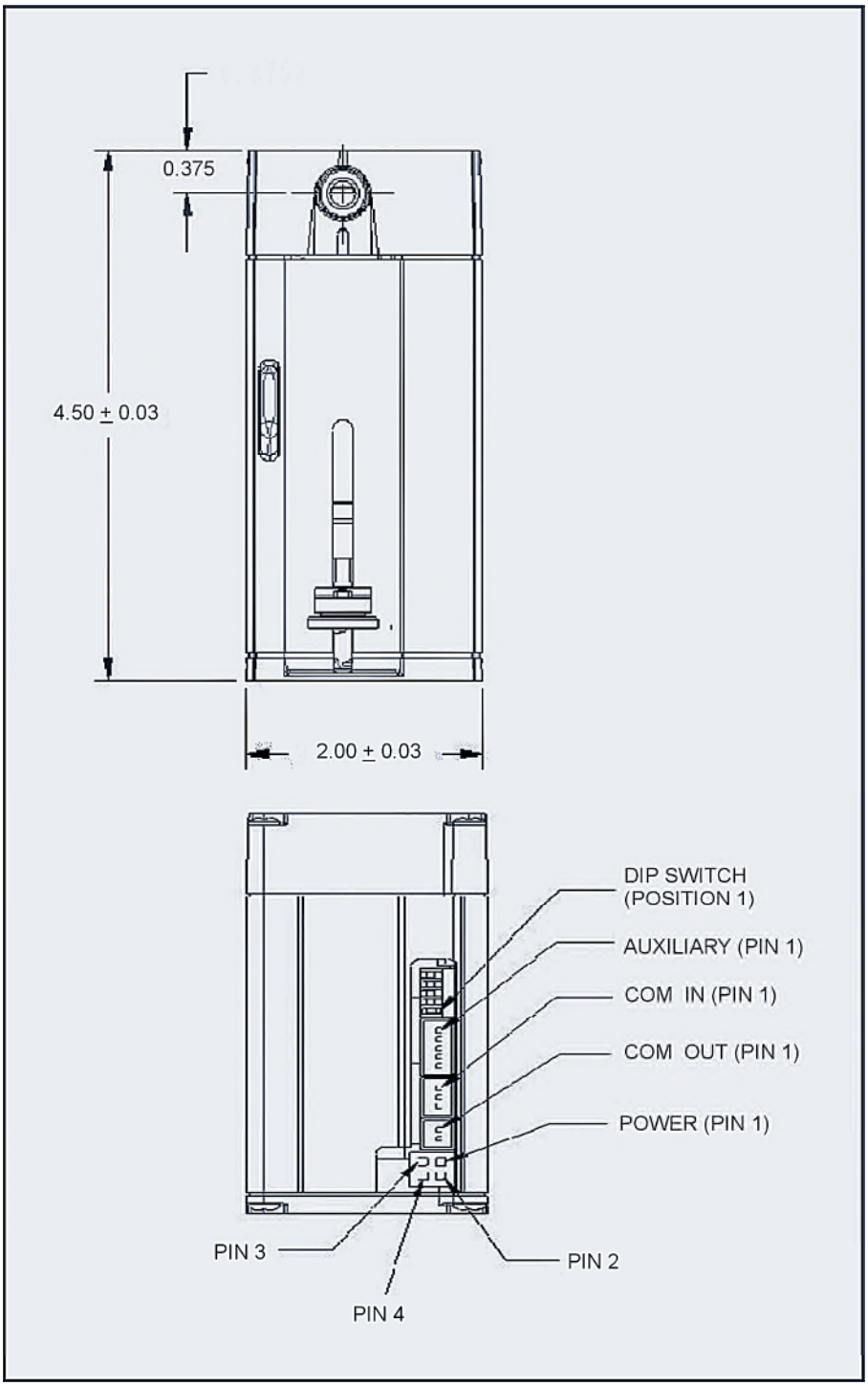


Figure 3-1: PSD/3 unit

Mounting the PSD/3

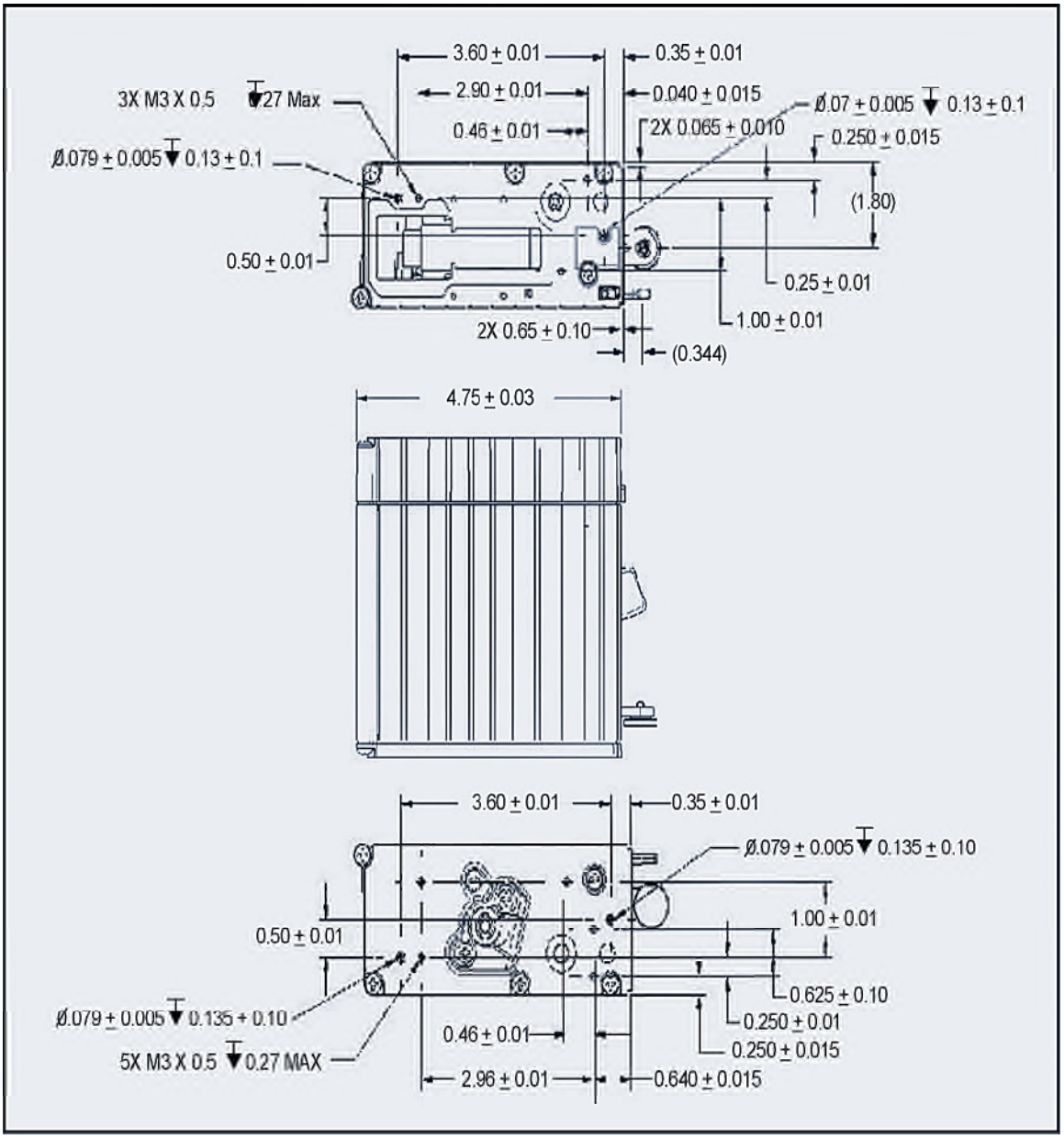


Figure 3-2: PSD/3 mounting holes

PSD/3 Power Requirements and Connector Information

The pump requires less than or equal to 2.0 A peak at 24.0 ± 1.2 VDC. Average continuous current is less than 1.0 A.

The power connector provides power, digital ground and chassis ground.

The power connector mates with Molex Series 5557 or compatible, 4 circuit, 2 x 2 x 0.165" dual row receptacle.

