PHD ULTRA™ Syringe Pump Module
Syringe Pump Series
USER'S GUIDE

PHD ULTRA™ Series

Harvard Apparatus

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Publication 5419-006-REV 3.2

Table of Contents

General Information

This guide describes basic procedures for operating the PHD ULTRA™ Syringe Pump Module Family, including both hardware operations and software operations accessed through a PC. This section discusses important conventions used in this guide.

Illustrations

Unless otherwise indicated, the values in the illustrations of this manual are examples only. They are not intended to indicate the exact values you will see or to suggest the values you should use.

Special Messages/Callouts

The following special messages and callouts appear throughout the guide to indicate information that requires special attention:

Warnings or hazard instructions provide information to help you avoid personal injury or damage to the PHD ULTRA™ Syringe Pump Module during operation.

Notes provide helpful instructions that can help you make better use of the PHD ULTRA™ Syringe Pump Module.

WARRANTY AND REPAIR INFORMATION

CAUTION: REFER TO SAFETY INFORMATION AND SETTING UP THE PHD ULTRA™ SYRINGE PUMP MODULE BEFORE PLUGGING IN PHD ULTRA™ SYRINGE PUMP MODULE.

Manual Description

This manual is designed to provide all operational and program information required to operate and maintain the PHD ULTRA™ Syringe Pump Module Family. The functions and features are described in the Technical Specifications section.

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 materials. 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 consumer purchaser.

IN NO EVENT SHALL HARVARD APPARATUS BE LIABLE FOR INCIDENTAL OR CONSEQUENTIAL DAMAGES. Some states do not allow the 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, OR 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, 84 October Hill Road, Holliston, Massachusetts 01746** using our toll free number **800-547-6766** , or outside the U.S. call **508-893-8999**. Email Address is techsupport@harvardapparatus.com. 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 for non-warranty repairs. Please allow a reasonable period of time for completion of repairs or replacement. 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 a part number obtained from our Technical Support department. If practical, enclose a sample part or sketch. We offer a complete reconditioning service.

Serial Numbers

All inquiries concerning our product should refer to the serial number of the unit, located on the rear panel.

Calibrations

All electrical apparatus are calibrated at rated voltage and frequency. While the flow and volume will stay calibrated, the peak pressure may vary. Harvard Apparatus recommends an annual calibration of the pump.

CAUTION: FOR RESEARCH USE ONLY. NOT FOR CLINICAL USE ON PATIENTS.

SAFETY INFORMATION

Please read the following safety precautions to ensure proper use of your syringe pump. If the equipment is used in a manner not specified, the protection provided by the equipment may be impaired.

To Prevent Hazard or Injury:

Use Proper Line Cord and Power Supply

Use only the specified line cord and power supply for this product and make sure line cord is certified for country of use. The operating voltage range for the PHD ULTRA™ Syringe Pump Module Family is 12 to 30 VDC. The universal power supply operating voltage range is 100 to 240 VAC, 50/60 Hz.

Ground the Product

This product is grounded through the grounding conductor of the power cord. 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 (See Note 1).

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 (except RS-485 pump-to-pump communication cable).

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.

Avoid Pinch Hazard

A pinch hazard may exist between the pusher block and end blocks. Avoid placing fingers between these points while the pump is running.

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.

Orient the Equipment Properly

Do not orient the equipment so that it is difficult to manage the connection and disconnection of devices.

Place Product in Proper Environment

Review the operating manual for guidelines for proper operating environments.

Observe all Warning Labels on Product

Read all labels on product to ensure proper usage.

CAUTION
Refer to Manual

Protective Ground
Terminal

NOTE 1: Satellite and Remote units are DC powered through the RS-485 cable. Earth ground connection is through this cable for these units.

Introduction To The PHD ULTRA™ Syringe Pump Module

PRODUCT OVERVIEW – THEORY OF OPERATION

The PHD ULTRA™ Syringe Pump Module series is a family of high-accuracy, microliter- and milliliter-compatible pumps designed for a wide variety of applications including mass spectroscopy, calibration, drug and nutritional infusions, microdialysis, dispensing, chromatography and LC/HPLC. The PHD ULTRA™ Syringe Pump Module incorporates a microprocessor controlled, small step angle stepping motor that drives a lead screw and Pusher Block. Advanced micro-stepping techniques are employed to further reduce the step angle to eliminate flow pulsation. The pump is engineered to provide flow accuracy within 0.25% and reproducibility within 0.05%.

The PHD ULTRA™ Syringe Pump Module requires control via a PC to control operation. External I/O interfaces permit external control via an independent computer or device.

PUMP CONFIGURATIONS

The PHD ULTRA™ Syringe Pump Module is available in two configurations:

- Standard Pump: This configuration is the most common. It consists of a single unit with a dual syringe pumping mechanism attached to the top of the chassis.
- Push/Pull Pump: This configuration consists of a single unit with the syringe pumping mechanism attached to the top of the chassis. The pump can hold up to four syringes; 2 on either side of the pusher block. The pump can simultaneously infuse and withdraw the exact same amount.

The PHD ULTRA™ 4400 Syringe Pump Module is available in two configurations:

- Standard Pump: This configuration consists of a single unit with a single syringe pumping mechanism attached to the top of the chassis.
- Open Baseplate Pump: This configuration consists of a single syringe pumping mechanism and control board mounted on a baseplate. This configuration is intended for instrument integration.

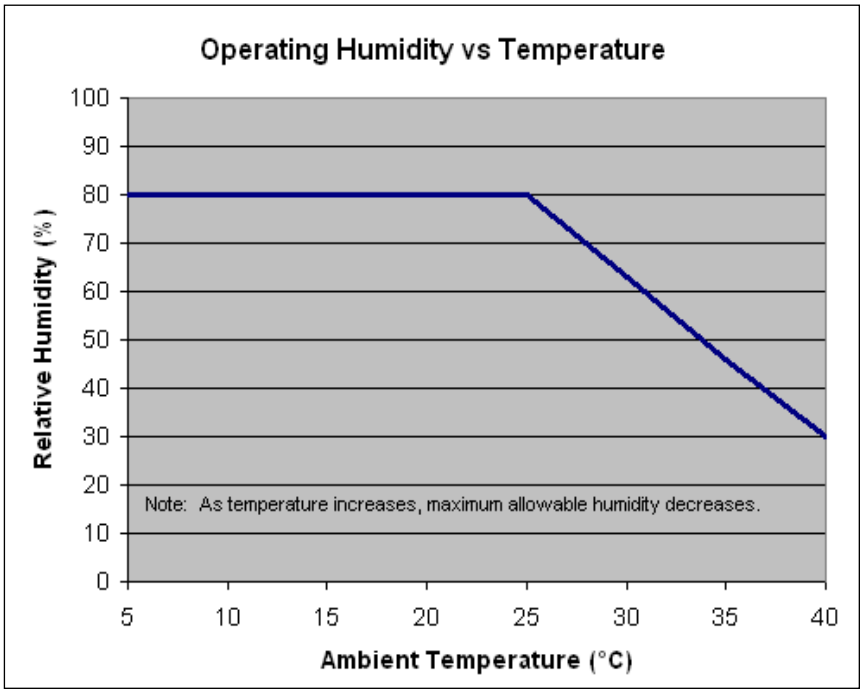
The PHD ULTRA™ XF Syringe Pump Module is available in one configuration:

- Standard Pump: High force mechanism with 4-syringe holder.

WARNING: ANY TIME THE PUMP IS USED WITH AUTOMATION SOFTWARE (LABVIEW, MATLAB OR ANY CUSTOM SOFTWARE), USE THE 'NVRAM NONE' COMMAND TO PROTECT THE NVRAM FROM BEING DAMAGED.

Specifications				
Specifications	**PHD ULTRA™ Syringe Pump Module**	**PHD ULTRA™ 4400 Syringe Pump Module**	**PHD ULTRA™ 4400 Open Baseplate Syringe Pump Module**	**PHD ULTRA™ XF Enclosed Syringe Pump Module**
Accuracy	± 0.25%	± 0.35%	± 0.35%	± 0.5%
Syringes (Min./Max.)	0.5 µl / 140 ml	0.5 µl / 140 ml	0.5 µl / 140 ml	20 ml / 200 ml
Flow Rate:				
Minimum	3.16 pl/min (0.5 µl syringe)	3.16 pl/min (0.5 µl syringe)	3.16 pl/min (0.5 µl syringe)	50.7 nl/min (20 ml syringe)
Maximum	15.8 ml/min (140 ml syringe)	215.8 ml/min (140 ml syringe)	215.8 ml/min (140 ml syringe)	144.08 ml/min (200 ml syringe)
Display	None	None	None	None
Non-Volatile Memory	Stores all settings	Stores all settings	Stores all settings	Stores all settings
Connectors:				
RS-485	IEEE-1394, 6 pos	IEEE-1394, 6 pos	IEEE-1394, 6 pos	IEEE-1394, 6 pos
USB	Type B	Type B	Type B	Type B
I/O & TTL	15-pin D-Sub Connector	15-pin D-Sub Connector	15-pin D-Sub Connector	15-pin D-Sub Connector
Footswitch	Mini phono jack	Mini phono jack	Mini phono jack	Mini phono jack
RS-232	9-pin D-Sub Connector	9-pin D-Sub Connector	Contact Technical Support	9-pin D-Sub Connector
Linear Force (Max), 30V, 100% Force	34 kg (75 lb)	91 kg (200 lb)	91 kg (200 lb) flow rate dependent	455 kg (1000 lb)
Drive Motor	0.9° Stepper Motor	0.9° Stepper Motor	0.9° Stepper Motor	0.9° Stepper Motor
Motor Drive Control	Microprocessor with 1/16 microstepping	Microprocessor with 1/16 microstepping	Microprocessor with 1/16 microstepping	Microprocessor with 1/16 microstepping
Motor Micro Steps per one revolution of Lead Screw	12,800	6,400	6,400	32,000
Step Resolution:	0.082 µm/µstep	0.082 µm/µstep	0.164 µm/µstep	0.082 µm/µstep
Step Rate:				
Minimum	27.5 sec/µstep	27.5 sec/µstep	27.5 sec/µstep	27.5 sec/µstep
Maximum	26 µsec/µstep	52 µsec/µstep	52 µsec/µstep	52 µsec/µstep
Pusher Travel Rate:				
Minimum	0.18 µm/min	0.36 µm/min	0.36 µm/min	0.18 µm/min
Maximum	190.80 mm/min	190.80 mm/min	190.80 mm/min	91.637 mm/min
input Power	12 to 30 VDC, 50W (30V recommended)	12 to 30 VDC, 50W (30V recommended)	12 to 30 VDC, 50W (30V recommended)	12 to 30 VDC, 50W (30V recommended)
Power Supply	GlobTek, Inc. (P/N: TR 9CR1666LCP-Y-MED)	GlobTek, Inc. (P/N: TR 9CR1666LCP-Y-MED)	Not included, part number 5005-070, please see Appendix H: for accessories.	GlobTek, Inc. (P/N: TR 9CR1666LCP-Y-MED)
Dimensions	11.75 x 5.5 x 6.5 in (29.8 x 14.0 x 16.5 cm)	11.75 x 5.5 x 6.5 in (29.8 x 14.0 x 16.5 cm)	11.9 x 6.0 x 6.5 (30.2 x 15.2 x 46.6 cm)	16 x 12 x 8.5 in (40.64 x 30.48 x 21.6 cm)
Weight	5.1 kg (11.2 lb)	5.3 kg (11.7 lb)	3.86 kg (8.5 lb)	20 kg (44 lb)

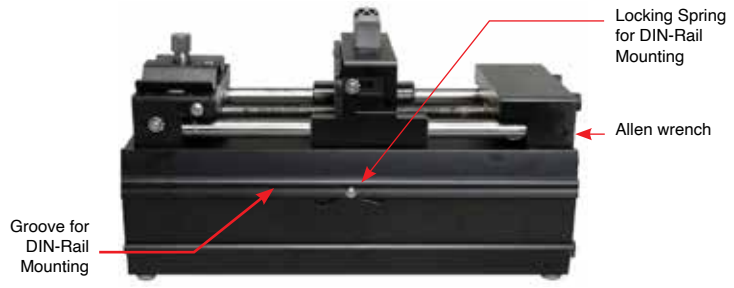
Specifications				
Specifications	**PHD ULTRA Syringe Pump Module**	**PHD ULTRA 4400 Syringe Pump Module**	**PHD ULTRA XF Syringe Pump Module**	**PHD ULTRA™ XF Enclosed Syringe Pump Module**
Atmospheric Conditions				
Operating Temperature	4°C to 40°C (40°F to 104°F)	4°C to 40°C (40°F to 104°F)	4°C to 40°C (40°F to 104°F)	4°C to 40°C (40°F to 104°F)
Storage Temperature	-10°C to 70°C (14°F to 158°F)	-10°C to 70°C (14°F to 158°F)	-10°C to 70°C (14°F to 158°F)	-10°C to 70°C (14°F to 158°F)
Operating Humidity	See Chart Below	See Chart Below	See Chart Below	See Chart Below
Storage Humidity	20% to 80% RH, non condensing	20% to 80% RH, non condensing	20% to 80% RH, non condensing	20% to 80% RH, non condensing
Method of Operation	Continous	Continous	Continous	Continous
Classification	Class I	Class I	Class I	Class I
Pollution Degree	1	1	1	1
Installation Category	II	II	II	II
Supplier Name	Harvard Apparatus	Harvard Apparatus	Harvard Apparatus	Harvard Apparatus
Supplier Address	84 October Hill Road, Holliston, MA 01746	84 October Hill Road, Holliston, MA 01746	84 October Hill Road, Holliston, MA 01746	84 October Hill Road, Holliston, MA 01746
Supplier Phone Number	(508) 893--8999	(508) 893-8999	(508) 893-8999	(508) 893-8999
Regulatory Certifications	CE, ETL (UL, CSA), WEEE, EU RoHS & CB Scheme	CE, ETL (UL, CSA), WEEE, EU RoHS & CB Scheme	WEEE, EU RoHS	CE, ETL (UL, CSA), WEEE, EU RoHS & CB Scheme
Safety Declarations	ANSI/UL 61010-1; CAN/CSA C22.2 No. 61010-1; IEC 61010-1; CB Scheme	ANSI/UL 61010-1; CAN/CSA C22.2 No. 61010-1; IEC 61010-1; CB Scheme	IEC 61010-1	ANSI/UL 61010-1; CAN/CSA C22.2 No. 61010-1; IEC 61010-1; CB Scheme
EMC Declaration	FCC 47CFR 15B; EN61326-1	FCC 47CFR 15B; EN61326-1	N/A	FCC 47CFR 15B; EN61326-1



