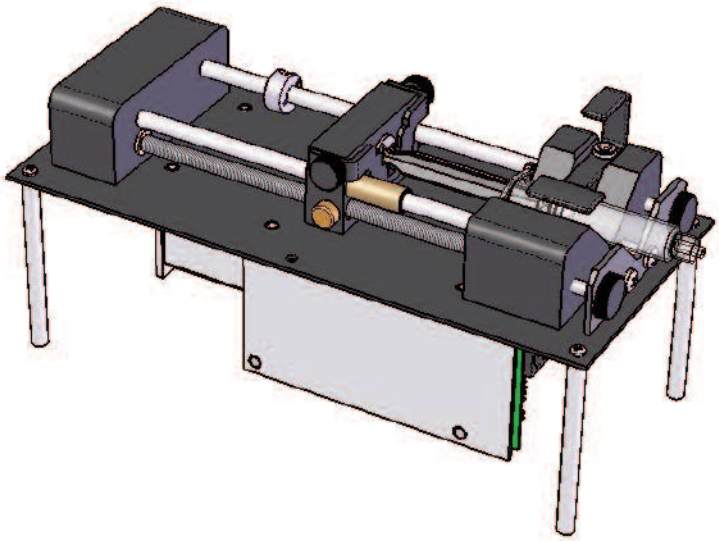
Milliliter Flow M.P.C

Modular Pump Component

User's Manual

Catalog # 70-2219 & 70-2226



RoHS COMPLIANT

HARVARD APPARATUS

Publication 5417-001 REV-A

WEEE/RoHS Compliance Statement

EU Directives WEEE and RoHS

To Our Valued Customers:

We are committed to being a good corporate citizen. As part of that commitment, we strive to maintain an environmentally conscious manufacturing operation. The European Union (EU) has enacted two Directives, the first on product recycling (Waste Electrical and Electronic Equipment, WEEE) and the second limiting the use of certain substances (Restriction on the use of Hazardous Substances, RoHS). Over time, these Directives will be implemented in the national laws of each EU Member State.

Once the final national regulations have been put into place, recycling will be offered for our products which are within the scope of the WEEE Directive. Products falling under the scope of the WEEE Directive available for sale after August 13, 2005 will be identified with a "wheelie bin" symbol.

Two Categories of products covered by the WEEE Directive are currently exempt from the RoHS Directive – Category 8, medical devices (with the exception of implanted or infected products) and Category 9, monitoring and control instruments. Most of our products fall into either Category 8 or 9 and are currently exempt from the RoHS Directive. We will continue to monitor the application of the RoHS Directive to its products and will comply with any changes as they apply.

- **Do Not Dispose Product with Municipal Waste**
- **Special Collection/Disposal Required**

Serial Number

All inquires concerning our product should refer to the serial number of the unit. Serial numbers are located on the underside of the mounting plate.

Calibration

All syringe pumps are designed and manufactured to meet their performance specifications at all rated voltages and frequencies.

Warranty

Harvard Apparatus warranties this instrument for a period of two years from date of purchase. At its option, Harvard Apparatus will repair or replace the unit if it is found to be defective as to workmanship or material.

This warranty does not extend to damage resulting from misuse, neglect or abuse, normal wear and tear, or accident.

This warranty extends only to the original customer purchaser.

IN NO EVENT SHALL HARVARD APPARATUS BE LIABLE FOR INCIDENTAL OR CONSEQUENTIAL DAMAGES. Some states do not allow exclusion or limitation of incidental or consequential damages so the above limitation or exclusion may not apply to you. THERE ARE NO IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR USE, OR OF ANY OTHER NATURE. Some states do not allow this limitation on an implied warranty, so the above limitation may not apply to you.

If a defect arises within the two-year warranty period, promptly contact Harvard Apparatus, Inc. 84 October Hill Road, Holliston, Massachusetts 01746-1388 using our toll free number 1-800-272-2775. Outside the U.S. call 508-893-8999. Goods will not be accepted for return unless an RMA (returned materials authorization) number has been issued by our customer service department. The customer is responsible for shipping charges. Please allow a reasonable period of time for completion of repairs, replacement and return. If the unit is replaced, the replacement unit is covered only for the remainder of the original warranty period dating from the purchase of the original device.

This warranty gives you specific rights, and you may also have other rights which vary from state to state.