Table 3-1. Power Connector

Power Connector Pin Assignments	
Pin Number	Description
1	+ 24 VDC
2	Chassis Ground
3	Ground
4	Chassis Ground

PSD/3 Communication Connection Information

Com-In Connector

The com-in connector provides send, receive, and ground connection between the device and a computer or similar controlling device. The com-in connector is also used to connect to the com-out of another PSD/3 or Hamilton device in order to daisy chain multiple Hamilton devices on the same RS232 port.

The com-in connector mates with a Molex Series 70066, 70400, 70430G or compatible, 3 circuit, 3 x 0.100" receptacle.

Table 3-2. Com-In Connector

Com-In Connector Pin Assignments	
Pin Number	Description
1	Communication In Receive (RXD-IN)
2	Communication In Transmit (TXD-IN)
3	Ground

Com-Out Connector

The com-out connector is used to daisy chain multiple PSD/3s by connecting to the com-in of the next unit.

The com-out connector mates with a Molex Series 70066, 70400, 70430G or compatible, 2 circuit, 2 x .100" receptacle. Note that the power connector carries the signal ground.

Table 3-3. Com-Out Connector

Com-Out Connector Pin Assignments	
Pin Number	Description
1	Communication Out Transmit (TXD-OUT)
2	Communication Out Receive (RXD-OUT)

Auxiliary Connector

The auxiliary connector provides a switch input to activate the Step, Prime and Auxiliary operating functions, and provides a Digital Output.

The connector mates with a Molex Series 70066, 70400, 70430G or compatible, 5 circuit, 5 x 0.100" receptacle.

Table 3-4. Auxiliary Connector

Auxiliary Connector Pin Assignments	
Pin Number	Description
1	Auxiliary In
2	Prime
3	Step
4	Auxiliary Output
5	Ground

DIP Switch

A 5 position DIP switch provides loop back and DIN hardware addressing selection.

Position 1 is used to designate the last unit in a daisy chain. This switch is required to be open on units in the middle of the daisy chain. The switch is required to be closed on a single unit (no daisy chain), or on the last unit in a daisy chain.

Table 3-5. Dip Switch (Loop Back)

PSD/3 DIP Switch	
Loop Back (First position from bottom.)	
Position 1	Description
Open	Feed Thru (Mid Unit in Chain)
Close	Loop Back (Last Unit in Chain)

Positions 2-5 are used for protocol configuration. With all switches open or off, the unit is set to operate using Protocol 1. With the switches closed in a binary pattern, the unit will operate using the DIN Protocol.

Table 3-6. Dip Switch (Protocol)

PSD3 DIP Switch				
Protocol 1/DIN Select and DIN Address				
Position 2	Position 3	Position 4	Position 5	Address
Open	Open	Open	Open	Protocol 1
Close	Open	Open	Open	01
Open	Close	Open	Open	02
Close	Close	Open	Open	03
Open	Open	Close	Open	04
Close	Open	Close	Open	05
Open	Close	Close	Open	06
Close	Close	Close	Open	07
Open	Open	Open	Close	08
Close	Open	Open	Close	09
Open	Close	Open	Close	10
Close	Close	Open	Close	11
Open	Open	Close	Close	12
Close	Open	Close	Close	13
Open	Close	Close	Close	14
Close	Close	Close	Close	15

PSD3 communication configuration using Protocol 1 (typical daisy chain):

Table 3-7. Daisy Chain (Example)

Computer Serial Port (DB-9)			PSD/3 - Unit 'a'					PSD/3 - Unit 'b'					PSD/3 - Unit 'c'			
Des.	Pin		Pin	Description	Description	Pin		Pin	Description	Description	Pin		Pin	Description	Description	Pin
TXD	3	→	1	RXD-IN	TXD-OUT	1	→	1	RXD-IN	TXD-OUT	1	→	1	RXD-IN	TXD-OUT	NC
RXD	2	→	2	TXD-IN	RXD-OUT	2	→	2	TXD-IN	RXD-OUT	2	→	2	TXD-IN	RXD-OUT	NC
GND	5	→	3	GND	---	---	→	NC	GND	---	---	→	NC	GND	---	---
			DIP Switch: Loop Back OPEN					DIP Switch: Loop Back OPEN					DIP Switch: Loop Back CLOSED			

Chapter 4
Selecting, Installing, and Removing PSD/3 Hardware

Hamilton Valves

The PSD3 works with Hamilton snap-in HVI valves such as P/N 39298 (0.059" ports) and P/N 35825 (0.070" ports).

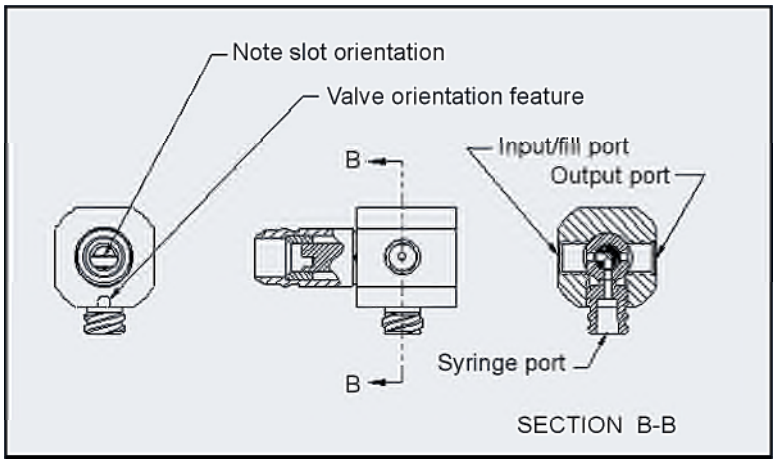


Figure 4-1: Typical Hamilton Snap-In, Snap-Out Valve

Selecting a Valve

(Please contact Technical Support)

Valve Installation and Removal

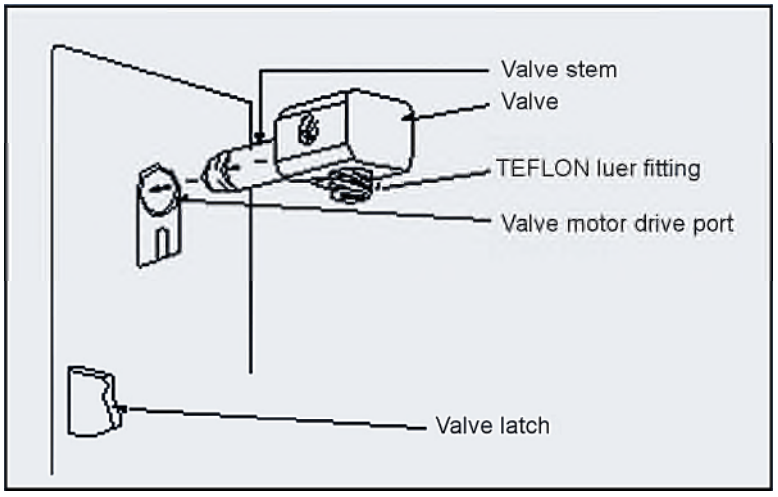


Figure 4-2: Valve installation and removal

Depress valve latch lever to install and remove valve.