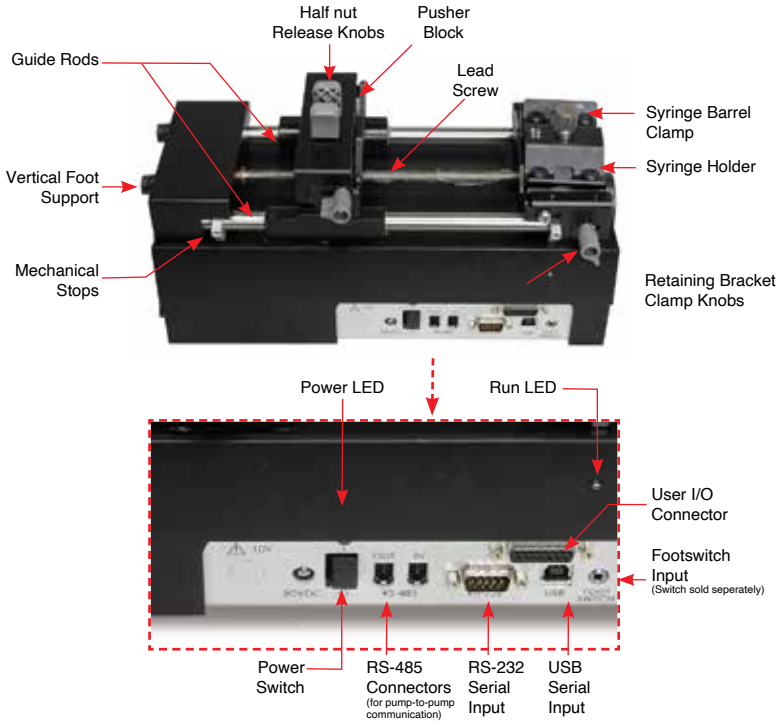
Setting Up The PHD ULTRA™ Syringe Pump Module

PHYSICAL VIEWS

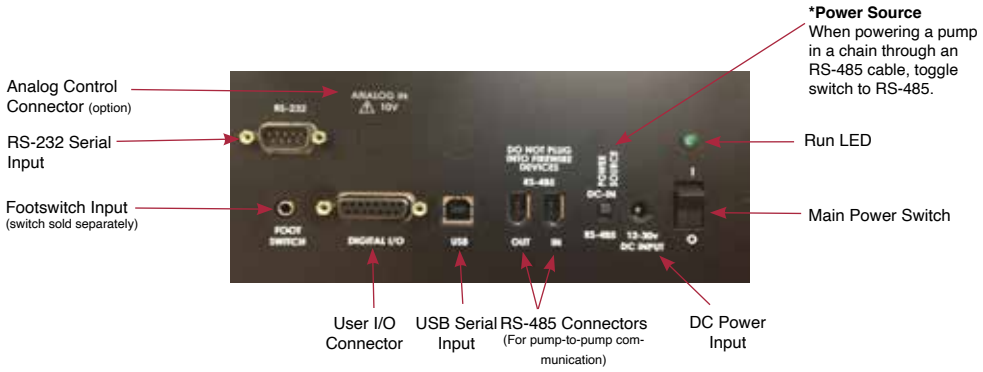
The following diagrams show the important components of the PHD ULTRA™ Syringe Pump Module.



Rear view of the PHD ULTRA™ Syringe Pump Module showing important connections.



Front view of the PHD ULTRA™ Syringe Pump Module showing important components and controls.



Close up of XF Syinge Pump Module showing important components and controls.

POWER CONNECTIONS AND PUMP STARTUP

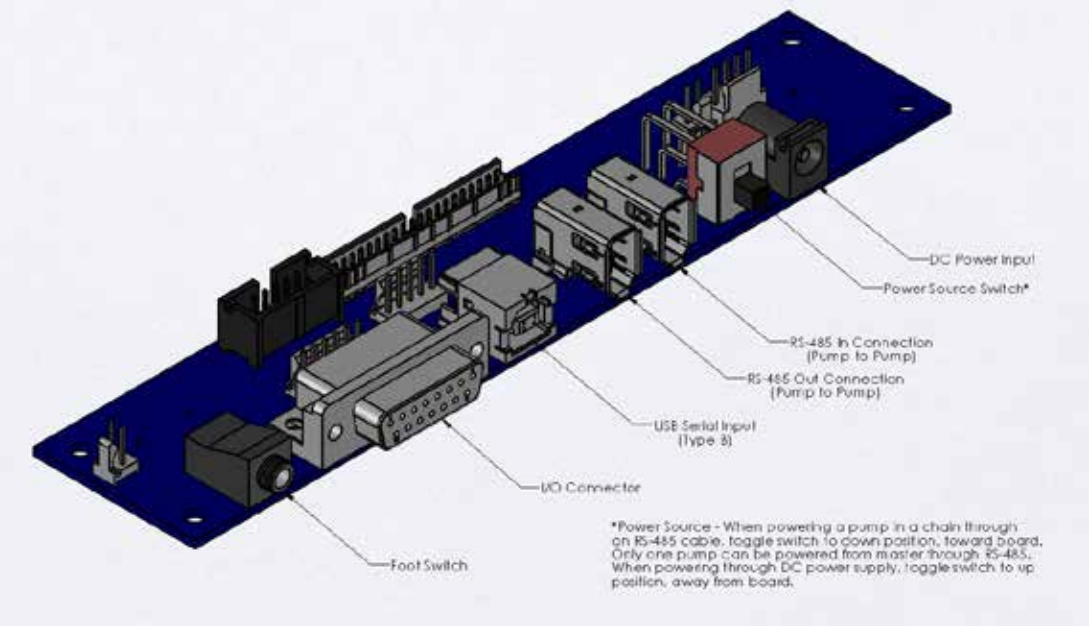
CAUTION: DO NOT CONNECT TO FIREWIRE DEVICES.
DAMAGE MAY OCCUR TO PUMP OR DEVICE.

The operating voltage range for the PHD ULTRA™ Syringe Pump Module is 12-30 VDC. Only use provided 30 VDC, 50W AC/DC adapter/power supply to guarantee specified operation and EMC compliance. Use only the specified line cord and power supply for this product and make sure they are certified for country of use.

1. Plug the power cord into the Universal Power supply.
2. Plug the Universal Power supply into the power jack of the PHD ULTRA™PC Controlled Syringe Pump.
3. Turn on main power switch located in the lower left corner of the front panel.
4. Power LED above the power switch will illuminate.

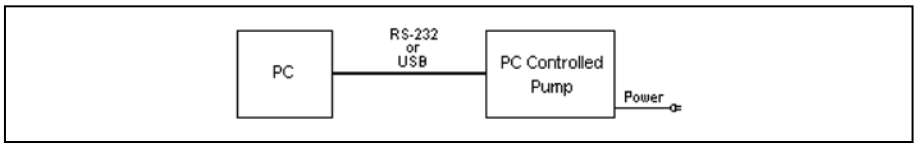
PHD ULTRA™ 4400 OPEN BASEPALTE CONNECTIONS

PHD ULTRA™ 4400 Open Baseplate Module Pinout diagram.



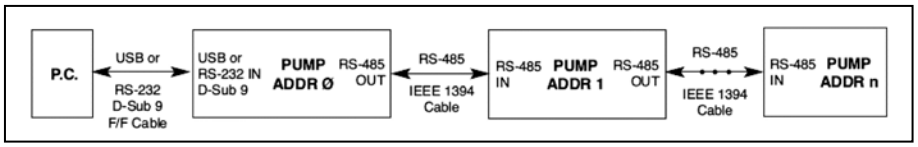
PC-TO-PUMP CONNECTION OPTIONS

Connect the Syringe Pump Module to a PC using either an RS-232 or USB cable.



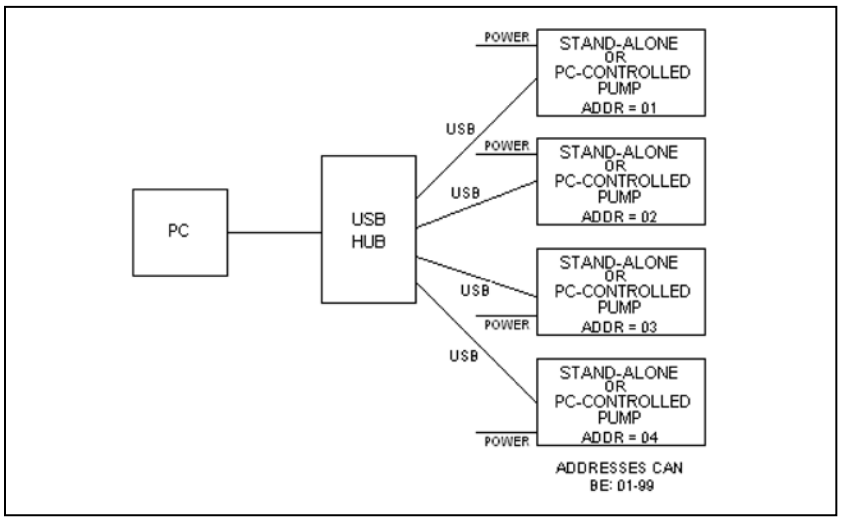
PC control via an RS-232 or USB cable

Pumps can be Daisy chained using RS-485 cables. (refer to Appendix E for more information)



Daisy chained pumps connected via RS-485 cables

Multiple Syringe Pump Modules can be controlled by a single PC by connecting through a USB Hub.



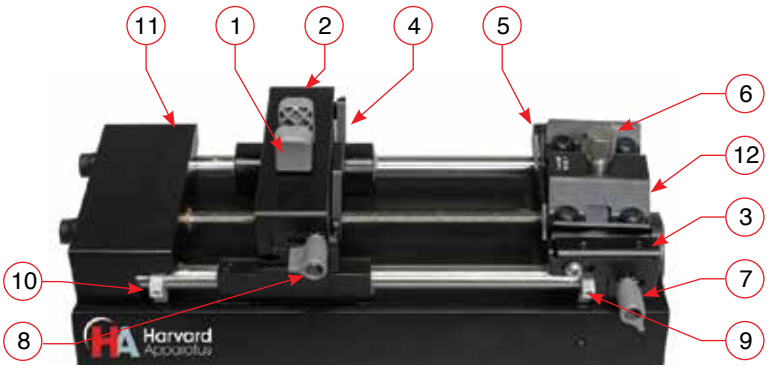
Setting Addresses on PC Controlled Units

1. Connect Syringe Pump Module unit to PC via an RS-232 or USB cable
2. Launch HyperTerminal on your computer or Method Manager on the included CD.
3. Set address using the appropriate Pump Chain commands (see page 20)

Setting Forces on PC Controlled Units

1. Connect Syringe Pump Module unit to PC via an RS-232 or USB cable
2. Launch HyperTerminal on your computer or Method Manager on the included CD.
3. Set force to desired percent using the appropriate Pump Chain commands (see page 21)

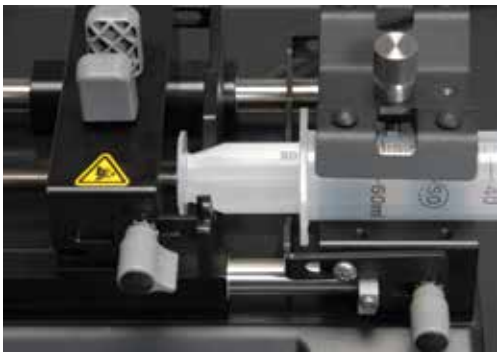
SYRINGE LOADING



1. Release Tabs
2. Pusher Block
3. Syringe Holder Block
4. Retaining Bracket (Pusher Block)
5. Retaining Bracket (Syringe Holder Block)
6. Syringe Barrel Clamp Knob
7-8. Bracket Clamping Knobs
9. Mechanical Stop (Infuse)
10. Mechanical Stop (Withdraw)
11. Pulley Cover (Allen Wrench Holder)
12. Syringe Barrel Clamp

Front view of PHD ULTRA™ Syringe Pump Module showing important controls for syringe loading.

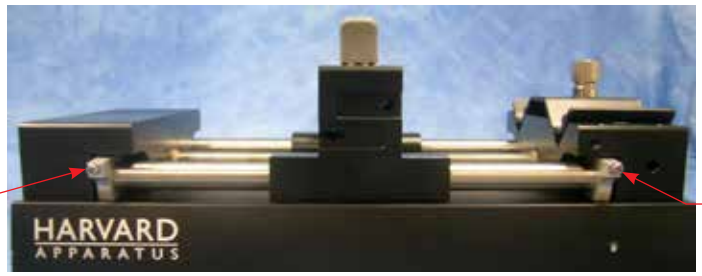
1. Adjust the Pusher Block (2) to the approximate length of the syringe(s) by squeezing the Release Tabs (1) and sliding the Pusher Block (2) into position.
2. Loosen the Retaining Brackets (4,5) on both the Pusher Block (2) and Syringe Holder Block (3) by unscrewing the Bracket Clamping Knobs (7,8). Lift the Syringe Barrel Clamp (12) by unscrewing the Syringe Barrel Clamp Knob (6).
3. Place the syringe(s) on the Syringe Holder Block (3). Ensure that the barrel flange is within the Syringe Holder Block's Retaining Bracket (5) and the plunger flange is within the Pusher Block's Retaining Bracket (4).