Repair Facilities and Parts

Harvard Apparatus stocks replacement and repair parts. When ordering, please describe parts as completely as possible, preferably using our part numbers. If practical, enclose a sample or drawing. We offer a complete reconditioning service.

CAUTION

This pump is not registered with the FDA and is not for clinical use on human or veterinary patients. It is intended for research use only.

CAUTION
NOT FOR CLINICAL USE ON HUMAN PATIENTS

Please read the following safety precautions to ensure proper use of your modular syringe pump. To avoid potential hazards and product damage, use this product only as instructed in this manual.

If the equipment is used in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired.

To Prevent Hazard or Injury

Use Appropriate Power Supply

Use only an approved power supply. Be sure to observe proper polarity of connections when hooking up DC supply voltage.

CAUTION: FAILURE TO MAINTAIN POLARITY MAY RESULT IN DAMAGE TO THE UNIT AND WILL VOID THE WARRANTY.

12-30Vdc positive–PIN 1 of 2 Pin Header (P8)

12-30Vdc return–PIN 2 of 2 Pin Header (P8)

Ground the Product

This product is grounded through a ground stud located on the under side of the base plate. To avoid electric shock, the grounding conductor must be connected to earth ground. Before making any connections to the input or output terminals of the product, ensure that the product is properly grounded.

Make Proper Connections

Make sure all connections are made properly and securely. Any signal wire connections to the unit must be no longer than 3 meters.

Orient Equipment Properly

Do not position the equipment such that it is difficult to reach the disconnecting device.

Observe All Terminal Ratings

Review the operating manual to learn the ratings on all connections.

Avoid Exposed Circuitry

Do not touch any electronic circuitry inside of the product.

Do Not Operate with Suspected Failures

If damage is suspected on or to the product do not operate the product. Contact qualified service personnel to perform inspection.

Avoid Pinch Hazards

Pinch hazards may exist between the pusher block and the end block and at the belt/pulley. Avoid placing fingers between these points while the pump is running.

Procedures which could result in injury shall only be carried out by operators who have been warned of the potential hazards and have received adequate training in carrying out the procedures in the safest possible manner.

General Safety Summary

Place Product in Proper Environment

Environmental Conditions:

- Indoor use only
- Temperature 5˚C to 40˚C (40˚F to 104˚F)
- Humidity 20% to 80% RH
- Well Ventilated Room
- Altitude up to 2000 m
- DC Voltage Fluctuation not to Exceed +/- 5% of Nominal
- Transient Over voltage Category II
- Pump is Rated Pollution Degree I

Observe all Warning Labels on Product

Read all labels on product to ensure proper usage.

CAUTION

Refer to Manual

Protective Ground Terminal

CAUTION

Pinch Hazard

CAUTION

ESD Sensitive Device

CAUTION

Pinch Hazard

Theory of Operation

The "mL" Modular Syringe Pump Component is designed as a highly precise, single-syringe infusion/withdrawal pump module capable of moderate to high back pressures. The module includes a mechanism, hardware and software.

Typically, the "mL" Modular Syringe Pump Component holds one syringe of most makes, from 0.5 µl to 60ml. The diameter of the syringe is entered via your PC or other controller, and the internal microprocessor drives a precision stepper motor to produce accurate fluid flow. This unit is designed to operate inside an appropriately rated fire/electrical/mechanical enclosure or cabinet.

Features: Two Modes of Operation

Constant Flow Rate and Volume Dispense

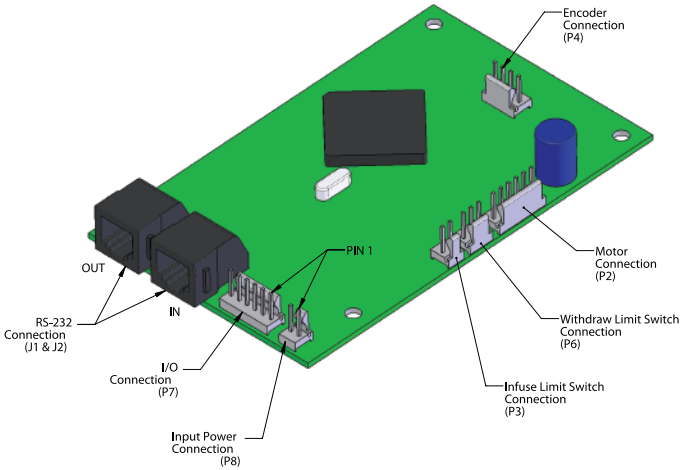
The "mL" Modular Syringe Pump Component will operate continuously in RATE mode, or accurately dispense a specific amount of fluid in VOLUME mode. When starting the pump, RATE mode will be the default mode. To operate in Volume mode, set a target volume and the pump will change modes to suit desired operation.