Syringes for the PSD/3

Table 4-1 lists the Hamilton Company syringes that can be used on the PSD3:

Syringe module	Volume	TTL (stain-less steel plunger)	TTLX (w/ stop)	CX (w/stop)
1701.5	5 ul	NA	NA	5496-05
1702.5	12.5 ul	NA	5495-10	NA
1705.5	2.5 ul	NA	5495-15	NA
1710.5	50 ul	NA	5495-20	NA
1725.5	125 ul	NA	5495-25	NA
1750.5	250 ul	NA	5495-30	NA
1001.5	500 ul	NA	5495-35	NA
1002.5	1.25 ml	5495-40	NA	NA
1005.5	2.5 ml	5495-45	NA	NA
1010.5	5 ml	5495-50	NA	NA
1025.5	12.5 ml	5495-55	NA	NA
Note: NA = Not Available when printed				

Table 4-1. Syringes

Syringe Installation and Removal

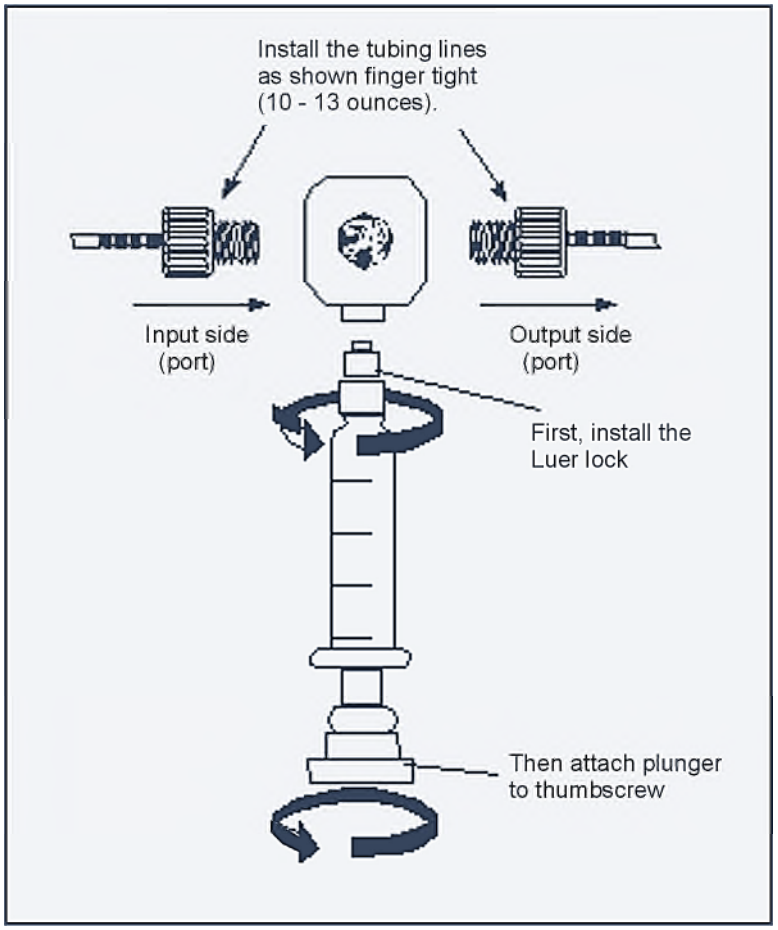


Figure 4-3: Syringe installation and removal

Tubing for the PSD/3

Selecting tubing or fittings

(Please contact Technical Support).

Chapter 5
Protocol Structure

Hamilton Protocol 1/RNO+ Syntax Overview

The Hamilton Protocol 1/RNO+ syntax is used to communicate with instruments (diluters, syringe modules, and valve positioners) designed and manufactured by Hamilton Company.

- Instruments are auto-addressed.

Data Format

Baud Rate:	9600
Parity:	Odd
Data bits:	7
Stop bits:	1

The Protocol 1/RNO+ syntax uses three basic control characters (table 5-1).

Notation	Name	ASCII code (decimal)	Description
<CR>	Carriage Return	13	A control character that terminates a data string.
<ACK>	Acknowledge	06	A control character transmitted by the instrument indicating an affirmative response to the controlling device.
<NAK>	Negative Acknowledge	21	A control character transmitted by the instrument indicating a non-affirmative response to the controlling device.

Table 5-1. Protocol 1/RNO+ Control Characters

Auto-addressing

Instruments configured to use the Protocol 1/RNO+ syntax are assigned their addresses by auto-addressing. Hardware addressing is not supported with this protocol.

The auto-address command should be the first sequence of characters transmitted to the instrument(s). Until the auto-address command is sent and addresses are assigned to the instrument(s), the instrument(s) will only respond to broadcast command strings.

Protocol 1/RNO+ instruments are auto-addressed using the following sequence:

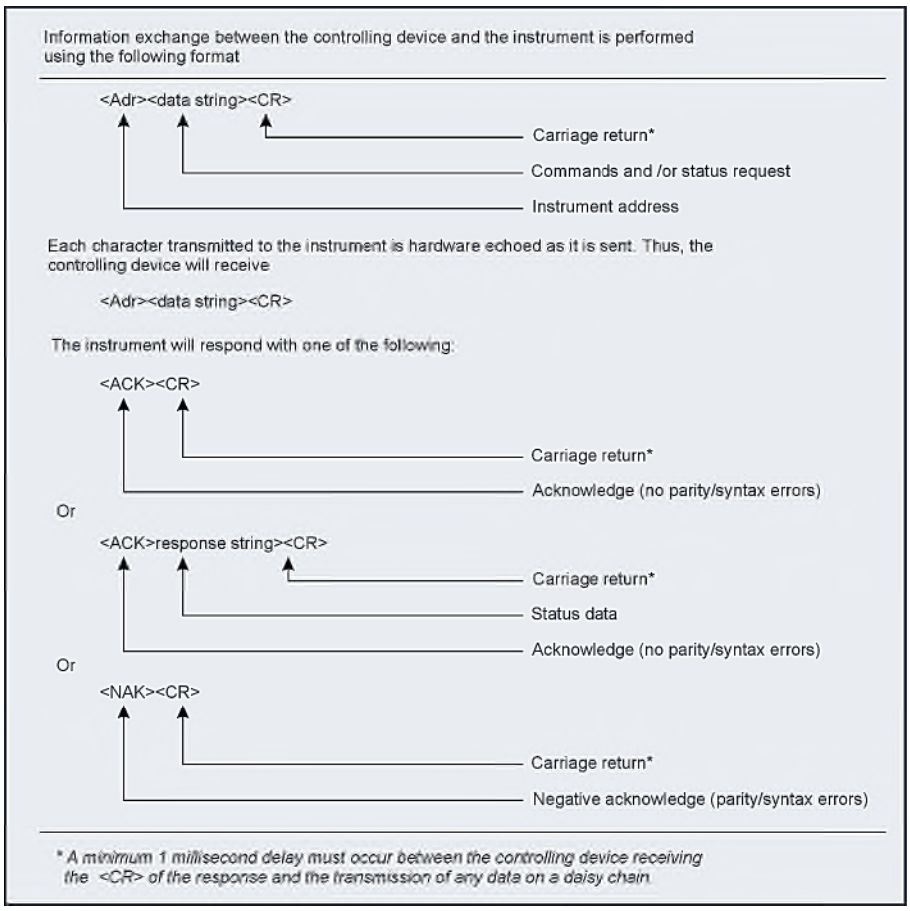
1a<CR>

will transmit the sequence 1b<CR> to the next instrument. The process of assigning the address received and transmitting the next address continues for all instruments in the daisy chain. The last instrument in the daisy chain responds to the controlling device with

1<last address + 1><CR>

EXAMPLE: Four instruments are on a daisy chain, and the controlling device transmits 1a<CR>. The controlling device will receive 1e<CR>, indicating that the instruments have been assigned addresses a, b, c, and d.

Data Transfer Format



Data String Components

A data string may contain one status request and/or one or more commands. Multiple status requests in a single data string should be avoided, as they are not explicitly supported. The instrument buffers the commands received until the execute command is received, at which time the commands are executed in the order received.

If a new command to a given device on the instrument is sent to the instrument before the execute command is sent, and if the instrument is unable to buffer any more commands for that device, the last command to that device will be replaced with the new command.

The instrument will ignore any new commands received for a given side of the instrument (with the exception of execution commands) while it is executing commands for that side.

A response string from the instrument contains the response to the status or parameter request sent from the controlling device.

Command Example #1: Auto-addressing the instrument

NOTE: The following example assumes a single instrument is on a daisy chain.

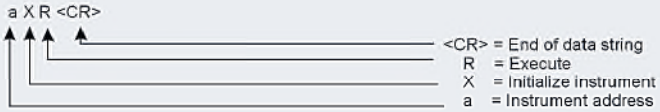
Controlling device transmits:

Controlling device receives:

Command Example #2: Initializing the instrument

NOTE: The following example assumes the instrument has already been auto-addressed as per the previous example.