Close-up of syringe positioning with plunger inserted in retaining bracket of pusher block.

4. Lower the Syringe Barrel Clamp (12) by screwing down the Syringe Clamp Knob (6) until the clamp is tight against the syringe barrel.
5. Push the Retaining Brackets (4,5) tightly against the syringe flanges then tighten the retaining brackets using the Bracket Clamping Knobs (7,8).
6. Squeeze the Release Tabs (1) and move the Pusher Block (2) to the right until the syringe plunger is located as far into the syringe as it will travel.
7. Using the Allen Wrench, located in its holder in the rear of the Pulley Cover (11), loosen the Infusion Mechanical Stop (9) and slide it to the left until it is in contact with the Pusher Block (2). Use the Allen Wrench to tighten it in this position.
8. Squeeze the Release Tabs (1) and move the Pusher Block (2) to the left until the plunger is located just to the left of the maximum volume allowable. Use the Allen Wrench to loosen the refill Mechanical Stop (10) and slide it to the right until it is in contact with the Pusher Block (2). Tighten the Withdraw Mechanical Stop (10) and then return the Allen Wrench to its holder (11).

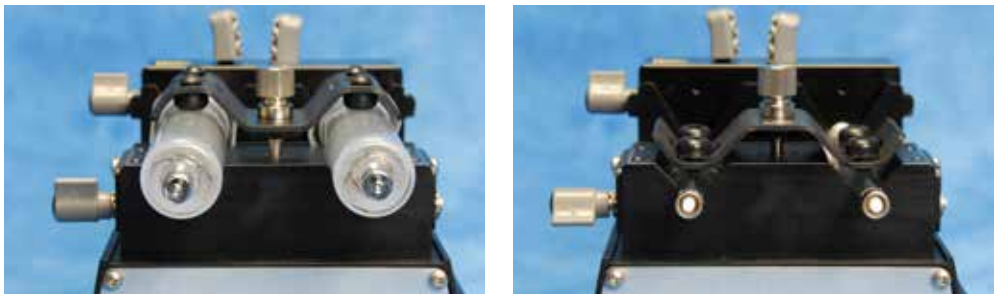
Note mechanical stops set in position to prevent excess travel of pusher block.



Changing the bracket for small (<30ml) vs large (>30ml) syringes:

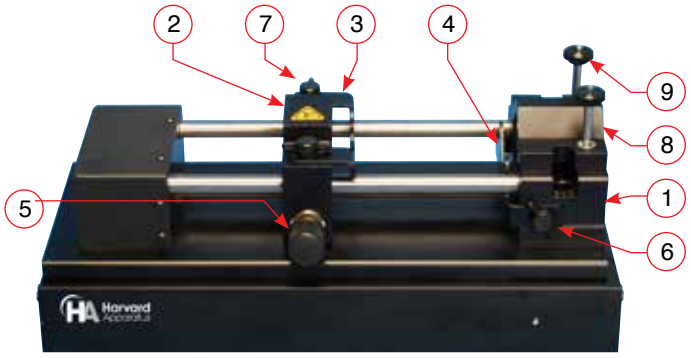
CAUTION: BE SURE THE MECHANICAL STOPS ARE POSTIONED PROPERLY TO PREVENT THE PLUNGER FROM BOTTOMING OUT ON GLASS SYRINGES.

1. Remove the Syringe Barrel Clamp Assembly by completely unscrewing the Syringe Barrel Clamp Knob.
2. Unscrew and remove the Retaining Nut and slide the clamp bar off the Syringe Barrel Clamp Knob.
3. Flip the bracket over, reassemble the Retaining Nut and screw the assembly back onto the pump.



Large vs. small diameter syringe clamping.

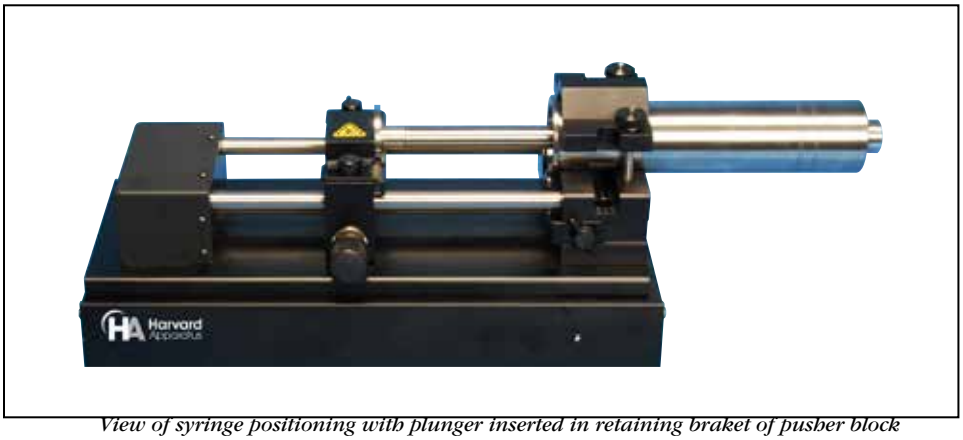
PHD ULTRA 4400 SYRINGE LOADING



1. Syringe Holder
2. Pusher Block
3. Retaining Bracket (pusher block)
4. Retaining Bracket (syringe holder)
5. Knob (leadscrew release)
6. T-knobs (syringe holder)
7. T-knobs (pusher block)
8. Syringe Clamp
9. Thumb Screws

View of PHD ULTRA™ 4400 Syringe Pump Module showing important controls for syringe loading.

1. The Syringe Holder (1) and Pusher Block (2) are fitted with movable Retaining Brackets (3,4) which hold firmly the syringe barrel and plunger when refilling. When loading the syringe into the pump it is necessary to adjust these brackets.
2. Loosen the two T-knobs (6) on the Syringe Holder and the two T-knobs (7) on the Pusher Block to free the Retaining Brackets (3,4).
3. To free the Pusher Block (2) from the leadscrew, turn the Knob (5) on the front of the block until the knob slips into the slots.
4. Place the syringe barrel on the Syringe Holder (1) and move the Pusher Block (2) to accommodate the plunger.



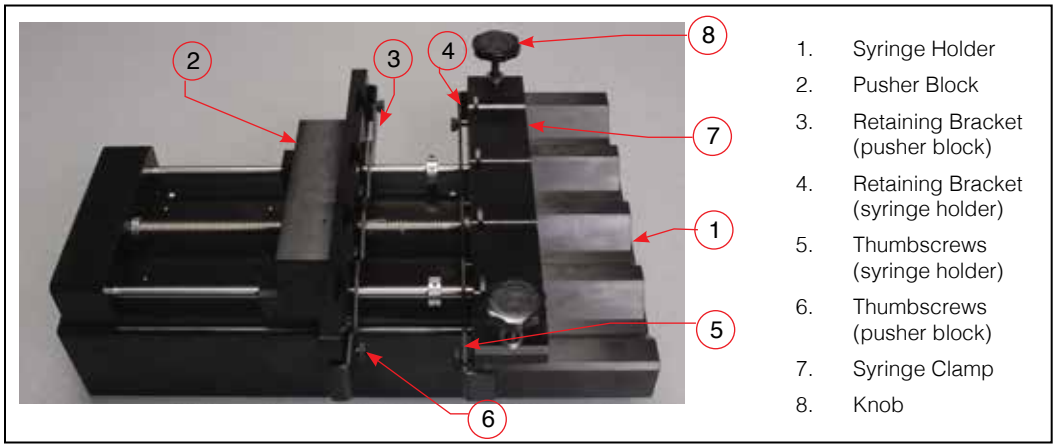
View of syringe positioning with plunger inserted in retaining braket of pusher block

5. Make sure the syringe barrel flange and the plunger flange are held by the Retaining Brackets (3,4). Press the Retaining Brackets firmly against the flanges and tighten with the T-knobs (6,7).
6. Place the Syringe Clamp (8) over the syringe barrel and secure to the Syringe Holder with the two Thumbscrews (9).

Close-up side view of bracket positioning for small and large syringe sizes.

NOTE: For larger syringes it may be necessary to flip the syringe clamp over.

PHD ULTRA XF SYRINGE LOADING



View of PHD ULTRA™ XF Syringe Pump Module showing important controls for syringe loading.

1. Unscrew the two Knobs (8) located on the Syringe Holder (1) enough to allow you to raise the Syringe Clamp bar (7).
2. Using the four Thumbscrews (5 & 6), loosen the Retaining Brackets (3 & 4) on both the Syringe Holder (1) and the Pusher Block (2).

NOTE: For larger syringes it may be easier to completely remove the Syringe Clamp bar, load the syringes, and then reattach the bar.

NOTE: For smaller syringes (<50 ml), remove the clamp bar and turn it over.

3. Lift the Syringe Clamp bar (7) and slide the syringe(s) underneath. Make sure the barrel flange is either within the Syringe Holder's Retaining Bracket (4) [plastic syringes] or sitting in the slot on the Syringe Holder [stainless steel syringes].
4. Slide the plunger's flange into the Pusher Block's Retaining Bracket (3) [plastic syringes] or into the slots in the pusher bar [stainless steel syringes].
5. Tighten the two Knobs (8) on the Syringe Holder (1) until the Syringe Clamp bar (7) is firmly against the syringe(s) barrel.
6. Press the Retaining Brackets (3 & 4) tight against the syringe's flanges and tighten into place using the four thumbscrews (5 & 6).

PHD ULTRA XF with syringes loaded

EXTERNAL PUMP CONTROL

This section of the PHD ULTRA™ Syringe Pump Module manual describes the control of the pump using HyperTerminal on your PC.

National Instruments offers a LabView Driver that can be used with the PHD ULTRA™ Syringe Pump Module. To download this driver, visit www.ni.com and search for "Harvard Apparatus".

NOTE: The Harvard Apparatus Pump Terminal program, provided on the PHD ULTRA CD, can be used for easy external control of the PHD ULTRA through RS-232 or USB connection.

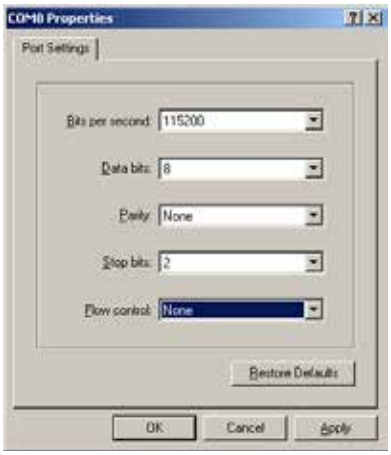
Setting Up HyperTerminal

HyperTerminal is a Windows application designed to support the external control of devices such as the PHD ULTRA™ Syringe Pump Module through an RS-232 or USB connection. The following instructions describe the configuration of the HyperTerminal application.

1. Select "Start – All Programs – Accessories – Communications – HyperTerminal".

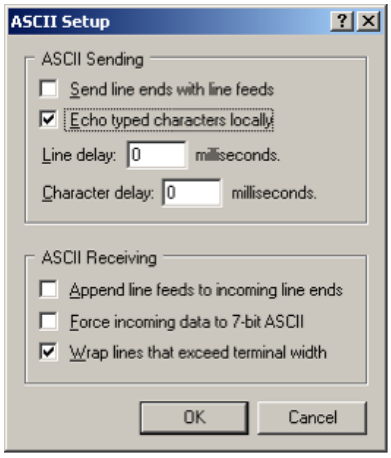
2. Enter a name for a New Connection (i.e PHD_Ultra_ Comm), then click OK.

3. Select the Virtual Comm Port from the "Connect using" drop-down list. Click OK.
(If the Virtual Comm Port is not known, use Device Manager to find it. Instructions on setting up the Virtual CommPort Driver are supplied in Appendix E.)



4. Set up the Port Settings as shown above and click OK.

5. Verify the Settings are as shown above.



6. Choose ASCII Setup and select "Echo typed characters locally"then click OK to complete the setup.

PUMP CHAIN COMMANDS

The Pump Chain commands allow all pump control information to be managed from an external computer source. These commands can also be used to control a series of pumps (up to 100) from a single computer interface.

PHD ULTRA™ Syringe Pump Module commands are communicated to the pump via the RS-232 or USB port interfaces through a terminal program such as the Harvard Apparatus Method Manager or HyperTerminal. In using the Pump Chain commands, you will need to assign each pump in the pump chain a unique address, using the Address command in HyperTerminal. The address range is from 00 to 99. This address value is used to identify which pump is to receive a command and which pump is responding. The first pump in the chain, the one connected to the computer, must use address 0 (zero). Configure each pump with its assigned address and baud rate as described in the Pump Settings section of this Guide.

WARNING: ANY TIME THE PUMP IS USED WITH AUTOMATION SOFTWARE (LABVIEW, MATLAB OR ANY CUSTOM SOFTWARE), USE THE 'NVRAM NONE COMMAND TO PROTECT THE NVRAM FROM BEING DAMAGED.

NOTE: Once communication is established, if you manipulate the touchscreen, you must reestablish communication <CR>.

NOTE: System commands and start/stop commands can be executed from method or Quickstart screens. For parameter commands it is necessary to run from Quickstart screen.

NOTE: To maximize communication speed [as fast as 50 ms rate changes]:
(a) prefix commands with the @ symbol to turn off GUI updates (ex: @irate 100 u/m)
(b) use the 'NVRAM off' command to turn off writes of rate to memory

Using the PHD ULTRA™ Syringe Pump Module Chain Commands

The following instructions will help you to utilize the Pump Chain commands feature on the PHD ULTRA™ Syringe Pump Module.