Infuse and Withdraw Limit Switch

An infuse limit switch is located on the syringe block and an adjustable actuator is located on the pusher block. When the pusher block actuator contacts the limit switch, infusing is stopped. Adjust the actuator appropriately such that the syringe plunger does not bottom out in the syringe barrel.

The withdraw limit switch is located in the pulley cover, which is connected to a movable guide rod. The guide rod is equipped with an adjustable clamp collar. When the pusher block comes in contact with the adjustable clamp collar, the withdraw limit switch is actuated and pusher block movement is halted. Adjust the clamp collar appropriately such that the syringe plunger does not pull out of the syringe barrel.

Input Connections



Connector Pin-outs

Input Power Connection	**Power**	**P8-1**
	Return	**P8-2**
Digital I/O Connection	**Run IND**	**P7-1**
	VCC	**P7-2**
	EXT ENABLE	**P7-3**
	Ground	**P7-4**
	Run/Stop	**P7-5**
	Ground	**P7-6**

Packing List

70-2219

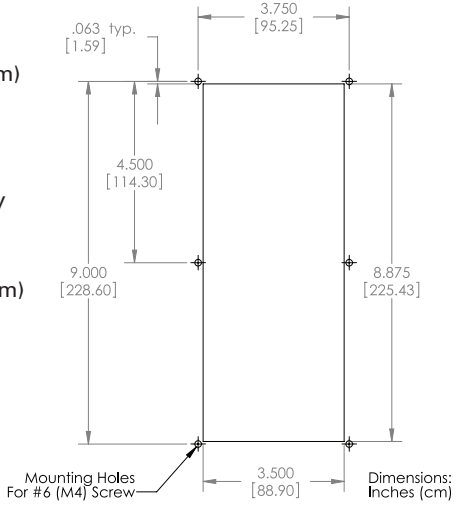
1) Main Unit
2) RS-232 Communications cable
3) User documentation
4) 6 oz. tube of grease
5) Allen wrench

70-2226

1) Main Unit
2) Universal inpu 100/250VAC, 50/60 Hz, 18 watt power supply
3) Line Cord
4) RS-232 Communication cable
5) Power Connection Cable
6) User documentation
7) 6 oz. tube of grease
8) Allen wrench

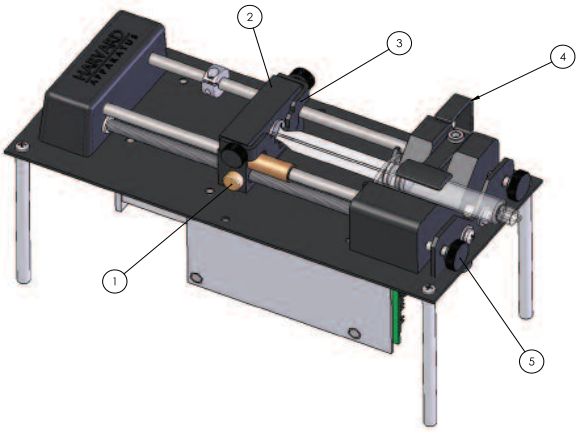
Location Requirements for the Syringe Pump

- A sturdy, level, clean and dry surface
- Minimum of one inch (2.5cm) clearance around the pump
- Appropriate environmental conditions
- Mount into an appropriately rated enclosure or cabinet
- Required clearance below mounting panel: 3.00" (7.5cm)



Loading the Syringe

1. Release the syringe pusher (2) by pressing the bronze button (1) on the side of the pusher.
2. While holding the bronze button 'in', slide the pusher to the left.
3. Raise the spring loaded syringe retainer (4) and swing it out of the way.
4. Lay the loaded syringe in the 'V' shaped holder.
5. Swing the retainer so it holds the syringe in place.
6. Move the pusher so it makes contact with the syringe plunger.
7. Adjust pusher block bracket (3) & Syringe retainer knobs (5) to capture plunger & body of syringe.



Operation

Getting started

Plug one end of the Power cable into P8 connection on board. Connect the other end of the cable into your power supply. Connect communication cable from PC to J1 connector. Refer to page 6 of this manual to reference the board connections.