Controlling device transmits:

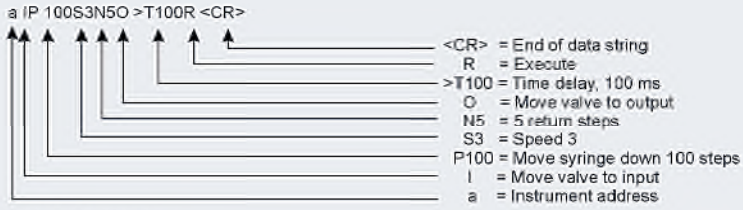


Controlling device receives:

Command Example #3: A complex command

NOTE: The following example assumes the instrument has already been auto-addressed and initialized as per the previous example.

Controlling device transmits:



Controlling device receives:

Command Example #4: A status or parameter request

NOTE: The following example assumes the instrument has already been auto-addressed as per the previous example. The response shown will vary depending upon the instrument model used.

Controlling device transmits:

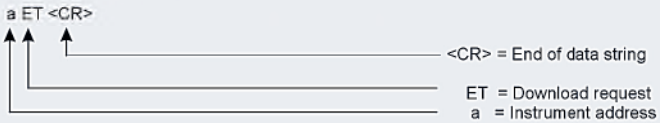
Controlling device receives:

Command Example #5: A Firmware Download Request

NOTE: The following example assumes the instrument is hardware addressed or has already been auto-addressed as per the previous example.

It is important to note that the firmware download request, as well as the actual firmware download itself, deviates from the standard Protocol 1/RNO+ protocol. The example given must be followed exactly in order to properly place the instrument in firmware download mode.

Controlling device transmits:



The instrument will not respond with either an ACK or a NAK for this command. After a delay of 100 milliseconds, the Download Protocol must be initiated.

DIN Protocol/BDZ+ Syntax Overview

The DIN Protocol/BDZ+ syntax is based on the DIN 66019 standard.

- Instruments are hardware or auto-addressed.

Data Format

Baud Rate:	9600
Parity:	Even
Data bits:	7
Stop bits:	2

The DIN Protocol/BDZ+ syntax uses six basic control characters (table 5-2).

Notation	Name	ASCII code (decimal)	Description
<STX>	Start of Text	02	A control character that indicates the beginning of a Data Block.
<ETX>	End of Text	03	A control character that indicates the end of a Data Block.
<EOT>	End of Transmission	04	A control character used to terminate a Data Transfer Session.
<ENQ>	Enquiry	05	A control character used to establish a Data Transfer Session.
<ACK>	Acknowledge	06	A control character transmitted by a receiving device indicating an affirmative response to the transmitting device.
<NAK>	Negative Acknowledge	21	A control character transmitted by a receiving device indicating a non-affirmative response to the transmitting device.

Table 5-2. DIN Protocol/BDZ+ Control Characters

Hardware Addressing

A unique address (01 through 16) must be set for each instrument on a daisy chain. Hamilton Company recommends the use of hardware addressing when using DIN Protocol/BDZ+.

Auto-Addressing

When auto-addressing is used with the DIN Protocol/BDZ+, a unique address is not required for each instrument on a daisy chain. If the addresses are not unique, however, then the auto-address sequence must be the first sequence of characters transmitted to the instruments. Failure to do so may cause communication errors.

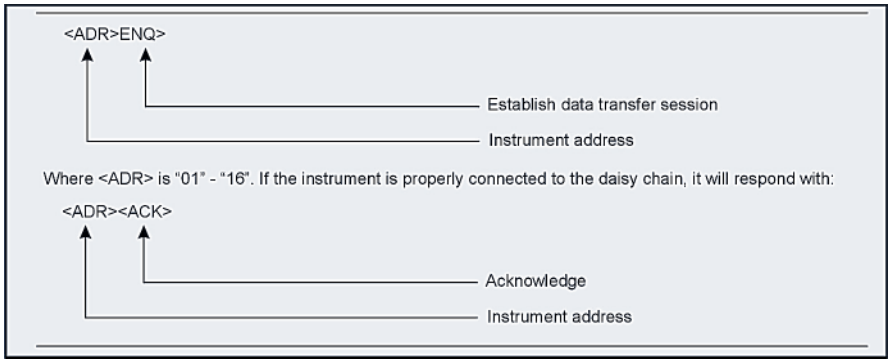
DIN Protocol/BDZ+ instruments are auto-addressed using the following sequence:

00<ENQ>	= Broadcast address all instruments
<STX>Y<ETX>%	= Prepare RS-232 for auto-addressing
<EOT>	= Terminate Data Transfer Session
!01<EOT>	= Auto-address starting from address 01

will transmit the sequence !02<EOT> to the next instrument. The process of saving the address received and transmitting the next address continues for all instruments in the daisy chain. The controlling device will NOT receive any indication as to the number of devices that have been auto-addressed.

Establishing a Data Transfer Session

Before a Data Transfer Session may take place between the controlling device and an instrument, the controlling device must first address the instrument. An instrument is addressed using the following sequence:



At this time, a Data Transfer Session may take place between the controlling device and the instrument.

Terminating a Data Transfer Session

The controlling device terminates a Data Transfer Session with the instrument(s) by transmitting an <EOT>. The instrument(s) will not acknowledge the reception of the <EOT>.

Data Transfer Session

The controlling device initiates a Data Transfer Session by transmitting a Data Block to the instrument. If a status request is sent to the instrument, the instrument will respond with a Data Block to the controlling device with the requested information. The controlling device may transmit as many or as few Data Blocks to the instrument as necessary, however, all Data Blocks from both the controlling device and the instrument must be completed before terminating the Data Transfer Session.

Data Block Format

Data is transmitted between the controlling device and the instrument in Data Blocks. Data Blocks may only be exchanged during Data Transfer Sessions. The format of a Data Block is as follows:

The receiver of a Data Block will reply with <ACK> if the Data Block was received with no communication errors and has a valid BCC. It will reply with a <NAK> otherwise.

The BCC (Block Control Character) is a 7-bit value used to detect errors in a Data Block. The BCC is the inverse of the result of Exclusive OR'ing (XOR) of all of the bytes in the data string and the <ETX>:

BCC = 0
BCC = BCC XOR <data string byte #1>
BCC = BCC XOR <data string byte #2>
...
BCC = BCC XOR <data string byte #n>
BCC = BCC XOR <ETX>
BCC = bit-wise inverse BCC
BCC = BCC truncated to 7-bits

For example, the BCC for the auto-address data block <STX>Y<ETX> is computed as:

BCC = 0

BCC = BCC XOR <ETX> (03 Hex), result is 5A Hex
BCC = Inverse BCC, result is A5 Hex