Commands may be abbreviated to the first four letters, i.e. address would be abbreviated addr. A space must follow the command if arguments are included.

If the pump address is nonzero, the one or two-digit pump address precedes the command. For example, to set the infuse rate for pump 12, the command would look like "12irat 3.2 µ/m".

In the command list below, the following convention is used:

{ }	Required parameter
[ ]	Optional parameter
|	Separator between parameter choices
#	Numeric value without preceding zeros
###	Numeric value with preceding zeros
#-#	A range of values
<cr>	Carriage return
<lf>	Line feed
<sp>	Space
[prefix]	Pump address prefix in the format #: if the pump address is not zero
<prompt>	Prompt (see below)

The following prompts are returned after a command is executed:

:	The pump is idle
>	The pump is infusing
<	The pump is withdrawing
*	The pump stalled
T*	The target was reached

If the pump is in poll REMOTE mode, there will be no prompts or carraige returns.

If the pump is in poll ON mode, a XON character is added after the prompt.

If the pump address is nonzero, the pump address is prefixed to the prompt without a colon.

In the following list of commands:

- The pump address is prefixed to every response line followed by a colon.
- <lf>[##]<prompt> is the response unless otherwise noted.

Error messages

Error messages are displayed if the entered command cannot be executed for some reason. The error message will take up two lines with the first line being the message type and the second line describing the error itself. The second line may be up to 80 characters long.

Command errors

Command errors are displayed when the command is unrecognized, entered in the wrong mode, or the state of the pump keeps the command from executing (i.e. using the IRUN command if a limit switch is active).

The command error has the following format:

<lf>[##:]Command error:<cr>

<lf>[##:]<sp><sp><sp>{error message}<cr>

<lf>[##]<prompt>

Argument errors

Argument errors are displayed when a command argument is unrecognized or out of range. The argument in question will be displayed except in the case of missing arguments.

The argument error has the following format:

<lf>[##:]Argument error: [bad argument]<cr>

<lf>[##:]<sp><sp><sp>{error message}<cr>

<lf>[##]<prompt>

System commands

address

Sets or displays the pump address. Valid range is 0 to 99.

Command format:

address [0-99]

Query response:

<lf>[##:]Pump address is #<cr>

<lf>[##]<prompt>

NOTE: Pumps with an address of 0 are masters, and pumps with an address between 1 and 99 are slaves.

baud

Sets or displays the RS-232 port baud rate. Valid baud rates are 9600, 19200, 38400, 57600, 115200, 128000, 230400, 256000, 460800, and 921600. Note that some computers may not be able to handle baud rates above 115200.

Command format:

baud [9600 | 19200 | 38400 | 57600 | 115200 | 128000 | 230400 | 256000 | 460800 | 921600]

Query response:

<lf>[##:]# baud<cr>

<lf>[##]<prompt>

CMD

NOTE: If this command is entered via RS-232, the prompt is displayed at the previous baud rate and then the baud rate is changed.

Sets or displays the command set. The pump is capable of operating in the ULTRA command set or the legacy Model 22 or PHD 44 command sets. Valid sets are ultra, 22, and 44.

Command format:

cmd [{command set}]

Query response:

<lf>[##:] Ultra<cr>

<lf>[##]<prompt>

or:

<lf>[##:] 22<cr>

<lf>[##]<prompt>

or:

<lf>[##:] 44<cr>

<lf>[##]<prompt>

config

Sets or displays the pump configuration.

Command format:

config [{config designation}|{value}]

echo

Sets or displays the RS-232/USB echo state. Valid states are on or off.

Command format:

echo [on|off]

Query response:

<lf>[##:]OFF<cr>

<lf>[##]<prompt>

or:

<lf>[##:]ON<cr>

<lf>[##]<prompt>

free

Displays the number of free method steps left on the disk.

Command format:

free

Query response:

<lf>[##:]# steps used<cr>

<lf>[##:]# steps free<cr>

<lf>[##:]# total steps<cr>

<lf>[##]<prompt>

The number of steps displayed is a four digit number, right justified, and padded with spaces.

force

Sets or displays the infusion force level in percent. Valid range is 1 to 100.

Command format:

force [1-100]

Query response:

<lf>[##:]#%<cr>

<lf>[##]<prompt>

ftswitch

Sets or displays the footswitch setting. The footswitch may be used in a toggle on or off mode (momentary), a press to run mode (falling), or a release to run mode (rising).

Command format:
ftswitch [mom|rise|fall]

Query response:
<lf>[##:]Momentary<cr>

<lf>[##]<prompt>

or:

<lf>[##:]Active high<cr>

<lf>[##]<prompt>

or:

<lf>[##:]Active Low<cr>

<lf>[##]<prompt>

poll

Sets or displays the polling mode state.

When polling mode is off, prompts are displayed when an event happens, such as a target being reached.

When polling mode is on, prompts are not displayed when an event happens, and a XON character is output when the pump is ready for another command

When polling mode is in remote mode, the following occurs

- Prompts are not displayed
- Carraige returns are not displayed
- The pump address is displayed even if 0
- Echo is forced off and the echo command is illegal

Command format:

poll [on|off|remote]

Query response:
<lf>[##:] OFF<cr>

<lf>[##]<prompt>

or:

<lf>[##:] ON<cr>

<lf>[##]<prompt><xon>

or:

[##:] REMOTE<lf>

time

Sets or displays the date and time.

Command format:

time [mm/dd/yy] [hh:mm:ss]*

Query response:

<lf>[##:]##/##/## ##:##:## #M<cr>

<lf>[##]<prompt>

*Time format is 24 hours

syrmanu

Sets or displays the syringe manufacturer. Quick Start mode only.

Valid 3-character manufacturer codes are shown in the table below.

Typing 'syrm' with no arguments displays the current syringe setting.

Typing 'syrm ?' displays a list of manufacturers with their associated 3-letter code.

Typing 'syrm {code} ?' shows a list of syringe sizes associated with the specified manufacturer.

air	Air-Tite, HSW Norm-Ject
bdg	Becton Dickinson, Glass (all types)
bdp	Becton Dickinson, Plasti-pak
cad	Cadence Science, Micro-Mate Glass
has	Harvard Stainless Steel
hm1	Hamilton 700, Glass
hm2	Hamilton 1000, Glass
hm3	Hamilton 1700, Glass
hm4	Hamilton 7000, Glass
hos	Hoshi
ils	ILS, Glass
nip	Nipro
sge	SGE (Scientific Glass Engineering)
smp	Sherwood-Monoject, Plastic
tej	Terumo Japan, Plastic
top	Top

Command format:

syrm [?|{3 char code}?|{volume} ul|ml]

Query response:

<lf>[##:]{manufacturer}, {diameter} mm<cr>

<lf>[##]<prompt>

or:

<lf>[##:]Custom, {diameter} mm<cr>

<lf>[##]<prompt>

or:

<lf>[##:]{code}, {diameter} mm<cr> This line is repeated for each syringe manufacturer.

<lf>[##]<prompt>

or:

<lf>[##:]{volume}, {unit}<cr> This line is repeated for each syringe size.

<lf>[##]<prompt>

valve

Displays or sets the valve state. When the value is set to auto, the motor direction determines the valve state. Valve defaults to Auto on power-up.

Command format:

valve [on|off|auto]

Query response:

<lf>[##:]Infuse<cr>

<lf>[##]<prompt>

or:

<lf>[##:]Refill<cr>

<lf>[##]<prompt>

vduty

Sets or displays the valve duty cycle in percent. Valid range is 5 to 80. Default value is 50%. If a valve actuates but does not hold in the actuated position, vduty command should be used to increase duty cycle percentage to allow valve to hold.

Command format:

vduty [5-80]

Query response:

<lf>[##:]#%<cr>

<lf>[##]<prompt>

ver

Displays the short version string.

Command format:

ver

Query response:

<lf>[##:]PHD Ultra #.#.#<cr>

<lf>[##]<prompt>

version

Displays the full version string.

Command format:

version

Query response:

<lf>[##:]Firmware:v#.#.#<cr>

<lf>[##:]RTOS: FreeRTOS v#.#.# (http://www.freertos.org)<cr>

<lf>[##:]Pump address: #<cr>

<lf>[##]<prompt>

Run commands

irun

Runs the pump in the infuse direction. Quick Start mode only.

Command format:

irun

rrun

Runs the pump in the opposite direction. Quick Start mode only.

Command format:

rrun

stop / stp

Stops the pump.

Command formats:

stop

stp

wrun

Runs the pump in the withdraw direction. Quick Start mode only.

Command format:

wrun

Rate commands

crate

Displays the current rate that the motor is running at. A valid response is returned only in dynamic situations (while the pump is running). Quick Start mode only.

Command format:

crate

Query response:

<lf>[##:]Infusing at # xl/xxx<cr>

<lf>[##]<prompt>

or:

<lf>[##:]Withdrawing at # xl/xxx<cr>

<lf>[##]<prompt>

diameter

Sets or displays the syringe diameter in mm. Quick Start mode only.

Command format:

diameter [{syringe diameter}]

Query response:

<lf>[##:]#.#### mm<cr>

<lf>[##]<prompt>

gang

Sets or displays the syringe count. Quick Start mode only.

Command format:

gang [{syringe count}]

Query response:

<lf>[##:]# syringes<cr>

<lf>[##]<prompt>

iramp

Sets or displays the infusion rates while ramping. Quick Start mode only.

Command format:

iramp [{start rate} {start units} {end rate} {end units} {ramp time in seconds}]

Query response:

<lf>[##:]Ramp not set up.<cr>

<lf>[##]<prompt>

or:

<lf>[##:]# xl/xxx to xl/xxx in # seconds<cr>

<lf>[##]<prompt>

irate

Sets or displays the infusion rate. Quick Start mode only. The rate arguement may be replaced by "max" or "min" to set the maximum or minimum rate, respectively. "lim" may be used to display the range limits.

Command format:

irate [max|min|lim|{rate} {rate units}]

Query response:

<lf>[##:]# xl/xxx<cr>

<lf>[##]<prompt>

or:

<lf>[##:]# xl/xxx to # xl/xxx<cr>

<lf>[##]<prompt>

wramp

Sets or displays the withdraw rates while ramping. Quick Start mode only.

Command format:

wramp [{start rate} {start units} {end rate} {end units} {ramp time in seconds}]

Query response:

<lf>[##:]Ramp not set up.<cr>

<lf>[##]<prompt>

or:

<lf>[##:]# xl/xxx to xl/xxx in # seconds<cr>

<lf>[##]<prompt>

NOTE: To clear a ramp, use CTTIME command.

wrate

Sets or displays the withdraw rate. Quick Start mode only. The rate arguement may be replaced by "max" or "min" to set the maximum or minimum rate, respectively. "lim" may be used to display the range limits.

Command format:

wrate [max|min|lim|{rate} {rate units}]

Query response:

<lf>[##:]# xl/xxx<cr>

<lf>[##]<prompt>

or:

<lf>[##:]# xl/xxx to # xl/xxx<cr>

<lf>[##]<prompt>

NOTE: For commands requiring rate units, use the following format: m, u, n, p/h, m, s. ex: m/m = milliliter/minute, n/s = nanoliter/second.

Volume commands

civolume

Clears the infused volume. Quick Start mode only.

Command format:

civolume

ctvolume

Clears the target volume. Quick Start mode only.

Command format:

ctvolume

cvolume

Clears both the infused and withdrawn volumes. Quick Start mode only.

Command format:

cvolume

cwvolume

Clears the withdrawn volume. Quick Start mode only.

Command format:

cwvolume

ivolume

Displays the infused volume. Quick Start mode only.

Command format:

ivolume

Query response:

<lf>[##:]# xl<cr>

<lf>[##]<prompt>

svolume

Sets or displays the syringe volume. Quick Start mode only.

Command format:

svolume

Query response:

<lf>[##:]#.#### ul<cr>

<lf>[##]<prompt>

or:

<lf>[##:]#.#### ml<cr>

<lf>[##]<prompt>

tvolume

Sets or displays the target volume. Quick Start mode only.

Command format:

tvolume [{target volume} {volume units}]

Query response:

<lf>[##:]Target volume not set<cr>

<lf>[##]<prompt>

or:

<lf>[##:] # xl<cr>

<lf>[##]<prompt>

wvolume

Displays the withdrawn volume. Quick Start mode only.

Command format:

wvolume

Query response:

<lf>[##:]# xl<cr>

<lf>[##]<prompt>

Time commands

citime

Clears the infused time. Quick Start mode only.

Command format:

citime

ctime

Clears both the infused and withdrawn times. Quick Start mode only.

Command format:

ctime

cttime

Clears the target time. Quick Start mode only.

Command format:

cttime

cwtime

Clears the withdrawn time. Quick Start mode only.

Command format:

cwtime

itime

Displays the infused time. Quick Start mode only.

Command format:

itime

Query response:

<lf>[##:]# seconds<cr>

<lf>[##]<prompt>

or:

<lf>[##:]##:##:##<cr>

<lf>[##]<prompt>

ttime

Sets or displays the target time. Quick Start mode only.

Command format:

ttime [{target time}]

Query response:

<lf>[##:]Target time not set<cr>

<lf>[##]<prompt>

or:

<lf>[##:]# seconds<cr>

<lf>[##]<prompt>

or:

<lf>[##:]##:##:##<cr>

<lf>[##]<prompt>

wtime

Displays the withdrawn time. Quick Start mode only.

Command format:

wtime

Query response:

<lf>[##:]# seconds<cr>

<lf>[##]<prompt>

or:

<lf>[##:]##:##:##<cr>

<lf>[##]<prompt>

Digital I/O commands

input

Reads and displays the trigger input port status.