Working with the pump

The safest way to use the "mL" Modular Syringe Pump Component is in the volume dispense mode. The pump will automatically stop when target volume is dispensed. **Enable must be tied to ground (Hardwire P7-3 to P7-4, or connect through switch)**.

Check Syringe Often

The "mL" Modular Syringe Pump Component will shut itself off when the syringe is empty or is otherwise overloaded. Although this presents no hazard to the user or the pump, it is prudent to check the syringe from time to time.

Maintenance

Keep the "mL" Modular Syringe Pump Component clean and dry. Avoid liquid spills that may find their way into the electronics.

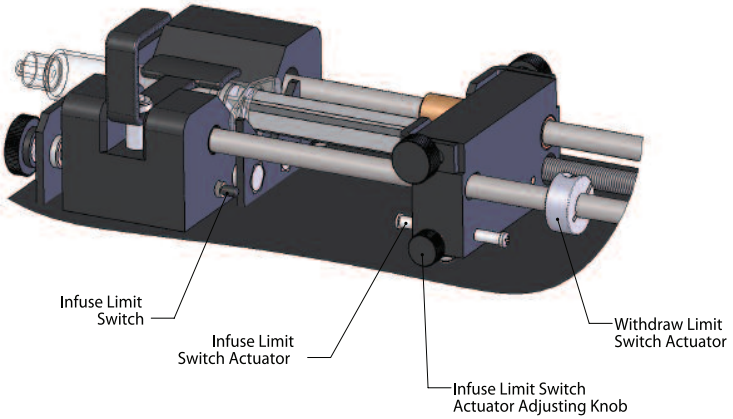
A small tube of grease is provided for periodic lubrication of the lead screw. It is important to keep the lead screw clean and lubricated.

To clean the exterior surfaces above the base plate, use a lint-free cloth to remove loose dust. For more efficient cleaning, use a soft cloth dampened with water or an aqueous solution of 75% isopropyl alcohol.

If the pump does not work properly, contact Harvard Apparatus for appropriate instructions.

Protecting Small, Fragile Syringes

The “mL” Modular Syringe Pump Component will hold micro liter size syringes down to 0.5µl size. These small syringes have fine wire plungers that may be damaged if allowed to bottom out. The “mL” Modular Syringe Pump Component is equipped with an adjustable limit switch actuator on the pusher block. Adjust the limit switch actuator position to prevent damage to small syringes.

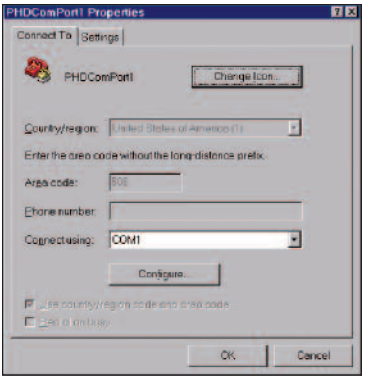


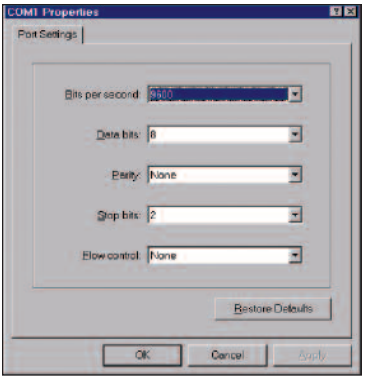
Remote Control via the RS-232 Interface Using HYPERTERMINAL*

** Normally included with most Windows® operating systems.*

Milliliter Modular Syringe Pump Component

1. Connect the RS-232 cable between the "uL" Modular Syringe Pump Component RS-232 IN port and a PC's serial port.
2. On the PC (running a Microsoft Windows Operating System), select START – PROGRAMS – ACCESSORIES – HYPERTERMINAL – HYPERTERMINAL to start the HyperTerminal application.
   If HyperTerminal is not available, install it from the Microsoft Windows Operating System Install disks or CD ROM.
3. Set up the appropriate COMPORT for the following:





Configure:

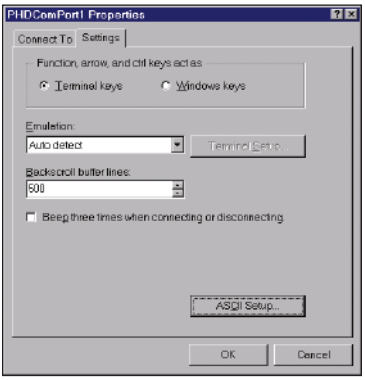
Baud Rate:	9600
Data Bits:	8
Parity:	None
Stop Bits:	2
Flow Cntrl:	None
Emulation:	Auto Detect

