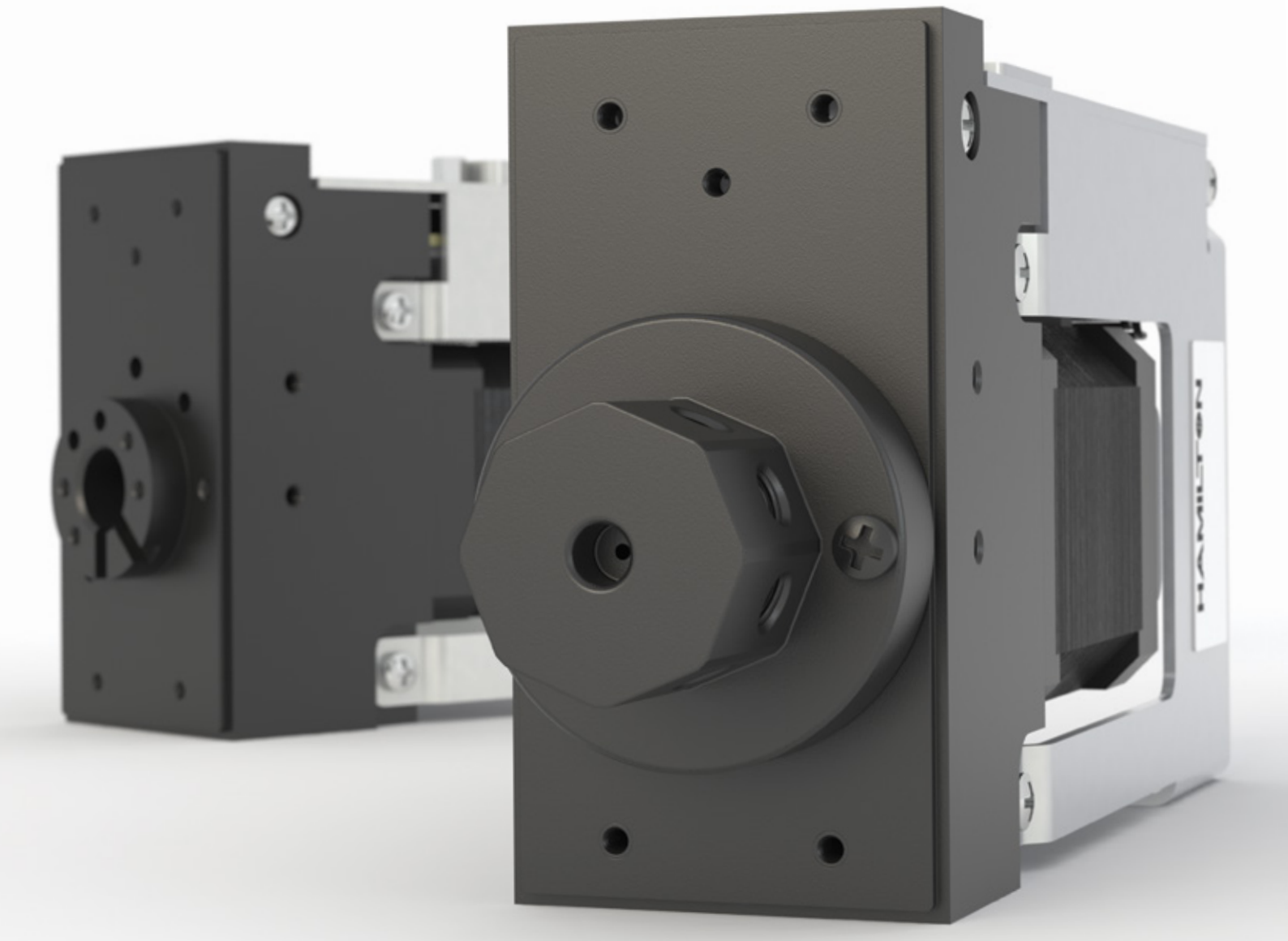
HAMILTON®

MVP/4 Valve Positioner Technical Manual



Product Number 97001-01 (Rev. A)

Warranty Information

Hamilton Company warrants this equipment[1] to be free of defects in material and workmanship for 12 months from the date of receipt. The warranty does not cover normal wear and tear of the valves or equipment. This warranty is extended to the buyer of record on the original purchase order to Hamilton Company. Hamilton Company or an authorized Hamilton representative agrees to repair or replace, at its option and free of charge to the buyer at a normal place of business or at a Hamilton repair facility, any part or parts that under proper and normal use prove to be defective during the warranty period.[2] Abuse, unauthorized replacement of parts, modifications or adjustments made by other than Hamilton Company or its assigned representatives voids this warranty.

This warranty gives you specific rights. No other warranties, expressed or implied, including implications of warranties of merchantability and fitness for a particular product, are made. Hamilton Company's liability on the sale of all products shall be limited to repair, replacement or refund of price of any defective product.[2]

Hamilton Company endeavors to provide prompt and satisfactory service.

[1] *All Hamilton Company valves are warranted to be free of defects in material and workmanship at the time of delivery.*

[2] *Hamilton Company reserves the right to refuse to accept the return of any instrument or valve that has been used with radioactive, microbiological substances, or any other material that may be deemed hazardous to employees of Hamilton Company.*

Table of Contents

Conventions Used in this Manual

Throughout this manual symbols are used to call your attention to various kinds of information.

Biohazard: Information that is related to interactions with biohazards.

Note: Interesting information that can help improve system performance.

CHAPTER 1:

Getting Started

1.1 Introduction

The Modular Valve Positioner/4 (MVP/4) is a self-contained, bidirectional valve positioner used for fluid selection and redirection.

These instruments utilize RS-232 serial communication. A built-in DC stepper motor ensures accurate valve port alignment and location for optimum fluid delivery precision.

This module can be fitted with a choice of valves to meet even the most demanding applications.

Operating on 24VDC, the MVP/4 can be used either as a single device or connected in series to form a bank of up to sixteen modules. Control is available in an RS-232, RS-485, or Control Area Network (CAN) format.

The fluid contact surfaces of the MVP/4 are chemically inert materials such as PTFE, CTFE, and ceramic.

1.2 Safety Precautions

For proper handling and care of the MVP/4 it is essential that operating personnel follow the general safety procedures and safety instructions described in this manual.

1.2.1 Operating the MVP/4

When using the MVP/4, Good Laboratory Practices (GLP) should be observed. Users should wear protective clothing, safety glasses, and protective gloves, especially if working with radioactive, biohazardous, or harsh chemicals.

During the operation of a MVP/4 instrument, stand clear of moving parts. Never try to remove valves or tubing when the MVP/4 valve drive is moving. Never move the MVP/4 while it is in operation.

1.2.2 Electrical

The MVP/4 must be disconnected from the power source when removing any mechanical or electrical components.

Do not connect the unit to a power source of any other voltage or frequency beyond the range stated on the power rating.

Avoid damaging the power cord while operating the instrument. Do not bend excessively, step on, or place heavy objects on the power cord. Any damaged power cord may easily become a shock or fire hazard. Never use a damaged power cord.

1.2.3 Radioactive, Biohazardous, or Harsh Chemicals

⚠ **Biohazard:** The MVP/4 does not provide any user protection against radioactivity, biohazardous, or harsh chemicals.

When operating the MVP/4 wear the appropriate laboratory clothing. Operators must be trained to handle hazardous materials before working with the MVP/4. If the MVP/4 becomes contaminated with radioactive, biohazardous, or harsh chemicals, it should be cleaned immediately. Failure to observe and carry out the procedures may impair or damage the MVP/4. Materials consumed or produced during use of this device should be disposed of in accordance with local, state, and federal laws.

CHAPTER 2:

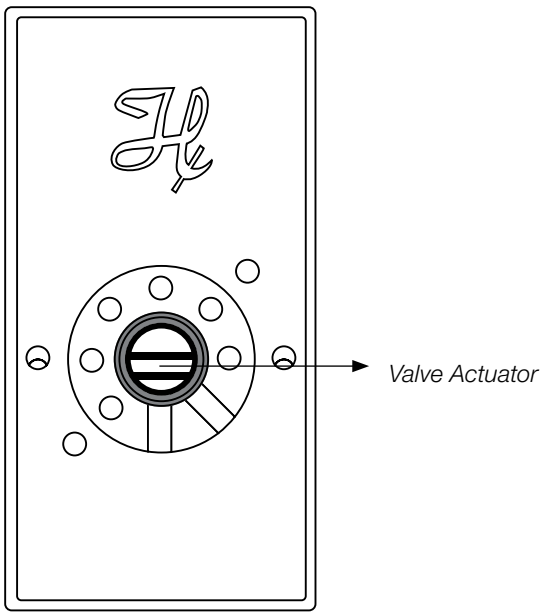
Hardware

2.1 Description of MVP/4 Components

The drive unit contains a precision drive motor and valve. This section will show a detailed diagram of the front and back of the MVP/4 and provide a description of the components required to operate the instrument.

2.1.1 Description of the Front View of the MVP/4

Figure 2-1 Front View of the MVP/4

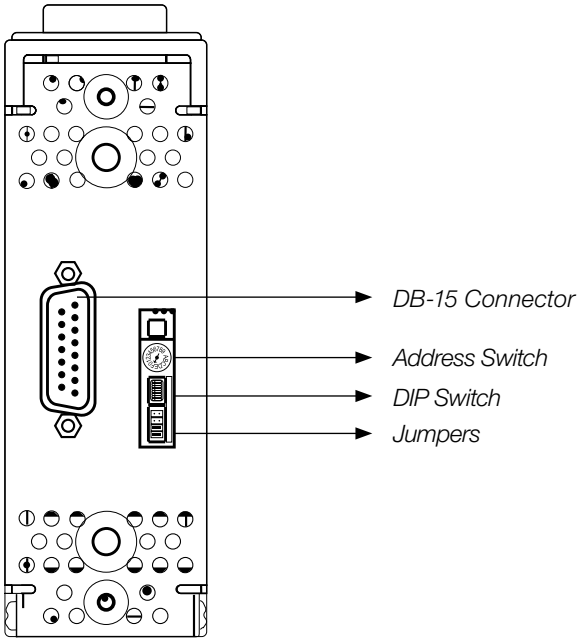


Valve Actuator

The valve actuator turns the valve at the appropriate time to fill and dispense solutions. A variety of valves can be mounted to the valve actuator. See Section 2.2.

2.1.2 Description of the Top View of the MVP/4

Figure 2-2 Top View of the MVP/4



Note: For mounting hole locations and dimensions of the MVP, see Appendix C for more details.

DB-15 Connector

The DB-15 connector is used for communication and power.

Address Switch

This is used when controlling multiple MVP units so that each MVP has a unique address.

DIP Switches

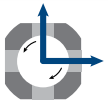
These switches are used to set the valve configuration and communication settings. For more details, see Appendix D.

2.2 Valve Selection and Installation

This section describes possible valve configurations for the MVP/4. Valves are available with PTFE or ceramic fluid paths. Contact your Hamilton representative for a quote on the right valve for your application.

2.2.1 Selecting the Appropriate Valve

Table 2-1 MVP/4 Valves

Flow Diagram	Valve Description	Valve Model
	Distribution Flow Path Two ports	2-5
	90° Flow Path Three ports	3-2
	Distribution Flow Path Three ports	3-5
	90° Flow Path Four ports	4-2
	“T” Flow Path Four ports	4-3
	Loop Flow Path Four ports	4-4
	Distribution Flow Path Four ports	4-5
	Distribution Flow Path Six ports	6-5
	Loop Flow Path Six ports	6-6
	Distribution Flow Path Eight ports	8-5
	Loop Flow Path Eight ports	8-7

Note: The valve ports have ¼”-28 UNF threaded connections.

2.2.2 Installation of the Valve onto the MVP/4

To install the valve:

Step 1. Insert valve shaft into the valve actuator and rotate the valve until the valve stem engages with the valve drive on the MVP/4. See Figure 2-3A.