Command format:

input

Query response:

<lf>[##:]Low<cr>

<lf>[##]<prompt>

or:

<lf>[##:]High<cr>

<lf>[##]<prompt>

output

Sets the level on one of the output ports.

Command format:

output {1|2} {high|low}

sync

Sets the level on the sync port.

Command format:

sync {high|low}

Internal commands

Internal commands are used by the pump when connected to a controlling computer, but are not meant to be entered by the user. They are listed here for completeness.

status

Displays the raw status for use with a controlling computer.

Command format:

status

The output is in three integer fields and one flag field, all separated by spaces and terminated by a carriage return/linefeed pair. The first integer is the current rate in femtoliters per second. The second integer is the infuse time in clock cycles. One clock cycle is 1/56,000,000 second. The time has a granularity of 1 millisecond. The third integer is the infused volume in femtoliters. All three values are for the current direction.

The flag field consists of six flags.

- Flag one is the motor direction and will be "I" if the pump is infusing and "w" if the pump is withdrawing. If the letter is lower case, the pump motor is idle. If upper case, the pump motor is running.
- Flag two is the limit switch status. If the infuse limit switch was hit, "I" is displayed. If the withdraw limit switch was hit, "W" is displayed. If no limit switch was hit or the pump does not have limit switches, "." Is displayed.
- Flag three is the stall status and will be "S" if the pump has stalled. Otherwise it will be ".".
- Flag four is the trigger input state and will be "T" if high and "." if low.
- Flag five is the direction port state and will be "I" for infuse and "W" for withdraw.
- Flag six is the target reached status. It will be "T" if the target time or volume was reached and "." if not.

Appendices

APPENDIX A: SYRINGE VOLUME/DIAMETER REFERENCE TABLE

Harvard Apparatus Stainless Steel

Size	Diameter
2.5 ml	4.851 mm
8	9.525
20	19.13
50	28.6
100	34.9

Air–Tite HSW Norm-Ject

Size	Diameter
1 ml	4.69 mm
2.5	9.65
5	12.45
10	15.9
20	20.05
30	22.9
50	29.2

Becton Dickinson 'Plasti-pak'

Size	Diameter
1 ml	4.699 mm
3	8.585
5	11.989
10	14.427
20	19.05
30	21.59
50	26.594
60	26.594

Terumo Japan

Size	Diameter
1 ml tb	4.70 mm
1 ml vc	6.50 mm
2.5	9.00
5	13.10
10	15.80
20	20.20
30	23.2
60	29.2

SGE Scientific Glass Engineering

Size	Diameter
5 µl	0.343 mm
10	0.485
25	0.728
50	1.03
100	1.457
250	2.303
500	3.257
1 ml	4.606 mm
2.5	7.284
5	10.301
10	14.567
25	23
50	27.5
100	35

Hamilton Glass - All Types

Size	Diameter
0.5 µl	0.103 mm
1	0.1457
2	0.206
5	0.3302*
5	0.343**
10	0.485**
10	0.461***
25	0.729
50	1.03
100	1.457
250	2.304
500	3.256
1 ml	4.608 mm
1.25	5.151
2.5	7.285
5	10.3
10	14.567
25	23.133
50	32.573
100	32.573

** = Series 7000*
*** = Series 700*
**** = Series 1700*

Cadence Science, Inc. Formerly Popper & Sons MICRO-MATE Glass

Size	Diameter
0.25 ml	3.47 mm
0.5	3.62
1	4.82
2	8.91
3	8.91
5	11.71
10	14.65
20	19.56
30	22.7
50	28.02
100	35.7

Becton Dickinson Glass-All Types

Size	Diameter
0.5 ml	4.64 mm
1	4.64
2.5	8.66
5	11.86
10	14.34
20	19.13
30	22.7
50	28.6
100	34.9

Sherwood–Monoject Plastic

Size	Diameter
1 ml	4.674 mm
3	8.865
6	12.600
12	15.621
20	20.142
35	23.571
60	26.568
140	37.948

Hoshi

Size	Diameter
1 ml	6.50 mm
2	9.10
3	10.00
5	12.60
10	15.10
20	20.45
30	22.50
50	25.60
100	34.00

ILS Glass

Size	Diameter
250 µl	2.303 mm
500 µl	3.260
1 ml	4.606 mm
2.5	7.280
5	10.300
10	14.567
25	23.132
50	32.573
100	32.573

Top

Size	Diameter
1 ml	6.40 mm
2.5	9.30
5	13.10
10	15.3
20	21.0
30	23.1
50	29.0

NIPRO

Size	Diameter
1 ml long	6.6 mm
1 ml short	4.7
2.5 ml	9.0
5	13.1
10	15.8
20	20.1
30	23.2
50	29.1

Suggested Force Level Settings for Common Syringes - PHD ULTRA & ULTRA 4400

Syringe Type/Material	Capacity	Force Setting	Common Manufacturer(s)
Plastic Syringes	≤20ml	50%	BD plastic, Sherwood, Airtite, Terumo
	>20ml	100%	
Stainless Steel	All	100%	Harvard Apparatus
Glass/Glass	≤20ml	20%	Cadence (Popper)
	>20ml	30%	
Glass/Plastic	≤1000µl	30%	Hamilton, SGE
	≤5ml	50%	
	>5ml	100%	

WARNING: PHD ULTRA XF: Although the pump will accept many syringe styles, it is recommended to use only Harvard Apparatus stainless steel syringes.

APPENDIX B: STAINLESS STEEL SYRINGES

Cat No	Product
Replacement Parts (20 to 200 ml)	
5013-089	Chemraz® O-Ring 20 ml
5013-090	Chemraz® O-Ring 50 ml
5013-091	Chemraz® O-Ring 100 ml
5013-092	Chemraz® O-Ring 200 ml
5013-109	Chemraz® Tip Seal O-Ring, sizes 20-200 ml
72-2472	Replacement Viton O-Ring 20 ml, pkg. of 10
72-2473	Replacement Viton O-Ring 50 ml, pkg. of 10
72-2474	Replacement Viton O-Ring 100 ml, pkg. of 10
72-2475	Replacement Viton O-Ring 200 ml, pkg. of 10
72-2616	Replacement Viton Tip Seal O-Ring, sizes 20-200 ml, pkg. of 20
72-2617	Stainless Steel Plunger Button to Adapt Syringe for Use with PHD 22/2000 HVP with Triple S Clamp (Required for 50 ml and 100 ml syringes only)

Harvard High Pressure Stainless Steel Syringes

Harvard offers a complete line (2.5 to 200 ml) of Stainless Steel Syringes intended for high pressure applications with good resistance to most aggressive liquids. Wetted parts are #316 stainless steel or Viton. Syringes are available in 2.5, 8, 20, 50, 100 and 200 ml sizes with removable replacement tips. The 20 to 200 ml stainless steel syringes offer SWAGELOK® fittings in 1/16, 1/8 and 1/4 inch sizes. A luer lock fitting is also available. The tips are interchangeable for 20 to 200 ml syringes. The 2.5 ml is available with a 1/16 inch SWAGELOK® tip only. The 8 ml offers SWAGELOK® fittings in 1/16 or 1/8 inch sizes.

All stainless steel syringes are constructed entirely of #316 stainless steel. The 20 to 200 ml stainless steel syringes come standard with two Viton O-rings for the barrel and one for the tip. These Viton O-ring seals insures against leakage. These syringes are guaranteed to be leak free for pressures up to 750 psi.

The 2.5 ml stainless steel syringe contains one Perfluoroelastomer O-ring seal on the tip and one Bal-Seal™ on the barrel. The 8 ml stainless steel syringe contains two Perfluoroelastomer O-ring seals and two Teflon O-Ring seals on the barrel, and a Perfluoroelastomers O-ring on the tip. These syringes were designed to utilize the high forces available in our syringe pumps to produce pressures up to 7500 psi and 1500 psi respectively.

All syringes are supplied with inside diameter dimensions for use with Harvard microprocessor controlled pumps and rate charts for use with older "classic" pumps. Replacement Viton O-rings are available, as are more chemically resistant Perfluoroelastomer O-rings.

High Pressure Stainless Steel Syringes				
Syringe Size	With SWAGLOK Diameter 1/16 inch	Diameter 1/8 inch	Diameter 1/4 inch	With Luer Lock
2.5 ml	70-2269	N/A	N/A	N/A
8 ml	70-2267	70-2268	N/A	N/A
20 ml	70-2251	70-2252	70-2253	70-2254
50 ml	70-2255	70-2256	70-2257	70-2258
100 ml	70-2259	70-2260	70-2261	70-2262
200 ml	70-2263	70-2264	70-2265	70-2266
Replacement Tips, Furnished with Sealing O-Ring				
2.5 ml	70-2246	N/A	N/A	N/A
8 ml	70-2246	70-2245	N/A	N/A
20 ml to 200 ml	70-2247	70-2248	70-2249	70-2250

NOTE: Only the PHD ULTRA™ XF Syringe Pump Module can accomodate 200 ml syringes.

APPENDIX C: MIN/MAX FLOW RATES

PHD ULTRA & ULTRA 4400 Nominal Minimum/Maximum Flow Rates for Various Syringes. (Actual Limits will vary depending on syringe manufacturer)					
Syringe Size	Syringe ID	Minimum Rate	Units	Maximum Rate	Units
0.5 µl	0.103 mm	3.160	pl/min	1.590	µl/min
1 µl	0.146 mm	6.120	pl/min	3.181	µl/min
2 µl	0.206 mm	12.240	pl/min	6.359	µl/min
5 µl	0.343 mm	33.900	pl/min	17.630	µl/min
10 µl	0.485 mm	67.860	pl/min	35.250	µl/min
25 µl	0.729 mm	153.400	pl/min	79.640	µl/min
50 µl	1.030 mm	306.200	pl/min	159.000	µl/min
100 µl	1.457 mm	612.700	pl/min	318.100	µl/min
250 µl	2.304 mm	1.532	nl/min	795.500	µl/min
500 µl	3.256 mm	3.160	nl/min	1.589	ml/min
1000 µl	4.608 mm	6.128	nl/min	3.182	ml/min
1 ml	4.699 mm	6.373	nl/min	3.309	ml/min
2.5 ml	4.851 mm	6.792	nl/min	3.526	ml/min
3 ml	8.585 mm	21.270	nl/min	11.040	ml/min
5 ml	11.989 mm	41.480	nl/min	21.540	ml/min
8 ml	9.525 mm	26.180	nl/min	13.600	ml/min
10 ml	14.427 mm	60.070	nl/min	31.191	ml/min
20 ml	19.050 mm	104.700	nl/min	54.380	ml/min
30 ml	21.590 mm	134.500	nl/min	69.850	ml/min
50 ml	26.594 mm	204.100	nl/min	106.000	ml/min
100 ml	35.700 mm	367.839	nl/min	182.500	ml/min
140 ml	37.948 mm	415.600	nl/min	215.800	ml/min

PHD ULTRA XF Nominal Minimum/Maximum Flow Rates for Various Syringes. (Actual Limits will vary depending on syringe manufacturer)			
Syringe Size	Syringe ID (mm)	Minimum Rate (nl/min)	Maximum Rate (ml/min)
20 ml	19.13	50.699	26.324
50 ml	28.60	113.317	58.837
100 ml	34.90	168.738	87.613
200 ml	44.75	277.489	144.08

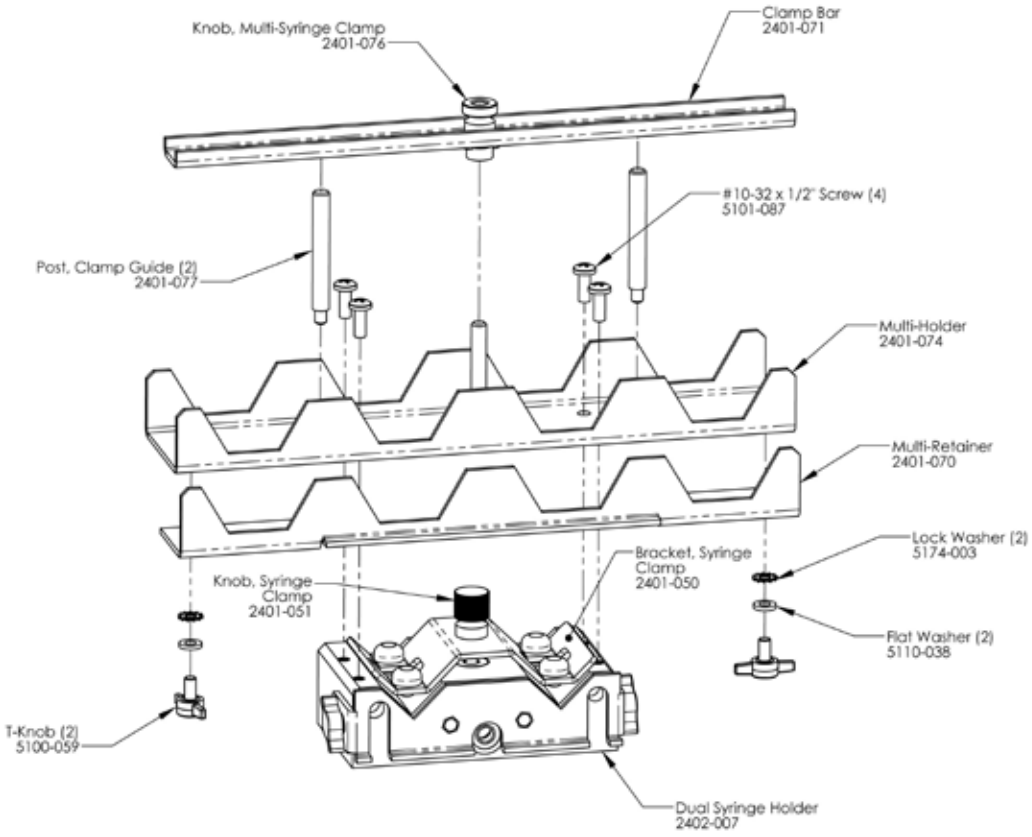
PHD ULTRA 4400 Pressure & Force Specs	
Rate ml/min*	Stall Force Lbs.
10	>200
20	>200
30	>200
50	>200
60	>200
70	>200
80	>200
90	>200
100	>175
110	>175