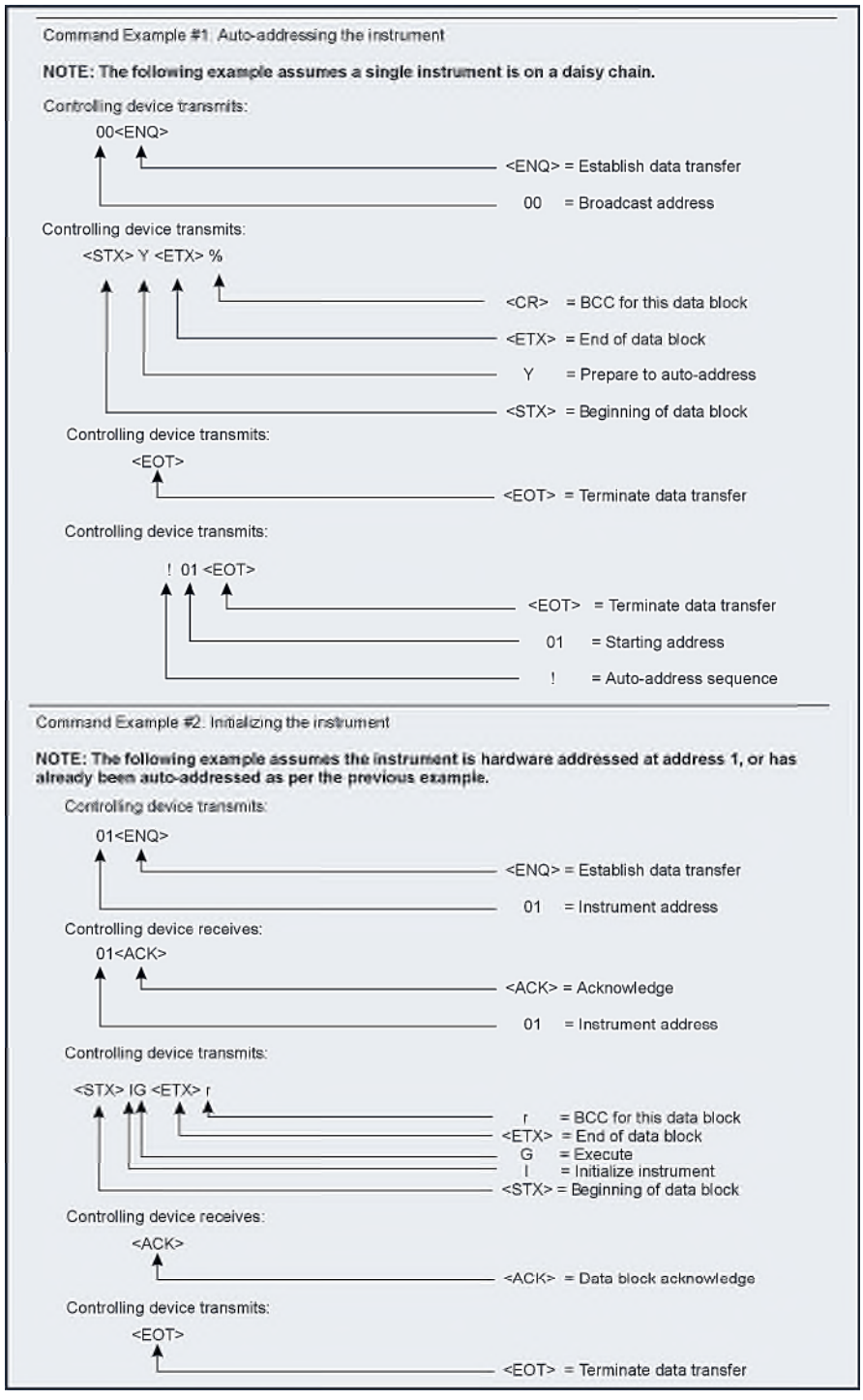
Data String Components

A data string from the controlling device may contain one status request and/or one or more commands. Multiple status requests in a single data string should be avoided, as they are not explicitly supported. The instrument buffers the commands received until the execute command is received, at which time the commands are executed in the order received.

If a new command to a given device on the instrument is sent to the instrument before the execute command is sent, and if the instrument has no more room to buffer that command, the last command to that device will be replaced with the new command.

The instrument will ignore any new commands received to devices on a given side of the instrument (with the exception of execution commands) while it is executing commands for that side from its buffer.

A data string from the instrument contains the response to the status or parameter request sent from the controlling device.


Command Example #1: Auto-addressing the instrument
NOTE: The following example assumes a single instrument is on a daisy chain.
Controlling device transmits:
00<ENQ>
<ENQ> = Establish data transfer
00 = Broadcast address
Controlling device transmits:
<STX> Y <ETX> %
<CR> = BCC for this data block
<ETX> = End of data block
Y = Prepare to auto-address
<STX> = Beginning of data block
Controlling device transmits:
<EOT>
<EOT> = Terminate data transfer
Controlling device transmits:
! 01 <EOT>
<EOT> = Terminate data transfer
01 = Starting address
! = Auto-address sequence
Command Example #2: Initializing the instrument
NOTE: The following example assumes the instrument is hardware addressed at address 1, or has already been auto-addressed as per the previous example.
Controlling device transmits:
01<ENQ>
<ENQ> = Establish data transfer
01 = Instrument address
Controlling device receives:
01<ACK>
<ACK> = Acknowledge
01 = Instrument address
Controlling device transmits:
<STX> IG <ETX> r
r = BCC for this data block
<ETX> = End of data block
G = Execute
I = Initialize instrument
<STX> = Beginning of data block
Controlling device receives:
<ACK>
<ACK> = Data block acknowledge
Controlling device transmits:
<EOT>
<EOT> = Terminate data transfer

Command Example #3: A complex command

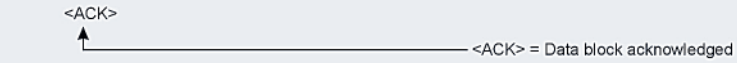
NOTE: The following example assumes the instruments is hardware addressed at address 1, or has already been auto-addressed as per the previous example, and has been initialized as per the previous examples.

Controlling device transmits:

Controlling device receives:

Controlling device transmits:

Controlling device receives:



Controlling device transmits:

Command Example #4: A status request

NOTE: The following example assumes the instruments is hardware addressed at address 1, or has already been auto-addressed as per the previous example. The response shown will vary depending upon the instrument mode used.

Controlling device transmits:

Controlling device receives:

Controlling device transmits:

Controlling device receives:

Controlling device transmits:

Broadcast Addressing

In addition to addressing a single unit on a daisy chain, both Protocol 1/RNO+ and DIN Protocol/BDZ+ allow all units on a daisy chain to be addressed at once using the broadcast address. Note, however, that the instrument(s) will NOT transmit protocol or status information when addressed with the broadcast address (to ensure no corruption of data on the serial line when multiple instruments attempt to transmit data at the same time).

Download Protocol Overview

The Hamilton Download Protocol is used to update the firmware on some small instruments designed and manufactured by Hamilton Company.

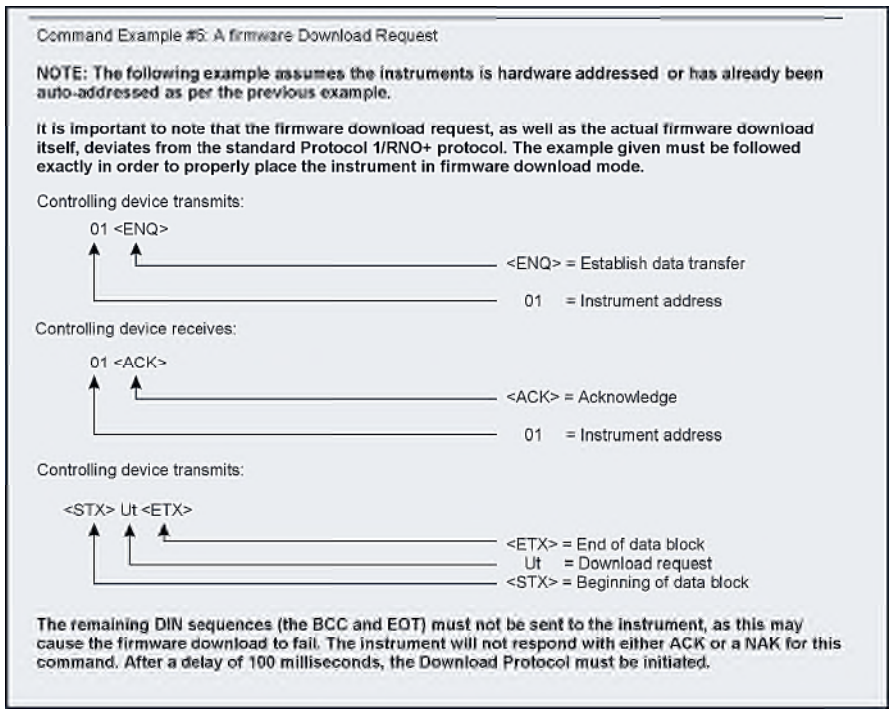
Data Format

Baud Rate:	9600
Parity:	Odd (not checked)
Data bits:	7
Stop bits:	1

The Download Protocol syntax uses two basic control characters (Refer to Table 5-3).

Notation	Name	ASCII code (decimal)	Description
<LF>	Line Feed	10	A control character that terminates a line.
<CR>	Carriage Return	13	A control character that terminates a data string.
<ACK>	Acknowledge	06	A control character transmitted by the instrument indicating an affirmative response to the controlling device.
<NAK>	Negative Acknowledge	21	A control character transmitted by the instrument indicating a non-affirmative response to the controlling device.

Table 5-3. Download Protocol Control Characters



Data Transfer Format

The firmware download file provided by Hamilton Company should be sent to the instrument exactly as is. The only exception allowed is that <CR><LF> pairs may be sent as a single <CR> character. The instrument will update its firmware as it receives the download data. The data sent to the instrument is not hardware echoed.