Step 2. Continue to rotate valve until the alignment pins slip into the front of the instrument. When the alignment pins engage, press the valve firmly against the MVP/4. See Figure 2-3B.

Step 3. Tighten the mounting screws on the valves no greater than 0.28 N-m. See Figure 2-3C.

Figure 2-3 Valve Installation

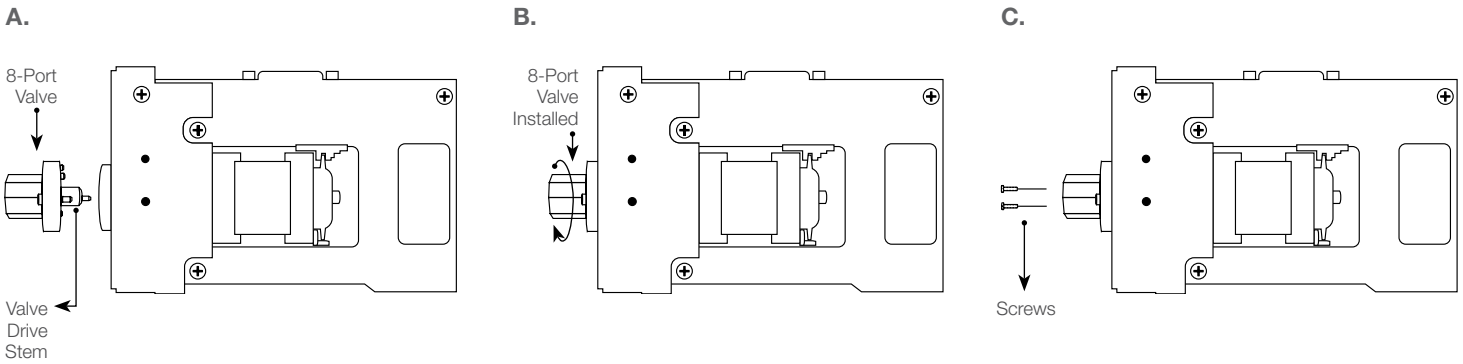


Table 2-2 Valve DIP Switch Settings

	Switch Circuit		
Switch Position Description	**4**	**5**	**6**
3-Port Y Valve	OFF	OFF	OFF
T-Port Valve	ON	OFF	OFF
3-Port Distribution Valve	OFF	ON	OFF
4-Port Distribution Valve 4-Port Wash Valve	OFF	OFF	ON
6-Port Distribution Valve	OFF	ON	ON
8-Port Distribution Valve	ON	ON	OFF

Note: Additional details on the DIP Switches can be found in Appendix D.

2.3 Powering the MVP/4

The MVP/4 requires a 24 VDC power supply with a current rating of at least 2.0 amp, which is provided through the DB-15 connector. It is not recommended to daisy chain power to more than two MVP units.

CHAPTER 3:

Cabling and Switches

3.1 Overview

This chapter will discuss the RS-232, RS-485, and CAN communication interfaces including discussions on the cabling, DIP Switch settings, and address settings.

3.2 RS-232/485 Communication

The following describes how the device is connected for operation using an RS-232 or RS-485 communication, such as a PC serial port. Figure 3-1 shows the cabling for RS-232 and Figure 3-2 shows cabling for RS-485 communication.

The first MVP is connected to an RS-232 port, see Table 3-1.

Table 3-1 RS-232 Computer to MVP #1 Cable

PC Serial Port Connector		MVP #1 Connector	
Function	**DB-9**	**Function**	**DB-15**
RXD	2	TXD	2
TXD	3	RXD	3
CTS1	8	RTS1	4
GND	5	GND	10

[1] This connection is only required if the host system makes use of the CTS line.

3.2.1 Communication Cabling

- **Successive MVP/4 units are connected through pins 11 (RS-485 A) and 12 (RS-485 B) of the DB-15 connectors.**
- **Power is supplied to pins 1 (24 VDC) and 9 (GND) of the DB-15 connectors. No more than two devices should be connected in parallel to the same power line.**
- **The Address Switch is set such that the first MVP/4 is set to "0," second to "1," and so forth.**
- **Up to sixteen devices can be addressed from one controller port.**
- **The communication termination switches must be set on both the first and last units. The middle units are left open. External resistors can be used instead of the communication switches on the last device in an RS-485 chain. If the resistors are used, the termination switches are not required.**

Figure 3-1 RS-232 Communication Cabling

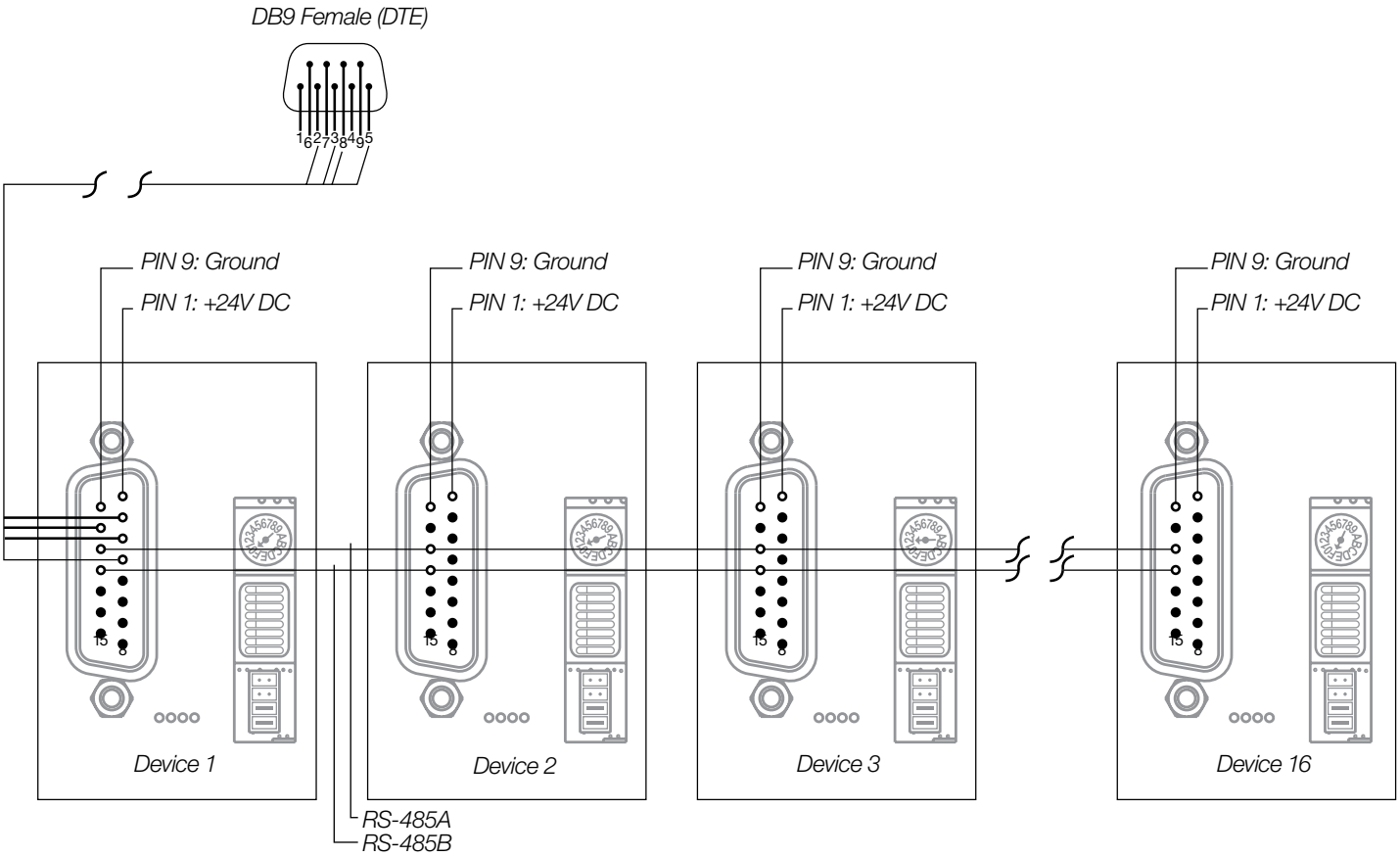


Figure 3-2 RS-485 Communication Cabling

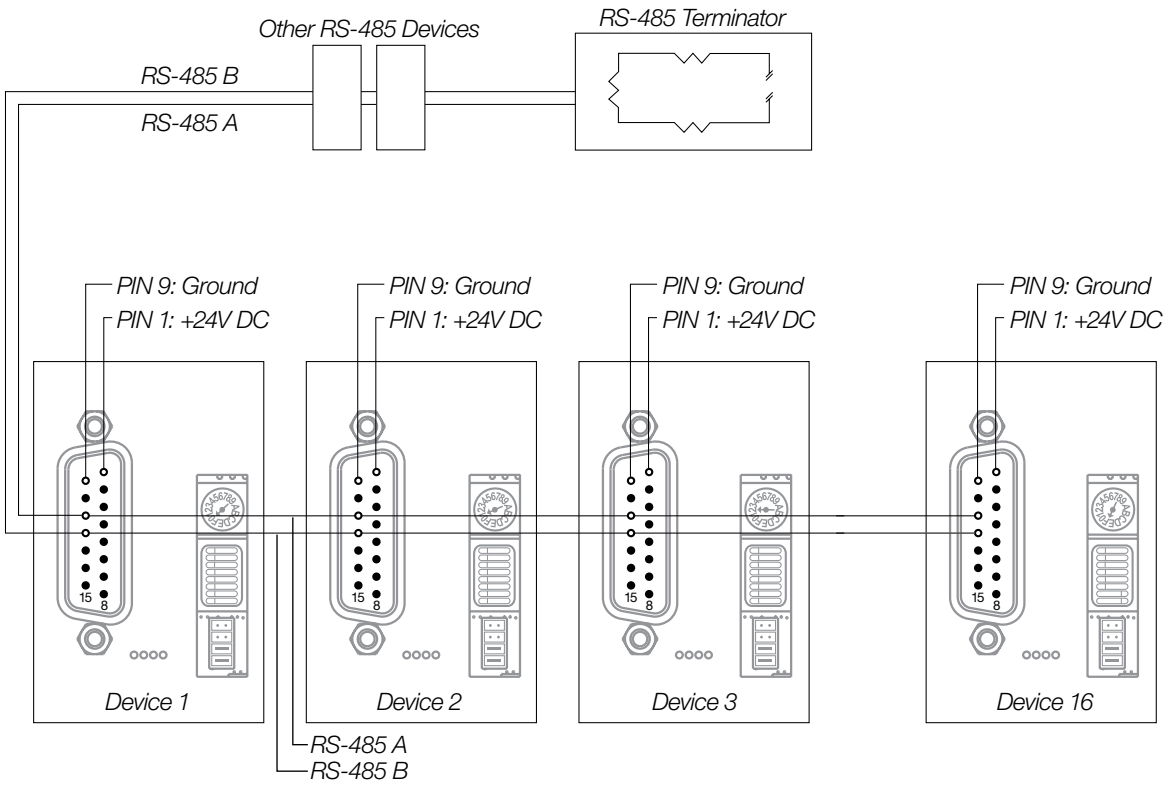


Table 3-2 DIP Switch Settings for RS-485 Communications

			Switch Circuit							
Switch Position Description	**Details**	**Default**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
RS-485 Communication Termination	Single unit, first or last in chain	X	–	–	–	–	–	–	ON[2]	ON[3]
	Non-end unit in chain		–	–	–	–	–	–	OFF	OFF

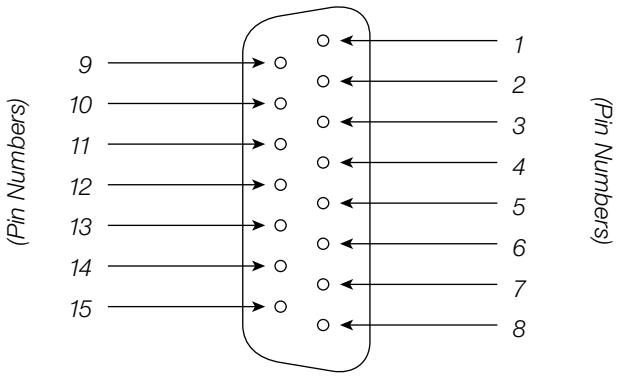
[1] *A dash "-," represents a switch circuit that has no effect on the associated configuration.*
[2] *RS-485 A*
[3] *RS-485 B*

3.2.2 DB-15 Connector Pins

Table 3-3 DB-15 Connector Pin Assignments

Pin	Function	Remark
1	24 VDC	
2	RS-232 TxD line	Output data
3	RS-232 RxD line	Input data
4	RS-232 RTS line	Line is high with power on
5	CAN high signal line	
6	CAN low signal line	
7	Auxiliary Input #1	Digital level
8	Auxiliary Input #2	Digital level
9	Ground	Power and logic
10	Ground	Power and logic
11	RS-485 A line	
12	RS-485 B line	
13	Auxiliary Output #1	Digital level
14	Auxiliary Output #2	Digital level
15	Auxiliary Output #3	Digital level

Figure 3-3 DB-15 Connector Pins



3.2.3 Setting Jumpers

Table 3-4 Jumper Configuration

Description	Settings
Normal Operation	5-6, 7-8
Updating Firmware	1-2, 3-4

Configuration

Contact Hamilton to update the firmware.