** This is the rate indicated with a Harvard Apparatus 50 ml stainless steel syringe. Diameter 28.6 mm, cross-sectional area 1.00 square inches.*

APPENDIX D: SYRINGE HOLDER OPTIONS

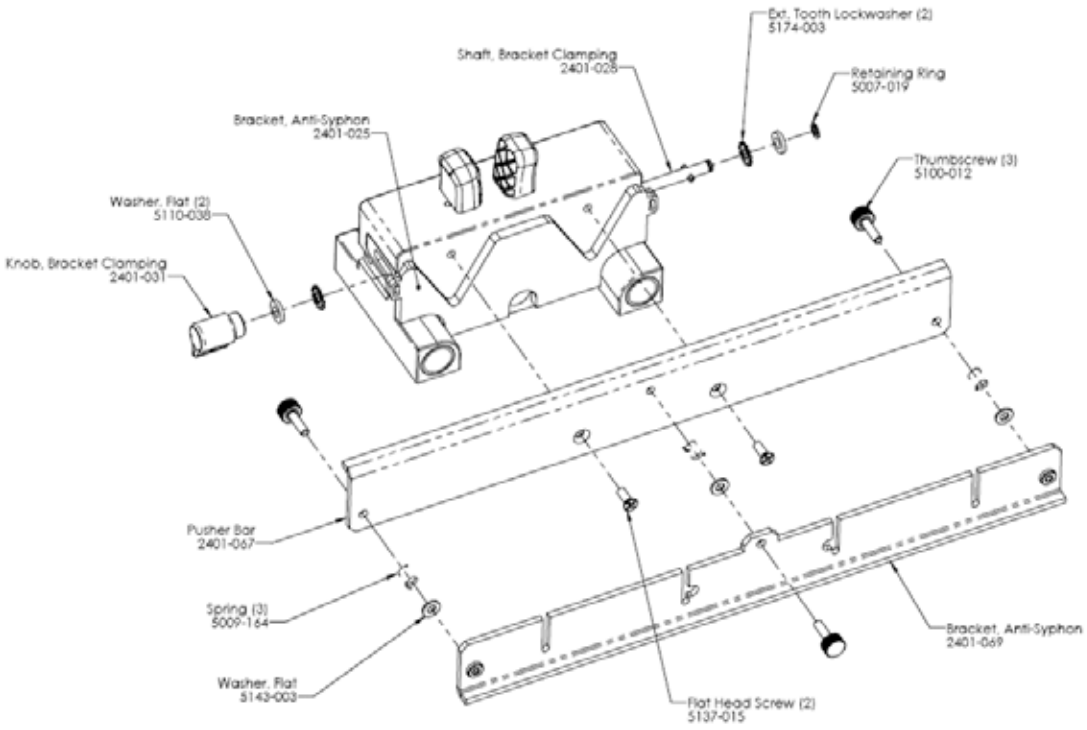
NOTE: Syringe holder options are not available for 4400, HPSI or XF mechanisms.

Mounting a 4x140 Multi-Rack



4x140 Multi-Rack Syringe Holder Assembly.

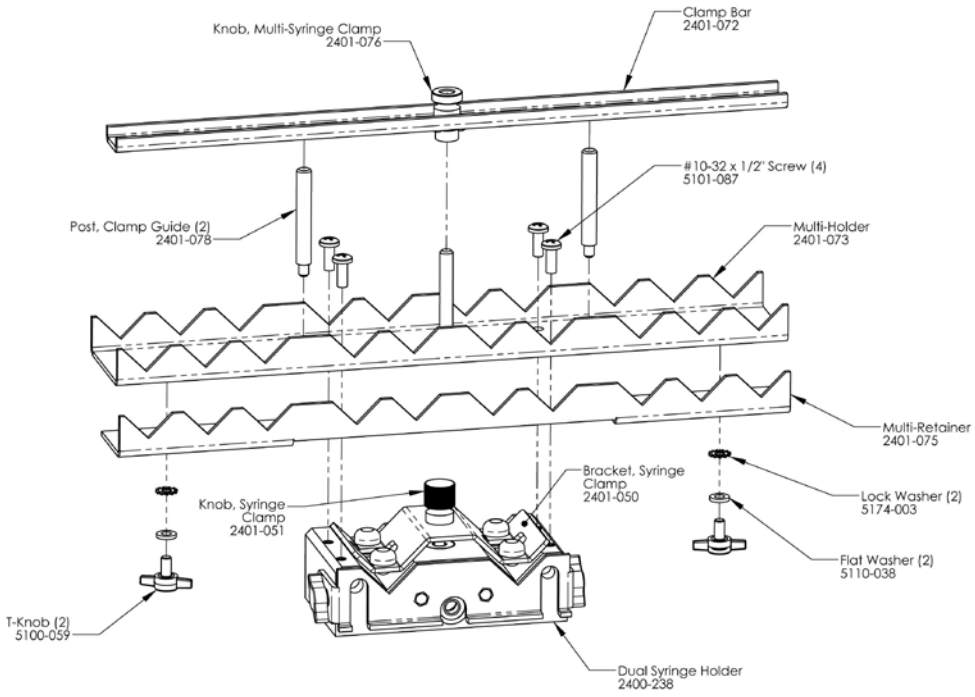
1. Remove the four Set Screws from Syringe Holder using the provided hex key.
2. Remove Syringe Clamp bracket from the Syringe Holder by unscrewing knob.
3. Place the Multi-Holder assembly on the Dual Syringe Holder and attach using four #10-32 x ½" Screws.
4. Attach Clamp Bar by screwing the Multi-Syringe Clamp Knob into the threaded bar attached to the Multi-Holder.



4x140 Multi-Rack Pusher Block Assembly.

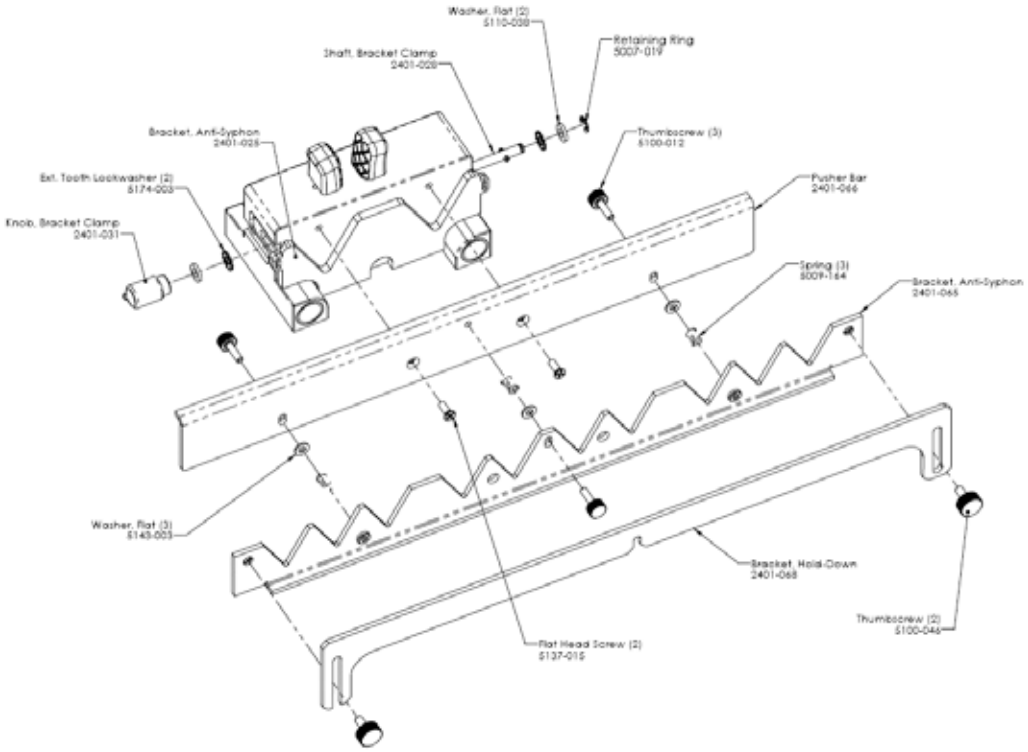
1. Remove Dual Syringe Anti-Syphon Bracket by unscrewing the Bracket Clamping Knob completely and removing the Bracket Clamping Shaft.
2. Attach the Pusher Bar assembly to the Pusher Block using two flat head screws.

Mounting a 6/10 Multi-Rack



6/10 Multi-Rack Syringe Holder Assembly.

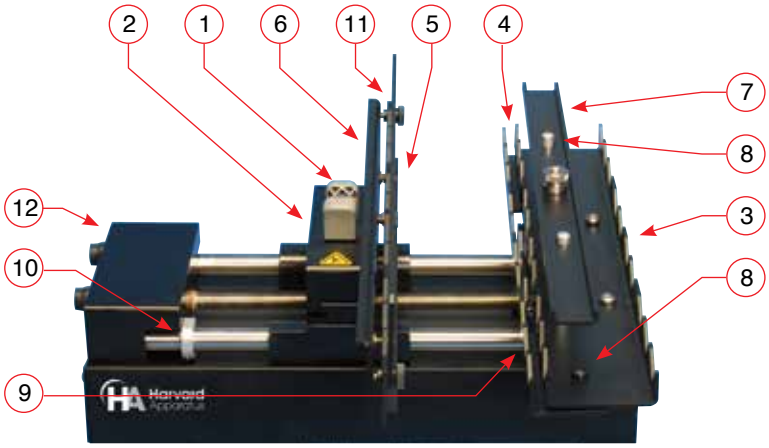
1. Remove the four Set Screws from Syringe Holder using the provided hex key.
2. Remove Syringe Clamp bracket from the Syringe Holder by unscrewing knob.
3. Place the Multi-Holder assembly on the Dual Syringe Holder and attach using four #10-32 x ½" Screws.
4. Attach Clamp Bar by screwing the Multi-Syringe Clamp Knob into the threaded bar attached to the Multi-Holder.



6/10 Multi-Rack Pusher Block Assembly.

1. Remove Dual Syringe Anti-Syphon Bracket by unscrewing the Bracket Clamping Knob completely and removing the Bracket Clamping Shaft.
2. Attach the Pusher Bar assembly to the Pusher Block using two flat head screws.

Syringe Loading – 4 x 140 & 6/10 Multi-Racks



1. Release Tabs
2. Pusher Block
3. Syringe Holder
4. Retaining Bracket (Syringe Holder)
5. Anti-Syphon Bar
6. Pusher Bar
7. Clamp Bar
8. T-Knobs
9. Mechanical Stop (Infuse)
10. Mechanical Stop (Withdraw)
11. Plunger Holder
12. Pulley Cover (Allen Wrench Holder)

Front view of PHD ULTRA™ Syringe Pump Module with 6/10 Multi-Rack showing controls for multi-rack syringe loading.

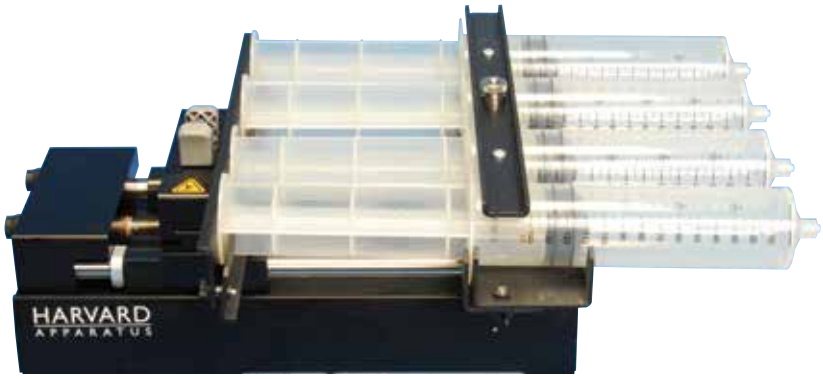
NOTE: Refer to Appendices for additional instructions on assembly of the Harvard Apparatus Multi-Rack Accessory.

1. Raise or remove Clamp Bar (7) by unscrewing thumb screw.
2. Loosen T-Knobs (8) and slide the Retaining Bracket (4) on the Syringe Holder (3) open.
3. Adjust the Pusher Block (2) to the approximate length of the syringe(s) by squeezing the Release Tabs (1) and sliding the Pusher Block into position.
4. Loosen the three thumb screws on the Anti-Syphon Bar (5) to provide enough room for the plunger flange of the syringe(s). If using the 6 x 10 rack, loosen the two thumb screws on the outside of the Plunger Holder (11). Flip the plunger holder open.
5. Place the syringe(s) on the Syringe Holder (3) ensuring that the barrel flanges are within the Syringe Holder's Retaining Bracket (4) and the plunger flanges are between the Pusher Bar (6) and Anti-Syphon Bar (5).

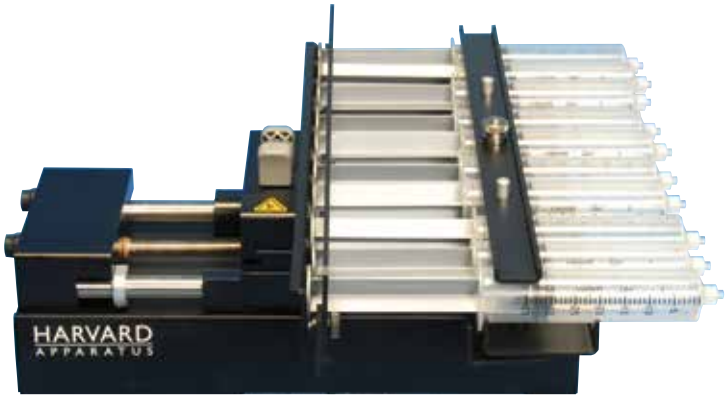
NOTE: If using fewer syringes than the maximum number of syringes, try to place them symmetrically about the lead screw to present a balanced load.