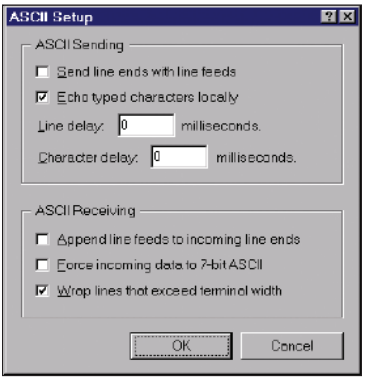
ASCII Setup:

Echo typed characters locally
Line delay: 0
Character delay: 0
Wrap lines

You may want to save the setup information under a descriptive filename.

4. At the PC, launch HyperTerminal with the above setup specifications (if it is not already running). Type VER at the PC keyboard and verify that the pump module's version is displayed at the PC terminal.
5. Type RUN to start the pump; type STP to stop the pump. After starting the pump, > should be displayed, indicating pump is infusing. After stopping the pump, : should be displayed.





Appendix A: Specifications

Accuracy	±0.5%
Reproducibility	±0.1%
Number of Syringes	One
Syringe Sizes	0.5µL (min), 50/60 mL B-D Plastic (max)
Flow Rate:	
Minimum	0.001µL/hr (w/ 0.5µL syringe (0.103mm dia.))
Maximum	44.283 mL/min (w/ 50/60 mL syringe (26.7mm dia.))
Linear Force	25lbs (peak min.) Adjustable
Drive	Motor: 0.9° Stepper
Control	Constant Current Drive, 0.50A peak per phase, 1/4 & 1/16 stepping
Drive Ratio	2.4:1
Leadscrew Pitch	20tpi
Encoder	Optical, 100 line (for stall detection)
Step Rate:	
Minimum	3.8 sec/step
Maximum	250 µsec/step
Pusher Travel Rate:	
Minimum	0.001 mm/min
Maximum	83mm/min
Display	None
Keypad	None
Interface	RS-232
Connectors	Power: 2 –pin Header, .1 centers
	Digital I/O: 6-pin Header, .1 centers
	RS-232: RJ-11 Phone jack
Power	+12 to +30VDC +/- 5%, 0.5A max
Dimensions	9.50" x 4.25" x 4.78" (L X W X H) 24.1cm x 10.8cm x 12.14cm
Mounting Dimensions	9.00" x 3.75" (Mounting holes for (6) #6 screws) 22.9cm x 9.5cm
Ground Stud	#6-32 UNC Thread
Weight	2.72 lbs (1.23kg)
Environmental Operating:	
Temperature	+5 to +40°C (natural convection cooling)
Humidity	20% to 80% RH non-condensing
Storage:	
Temperature	-30 to +45°C
Humidity	10% to 90% RH non-condensing
Pollution Degree	Class I
Compliance	Lead Free, RoHS Compliant

Appendix A: Specifications

The pump is set to the following default parameters on power-up and after an external enable command.

Default Settings

Syringe Diameter:	2.300 mm
Rate:	3.000 ul/min
Range:	ul/min
Baud Rate:	9600

I/O Specifications

Inputs

RUN/STOP

This is an active low, TTL level input, pulled up to +5V through a 10K ohm resistor. It is ESD protected through a TVS device and filtered with a 0.1uF capacitor to ground. Each pulse to a logic low toggles the pump between the RUN and STOP states.

EXT_ENABL/

This is an active low, TTL level input, pulled up to +5V through a 10K ohm resistor. It is ESD protected through a TVS device and filtered with a 0.1uF capacitor to ground. A transition from logic high to logic low causes the processor to reset to its default state and enables the motor drive. A transition from logic low to logic high disables the motor drive through hardware (independent of firmware). This input may be used for an emergency stop function.

Note: To enable pump, this input must be connected to ground or a logic low.

Outputs

RUN_IND/

This is an active low output driven by two 74HCT14 inverters in parallel. An on-board resistor may be placed in series with this output to provide current limiting. The default resistor value is zero ohms. A logic low indicates RUN. A logic high indicates STOP.

Indicators

Power-on LED

When illuminated, indicates that board is powered on and +5VDC supply is operating.