3.2.4 Address Switch

A sixteen position rotary switch is provided for setting the address position of each module for RS-232, RS-485 or CAN communication.

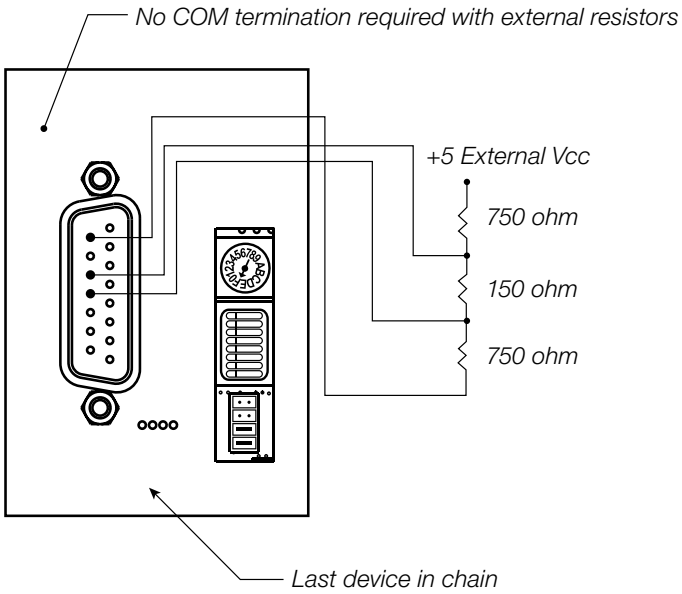
Table 3-5 Address Switch Settings for RS-232 or RS-485 Communication

	Address	
Address Switch	**Hex**	**ASCII**
0	31	1
1	32	2
2	33	3
3	34	4
4	35	5
5	36	6
6	37	7
7	38	8
8	39	9
9	3A	:
A	3B	;
B	3C	<
C	3D	=
D	3E	>
E	3F	?
F	40	@

3.2.5 RS-485 Communication Termination with External Resistors

External resistors can be used, see Figure 3-4, instead of the communication switches on the last device in an RS-485 chain. If the resistors are used, the termination switches are not required.

Figure 3-4 RS-485 Termination with External Resistors



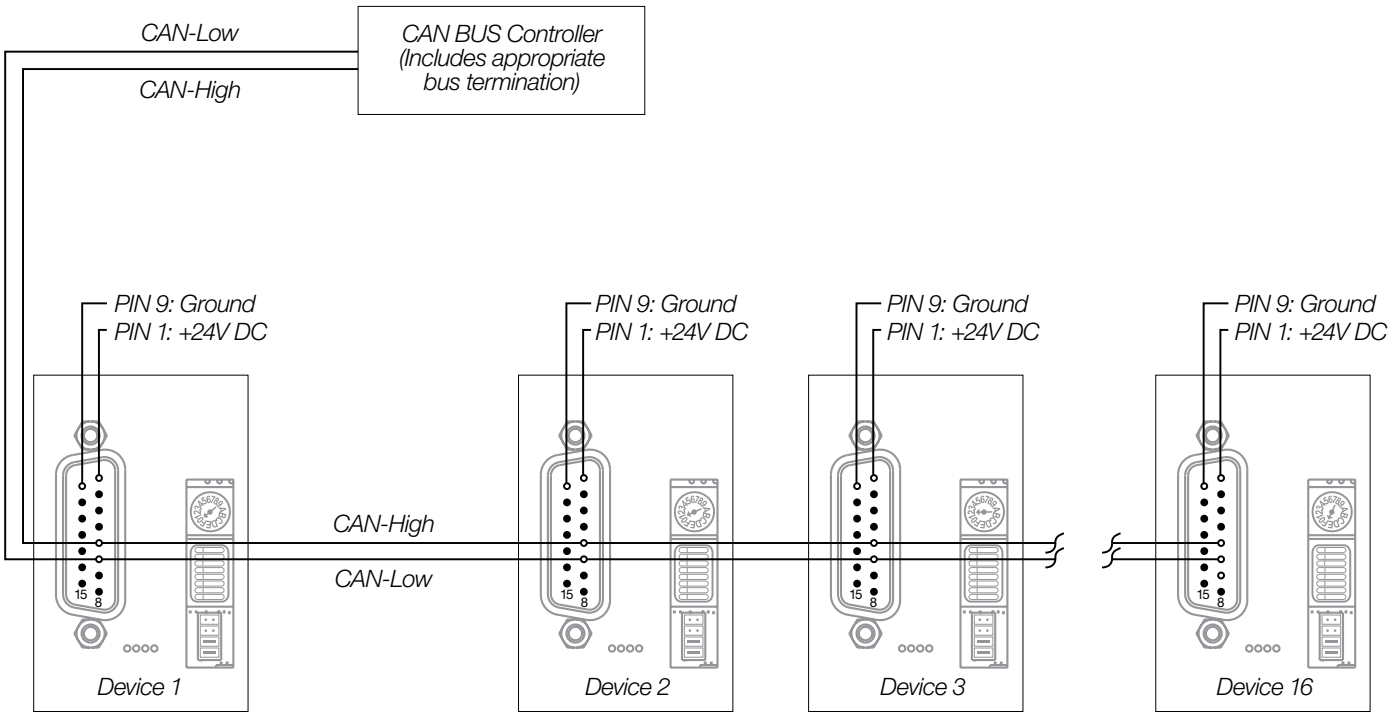
3.3 CAN Communication

The following describes how the device is connected when operating from a Controller Area Network (CAN) controller, see Figure 3-5.

3.3.1 Communication Cabling

- MVP/4 units are connected through pins 5 (CAN high) and 6 (CAN low) of the DB-15 connectors to the CAN controller and/or other devices in the chain.
- Power is supplied to pins 1 (24 VDC) and 9 (GND) of the DB-15 connectors. No more than two devices should be connected in series to the same power line.
- The Address Switch is set such that the first MVP/4 is set to “0,” second to “1”, and so forth.
- Up to sixteen devices can be addressed from one controller port.
- The communication termination switches are not needed for CAN hook-up.
- CAN termination is not provided by the MVP/4.

Figure 3-5 CAN Connections



3.3.2 Address Switch

Table 3-6 Address Switch Settings for CAN Communication

	MVP/4 CAN Address		
MVP/4 Address Switch Setting	**Binary**	**Hex**	**ASCII**
0	0000	31	1
1	0001	32	2
2	0010	33	3
3	0011	34	4
4	0100	35	5
5	0101	36	6
6	0110	37	7
7	0111	38	8
8	1000	39	9
9	1001	3A	:
A	1010	3B	;
B	1011	3C	<
C	1100	3D	=
D	1101	3E	>
E	1110	3F	?
F	1111	40	@

Note: CAN communication does not support broadcast command strings.

CHAPTER 4:

Communication Protocols

4.1 Overview

The MVP/4 supports three different protocols for communicating between the MVP and a controlling device. Terminal Protocol and Standard Protocol can both be used with an RS-232 or RS-485 physical layer. The third protocol is used for controlling the device on a Control Area Network or CAN bus.

Terminal Protocol – is ideal for prototyping and qualification testing as it is easy to send commands from a simple Serial Terminal Emulator program. While Terminal Protocol is ideal for simple benchtop testing, it lacks mechanisms for ensuring that data integrity is not lost between the device and the controller. For most applications this protocol is not robust enough for integration into production units.

Standard Protocol – uses checksums and sequence numbers to ensure that no data is lost and provides mechanisms for retransmitting lost or corrupt data. Standard Protocol is the preferred method for communicating with the MVP/4 via RS-232/485.

CAN Protocol – offers the same data integrity features as the Standard Protocol with the added benefit that polling sequences are eliminated. The MVP units will asynchronously report back to the control device upon completion of the current task. This protocol communicates via a CAN bus.

4.2 Terminal Protocol (RS-232/485)

Terminal Protocol commands sent from a controlling device to a MVP/4 must begin with a '/' followed by the instrument's address and end with a carriage return <CR>. Instruments will only respond to commands that contain their unique address. If it is desirable to send a single command to multiple instruments there are a series of broadcast addresses listed in Table 4-2. These broadcast addresses will be acted upon by the appropriate instruments in the chain, but no response string will be sent from the MVP back to the controlling device. Terminal Protocol is most easily expressed in ASCII characters, which are displayed below. For conversion to Hex, Decimal, or Binary check Appendix F.

Table 4-1 Parameter Settings for RS-232/485 Communication with Terminal Protocol

Description	Settings
Baud rate	9,600 (DIP Switch 3 OFF) 38,400 (DIP Switch 3 ON)
Data bits	8
Parity	None
Stop bit	1
Handshaking	None

Commands Sent from the Controlling Device to the MVP/4:

/<Address><Data><CR>

Beginning of Command	Command String (See Section 4.3)
Address of the MVP(s) (See Section 4.2.1)	End of Command

Responses from the MVP/4 to the Controlling Device:

/0<Status Byte><Data><ETX><CR><LF>

Beginning of Command	Response String (This will be blank unless the command asked the MVP for a response. See Section 4.3)
Address of the control device	Three characters at the End of the Response
Status Byte (See Table 4-3)	

4.2.1 Addressing the MVP Units

Instruments will only respond to commands that start with their unique address. If it is desirable to send a single command to multiple instruments there are a series of broadcast addresses listed in Table 4-2. These broadcast addresses will be acted upon by the appropriate instruments in the chain but no response string will be sent from the MVP back to the controlling device.

Table 4-2 Address Switch Settings

	1 MVP/4 Address		2 MVP/4 Address		4 MVP/4 Address		16 MVP/4 Address	
Address Switch	**ASCII**	**Hex**	**ASCII**	**Hex**	**ASCII**	**Hex**	**ASCII**	**Hex**
0	1	31	A	41	Q	51	–	5F
1	2	32						
2	3	33	C	43				
3	4	34						
4	5	35	E	45	U	55		
5	6	36						
6	7	37	G	47				
7	8	38						
8	9	39	I	49	Y	59		
9	:	3A						
A	;	3B	K	4B				
B	<	3C						
C	=	3D	M	4D	]	5D		
D	>	3E						
E	?	3F	O	4F				
F	@	40						

4.2.2 Status Byte

The status byte is used in MVP/4 responses from the MVP to tell the control device if the MVP was ready to receive a new command and if an error has occurred in the execution of that command. The table below shows all the possible status bytes which are constructed from the bits as follows:

Bit 7	**Always 0**
Bit 6	**Always 1**
Bit 5	**1 if ready, 0 if busy**
Bit 4	**Always 0**
Bits 3-0	**Error Status**

Table 4-3 Definition of Status Bytes

	ASCII		Decimal	
Status Bytes 76543210	**Bit 5 = 0***	**Bit 5 = 1****	**Error Code**	**Error Description**
01X00000	@	‘	0	No error
01X00001	A	a	1	Initialization error – occurs when the valve fails to initialize.
01X00010	B	b	2	Invalid command – occurs when an unrecognized command is used.
01X00011	C	c	3	Invalid operand – occurs when and invalid parameter is given with a command.
01X00100	D	d	4	Invalid command sequence – occurs when the command communication protocol is incorrect.
01X00110	F	f	6	EEPROM failure – occurs when the EEPROM is faulty.
01X01010	J	j	10	Valve overload – occurs when the valve drive encounters excessive back pressure.
01X01111	O	o	15	MVP is busy – occurs when the command buffer is full.