6. Push the Syringe Holder's Retaining Bracket (4) tight against the barrel flanges and tighten into place using the two T-Knobs (8).
7. Tighten the Anti-Syphon Bar (5) using the three thumb screws. If using the 6 x 10 rack, flip the Plunger Holder (11) back into place and secure by tightening thumb screws.
8. Lower or replace the Clamp Bar (7) and tighten thumb screw until Clamp Bar is firm against syringe(s).
9. Squeeze the Release Tabs (1) and move the Pusher Block (2) to the right until the syringe plunger is located as far into the syringe as it will travel.
10. Using the Allen Wrench, located in its holder in the rear of the Pulley Cover (12), loosen the Infusion Mechanical Stop (9) and slide it to the left until it is in contact with the Pusher Block (2). Use the Allen Wrench to tighten it in this position.

11. Squeeze the Release Tabs (1) and move the Pusher Block (2) to the left until the plunger is located just to the left of the maximum volume allowable. Use the Allen Wrench to loosen the refill Mechanical Stop (10) and slide it to the right until it is contact with the Pusher Block (2). Tighten the Withdraw Mechanical Stop (10) and then return the Allen Wrench to its holder (12).



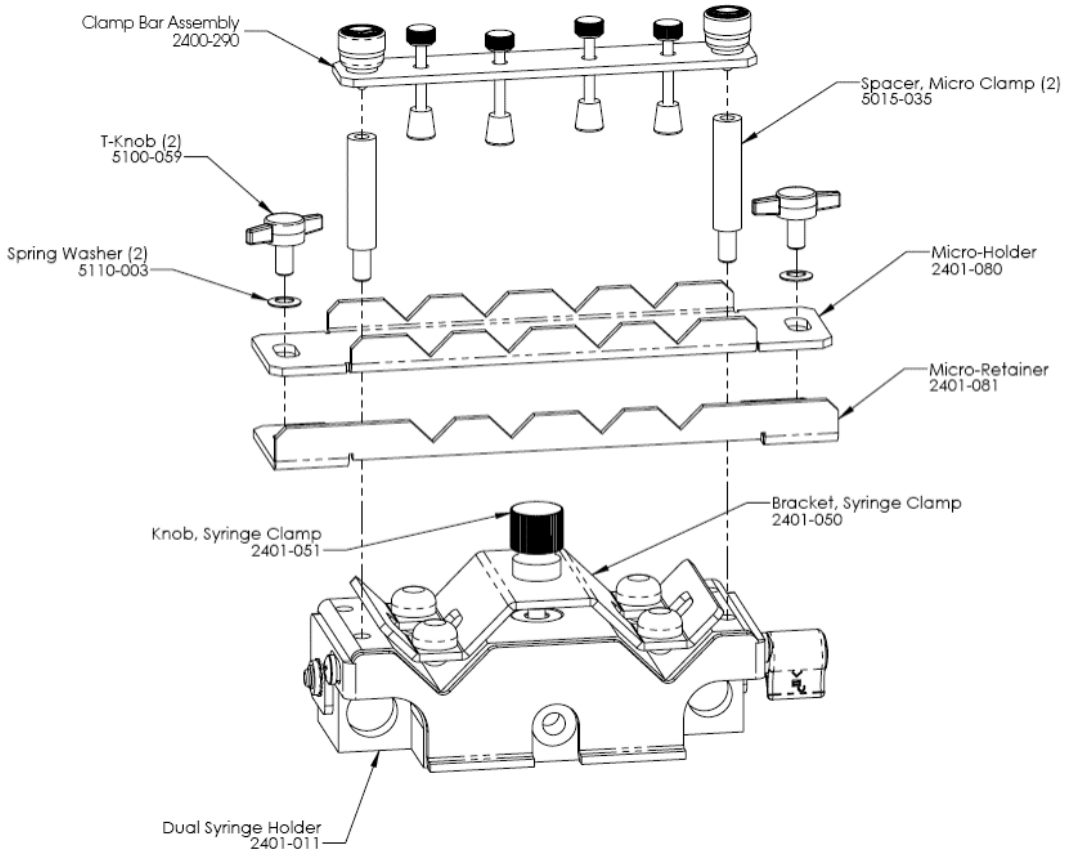
4 x 140 Multi-Rack



6/10 Multi-Rack

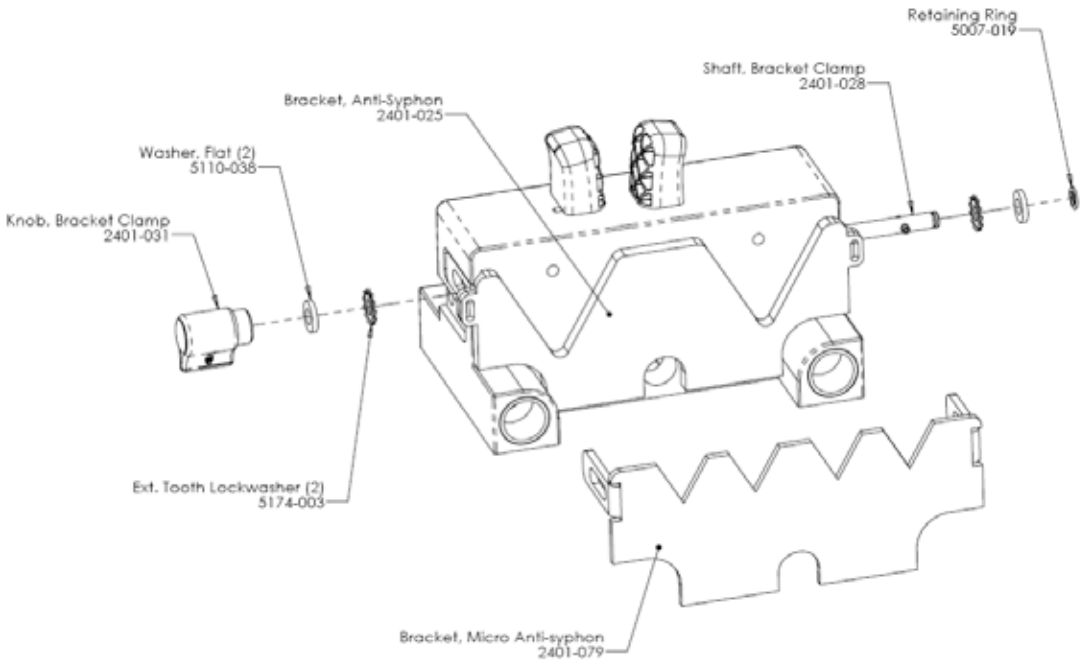
NOTE: When multiple syringes are loaded it may be difficult to manually move the Pusher Block in order to set the Mechanical Stops. Instead, use a single empty syringe to measure the proper lengths and set both the Infuse and Withdraw Mechanical Stops first. Then use the above procedure to load your syringes.

Mounting a Microliter Multi-Rack



Microliter Multi-Rack Syringe Holder Assembly.

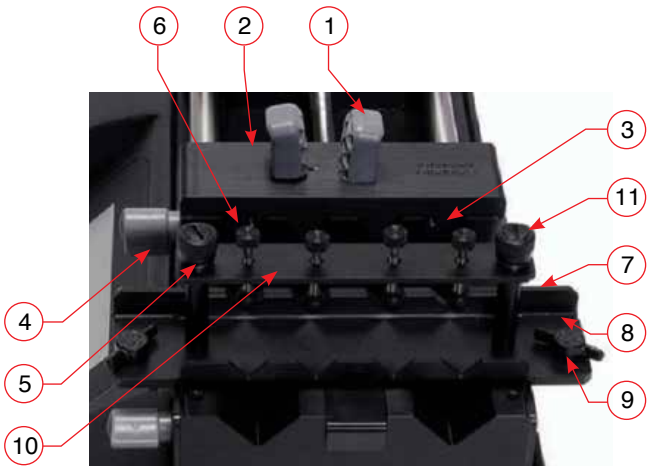
1. Remove the four Set Screws from Syringe Holder using provided hex key.
2. Remove Syringe Clamp and Knob from the Syringe Holder.
3. First assemble the Retaining Bracket to the Micro Holder using the two T-Knobs.
4. Place the assembled Micro Holder onto the syringe holder and screw in the two Standoff Bars.
5. Place the Clamp Bar Assembly onto the Micro Holder by screwing the Thumbscrew Caps into the Standoff Bars.



Microliter Multi-Rack Pusher Block Assembly.

5. Remove the Pusher Blocks Retaining Bracket by unscrewing the Bracket Clamping Knob completely and removing the Clamp Shaft.
6. Attach Anti-Syphon Bracket using the Clamp Shaft and Bracket Clamping Knob.

Syringe Loading – Microliter Multi-Rack



1. Release Tabs
2. Pusher Block
3. Retaining Bracket (Pusher Block)
4. Bracket Clamping Knob
5. Thumbscrew Cap
6. Screw Cap
7. Retaining Bracket (Syringe Holder)
8. Syringe Holder
9. T-Knob
10. Bumper
11. Clamp Bar Assembly

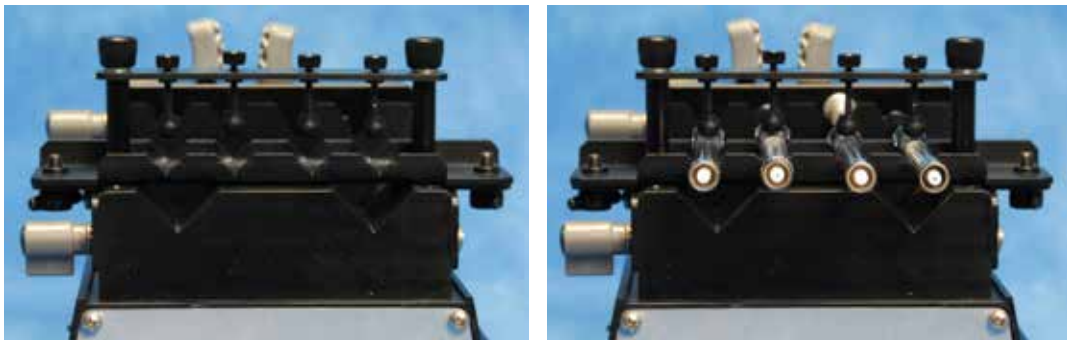
Front view of PHD ULTRA™ Syringe Pump Module showing controls for microliter multi-rack syringe loading.

1. Squeeze Release Tabs (1) and adjust the Pusher Block (2) to the approximate length of the syringe(s).
2. Loosen the Retaining Bracket (3) on the Pusher Block (2) by unscrewing the Bracket Clamping Knob (4).
3. Loosen the Retaining Bracket (7) on the Syringe Holder (8) by unscrewing the two T-Knobs (9).
4. Create room for the syringe(s) by unscrewing the Screw Caps (6) until the Bumpers (10) are at their maximum height.
5. Slide the syringe under the Bumper (10) placing the barrel flange within the Syringe Holder's Retaining Bracket (7) and the plunger flange within the Pusher Block's Retaining Bracket (3).

NOTE: If you are using syringes larger than 1 ml it may be easier to unscrew one of the Thumbscrew Caps (5) and swing the Clamp Bar Assembly (11) to the side, making more room to load the syringe(s). After the syringe(s) are in place swing the Clamp Bar back over the Syringe Holder (8) and reattach the Thumbscrew Cap (5).

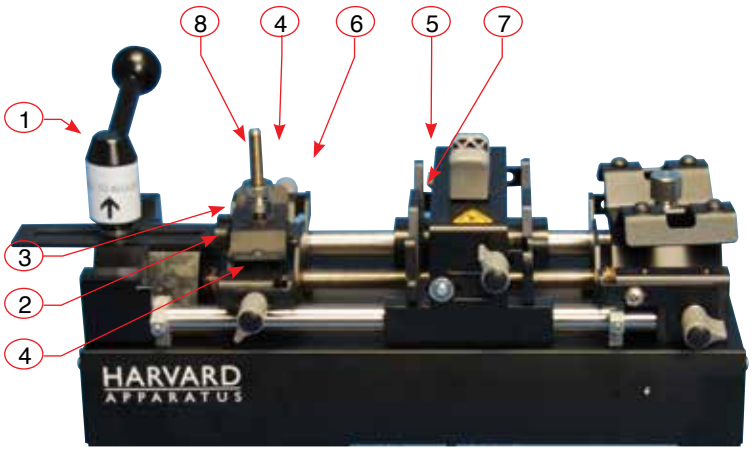
6. Lower the bumpers (10) until they are firm against the syringe(s) by screwing in the Screw Cap (6).
7. Push the Syringe Holder's Retaining Bracket (7) tight against the barrel flange and tighten into place using the T-knobs (9). Then push the Pusher Block's Retaining Bracket (3) tight against the plunger flange and tighten using the Bracket Clamping Knob (4).

NOTE: Mechanical stops are set using the same steps as a standard 2 syringe holder.



Microliter Multi-Rack Configuration.