Upon successful reception of the entire firmware download file, the instrument will respond with an <ACK>. If for any reason the download fails, the instrument will response with a <NAK>. The instrument will reset itself upon completion (successful or not) of the download.

Stored Methods

This instrument is capable of storing only one method in non-volatile memory. Storing a method on an instrument allows the instrument to perform a specific sequence of operations without the intervention of a controlling device. The stored method must be entered into the instrument using RS-232 and the configured protocol.

Stored Method Definition

A stored method consists of a method environment (the instrument's environmental parameters for the method) and one or more sequentially executed functions. Each function is a copy of an instrument command buffer, thus it may contain any or all of the commands the instrument can buffer at one time. A function will be automatically executed if the execute command was included with the command string, otherwise the function will be executed after an external trigger.

Creating Stored Methods

Using the appropriate protocol commands for the instrument, perform the following steps:

1. Issue the Stored Method Parameter Change command with the parameter to erase all methods if this has not been done before.
2. Load the required environmental parameters into the instrument.
3. Issue the Stored Method Parameter Change command with the parameter to begin method download for the desired method number.
4. Enter the command strings in order of execution. All commands for a given function MUST be sent in the same data string, as each function is stored after the receipt of each data string.
5. Issue the Stored Method Parameter Change command with the parameter to end method download.
6. If the instrument can store more than one method, select the desired method.
7. Power the instrument OFF then ON to activate the method.

Stored Method Execution

The instrument's environmental parameters are overwritten by those for a given method when the method is selected. These parameters will stay in effect until a new method is selected.

Upon receipt of the first trigger command, the instrument will begin execution of the first function in the method. If the instrument was not previously initialized, the instrument will automatically initialize all devices before executing the first function. The instrument will continue to execute the functions in the method until the last function has completed. The instrument will then automatically restart the method beginning with the first function.

The status of the instrument may be monitored via the RS-232 line while a stored method is running. All status and execution control commands are recognized while a stored method is running.

Chapter 6
Protocol Command Summary

Channel Selection Commands
Initialization Commands
Syringe Positioning Commands
Valve Positioning Commands
Timer and Digital I/O Commands
Execution Commands
Instrument Control Commands
Syringe Parameter Change
Valve Parameter Change
Stored Method Parameter Change
Instrument Information Requests
Instrument Status Requests
Syringe Parameter Request
Valve Parameter Request
Timer and Digital I/O Requests
Firmware Version Request

This section provides detailed information on the two protocols supported by Hamilton Company: Protocol 1/RNO+ and DIN Protocol/BDZ+.

- Channel Selection commands
- Initialization Commands
- Syringe Positioning Commands
- Valve Positioning Commands
- Timer and Digital I/O Commands
- Execution commands
- Instrument Control Commands
- Syringe Parameter Change
- Valve Parameter Change
- Stored Method Parameter Change
- Instrument Information Requests
- Instrument Status Requests
- Syringe Parameter Request
- Valve Parameter Request
- Timer and Digital I/O Requests
- Firmware Version Request

Channel Selection Commands

Table 6-1. Channel Selection Commands

Protocol 1/RNO+		DIN Protocol/BDZ+		Description
Command	**Parameters**	**Command**	**Parameters**	
B		S	c0	Select left channel
C		S	c1	Select right channel

For instruments without dual valve or syringe capabilities, all devices are considered to be on the left (default) side. Commands attempted on the right side will result in an error.

If a channel selection command is not sent before a given command, the left (default) side is assumed as the target for commands and parameter change requests, and the instrument as a whole for status requests. Exceptions to this rule are noted after the given commands.

Initialization Commands

Table 6-2. Initialization Commands

Protocol 1/RNO+		DIN Protocol/BDZ+		Description
Command	**Parameters**	**Command**	**Parameters**	
X	Sxxxxx	I	jxxxxx	Initialize Instrument xxxxx = Initialization speed (see syringe mode) Initialization sequence: 1) Valve(s) to output position 2) Syringe(s) drive up until overload (bottomed out) 3) Valve(s) to input position 4) Syringe(s) back off backoff steps plus return steps 5) Syringe(s) drive up return steps
X1	Sxxxxx	I2	jxxxxx	Initialize Syringe(s) Only xxxxx = Initialization speed (see syringe mode)
X2	Sxxxxx	I3	jxxxxx	Initialize Syringe(s) Only xxxxx = Initialization speed (see syringe mode) If a syringe overloads before the top of the stroke, set the 'syringe position' error bit.
LX		I1		Initialize Valve(s) Only Initialization sequence: 1) Rotate valve(s) at least 395º 2) Stop valve(s) at the input position

If a channel has not been explicitly specified via one of the channel selection commands, the initialization commands will be performed on all sides available on the instrument.

If a speed is specified with DIN Protocol/BDZ+, that speed will become the default for the syringe(s) specified.

The instrument will not execute any initialization commands until an execute command or an external trigger is received.

Syringe Positioning Commands

Table 6-3. Syringe Positioning Commands

Protocol 1/RNO+		DIN Protocol/BDZ+		Description
Command	**Parameters**	**Command**	**Parameters**	
Pxxxxx Snnnnn Nr		P 	pxxxxx ennnnn cr	Syringe Pickup xxxxx = Syringe steps (see syringe mode) nnnnn = Syringe drive speed (see syringe mode) r = return steps (0-9)
Dxxxxx	Snnnnn	D	dxxxxx fnnnnn	Syringe Dispense xxxxx = Syringe steps (see syringe mode) nnnnn = Syringe drive speed (see syringe mode)
Mxxxxx Snnnnn Nr		M 	mxxxxx xnnnnn cr	Syringe Absolute Move xxxxx = Syringe steps (see syringe mode) nnnnn = Syringe drive speed (see syringe mode) r = return steps (0-9)

If a speed is specified with DIN Protocol/BDZ+, that speed will become the default for the syringe(s) specified.

If return steps are specified with DIN Protocol/BDZ+, that number of return steps will become the default for the syringe(s) specified.

The instrument will not execute any syringe positioning commands until an execute command or an external trigger is received.

Valve Positioning Commands

Table 6-4. Valve Positioning Commands

Protocol 1/RNO+		DIN Protocol/BDZ+		Description
Command	**Parameters**	**Command**	**Parameters**	
I				Valve to Input Position (position 1)
O				Valve to Output Position (position 4)
W				Valve to Wash Position (position 3)
LPdpp Adaaa		V	vd npp waaa	Valve Positioning d = direction (0 = CW, 1 = CCW) pp = valve position (1-8) aaa = valve angle in absolute angles from 0º in 15º increments

The instrument will not execute any valve positioning commands until an execute command or an external trigger is received.

Timer and Digital I/O Commands

Table 6-5. Timer and Digital I/O Commands

Protocol 1/RNO+		DIN Protocol/BDZ+		Description
Command	**Parameters**	**Command**	**Parameters**	
>Dxxx		S	dxxx	TTL Data Output xxx = TTL data (decimal)
>Txxxxx		S	txxxxx	Timer Delay xxxx = delay time in milliseconds (0-65535)

There is a maximum of one Digital I/O device on system, however, it may be accessed with all valid channel selections.

The instrument will not execute any timer or digital I/O commands until an execute command or an external trigger is received.

Execution Commands

Table 6-6. Execution Commands

Protocol 1/RNO+		DIN Protocol/BDZ+		Description
Command	**Parameters**	**Command**	**Parameters**	
R	1wxyz	G	gwxyz	Execute Command Selective Execute Command wxyz = 4 bytes of ASCII data: Bit: 7 6 5 4 3 2 1 0 w = 0 1 0 0 16 15 14 13 x = 0 1 0 0 12 11 10 9 y = 0 1 0 0 8 7 6 5 z = 0 1 0 0 4 3 2 1 Numbers 1-16 refer to the instrument number on the daisy chain 1 = Execute command 0 = No operation
K		U	k	Halt execution of commands
$		U	r	Resume execution of commands
v		U	c	Clear all buffered commands

If a channel has not been explicitly specified via one of the channel selection commands, the execution commands will be performed on all sides available on the instrument.

The execute command informs the instrument to execute all buffered commands (initialization, syringe positioning, valve positioning, or timer and digital I/O commands).