** Indicates that the MVP is busy and will only accept Query and Asynchronous commands.*
*** Indicates the MVP is ready to receive new command.*

4.2.3 General Program Flow

When creating a program to control the MVP/4 Hamilton recommends the commands are sent according to the following flow:

1. **Initialize the MVP(s) to be controlled (once at the beginning when the devices are first turned on).**
2. **Send the first command to each MVP or to multiple MVPs via the broadcast addresses.**
3. **Process response from the MVP. If a broadcast address is used there will be no response.**
4. **Poll each MVP individually with a 100 ms delay using the 'Q' command to make sure each MVP completes the task with no errors before the next command is sent. While the MVP is busy with the current task it will only respond to Query and Asynchronous commands.**
5. **Send the second command and monitor with the Q command.**
6. **Repeat the process of sending and polling for all remaining commands.**

Examples:

Example 1: The control device sends a command to the first MVP on the bus and it is successfully received by the MVP and executed.

Command Sent: /1ZR<CR>

Response Received: /0 ‘ <ETX><CR><LF>

Example 2: The controlling device sends the Q command to the first MVP to see if it has completed the previous command and is now ready for the next command.

Command Sent: /1Q<CR>

Response Received if Busy: /0@<ETX><CR><LF>

Response Received if Ready: /0 ‘ <ETX><CR><LF>

4.3 Standard Protocol (RS-232/485)

Standard Protocol commands sent from a controlling device to MVP/4 Instruments will only respond to commands that start with their unique address. If it is desirable to send a single command to multiple instruments there are a series of broadcast addresses listed in Section 4.2.1. These broadcast addresses will be acted upon by the appropriate instruments in the chain but no response string will be sent from the MVP back to the controlling device. Standard Protocol is most easily expressed in ASCII characters which are displayed below.
For conversion to Hex, Decimal or Binary check Appendix G.

Table 4-4 Settings for RS-232/485 Communication with Standard Protocol.

Parameter	Setting
Baud rate	9,600 or 38,400
Data bits	8
Parity	None
Stop bit	1
Handshaking	None

Note: The Baud rate is set by the DIP Switches. See Appendix D for more details.

Example 1

Commands sent from the controlling device to the MVP:

<STX><Address><Sequence><Data><ETX><Checksum>

Beginning of Command	Command String (See Section 4.2.1)
Address of the MVP(s) (See Section 4.2.1)	End of Command
Sequence Data (See Table 4-5)	Checksum (See Table 4-6)

Responses from the MVP/4 to the controlling device:

<STX>0<Status Byte><Data><ETX><Checksum>

Beginning of Command	Response String (This will be blank unless the command asked the MVP for a response. See Section 4.2.1)
Address of the control device	End of Response
Status Byte (See Table 4-3)	Checksum (See Table 4-6)

4.3.1 Sequence Data

The Sequence Data is used to ensure that a command is not skipped or the same command is not executed twice due to a communication error. During normal operation the repeat bit is set to 0 and the sequence number noted by the MVP. When the repeat bit is set to 1 this indicates that this command had been sent previously. When the MVP sees the command is a repeat, it checks the current sequence number with the last command that was received. If the command was already received the MVP acknowledges the command but does not execute it. If the sequence number does not match the MVP will acknowledge the command and execute it.

The current command is compared to the last executed command so it is not necessary for the control device to increment through all 7 sequence numbers. It is just critical that two consecutive commands do not have the same sequence number.

Bit 7	**Always set to 0**
Bit 6	**Always set to 0**
Bit 5	**Always set to 1**
Bit 4	**Always set to 1**
Bit 3	**Repeat Bit**
Bits 2 - 0	**Sequence Number**

Table 4-5 ASCII Commands for all Possible Combinations of Sequence Number and Repeat Bit

	Sequence Bits	ASCII	
Sequence Number	**76543210**	**Bit 3 = 0**	**Bit 3 = 1**
1	0011X001	1	9
2	0011X010	2	:
3	0011X011	3	;
4	0011X100	4	<
5	0011X101	5	=
6	0011X110	6	>
7	0011X111	7	?

4.3.2 Checksum Calculation

The Checksum for a Data Block consists of the bitwise exclusive OR (XOR) of the bytes in the Data Block from the STX to the ETX, inclusive. A Data Block received with a Checksum that matches the computed Checksum is considered to be received successfully. A Data Block received with an invalid Checksum is ignored.

Table 4-6 Example of a Checksum Calculation for the Command

			Binary							
	ASCII	**Hex**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
Example Data Block	<STX>	02	0	0	0	0	0	0	1	0
	1	31	0	0	1	1	0	0	0	1
	1	31	0	0	1	1	0	0	0	1
	Z	5A	0	1	0	1	1	0	1	0
	R	52	0	1	0	1	0	0	1	0
	<ETX>	03	0	0	0	0	0	0	1	1
Checksum	**<HT>**	**09**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**1**

Note: To calculate a Checksum add up all the values in the Bit 0 column. If the total is odd then the value for that bit is 1 if the total is even then the value is 0. Repeat this process for the seven remaining bits.

4.3.3 General Program Flow

When creating a program to control the MVP/4 Hamilton recommends the commands are sent according to the following flow:

1. **Initialize the MVP unit(s) to be controlled (once at the beginning when the MVP units are first turned on).**
2. **Send the first command to each MVP or to multiple MVPs via the broadcast addresses.**
3. **Process response from the MVP. If a broadcast address is used there will be no response.**
4. **Poll each MVP individually with a 100 ms delay using the Q command to make sure each MVP completes the task with no errors before the next command is sent. While the MVP is busy with the current task it will only respond to Query and asynchronous commands.**
5. **Send the second command and monitor with the Q command.**
6. **Repeat the process of sending and polling for all remaining commands.**

Examples

Example 1: The control device sends a command to the first MVP on the bus and it is successfully received by the MVP and executed.

Command Sent: <STX>11ZR<ETX><HT>

Response Received: <STX>0 @ <ETX>q

Example 2: The controlling device sends a valve move command but the MVP does not receive it because the Checksum indicated the data was corrupt. The control device reissues the command with the repeat bit set to 1 after timing out on the transaction. The MVP receives this command and checks it against the previous command that was received. The MVP sees the command is unique and responds and executes accordingly.

Command Sent: <STX>11IR<ETX>!

Repeat of Command Sent: <STX>19IR<ETX>)

Response Received: <STX>0 @ <ETX>q

4.4 CAN Protocol

Controller Area Network or CAN bus was developed by Bosch for the automotive industry. Since then it has become a popular standard for industrial automation and medical equipment. CAN protocol eliminates the need for polling to verify when a task is completed. With CAN the MVP units are able to asynchronously respond to the control device once the task has been completed.

With CAN the data is sent via a standard length frame like the one below. This manual will only discuss the highlighted MVP/4 specific aspects of communication using the CAN 2.0 standard.

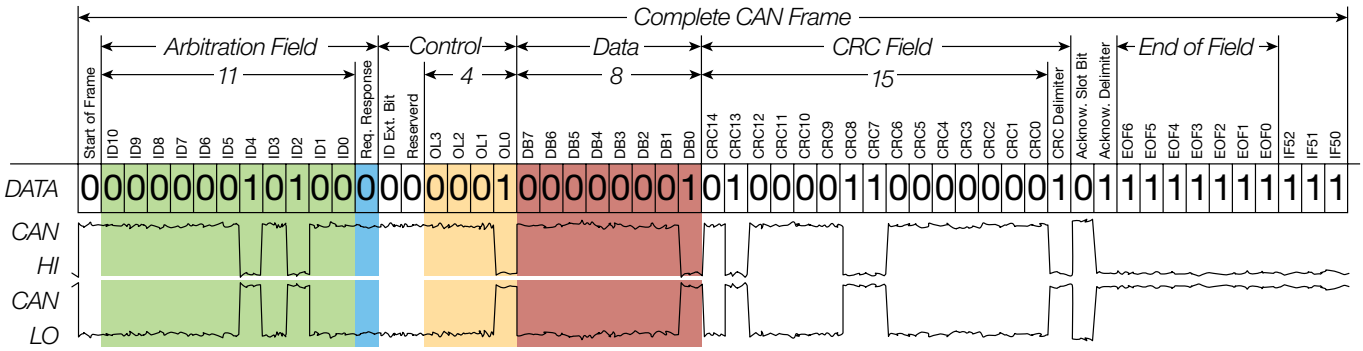


Table 4-7 CAN Parameter Settings

Parameter	Setting
Baud rate	100,000 (DIP Switch 3 OFF)
	125,000 (DIP Switch 3 ON)

Frame ID

The Frame ID is 11 bits of information that communicate the direction of the frame, the address of the device, and the type of frame being sent. The Frame ID field is broken up according to the figure below.

Table 4-8 Frame ID Bits

	Frame ID Bits										
	10	9	8	7	6	5	4	3	2	1	0
Description	**Direction**	**Group**			**Address**				**Type**		
Frames from master to slave	0										
Frames from slave to master	1										
Boot requests use group 1		0	0	1							
All communication uses group 2		0	1	0							
Address Switch 0					0	0	0	0			
Address Switch 1					0	0	0	1			
Address Switch 2					0	0	1	0			
Address Switch 3					0	0	1	1			
Address Switch 4					0	1	0	0			
Address Switch 5					0	1	0	1			
Address Switch 6					0	1	1	0			
Address Switch 7					0	1	1	1			
Address Switch 8					1	0	0	0			
Address Switch 9					1	0	0	1			
Address Switch A					1	0	1	0			
Address Switch B					1	0	1	1			
Address Switch C					1	1	0	0			
Address Switch D					1	1	0	1			
Address Switch E					1	1	1	0			
Address Switch F					1	1	1	1			
On the fly commands (Type 0)									0	0	0
Action Commands (Type 1)									0	0	1
Common commands (Type 2)									0	1	0
Multi-frame start (Type 3)									0	1	1
Multi-frame data (Type 4)									1	0	0
Report answer commands (Type 6)									1	1	0

Note: Broadcasting of commands is not supported by this implementation of CAN protocol.

Frame Types

The frame type indicates what kind of command is being sent to enable faster processing of the command. The MVP/4 supports the following types:

Table 4-9 Frame Types

Type	Commands	Details
0	On-the-fly commands	This type is used for asynchronous Action Commands that can be executed while the MVP is currently busy executing another action command. This includes speed change and termination commands.
1	Action or end of multi-frame commands	This type is used with commands that ask the MVP to perform a task like initialization, valve move, or parameter changes. This type also indicates the last data in a multi-frame message indicates that the CAN Frame is the end of a MVP/4 CAN Data Block that contains Action Commands.
2	Common commands	This type is used for boot requests from the MVP to the control device and for the following commands one byte commands from the control device to the MVP:
3	Multi-frame start data	In CAN protocol if a block of data exceeds 8 bytes it must be sent in multiple frames. This frame type tells the receiving device to expect additional frames in this message.
4	Multi-frame middle data	When sending a command that exceeds 16 bytes this type is used for all data between the first frame (type 3) and the last frame (type 1).
6	Report/answer commands	This type is used with Query Commands. See Section 5.6 for details on the available commands.

ASCII	Description
0	Reset MVP/4.
1	Execute command buffer.
2	Clear command buffer.
3	Execute command buffer from beginning, same as “X” command.
4	Terminate execution, same as “T” command.