Run LED

When illuminated, indicates that pump is running. When extinguished, indicates pump is stopped.

Appendix B: Syringe Inside Diameter

Terumo

Size	Diameter
3 cc	8.95 mm
5	13.00
10	15.80
20	20.15
30	23.10

Sherwood–Monoject Plastic

Size	Diameter
1 cc	4.65 mm
3	8.94
6	12.70
12	15.90
20	20.40
35	23.80
60	26.60

Stainless Steel

Size	Diameter
2.5 cc	
8 cc	9.525mm
20 cc	19.130
50 cc	28.600

Becton Dickinson Plastic "Plasticpak"

Size	Diameter
1 cc	4.78 mm
3	8.66
5	12.06
10	14.50
20	19.13
30	21.70
50/60	26.70

Air–Tite "All Plastic"

Size	Diameter
2.5 cc	9.60 mm
5.0	12.45
10	15.90
20	20.05
30	22.50

SGE Scientific Glass Engineering

Size	Diameter
25 µl	0.73 mm
50	1.03
100	1.46
250	2.30
500	3.26
1.0 ml	4.61 mm
2.5	7.28
5	10.30
10	14.57

Hamilton–Microliter Series Gastight

Size	Diameter
.5 µl	0.103mm
1	0.1457
2	0.206
5	0.3257
10	0.460
25	0.729
50	1.031
100	1.46
250	2.3
500	3.26
1.0 ml	4.61 mm
2.5	7.28
5	10.3
10	14.57
25	23.00
50	32.60

Appendix C: Flow Rates

nominal syringe size	nominal diameter (mm)	ul/hr min	ul/hr max	ul/min min	ul/min max	ul/hr min	ul/hr max	ml/min min	ml/min max
0.5 µ	0.103	0.001	39.840	0.001	0.664	0.001	.0398	0.001	0.001
1 µ	0.150	0.002	84.481	0.001	1.408	0.001	0.084	0.000	0.001
2 µ	0.210	0.003	165.602	0.001	2.760	0.001	0.165	0.001	0.003
5 µ	0.330	0.007	408.963	0.001	6.816	0.001	0.408	0.001	0.007
10 µ	0.460	0.013	794.581	0.001	13.243	0.001	0.794	0.001	0.013
25 µl	0.730	0.033	1999.999	0.001	33.352	0.001	1.998	0.001	0.033
50 µ	1.030	0.066	1999.999	0.001	66.397	0.001	3.983	0.001	0.066
100 µ	1.460	0.131	1999.999	0.001	133.407	0.001	8.004	0.001	0.133
250 µ	2.300	0.325	1999.999	0.005	331.077	0.001	19.864	0.001	0.331
500 µ	3.260	0.653	1999.999	0.012	665.133	0.001	39.907	0.001	0.665
1 ml	4.610	1.306	1999.999	0.022	1330.073	0.001	79.842	0.001	1.330
2.5 ml	7.280	3.256	1999.999	0.054	1999.999	0.003	199.027	0.001	3.317
3 ml	8.660	4.533	1999.999	0.076	1999.999	0.005	277.080	0.001	4.618
5 ml	10.300	6.517	1999.999	0.109	1999.999	0.007	398.402	0.001	6.640
10 ml	14.570	13.040	1999.999	0.217	1999.999	0.013	797.165	0.001	13.286
20 ml	20.050	22.291	1999.999	0.372	1999.999	0.023	1362.721	0.001	22.712
30 ml	23.100	28.631	1999.999	0.477	1999.999	0.029	1750.384	0.001	29.173
60 ml	26.600	43.460	1999.999	0.724	1999.999	0.043	1999.999	0.001	44.283

Appendix D: Serial Communication

Commands, Queries and Responses

After each transmission to the pump terminating with a CR character (ASCII 13), the pump enters remote mode and responds with the character sequence:

CR LF prompt

The prompt characters indicate the status of the pump as follows:

prompt	meaning	ASCII code
:	Stopped	(ASCII 58 decimal)
>	Running forward	(ASCII 62 decimal)
<	Running reverse	(ASCII 60 decimal)
*	Stalled	(ASCII 42 decimal)
*I	Infuse limit switch actuated	(ASCII 42 decimal + ASCII 73 decimal)
*W	Withdraw limit switch actuated	(ASCII 42 decimal + ASCII 87 decimal)
*D	Disabled by emergency stop	(ASCII 42 decimal + ASCII 68 decimal)
*T	Target volume reached	(ASCII 42 decimal + ASCII 68 decimal)