Instrument Control Commands

Table 6-7. Instrument Control Commands

Protocol 1/RNO+		DIN Protocol/BDZ+		Description
Command	**Parameters**	**Command**	**Parameters**	
!		R		Total System Reset
		Y		Prepare RS-232 for auto-addressing if this command sent via a broadcast address
ET		U	t	Perform instrument diagnostic

These commands are not effected by channel selection commands.

Syringe Parameter Change

Table 6-8. Syringe Parameter Change

Protocol 1/RNO+		DIN Protocol/BDZ+		Description
Command	**Parameters**	**Command**	**Parameters**	
YSBxx		S	bxx	Set default backoff steps xx = steps (0-99)
YSNx				Set default return steps x = return steps (0-9)
YSSxxxxx				Set syringe default speed xxxxx = Syringe drive speed (see syringe mode)
YSVxxxxx		S	fxxxxx	xxxxx = Syringe drive speed (see syringe mode)
YSMxx		S	mxx	Set syringe mode xx = Syringe mode in decimal Bit definition for byte x: 0: 0 = Half resolution 1 = Full resolution 1: 0 = Normal operation 2 = Full resolution with overload detection disabled 2: 0 = Standard resolution (1000 steps in Half resolution mode, 2000 steps in Full resolution mode) 1 = High resolution (15000 steps in Half resolution mode, 30000 steps in Full resolution mode 3: 0 = Standard speed mode 1 = Extended speed mode 4: 0 = Speed X 0.1 mode in extended speed mode 1 = Speed X 0.01 mode in extended speed mode Examples: 4 = 15000 step mode 5 = 30000 step mode 8 = Speed X 0.1 mode (e.g. 105 = speed 10.5 in seconds per full stroke) 24 = Speed X 0.01 mode (e.g. 105 = speed 1.05 in seconds per full stroke) 29 = 30000 step and speed X 0.01 mode

Syringe return steps are used to compensate for the mechanical drive system backlash, which improves accuracy and precision. Return steps are added to all downward movements, which are then subtracted by an upward movement immediately following the downward movement.

Syringe backoff steps are used to improve accuracy and precision by adjusting the zero position of the drive a small distance away from the initialization overload point.

Valve Parameter Change

Table 6-9. Valve Parameter Change

Protocol 1/RNO+		DIN Protocol/BDZ+		Description
Command	**Parameters**	**Command**	**Parameters**	
LSTx		S	vx	Set Valve Configuration x = Valve type (1-7) 1 = 4 ports at -90º 2 = 8 ports at 45º 3 = 6 ports at 60º 4 = 3 ports at 90º 5 = 2 ports at 180º 6 = 2 ports at 90 7 = 4 ports at 90º
LSFx		S	zx	Set Valve Speed x = Valve speed (0-9) Note: It is recommended to use the default valve speed.

Stored Method Parameter Change

Table 6-10. Stored Method Parameter Change

Protocol 1/RNO+		DIN Protocol/BDZ+		Description
Command	**Parameters**	**Command**	**Parameters**	
#SPxx		S	exx	Set Stored Method mode xx = Mode

This command is not effected by channel selection commands.

Instrument Information Requests

Table 6-11. Instrument Information Requests

Protocol 1/RNO+		DIN Protocol/BDZ+		Description
Request	**Answer**	**Request**	**Answer**	
F	x			Instrument done request x = Instrument status Y = Instrument is idle and command buffer is empty N = Instrument is idle and command buffer is not empty * = Instrument is busy
Z	x			Syringe error request x = Syringe status Y = Syringe overload or initialization error N = No syringe error * = Instrument is busy
G	x			Valve error request x = Valve status Y = Valve overload or initialization error N = No valve error * = Instrument is busy
H	x			Instrument configuration x = Instrument configuration Y= 1 valve, 1 syringe N = Not 1 valve, 1 syringe * = Instrument is busy
J	x			Instrument configuration x = Instrument configuration Y= 1 valve, 2 syringe N = Not 1 valve, 2 syringe * = Instrument is busy
Q	x			Hand/Foot switch status x = Switch status Y= Switch pressed N = Switch not pressed * = Instrument is busy

Instrument Status Requests

Table 6-12. Instrument Status Requests

Protocol 1/RNO+		DIN Protocol/BDZ+		Description
Request	**Answer**	**Request**	**Answer**	
E1	x	Q	Qx	Instrument Status Request x = Instrument status byte Bit definition for byte x: 0: Instrument idle, command buffer is not empty 1: Syringe drive(s) busy 2: Valve drive(s) busy 3: Syntax Error 4: Instrument Error (valve or syringe error) 5: Always 0 6: Always 1 7: Always 0 Bit = 1, condition is TRUE Bit = 0, condition is FALSE Instrument Error bit is reset after an Instrument Error Request. Syntax Error bit is reset after the response is sent.

Protocol 1/RNO+		DIN Protocol/BDZ+		Description
Request	**Answer**	**Request**	**Answer**	
E2	abcd	Xi	Xiabcd	Instrument Error Request abcd = Instrument error bytes Bit definition for byte a, left syringe error(s): 0: Not initialized 1: Overload error 2: Stroke too large 3: Position error 4: Non-existent 5: Always 0 6: Always 1 7: Always 0 Bit definition for byte b, left valve error(s): 0: Not initialized 1: Initialization error 2: Overload error 3: Always 0 4: Non-existent 5: Always 0 6: Always 1 7: Always 0 Bit definition for byte c, right syringe error(s): 0: Not initialized 1: Overload error 2: Stroke too large 3: Position error 4: Non-existent 5: Always 0 6: Always 1 7: Always 0 Bit definition for byte d, right valve error(s): 0: Not initialized 1: Initialization error 2: Overload error 3: Always 0 4: Non-existent 5: Always 0 6: Always 1 7: Always 0 Bit = 1, condition is TRUE Bit = 0, condition is FALSE For instruments with a single valve and/or syringe, the valve and/or syringe is considered to be on the left side. The right side valve and/or syringe is considered to not exist.

Protocol 1/RNO+		DIN Protocol/BDZ+		Description
Request	**Answer**	**Request**	**Answer**	
		E	Eab	Instrument Error Request ab = Instrument error bytes Bit definition for byte a, syringe(s) error(s): 0: Not initialized 1: Overload error 2: Stroke too large 3: Position error 4: Non-existent 5: Always 0 6: Always 1 7: Always 0 Bit definition for byte b, valve(s) error(s): 0: Not initialized 1: Initialization error 2: Overload error 3: Always 0 4: Non-existent 5: Always 0 6: Always 1 7: Always 0 Bit = 1, condition is TRUE Bit = 0, condition is FALSE
		C	Cx	Instrument Configuration x = Configuration byte Bit definition for byte x: 0: Always 0 1: Valve drive available 2: Syringe drive available 3: Self test active 4: Always 0 5: Always 0 6: Always 1 7: Always 0 Bit = 1, condition is TRUE Bit = 0, condition is FALSE

Protocol 1/RNO+		DIN Protocol/BDZ+		Description
Request	**Answer**	**Request**	**Answer**	
E3	x	Xs	Xsx	Instrument Device Status x = Device status byte Bit definition for byte x: 0: Timer(s) busy 1: Self test busy 2: Stored method busy 3: IIC Error 4: Over temperature error 5: Always 0 6: Always 1 7: Always 0 Bit = 1, condition is TRUE Bit = 0, condition is FALSE
E4				Instrument Sensor Status x = Sensor status bytes Bit definition for byte a: 0: Left syringe encoder A 1: Left syringe encoder B 2: Left valve encoder 3: Always 0 4: Always 0 5: Always 0 6: Always 1 7: Always 0 Bit definition for byte b: 0: Right syringe encoder A 1: Right syringe encoder B 2: Right valve encoder 3: Always 0 4: Always 0 5: Always 0 6: Always 1 7: Always 0 For instruments with a single valve and/or syringe, the valve and/or syringe is considered to be on the left side. The right side valve and/or syringe sensor values are undefined.