Remote Transmission Request Bit (RTR)

This is a standard CAN bit and is always set to 0 when communicating with the MVP/4.

Data Length

In CAN communication the Data Block can be between 0 and 8 bytes in length. If the command is longer than 8 bytes is must be sent in more than one CAN frame. Within a single CAN frame the Data Length field indicates how many bytes to expect in the data field.

Table 4-10 Data Length

Number of Bytes	Data Length (Binary)			
0	0	0	0	0
1	0	0	0	1
2	0	0	1	0
3	0	0	1	1
4	0	1	0	0
5	0	1	0	1
6	0	1	1	0
7	0	1	1	1
8	1	0	0	0

Data Field

The data field contains the command string to the MVP or the response string from the MVP. The possible commands and responses are detailed in Chapters 5 and 6 of this manual.

When the MVP responds the first byte in the data field will be the Status Byte as defined in Section 4.3. The second byte is the <NUL> character. Then the remaining 6 bytes are for any response data. If the response data exceeds 6 bytes the information is sent in a multi-frame message.

4.4.1 General Program Flow

When creating a program to control the MVP/4, Hamilton recommends the commands are sent according to the following flow:

1. When an MVP is first turned on it will send a boot request every 100 ms to let the control device know it exists.
2. The control device must respond to this boot request before attempting to communicate with the MVP.
3. After responding to the boot request the MVP unit(s) can be initialized (must be initialized once before any movement commands will be accepted by the MVP).
4. Send the first CAN frame to the MVP and follow with additional frames if this is a multi-frame message.
5. Once the end of the message is received by the MVP it will respond with a frame containing no data to acknowledge the command has been received.
6. The MVP will execute the command and upon completion will send another response to the MVP that contains the Status Byte, see Table 4-3, a <NUL> character, and then any additional information if relevant.
7. The control device must wait for the MVP's completion response before sending the next command. The MVP will only process one command of a given type at the same time. Alternatively, commands of different frame types like query and Action Commands will be processed at the same time.

Examples:

Example 1: An MVP at address 1 has just been powered up and is now sending the Boot Request every 100 ms. The Control device sees this request and sends the appropriate response which is the MVP's group and address repeated twice, see below. The next MVP at address 2 is powered up and begins sending Boot Requests. The control device sees this and responds accordingly.

CAN Frame Data

	Frame ID											RTR	Length				Data
Description	**Direction**	**Group**			**Address**				**Type**								**Hex**
Boot Request Address 0	1	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	
Host Response	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	20 20*
Boot Request Address 2	1	0	0	1	0	0	1	0	0	1	0	0	0	0	0	0	
Host Response	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	22 22*

*The boot response from the MVP is the instruments group and the address constructed as follows:

Bit 7	**Always set to 0**
Bit 6-4	**Instrument Group**
Bit 3-0	**Instrument Address**

Example 2: The control device sends a command (ZR) to the first MVP on the bus. The MVP receives the command and acknowledges and executes the command. When execution is complete the MVP notifies the control device by sending the Status Byte followed by the <NUL> character.

CAN Frame Data

	Frame ID											RTR	Length				Data
Description	**Direction**	**Group**			**Address**				**Type**								**Hex**
Address = 0 Action command type = 1 Message length = 2 Data = ZR	0	0	1	0	0	0	0	0	0	0	1	0	0	0	1	0	5A 52
MVP acknowledges	1	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	
Execution is complete Data = [1]<NUL>	1	0	1	0	0	0	0	0	0	0	1	0	0	0	1	0	60 00

Example 3: The control device wants to query the MVP for its current status using query command 29.

	CAN Frame Data																			
	Frame ID												RTR	Length				Data		
Description	Direction	Group			Address				Type									Hex		
Address = 0 Action command type = 6 Message length = 2 Data = 29	0	0	1	0	0	0	0	0	1	1	0		0	0	0	1	0	32	39	
Report/answer type = 6 Message length = 2 Data = [1]<NUL>	1	0	1	0	0	0	0	0	1	1	0		0	0	0	1	0	60	00	

Note: For Query Commands they do not elicit an acknowledgement response.

CHAPTER 5:

Basic Command Set

5.1 Execute Commands

R - Execute Command Buffer

- *R* executes the commands in the command buffer starting with the first unexecuted command in the command buffer.
- When a Command String that consists of only an *R* is sent to the MVP/4, the MVP/4 will execute the command buffer starting with the first unexecuted command in the command buffer.
- *R* is not required to execute Query Commands

Table 5-1 Execute Command Buffer - Example

Command Example	Description
IM1000OG8**R**	Moves the valve to Input position, waits 1 second then moves the valve to Output position. The sequence is repeated 8 times.
R	Send R again, no action takes place.

X - Execute Command Buffer from Beginning

- *X* executes the commands in the command buffer starting with the first command in the command buffer.
- When a Command String that consists of only an *X* is sent to the MVP/4, the MVP/4 will execute the command buffer from the beginning.

Table 5-2 Execute Command Buffer from Beginning - Example

Command Example	Description
IM1000OG8**X**	Moves the valve to Input position, waits 1 second then moves the valve to Output position. The sequence is repeated 8 times.
X	Send ***X*** again, the Command String repeats from the beginning.

5.2 Initialize Commands

Note: See MVP/4 CAN Examples on page 33, for additional CAN initialization command information.

Z - Initialize MVP/4, Assign Valve Output to Right

- *Z* initializes the valve output position to the right side of the MVP/4 (as viewed from the front of the MVP/4).
- All of the valves used on the MVP/4 have a designated input and output port for MVP/4 initialization. Please refer to Table 2-1 for input/output port designations.

Table 5-3 Initialize MVP/4, Assign Valve Output to Right – Example

Command Example	Description
ZR	Initialize valve output position to the right side of the MVP/4.

Y - Initialize MVP/4, Assign Valve Output to Left

- *Y* sets valve output to the left side of the MVP/4 (as viewed from the front of the MVP/4).
- All of the valves used on the MVP/4 have a designated input and output port for MVP/4 initialization. Please refer to Table 2-1 for input/output port designations.

Table 5-4 Initialize MVP/4, Assign Valve Output to Left – Example

Command Example	Description
YR	Initialize valve output position to the left side of the MVP/4.

5.3 Valve Commands

Ix - Move Valve to Input Position

- *I* without *x* parameter moves the valve to the input position set by the *Y* and *Z* Initialize Commands.
- Parameter – Input position where *x* = valve position 1 – 8 on multi-port valves.
  See Table 2-1 input/output port location.

Table 5-5 Move Valve to Input Position – Example

Command Example	Description
IM1000OG8R	Moves the valve to Input position, waits 1 second then moves the valve to Output position. The sequence is repeated 8 times.

Ox - Move Valve to Output Position

- *O* without *x* parameter moves the valve to the output position set by the *Y* and *Z* commands.
- Parameter - Output position where *x* = valve position 1 – 8 on multi-port valves.
  See Table 2-1 input/output port location.

Table 5-6 Move Valve to Output Position – Example

Command Example	Description
IM1000OG8R	Moves the valve to Input position, waits 1 second then moves the valve to Output position. The sequence is repeated 8 times.

B - Move Valve to Bypass (Throughput Position)

- *B* connects the input and output positions. See Table 2-1, Valve input/output port locations, on page 8.

Table 5-7 Move Valve to Bypass – Example

Command Example	Description
IM1000BR	Moves the valve to Input position, waits 1 second then moves the valve to bypass.

E - Move Valve to Extra Position

- *E* moves the valve to the extra position (port) relative to the *Y* and *Z* commands.

Table 5-8 Move Valve to Extra Position – Example

Command Example	Description
IM1000ER	Moves the valve to Input position, waits 1 second then moves the valve to the extra position.

5.4 Action Commands

Note: See MVP/4 CAN examples on page 33, for additional CAN Action Command information.

g - Define a Position in a Command String

- *g* marks a position in a Command String that can be matched with *G* commands.
- The *G* command is used with the *g* command to repeat commands within a Command String. *g* marks the start of the commands and is paired with *Gx* to mark the end of the commands and repeats them *x* number of times. Up to ten pairs of *g* / *Gx* can be nested in a string.

Gx - Repeat Commands

Table 5-9 Repeat-sequence Example for the Command I1gI2M1000I8gI3M1000I5M1000G10G5R

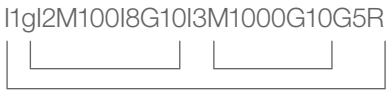
Command Segment	Description
I1	Move valve to position 1.
g	Outer loop start.
I2	Move valve to input, move valve to position 2.
M1000I8	Wait 1 second, move valve to position 8.
g	Inner loop start.
I3M1000	Move valve to position 3, wait 1 second.
I5M1000	Move valve to position 5, wait 1 second.
G10	Inner loop end, repeat ten times.
G5	Outer loop end, repeat five times.
R	Execute command.

- *G* repeats a command in the command buffer *x* number of times.
- Parameter - *x* where 1 ≤ *x* ≤ 65,535. For *x* = 0 and if *x* is omitted, the sequence is repeated until a terminate command is received at the MVP/4.
- The *G* command allows the user to define the number of times a command in the Command String will be repeated. A *G* command without a matching *g* command repeats from the beginning of the command buffer.

Table 5-10 Repeat Commands – Example

Command Example	Description
1M1000O**G8**R	Moves the valve to Input position, waits 1 second, then moves the valve to Output position. The sequence is repeated 8 times.

The *G* command is used with the *g* command to repeat commands within a Command String. *g* marks the start of the commands and is paired with *Gx* to mark the end of the commands and repeats them *x* number of times. Up to ten pairs of *g/GX* can be nested in a string.



***M*x** - Delay

- *M* performs a delay of *x* milliseconds.
- Parameter *x* where 5 ≤ *x* ≤ 30,000 milliseconds.
- Use the *M* command to pause the execution of the Command Buffer for a given amount of time.

Table 5-11 Delay Example

Command Example	Description
M10000I8R	MVP/4 waits 10 seconds after the command string is sent, then moves valve to position 8.

Hx - Halt Command Execution

- *H* halts execution of the commands in the command buffer. Execution of the command buffer can be resumed with an appropriate digital signal or with the execute command buffer command.
- Parameter - *x* where
- *x* = 0 - Waits for control command or either input 1 or input 2 to go from high to low.
- *x* = 1 - Waits for control command or input 1 to go from high to low.
- *x* = 2 - Waits for control command or input 2 to go from high to low.
- Unlike the *M* command, the *H* command is used to put an indefinite pause in a Command String or sequence. The operator can use an external device to trigger the Command String to resume.

Note: The status of the digital input lines can be read using ?13 and ?14 commands as described in the Query Commands section of this manual.

Jx - Auxiliary Outputs

- *J* sets the digital output lines.
- Parameter - *x* where $0 \leq x \leq 7$ and is defined in Table 5-24.
- Use the *J* command to control the three digital outputs in the DB15 connector located on the back of the MVP/4.

Table 5-12 Digital Output Control

MVP/4 Command	Output 3 (pin 15)	Output 2 (pin 14)	Output 1 (pin 13)
J0	0	0	0
J1	0	0	1
J2	0	1	0
J3	0	1	1
J4	1	0	0
J5	1	0	1
J6	1	1	0
J7	1	1	1

Table 5-13 Auxiliary Output Example

Command Example	Description
J7R	Set digital outputs 1, 2, and 3 high.

sx - Store Command String

- *s* stores the commands following the *s* command in the Command String in the specified EEPROM location.
- Parameter *x* where 0 ≤ *x* ≤ 14 and *x* identifies the EEPROM location.
- Use the *s* command to store the remaining commands in the Command String into the EEPROM. The Command String can then be executed by the controlling device, or upon power-up. (See Chapter 4, Communication Protocols.)
- Up to 15 Command Strings, numbered 0 through 14 can be loaded into the EEPROM. Each Command String contains up to 42 commands.
- This is an example of how to store a Command String to execute a valve initialization and movement from an external controlling device.

Note: Use of the H command in the Command Strings to digitally control execution of the Command Strings stored in the EEPROM.