Serial Commands and Their Meanings

Commands

RUN	Start infuse (forward direction)
RUNW	Starts withdraw (reverse direction)
STP	Stop motor
CLV	Clears infuse volume accumulator to zero
CLVW	Clears withdraw volume accumulator to zero
CLT	Clears target infuse volume to zero, dispense disabled
CLTW	Clears target withdraw volume to zero
REV	Reverses pumping direction

Commands with Numbers

(Must have space before number)

MMD	number	Set syringe diameter, units are mm. Rate is set to zero after MMD command.
ULM	number	Set infuse flow rate and range, units are microliters per minute.
ULMW	number	Set withdraw flow rate and range, units are microliters per minute.
MLM	number	Set infuse flow rate and range, units are milliliters per minute.
MLMW	number	Set withdraw flow rate and range, units are milliliters per minute.
ULH	number	Set infuse flow rate and range, units are microliters per hour.
ULHW	number	Set withdraw flow rate and range, units are microliters per hour.

Commands with Numbers (continued)

FOR	number	Force setting as percentage (number can be 0-100).
MLH	number	Set infuse flow rate and range, units are milliliters per hour.
MLHW	number	Set withdraw flow rate and range, units are milliliters per hour.
MLT	number	Set target infusion volume, units are ml or µl depending on range.
MLTW	number	Set target withdraw volume, units are ml or µl depending on range.

Numbers can be between 0 and 1999

Leading zeros and trailing decimal point are optional. Any number of digits to the right of the decimal point may be transmitted. The number will be rounded.

****For rate numbers only – use "X" instead of a number to get maximum rate****

Queries

DIA	Returns diameter value units in mm
RAT	Returns infusion rate value set in current range units
RAT W	Returns withdraw rate value set in current range units
VOL	Returns current accumulated infused volume, units in ml or µl depending on range.
VOL W	Returns current accumulated withdraw volume, units in ml or µl depending on range.
VER	Returns model and version number of firmware
TAR	Returns target infuse volume, units in ml or µl depending on range
TAR W	Returns target withdraw volume, units in ml or µl depending on range
FRC	Returns force setting and percent

Value format: nnnn.nnn

The returned value is an 8 character string with leading zeros converted to SP characters (ASCII 32 decimal). The fifth character is a decimal point (ASCII 46 decimal).

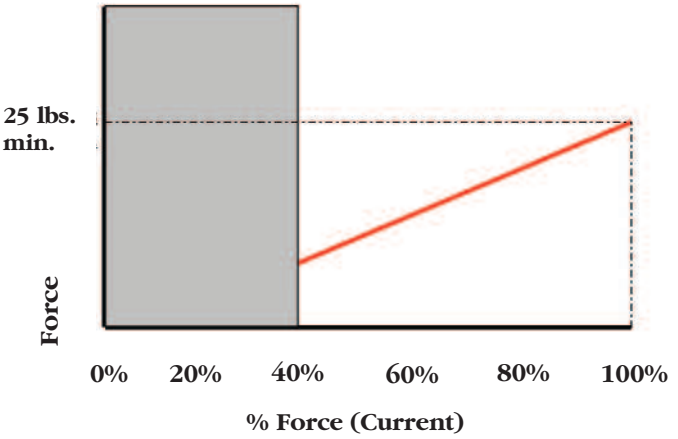
Queries with String Response

RNG	Returns infuse range message (character string either: ML/H, ML/M, UL/H, UL/M)
RNG W	Returns withdraw range message (character string either: ML/H, ML/M, UL/H, UL/M)
EMG	Returns emergency stop input status (True/False); True = Emergency Stop
LIM	Returns "*I", "*W" or "false"; indicating limit switch actuation status.