Protocol 1/RNO+		DIN Protocol/BDZ+		Description
Request	**Answer**	**Request**	**Answer**	
T1	x	Xb	Xbx	Instrument Busy Status x = Busy status byte Bit definition for byte x: 0: Left valve busy 1: Left syringe busy 2: Right valve busy 3: Right syringe busy 4: Prime/Step active 5: Hand/Foot switch active 6: Always 1 7: Always 0 Protocol 1/RNO+: Bit = 0, condition is TRUE Bit = 1, condition is FALSE DIN Protocol/BDZ+: Bit = 1, condition is TRUE Bit = 0, condition is FALSE For instruments with a single valve and/or syringe, the valve and/or syringe is considered to be on the left side. The right side valve and/or syringe busy status is always FALSE.
T2	x			Instrument Error Status x = Error status byte Bit definition for byte x: 0: Left valve error 1: Left syringe error 2: Right valve error 3: Right syringe error 4: Always 0 5: Always 0 6: Always 1 7: Always 0 Bit = 0, condition is TRUE Bit = 1, condition is FALSE For instruments with a single valve and/or syringe, the valve and/or syringe is considered to be on the left side. The right side valve and/or syringe error status is always FALSE.

These commands are not effected by channel selection commands.

Syringe Parameter Request

Table 6-13. Syringe Parameter Request

Protocol 1/RNO+		DIN Protocol/BDZ+		Description
Request	**Answer**	**Request**	**Answer**	
YQS	xxxxx			Syringe default speed xxxxx = Syringe drive speed (see syringe mode)
YQN	x			Syringe default return steps x = return steps (0-9)
YQP	xxxxx	Ay	Ayxxxxx	Syringe position xxxxx = Syringe steps (see syringe mode)
YQE	xxxxx	An	Anxxxxx	Syringe encoder position xxxxx = Syringe encoder steps (see syringe mode)
YQM	xx	Am	Amxx	Syringe mode xx = Syringe mode in decimal Bit definition for byte x: 0: 0 = Half resolution 1 = Full resolution 1: 0 = Normal operation 2 = Full resolution with overload detection disabled 2: 0 = Standard resolution (1000 steps in Half resolution mode, 2000 steps in Full resolution mode) 1 = High resolution (15000 steps in Half resolution mode, 30000 steps in Full resolution mode) 3: 0 = Standard speed mode 1 = Extended speed mode 4: 0 = Speed X 0.1 mode in extended speed mode 1 = Speed X 0.01 mode in extended speed mode Examples: 4 = 15000 step mode 5 = 30000 step mode 8 = Speed X 0.1 mode (e.g. 105 = speed 10.5 in seconds per full stroke) 24 = Speed X 0.01 mode (e.g. 105 = speed 1.05 in seconds per full stroke) 29 = 30000 step and speed X 0.01 mode

Protocol 1/RNO+		DIN Protocol/BDZ+		Description
Request	Answer	Request	Answer	
YQB	xx	Ab	Abxx	Syringe default backoff steps xx = backoff steps (0-99)

Valve Parameter Request

Table 6-14. Valve Parameter Request

Protocol 1/RNO+		DIN Protocol/BDZ+		Description
Request	**Answer**	**Request**	**Answer**	
LQP	xx	Ap	Apxx	Valve position xx = valve position (1-8)
LQA	xxx	Aa	Aaxxx	Valve angle xxx = valve angle (0-345)
LQT	x	Av	Avx	Valve Configuration x = Valve type (1-7) 1 = 4 ports at -90º 2 = 8 ports at 45º 3 = 6 ports at 60º 4 = 3 ports at 90º 5 = 2 ports at 180º 6 = 2 ports at 90º 7 = 4 ports at 90º
LQF	x	Az	Azx	Valve Speed x = Valve speed (0-9)

Timer and Digital I/O Requests

Table 6-15. Timer and Digital I/O Requests

Protocol 1/RNO+		DIN Protocol/BDZ+		Description
Request	**Answer**	**Request**	**Answer**	
<D	xxx	Ad	Adxxx	TTL Data Input xxx = TTL data (decimal)
<T	xxxx	At	Atxxxxx	Timer Delay Value xxxxx = current delay time in milliseconds (0-65535)

There is a maximum of one Digital I/O device on a system, however, it may be accessed with all valid channel selections.

Firmware Version Request

Table 6-16. Firmware Version Request

Protocol 1/RNO+		DIN Protocol/BDZ+		Description
Request	**Answer**	**Request**	**Answer**	
U	xxii.jj.k	F	FXXii.jj.k	Firmware Version Request XX = Product Identifier ii = Major version (01-99) jj = Minor version (01-99) k = Revision (A-Z) Product Identifiers/Version AV07 = ML900, original AV08 = ML900, PSD/2 valve AV09 = ML900, ML900 valve BV01 = ML500A, original BV02 = ML500A, current CV01 = ML500B and ML500C DV01 = ML500C, OEM OM01 = PSD/2 OM02 = PSD3 MV = MVP

This command is not effected by channel selection commands.

Chapter 7
PSD/3 Product Specific Details

PSD/3 Default Environmental Parameters
PSD/3 Command Buffer
PSD/3 Methods
PSD/3 Specific Protocol Information
- Perform Instrument Diagnostic (RNO+ 'ET', BDZ+ 'Ut')
- Set Stored Method mode (RNO+ '#SP', BDZ+ 'Se')
- Digital I/O Command (RNO+ '>D', BDZ+ 'Sd')
- Digital I/O Request (RNO+ '<D', BDZ+ 'Ad')
- Instrument Device Status (RNO+ 'E3', BDZ+ 'Xs')
- Instrument Valve Speed (RNO+ 'LSF', 'LQF', BDZ+ 'Sz', 'Az')
- Return steps (various RNO+ and BDZ+)
- PSD/3 Diagnostic LED codes

PSD/3 Default Environmental Parameters

The PSD/3 default environmental parameters:

Syringe mode:	0
Syringe speed:	4
Syringe return steps:	3 (60 mm stroke), 6 (30 mm stroke)
Syringe backoff steps:	15 (60 mm stroke), 30 (30 mm stroke)
Left valve type:	7
Right valve type:	1
Valve speed:	3 (60 RPM)

This instrument supports syringe speeds in the range from 1 to 65000, 0.1 to 6500, and 0.01 to 650 seconds per full stroke, depending on the syringe mode

PSD/3 Command Buffer

The PSD/3 can buffer the following commands for execution on both the left and right side:

- 2 valve commands
- 1 syringe command
- 1 timer delay command
- 1 digital output command

PSD/3 Methods

The PSD/3 stores a single method of 63 functions into non-volatile memory. The PSD/3 will automatically select the stored method after the method has been downloaded and after power-up.

PSD/3 Specific Protocol Information

Perform Instrument Diagnostic (RNO+ 'ET', BDZ+ 'Ut')

The PSD/3 does not have a diagnostic mode. The PSD/3 shall interpret this command as a 'Firmware Download' request.

Set Stored Method mode (RNO+ '#SP', BDZ+ 'Se')

The PSD/3 supports the following Stored Method modes:

0 = End method download
1 = Start method download for method #1
2 = Erase all methods.
3 = Temporarily disable method execution
4 = Enable method execution

Digital I/O Command (RNO+ '>D', BDZ+ 'Sd')

The PSD/3 has one digital output line.

Digital I/O Request (RNO+ '<D', BDZ+ 'Ad')

The PSD/3 does not have any digital input lines, so this command will always

Instrument Device Status (RNO+ 'E3', BDZ+ 'Xs')

The IIC Error bit on the PSD/3shall always be “0”.

Instrument Valve Speed (RNO+ 'LSF', 'LQF', BDZ+ 'Sz', 'Az')

The PSD/3 supports the following valve speeds:

0	= 30 RPM
1	= 40 RPM
2	= 50 RPM
3 - 9	= 60 RPM

Return steps (various RNO+ and BDZ+)

Return steps will always be performed at speed 6 with the PSD/3.

PSD/3 Diagnostic LED codes

The instrument provides the following information on the status LED.

Flashes	Repeats	Description
Steady ON	No	Pump is in normal operating condition.
Steady OFF	No	Pump or LED is defective or has invalid firmware
One short	Yes	RAM failure on power up.
Two short	Yes	LM628 controller failure on power up.
Equal ON/OFF	Yes	Pump is in download firmware mode.

MICROLAB® PSD/3

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