Table 5-14 Load Command s2ZgI1M10000I6H2GR into EEPROM

Command Example	Description
s2ZgI1M10000I6H2GR	Store the following command string in EEPROM location #2: Initialize valve motor, move valve to position 1, wait 10 seconds, move valve to position 6, halt the command execution, and waits for response signal. Repeat from the start of loop endlessly.

ex - Execute Command String in EEPROM Location

- *e* executes the Command String stored in an EEPROM location.
- Parameter *x* where 0 ≤ *x* ≤ 14, *x* identifies the EEPROM location.

Note: Link Command Strings stored in the EEPROM by ending one Command String with an *ex* where *x* refers to the second Command String.

Table 5-15 Execute Command String From EEPROM Location – Example

Command Example	Description
e2R	Executes command string from stored position 2.

5.5 Async Commands

Note: See MVP/4 CAN Examples on page 33, for additional CAN Async Command Information

T - Terminate Command Buffer

- *T* stops execution of the command buffer. It also aborts the command being executed, except for valve commands.
- The *R* command may be used to resume the execution of the command buffer from the next unexecuted command.
- *T* is used to terminate a command or Command Strings. *T* will not terminate a valve movement however it will terminate the Command String at the end of the valve move. Use *R* to resume the Command String or sequence.
- *T* is an Async command.

Note: This command will not execute until the current valve move is complete.

Table 5-16 Terminate Command Buffer – Example

Command Example	Description
T	Stop execution of the Command Buffer.

5.6 Query Commands

Note: See MVP/4 CAN Query Commands on page 33, for CAN Query information.

Note: A Control Command is not required to execute a Query Command.

F - Command Buffer Status

- *F* reports the command buffer status

Table 5-17 Report Buffer Status

Command Buffer Status	Return Status Code
Empty	0
Not Empty	1

& - Firmware Version

- *&* reports the firmware revision in ASCII.

- Firmware Checksum

- *#* reports the firmware checksum.
- Returned as 4 digit hexadecimal value.

Q - MVP Status

- *Q* reports the MVP status.
- See 'MVP Status' definition in Glossary.

?13 - Status of Auxiliary Input #1

- *?13* reports the Status of the Auxiliary Input #1.
- 0 - Auxiliary Input Low; 1 - Auxiliary Input High.

?14 - Status of Auxiliary Input #2

- *?14* reports the Status of the Auxiliary Input #2.
- 0 - Auxiliary Input Low; 1 - Auxiliary Input High.

?22 - Returns 255

- *?22* Returns 255.

CHAPTER 6:

Extended Command Set

6.1 h Factor Command Details

The MVP/4 has a set of commands known as h Factor commands. These augment the capabilities of the MVP/4 by enabling the user to access expanded features such as multi-port valving and digital input/output controls.

Note: In order to access the h Factor commands, they must first be enabled by sending h30001R to the MVP/4.

6.1.1 Enable/Disable h Factor Commands

h30001 - Enable h Factor Commands and Queries

- *This command is enabled by default.*

h30000 - Disable h Factor Commands and Queries

- *Disable h Factor Commands and Queries* turns off the Hamilton Company extension commands.

6.1.2 Valve Commands

h20000 - Initialize Valve

- *Initialize Valve initializes* the valve.

h20001 - Enable Valve Movement

- *Enable Valve Movement* enables the valve to be moved after valve movement was disabled.

h20002 - Disable Valve Movement

- *Disable Valve Movement* makes the MVP/4 ignore all subsequent valve movement commands.

h2100x - Set Valve Type

- Configure MVP/4 for specific valve type.
- *x* =

  0 - 3-way 120 degree Y valve
  1 - 4-way 90 degree T valve
  2 - 3-way 90 degree distribution valve
  3 - 8-way 45 degree valve
  4 - 4-way 90 degree valve
  5 – Reserved
  6 – 6-way 45 degree valve

h23001 - Move Valve to Input Position in Shortest Direction

- *Move Valve to Input Position in Shortest Direction* moves the valve to the input position taking the shortest route in terms of degrees traveled.

h23002 - Move Valve to Output Position in Shortest Direction

- *Move Valve to Output Position in Shortest Direction* moves the valve to the output position taking the shortest route in terms of degrees traveled.

h23003 - Move Valve to Wash Position in Shortest Direction

- *Move Valve to Wash Position in Shortest Direction* moves the valve to the wash position taking the shortest route in terms of degrees traveled.

h23004 - Move Valve to Return Position in Shortest Direction

- *Move Valve to Return Position in Shortest Direction* moves the valve to the return position taking the shortest route in terms of degrees traveled.

h23005 - Move Valve to Bypass Position in Shortest Direction

- *Move Valve to Bypass Position in Shortest Direction* moves the valve to the bypass position taking the shortest route in terms of degrees traveled.

h23006 - Move Valve to Extra Position in Shortest Direction

- *Move Valve to Extra Position in Shortest Direction* moves the valve to the extra position taking the shortest route in terms of degrees traveled.

h2400x - Move Valve in Clockwise Direction

- *Move Valve in Clockwise Direction* moves the valve in a clockwise direction to one of eight positions.
- $1 \leq x \leq 8$

h2500x - Move Valve in Counterclockwise Direction

- *Move Valve in Counterclockwise Direction* moves the valve in a counterclockwise direction to one of eight positions.
- $1 \leq x \leq 8$

h2600x - Move Valve in Shortest Direction

- *Move Valve in Shortest Direction* moves the valve to position *x* in shortest direction in terms of degrees traveled.
- $1 \leq x \leq 8$

h27xxx - Clockwise Angular Valve Move

- *Clockwise Angular Valve Move* moves the valve to angle *x* in clockwise direction in 3° increments.
- Sum of 27,000 and $0 \leq x \leq 351$

h28xxx - Counterclockwise Angular Valve Move

- *Counterclockwise Angular Valve Move* moves the valve to angle *x* in counterclockwise direction in 3° increments.
- Sum of 28,000 and $0 \leq x \leq 351$

h29xxx - Shortest Direct Angular Valve Move

- *Shortest Direct Angular Valve Move* moves the valve to angle *x* in shortest direction in terms of degrees traveled.
- Sum of 29,000 and $0 \leq x \leq 351$

6.2 Query Commands

6.2.1 Valve Query Commands

?20000 - Valve Status

- *Valve Status* queries the valve. Response to query is decoded to determine the valve status.
- MVP/4 Response: *xx* where *xx* is decoded as the sum of:

  0 - Valve initialized
  1 - Valve not initialized

  0 - No valve initialization error
  2 - Valve initialization error

  0 - No valve stall
  4 - Valve stall

  0 - Valve enabled
  16 - Valve not enabled

  0 - Valve is not busy
  32 - Valve is busy

?21000 - Valve Type

- Response to *Valve Type* is the valve type.
- MVP/4 Response: *x* is between 0 and 6.

  0 – 3-way 120 degree Y valve
  1 – 4-way 90 degree T valve
  2 – 3-way 90 degree distribution valve
  3 – 8-way 45 degree valve
  4 – 4-way 90 degree valve
  5 – Reserved
  6 – 6-way 45 degree valve

?23000 - Valve Logical Position

- Response to *Valve Logical Position* is defined below in MVP/4 Response.
- MVP/4 Response: *x* where *x* is defined as:

  0 – Not at logical position
  1 – Input
  2 – Output
  3 – Wash
  4 – Return
  5 – Bypass
  6 – Extra

?24000 - Valve Numerical Position

- Response to *Valve Numerical Position* is defined below in MVP/4 Response.
- MVP/4 Response: *x* where 0 ≤ *x* ≤ 8 (0 corresponds to not a numerical position).

?25000 - Valve Angle

- Response to *Valve Angle* is defined below in MVP/4 Response.
- Parameters: none.
- MVP/4 Response: *xxx* where 0 ≤ *xxx* ≤ 345.

6.2.2 System Query Commands

?37000 - Last Digital Out Value

- Reports the last digital output value.
- MVP/4 Response: *x* where 0 ≤ *x* ≤ 7 corresponding to the last digital out values.

6.2.3 Action Reset

h30003 - Reset MVP/4

- *Reset MVP/4* resets the MVP/4 and sets power-up default values.

Appendices

Appendix A

Contacting Hamilton Company

In the Americas & Pacific Rim:

Hamilton Company, Inc.

4970 Energy Way

Reno, Nevada 89502

Customer Service

1 (888) 525-2123

Technical Support/Service

1 (800) 648-5950

Outside the U.S.

+1 (775) 858-3000

In Europe, Asia, & Africa:

Hamilton Central Europe S.R.L.

DJ 691 No. Km8+390m dreapta

307210 Giarmata, Romania

Customer Service

Tel: +40-356-635-050

Fax: +40-356-635-060

Appendix B

Specifications

Table B-1 MVP/4 Specifications

General Specifications	
Fluid Path	PTFE, CTFE, or ceramic
Weight	1.75 lbs (0.79 kg) (P/N 94747-01) 2.25 lbs (1.02 kg) (P/N 94747-02)
Dimensions	Height: 3.41 inches (86.6 mm) Width: 1.75 inches (44.5 mm) Depth: 5.49 inches (139.4 mm)
RoHS Compliant	Yes
Power Requirements	
Supply Voltage	24 VDC
Average Current	1.7 A maximum
Valve and Valve Drive	
Valve Drive Speed	250 ms per 120° rotation
Valve Drive Mechanism	Stepper motor with optical encoder
Valve Fittings	¼”-28
Valve Materials	PTFE, CTFE, or ceramic
Breakaway Torque	25 in-oz (0.18 N-m) (P/N 94747-01) 75 in-oz (0.53 N-m) (P/N 94747-02)
Nominal Fluid Path Diameter	Ceramic: 0.060” (1.524 mm) PTFE: 0.059” (1.498 mm) unless otherwise noted

Table B-1 MVP/4 Specifications (Continued)