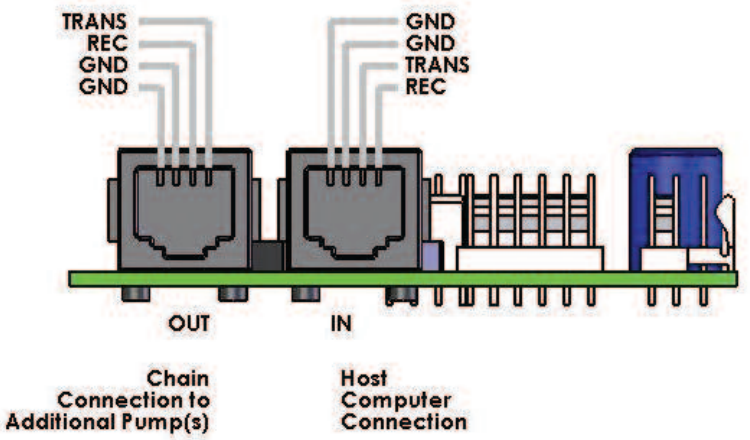
Error responses

CR LF ? CR LF prompt	Unrecognized command
CR LF OOR CR LF prompt	Entered value is out of range

***Note: Adjustable force settings



Due to differences in mechanical drug forces, we do not recommend operating the pump below 40% force level.



Appendix E: Optional – Daisy-Chaining

The RS-232 Connection to the first board in the daisy-chain is made through the 9-pin D-Sub connector or RJ-11 input (J1). Use an appropriate adapter to connect a 9-pin or 25-pin D-Sub at a PC to the RJ-11 input. A straight-through RJ-11 to RJ-11 cable is used to connect from the RJ-11 output (J2) of the first board to the input of the next board in the daisy-chain. Set each board in the chain to be at a unique address (00 to 15) by setting the DIP switches (SW1) as follows:

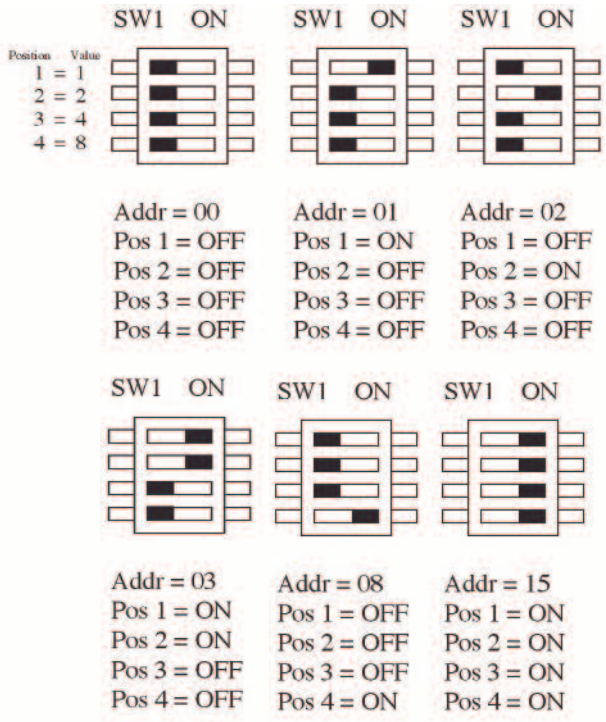


Fig. 1 – 5 Examples of the 16 Possible Address Configuration Settings

To communicate with each board in the daisy-chain, prefix commands and queries with the address. Addresses must be two digits (i.e. 00 to 15). These addresses are based on the principle of binary notation. Add up your address value by moving the appropriate switch to the "on" position.

****Pump must be power-cycled or reset for address change to be recognized.****

Appendix F: Optional Accessories

Catalog No.	*Product*
70-2231	1.8m (6 ft) motor/encoder extension cable
70-2232	1.8m (6 ft) limit switch extension cable
55-7760	0.6m (2 ft) RJ11 daisy-chain cable
72-2478	1.8m (6 ft) RJ11 daisy-chain cable 1140-352 I/O & E-stop cable w/ LED

Declaration of Conformity

In Accordance with ISO/IEC Guide 22 and EN 45014

Manufacturer: *HarvardApparatus, Inc.*
84 October Hill Rd.
Holliston, MA 01746-1388
U.S.A.Phone: (508) 893-8999

We herewith declare that the following product:

Product Name: *Milliliter Flow Modular Pump Component*

Model No.: *70-2219 / 70-2226*

To which this declaration relates, is in conformity with the applicable EC Directives, harmonized standards, and other normative requirements:

Application of
Council Directive(s): *89/336/EEC*

Standard(s) to which
Conformity is Declared:

Emissions/Immunity:
EN 61326-1:2005
EN 61000-4-2
EN 61000-4-3
EN 61000-4-4
EN 61000-4-5
EN 61000-4-6
EN 61000-4-11
C1SPR 11:2004 Class A

Beth Bauman
(Signature)

Beth Bauman
(Full Name)

VP Engineering / Operations
(Position)

CE

HARVARD
APPARATUS