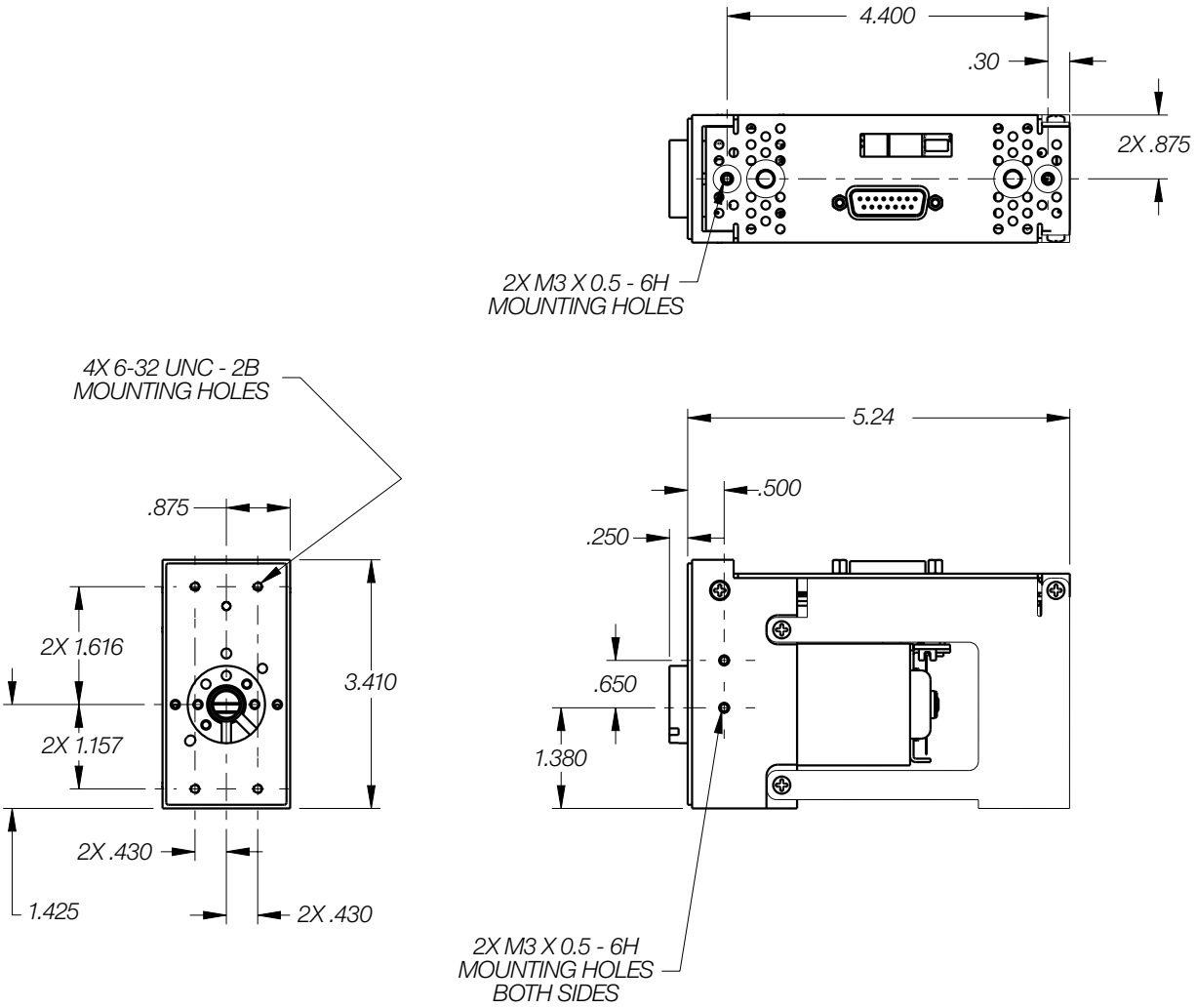
Communication	
Type	RS-232, RS-485, or CAN
Protocols	Terminal or Standard
Baud Rate	9,600 or 38,400 (RS-232, RS-485) 100,000 or 125,000 (CAN)
Data Bits	8
Parity	None
Stop Bit	1, Half duplex
Daisy Chain Length	Up to 16 individual MVP units
Programmable Capabilities	Loops, terminate moves and delays, error detection, valve rotation selection, enhanced “h” Factor capabilities including valve rotation clockwise and counter-clockwise, 15 location method storage
Environmental Operating and Storage Range	
Operating Temperature	59 - 104 °F (15 - 40 °C)
Operating Humidity	20 – 95% relative humidity, non-condensing
Storage Temperature	-4 - 149 °F (-20 - 65 °C)
Storage Humidity	20 – 95% relative humidity, non-condensing
Additional Regulator Compliance Information	
Pollution Degree	2
Installation Category	II
Altitude	6,562 ft (2000 m)

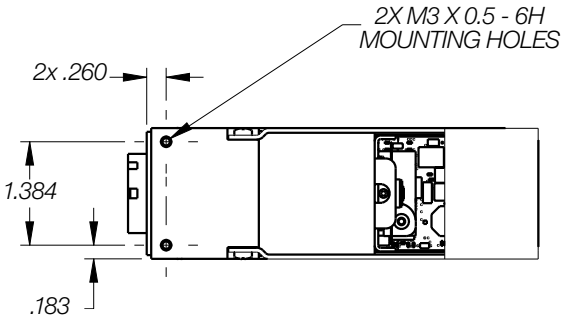
Indoor operation and use only

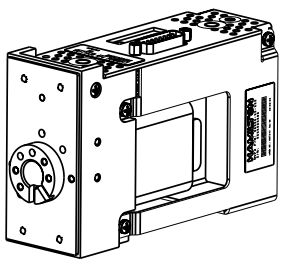
Appendix C

Mounting Hole Locations and Product Dimensions

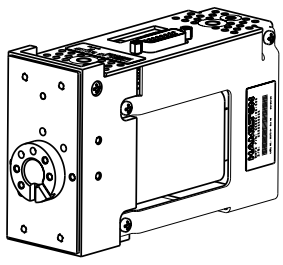
Suggested Mounting Holes for New Hamilton MVP Module







94747-01



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Appendix D

DIP Switch Settings

Table D-1 DIP Switch Settings

			Switch Circuit							
Switch Position Descriptions	**Details**	**Default**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Setting Not Used			–	–	–	–	–	–	–	–
EEPROM AutoStart/ Self-Test	Disabled	X		OFF	–	–	–	–	–	–
	Enabled		–	ON[1]	–	–	–	–	–	–
Baud Rate	9,600 baud 100,000 baud for CAN	X	–	–	OFF	–	–	–	–	–
	38,400 baud for CAN		–	–	ON	–	–	–	–	–
Force Boot	Enabled		–	–	–	ON	ON	ON	–	–
3-Port Y Valve		X	–	–	–	OFF	OFF	OFF	–	–
T-Port Valve			–	–	–	ON	OFF	OFF	–	–
3-Port Distribution Valve			–	–	–	OFF	ON	OFF	–	–
4-Port Distribution Valve										
4-Port Wash Valve			–	–	–	OFF	OFF	ON	–	–
6-Port Distribution Valve			–	–	–	OFF	ON	ON	–	–
8-Port Distribution Valve			–	–	–	ON	ON	OFF	–	–
RS-485 Communication Termination	Single unit, first or last in chain	X	–	–	–	–	–	–	ON[2]	ON[3]
	Non-end unit in chain		–	–	–	–	–	–	OFF	OFF

[1] Self-Test actuated with Address Switch set to "F," Address Switch set to "0-E" executes. Command Strings stored in EEPROM locations 0-14
[2] RS-485-A
[3] RS-485-B
[4] A dash "-," represents a switch circuit that has not effect on the associated configuration.

Appendix E

Basic Command Quick Reference

Table E-1 Command Summary

ASCII Command RS-232/485	Parameters	Description	ASCII Command CAN
Control Commands			
R		Execute Command Buffer	R
X		Execute Command Buffer From Beginning	X
Initialization Commands			
Z		Initialize MVP/4, assign output position to right side.	Zx
Y		Initialize MVP/4, assign output position to left side.	Yx
Valve Commands			
Ix	x where 1 ≤ x ≤ 8 valve position	Move valve input position	Ix
Ox	x where 1 ≤ x ≤ 8 valve position	Move valve output position	Ox
B		Move valve to bypass position	B
E		Move valve to extra position	E
Action Commands			
g		Marks a position in a Command String that can be matched with G commands.	g
Gx	x where 1 ≤ x ≤ 65535	Repeats the Command String x number of times. If x = 0 or x is omitted, the sequence is repeated until a terminate command is received.	Gx
Mx	x where 5 ≤ x ≤ 30,000	Executes a delay of x milliseconds	Mx
Hx	x = 0 – Waits for R or either input 1 or input 2 to go from high to low x = 1 – Waits for R or input 1 to go from high to low x = 2 – Waits for R or input 2 to go from high to low	Halts execution of the commands in the command buffer, x defines resume parameter.	Hx
Jx	0 ≤ x ≤ 7	Sets digital output lines. See Table 5-24, Digital output control	Jx
sx	x where 0≤ x ≤ 14	Stores all commands listed after the s command in the EEPROM location x.	sx
ex	x where 0≤ x ≤ 14	Executes the Command String stored in an EEPROM location x.	ex
^x	x – is set to 255	(command ignored)	^x
Async Commands			
T		Terminate Command Buffer	T

Table E-2 Query Commands

RS-232/485 Query	Response	Description	CAN Query
F	0 – Empty 1 – Not Empty	Report command buffer status	10
&	(string response)	Report firmware version	23
#	*xxxx*	Report firmware Checksum in hexadecimal	
Q		MVP status	29
?13	0 – Auxiliary Input Low; 1 – Auxiliary Input High	Report status of auxiliary input 1	13
?14	0 – Auxiliary Input Low; 1 – Auxiliary Input High	Report status of auxiliary input 2	14
?22	Returns 255	Report 255	22

Appendix F

h Factor Command Quick Reference

Table F-1 Command Summary

Command	Parameters	Description
Enable/Disable h Factor Commands		
h30001		This is now set by default
h30000		Disable h Factor Commands and Queries
Valve Commands		
h20000		Initialize Valve
h20001		Enable Valve Movement
h20002		Disable Valve Movement
h2100x	x = 0: 3-way 120 degree Y valve 1: 4-way 90 degree T valve 2: 3-way 90 degree valve 3: 8-way 45 degree valve 4: 4-way 90 degree valve 5: Reserved 6: 6-way 45 degree valve	Set Valve Type to type x
h23001		Move Valve to Input Position in Shortest Direction
h23002		Move Valve to Output Position in Shortest Direction
h23003		Move Valve to Wash Position in Shortest Direction
h23004		Move Valve to Return Position in Shortest Direction
h23005		Move Valve to Bypass Position in Shortest Direction
h23006		Move Valve to Extra Position in Shortest Direction
h2400x	24000 + 1 ≤ x ≤ 8	Move Valve in Clockwise Direction
h2500x	25000 + 1 ≤ x ≤ 8	Move Valve in Counterclockwise Direction
h2600x	26000 + 1 ≤ x ≤ 8	Move Valve in Shortest Direction
h27xxx	27000 + 0 ≤ xxx ≤ 351	Clockwise Angular Valve Move
h28xxx	28000 + 0 ≤ xxx ≤ 351	Counterclockwise Angular Valve Move to angle x
h29xxx	29000 + 0 ≤ xxx ≤ 351	Shortest Direct Angular Valve Move to angle x
Firmware Commands		
h30003		Reset MVP/4

Table F-2 Query Commands

Query	Response	Description
?20000	Response: *xx* where *xx* is decoded as the sum of: 0 – Valve initialized 1 – Valve not initialized 0 - No valve initialization error 2 - Valve initialization error 0 – No valve stall 4 – Valve stall 0 – No valve positioning error 8 – Valve positioning error 0 – Valve enabled 16 – Valve not enabled 0 – Valve is not busy 32 – Valve is busy	Valve Status
?21000	x where 0 to 6 corresponds to: 0 – 3-way 120 degree Y valve 1 – 4-way 90 degree T valve 2 – 3-way 90 degree distribution valve 3 – 8-way 45 degree valve 4 – 4-way 90 degree valve	Valve Type
?23000	x where x is defined as: 0 – Not at a logical position 1 – Input 2 – Output 3 – Wash 4 – Return 5 – Bypass 6 – Extra	Valve Logical Position
?24000	x where $0 \leq x \leq 8$ (0 corresponds to not at a numerical position)	Valve Numerical Position
?25000	xxx where $0 \leq xxx \leq 351$	Vave Angle
?37000	x where $0 \leq x \leq 7$ corresponding to the last digital out values	Last Digital Out Value

Appendix G

Table G-1 ASCII Chart

Binary	Decimal	Hex	ASCII	Binary	Decimal	Hex	ASCII
00000000	0	00	<NUL>	00100000	32	20	
00000001	1	01	<SOH>	00100001	33	21	!
00000010	2	02	<STX>	00100010	34	22	“
00000011	3	03	<ETX>	00100011	35	23	#
00000100	4	04	<EOT>	00100100	36	24	$
00000101	5	05	<ENQ>	00100101	37	25	%
00000110	6	06	<ACK>	00100110	38	26	&
00000111	7	07	<BEL>	00100111	39	27	‘
00001000	8	08	<BS>	00101000	40	28	(
00001001	9	09	<HT>	00101001	41	29	)
00001010	10	0A	<LF>	00101010	42	2A	*
00001011	11	0B	<VT>	00101011	43	2B	+
00001100	12	0C	<FF>	00101100	44	2C	,
00001101	13	0D	<CR>	00101101	45	2D	-
00001110	14	0E	<SO>	00101110	46	2E	.
00001111	15	0F	<SI>	00101111	47	2F	/
00010000	16	10	<DLE>	00110000	48	30	0
00010001	17	11	<DC1>	00110001	49	31	1
00010010	18	12	<DC2>	00110010	50	32	2
00010011	19	13	<DC3>	00110011	51	33	3
00010100	20	14	<DC4>	00110100	52	34	4
00010101	21	15	<NAK>	00110101	53	35	5
00010110	22	16	<SYN>	00110110	54	36	6
00010111	23	17	<ETB>	00110111	55	37	7
00011000	24	18	<CAN>	00111000	56	38	8
00011001	25	19	<EM>	00111001	57	39	9
00011010	26	1A	<SUB>	00111010	58	3A	:
00011011	27	1B	<ESC>	00111011	59	3B	;
00011100	28	1C	<FS>	00111100	60	3C	<
00011101	29	1D	<GS>	00111101	61	3D	=
00011110	30	1E	<RS>	00111110	62	3E	>
00011111	31	1F	<US>	00111111	63	3F	?

Table G-1 ASCII Chart (Continued)

Binary	Decimal	Hex	ASCII
01000000	64	40	@
01000001	65	41	A
01000010	66	42	B
01000011	67	43	C
01000100	68	44	D
01000101	69	45	E
01000110	70	46	F
01000111	71	47	G
01001000	72	48	H
01001001	73	49	I
01001010	74	4A	J
01001011	75	4B	K
01001100	76	4C	L
01001101	77	4D	M
01001110	78	4E	N
01001111	79	4F	O
01010000	80	50	P
01010001	81	51	Q
01010010	82	52	R
01010011	83	53	S
01010100	84	54	T
01010101	85	55	U
01010110	86	56	V
01010111	87	57	W
01011000	88	58	X
01011001	89	59	Y
01011010	90	5A	Z
01011011	91	5B	[
01011100	92	5C	\
01011101	93	5D	]
01011110	94	5E	^
01011111	95	5F	_
01100000	96	60	`

Binary	Decimal	Hex	ASCII
01100001	97	61	A
01100010	98	62	b
01100011	99	63	c
01100100	100	64	d
01100101	101	65	e
01100110	102	66	f
01100111	103	67	g
01101000	104	68	h
01101001	105	69	i
01101010	106	6A	j
01101011	107	6B	k
01101100	108	6C	l
01101101	109	6D	m
01101110	110	6E	n
01101111	111	6F	o
01110000	112	70	p
01110001	113	71	q
01110010	114	72	r
01110011	115	73	s
01110100	116	74	t
01110101	117	75	u
01110110	118	76	v
01110111	119	77	w
01111000	120	78	x
01111001	121	79	y
01111010	122	7A	z
01111011	123	7B	{
01111100	124	7C	|
01111101	125	7D	}
01111110	126	7E	~
01111111	127	7F	

Appendix H

Chemical Compatibility

This section contains information about chemical compatibility with the MVP/4 instrument at room temperature. Depending on the valve chosen the internal components are made of PTFE, CTFE, and/or ceramic.

Table I-1 Chemical Compatibility of the MVP/4 units

Legend

0 = No data available
A = No effect, excellent
B = Minor effect, good
C = Moderate effect, fair
D = Severe effect, not recommended

Solvent	PTFE	CTFE	Ceramic
Acetaldehyde	A	A	0
Acetates	A	A	0
Acetic acid	A	A	A
Acetic anhydride	A	A	A
Acetone	A	A	A
Acetonitrile	A	A	0
Acetyl bromide	A	0	0
Ammonia	A	A	A
Ammonium acetate	A	0	0
Ammonium hydroxide	A	A	A
Ammonium phosphate	A	A	0
Ammonium sulfate	A	A	A
Amyl acetate	A	A	A
Aniline	A	A	A
Benzene	A	B-C	A
Benzyl alcohol	A	A	A
Boric acid	A	A	A
Bromine	A	A	A
Butyl acetate	A	A	0
Butyl alcohol	A	B	0
Carbon sulfide	A	A	0
Carbon tetrachloride	A	B-C	A

Table H-1 Chemical Compatibility of the MVP/4 units (Continued)

Solvent	PTFE	CTFE	Ceramic
Chloracetic acid	A	A	0
Chlorine, liquid	A	B	A
Chlorobenzene	A	B	A
Chloroform	A	B	A
Chromic acid	A	A	A
Cresol	A	A	0
Cyclohexane	A	B	0
Ethers	A	B	0
Ethyl acetate	A	B-C	A
Ethyl alcohol	A	0	0
Ethyl chromide	A	B	0
Ethyl ether	A	A-B	0
Formaldehyde	A	A	0
Formic acid	A	A	0
Freon 11, 12, 22	A	B-C	0
Gasoline	A	A	A
Glycerin	A	A	A
Hydrochloric acid	A	A	C
Hydrochloric acid (conc)	A	A	C
Hydrofluoric acid	A	B	0
Hydrogen peroxide	A	B	A
Hydrogen peroxide (conc)	A	B	A
Hydrogen sulfide	A	A-B	A
Kerosene	A	A	A
Methyl alcohol	A	A	A
Methyl ethyl ketone (MEK)	A	A-B	A
Methylene chloride	A	B	0
Naptha	B	A	0
Nitric acid	A	A	A
Nitric acid (conc)	A	A-B	A
Nitrobenzene	A	A-B	0
Phenol	A	B	A
Pyridine	A	A	A

Table H-1 Chemical Compatibility of the MVP/4 Units (Continued)

Solvent	PTFE	CTFE	Ceramic
Silver nitrate	A	B	0
Soap solutions	A	A	A
Stearic acid	A	0	0
Sulfuric acid	A	A	A
Sulfuric acid (conc)	A	A	A
Sulturous acid	A	A-B	0
Tannic acid	A	A-B	A
Tanning extracts	0	0	0
Tartartic acid	A	B	A
Toluene	A	B	A
Trichlorethane	A	B	0
Trichloroethylene	A	B-C	A
Turpentine	A	A	A
Water	A	A	A
Xylene	A	B-C	A

Glossary

Action Commands
Action Commands consist of the set of commands that may be stored in the Command Buffer.

ASCII
American Standard Code for Information Interchange; a standard 8-bit information code that allows computers made by different manufacturers to interpret code in the same way.

Async Commands
Async Commands consist of those commands that affect the MVP/4 while the Command Buffer is being executed.

Baud
A measurement of the speed at which information can be transmitted between computer devices. If the baud rate is 9600, then 9600 bits can be transmitted per second.

Checksum
A digit representing the correct sum of digits which is stored as digital data and is used to compare with data strings later to detect errors.

Command Buffer
The Command Buffer is a list of zero or more Action Commands to be executed by the MVP/4.

Command String

A valid Command String consists of one of the following:

a. Nothing
b. An Async Command
c. A Query Command
d. A Control Command
e. One or more Action Commands
f. One or more Action Commands followed by a Control Command

In cases a, e, and f:

1. The Command Buffer is cleared before the Command String is processed.
2. The Action Commands (if any) in the Command String are placed into Command Buffer.
3. A Control Command that starts execution of the Command Buffer starts execution from the beginning of the Command Buffer.

In cases b, c, and d:

1. The command is processed immediately.

Commands

Commands are the primary communications syntax used by the MVP/4. All commands are a single character followed by a numeric parameter. If the parameter is omitted, it is assumed to be zero. Some commands do not require a parameter, and therefore ignore the parameter.

Control Commands

Control Commands consist of those commands that are used to start or resume execution of the Command Buffer.

Controlling Device

The system used to communicate with the MVP/4.

Daisy Chain

A string of instruments connected in a serial configuration.

Data Block

The basic unit of communication between the Controlling Device and the MVP/4 when using Standard or Terminal Protocols.

Default

A predetermined value in a program or in computer circuitry that an operator may or may not alter.

Execute
To run a computer program or a method; to interpret machine instructions to perform programmed operations.

Initialize
To establish the basic or “home” conditions for starting a process.

MVP Status
The first byte of all Response Strings.

Prime
Fluid running through the tubing lines of an instrument ensure that neither bubbles nor air gaps exist in the tubing. The system must be primed before using it for the first time such as at the start of a work day or between fluid changes.

Query Commands
Query Commands consist of those commands that are used to return information about the MVP/4 to the Controlling Device.

Response String
A Response String consists of data being returned from the MVP/4 to the Controlling Device. The first byte of all Response Strings is the MVP Status. The term Response String does not refer to any of the protocol information that accompanies the response data.

Sequence Data
Ensures that a command is not skipped or the same command is not executed twice due to a communication error.

Index

A

B

C

D

F

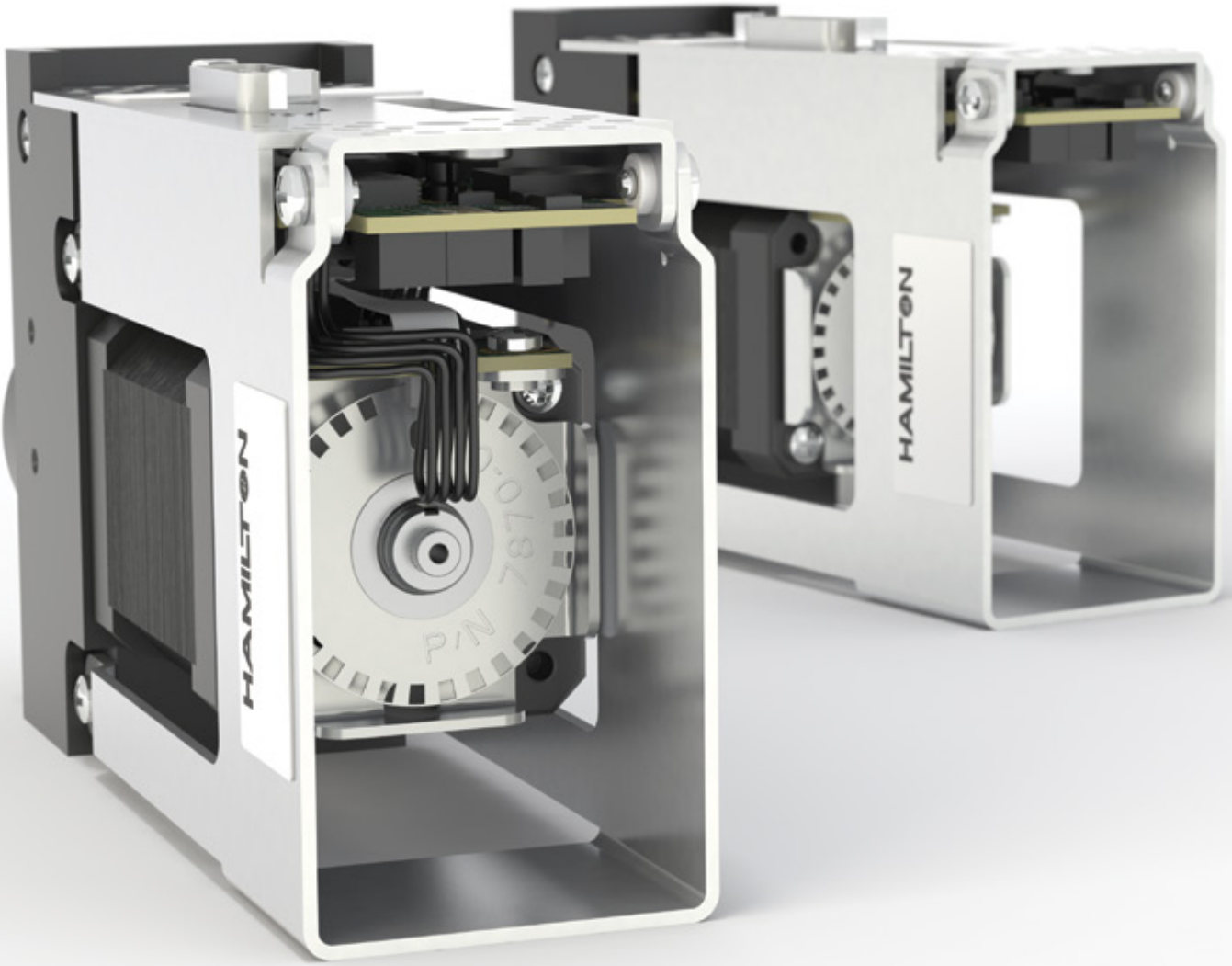
I

J

R

S

T



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