Syringe Loading – Push-Pull Mechanism

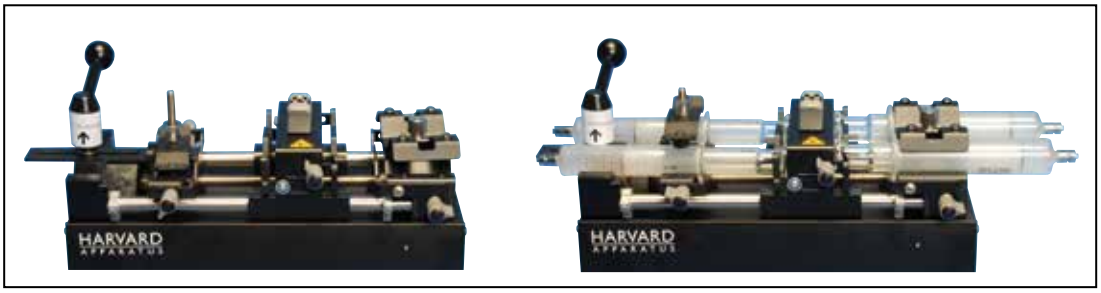


1. Adjustable Knob (Syringe Holder)
2. Adjustable Syringe Holder
3. Syringe Clamp
4. Bracket Clamping Knobs (Syringe Holder)
5. Bracket Clamping Knob (Pusher Block)
6. Retaining Bracket (Syringe Holder)
7. Retaining Bracket (Pusher Block)
8. Thumb Nut (Syringe Clamp)

PHD ULTRA™ showing Push-Pull Mechanism installed.

To load syringes on the push/pull pump:

1. Loosen Adjustable Knob (1) to release the Adjustable Syringe Holder (2).
2. Loosen the Retaining Bracket (7) on the Pusher Block using the Bracket Clamping Knob (5).
3. Loosen the Retaining Bracket (6) on the Adjustable Syringe Holder (2); note that there are bracket clamping knobs (4) on both the front and rear of this assembly that need to be loosened.
4. Extend Plunger on syringe(s) to maximum capacity.
5. Loosen Thumb Nut (8) and lift Syringe Clamp (3). Place the syringe on the Adjustable Syringe Holder (2), extend as necessary then lock into place by tightening the Adjustable Knob (1).
6. Lock the syringe flanges into place by tightening the Retaining Brackets (6,7).
7. Secure the syringe clamp (3) and tighten using the Thumb Nut (8).



PHD ULTRA™ showing syringes installed on both sides of the Pusher Block.

NOTE: For Syringes <10ml you will need to remove the Thumb Nut (8) and then remove and flip over the Syringe Clamp (3).

APPENDIX E: EXTERNAL CONNECTIONS

User I/O Connector Specifications

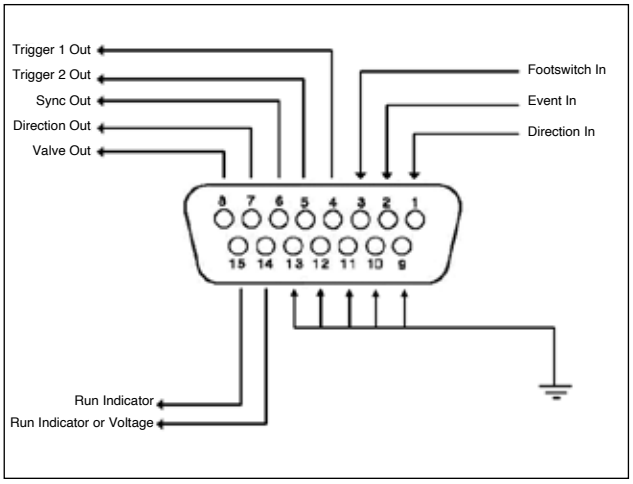
Pin Assignments

1. **Direction control input**
   Rising edge sets pump to infuse
   Falling edge sets pump to refill
2. **Trigger Input**
   Event trigger – falling edge triggers a program event
3. **Footswitch Input (or Timer)**
   Settable to work as:
   - Momentary switch closure to ground or TTL Logic Low; falling edge toggles between states (run/stop)
   -Starts on rising edge, stops on falling edge
   -Starts on falling edge, stops on rising edge
4. **Trigger 1 Output**
   TTL Logic Output-Default = Low Control thru method or serial comm
5. **Trigger 2 Output**
   TTL Logic Output-Default = Low Control thru method or serial comm
6. **Sync Output**
   TTL Logic Output –
   Rising Edge = Start Infuse
   Falling Edge= Start Refill
7. **Direction Output**
   TTL Logic Output –
   High = Refill
   Low = Infuse
8. **Valve Output** (controls voltage only)
   TTL Logic Output –
   High = Valve Actuated
   Low = Valve Off
   Note: Valve follows direction change when state is 'auto'.

9-13. **Signal Return / Ground**

14. **Run Indicator Voltage**
    +5V through a 470 ohm resistor (connect to LED Anode)
15. **Run Indicator Output**
    TTL Logic Output, active low (low = run) (connect to LED Cathode)

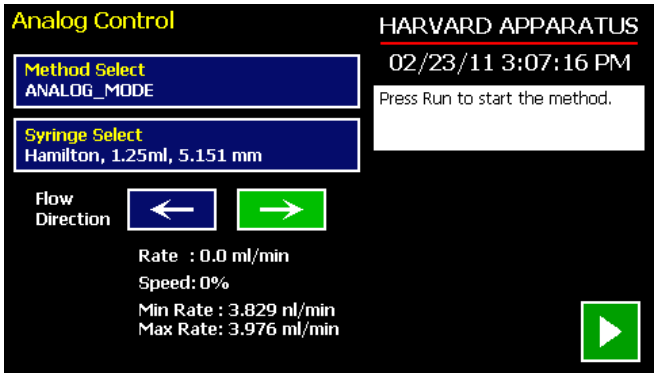
All Inputs are pulled high to +5 VDC through a 10k resistor
All Outputs are at TTL Logic Levels. Pulse duration should be 0.1s minimum.



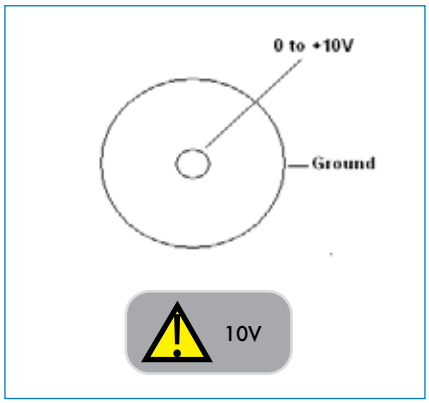
Electrical Specifications:

Inputs:	**$V_{IH} \geq 2V$**	**$I_{IH} \leq 20\mu A$**
	$V_{IL} \leq 0.4V$	**$I_{IL} \leq 0.5mA$**
Outputs:	**$V_{OH} \geq 3.8V$**	**$I_{OH} \leq 6mA$**
	$V_{OL} \leq 0.4V$	**$I_{OL} \leq 6mA$**

Analog Input Option



: *Analog Control Screen.*



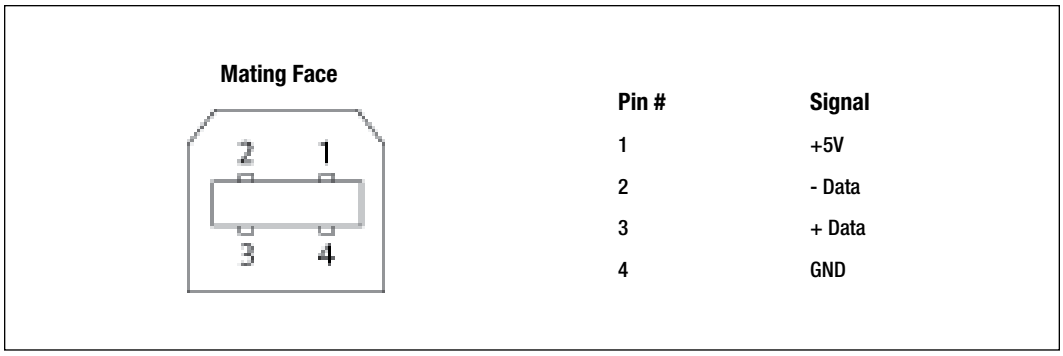
BNC Connector

NOTE: Voltage must be set to 0 VDC when pump is turned on.

NOTE: Although the Analog Mode cycle time is 100 ms, when changing from min to max (or max to min) rates please allow a minimum of 250 ms.

NOTE: Not available on satellite units.

USB

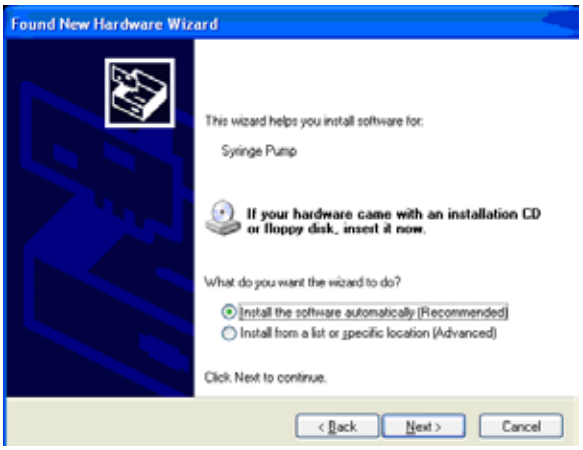


USB Type B Female

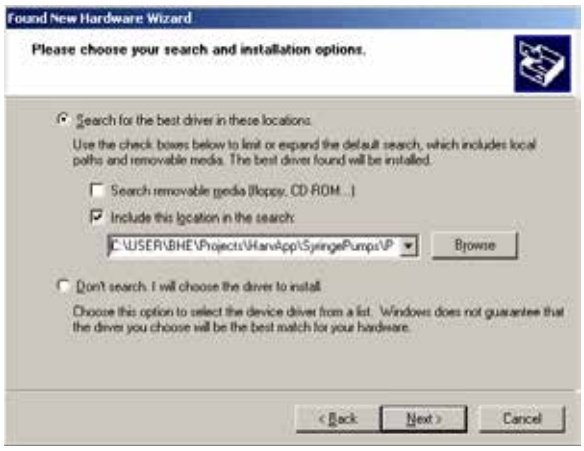
USB VIRTUAL COMMPORT DRIVER INSTALLATION

When you connect the PHD Ultra pump to a computer via USB, Windows will seek to install a driver for communication. The following section details the installation of the Virtual CommPort Driver supplied with the PHD Ultra pump.

1. On connection of the pump to the computer via USB, the Found New Hardware Wizard will launch and ask how you wish to locate the driver. Choose "No, not this time" and click Next.



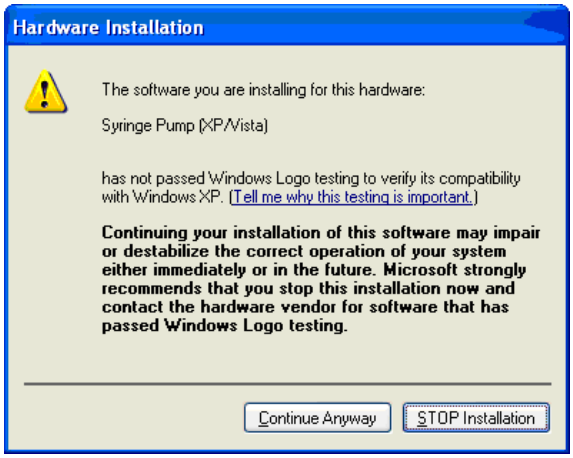
2. Choose "Install from a list or specific location (Advanced)" and click Next.



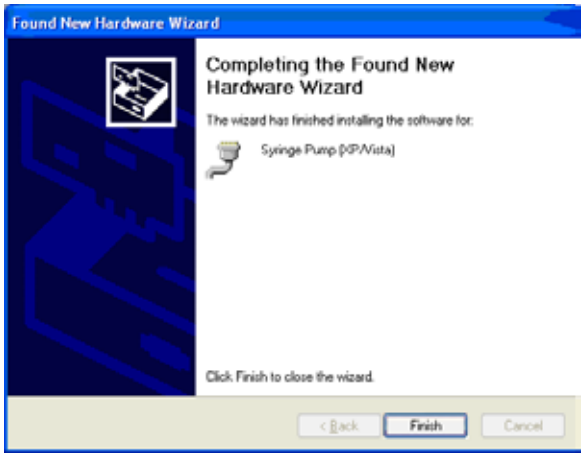
3. Browse for the proper driver installation file and then click next. It can be found on the CD supplied with the PHD ULTRA™ Syringe Pump Module.

   Windows XP or Vista: PHDUltra-XPVista.inf

   Windows 2000: PHDUltra-w2k.inf.

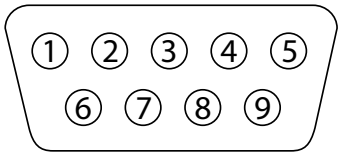


4. If a warning message regarding Windows Logo testing is displayed, choose Continue Anyway to proceed with the installation.



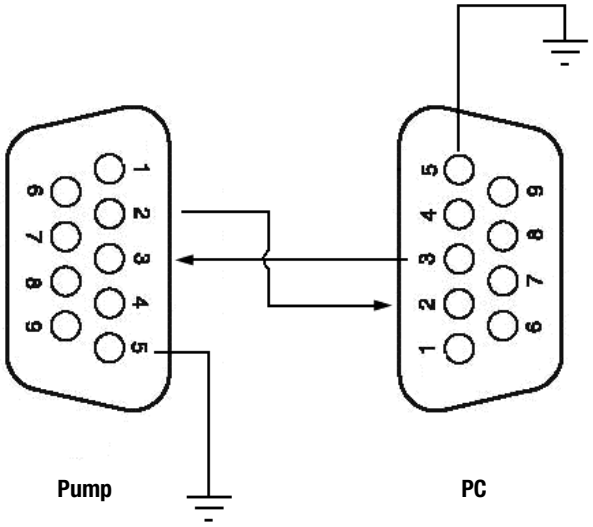
5. The Virtual Commport software will be installed. When the software installation is complete, click Finish to close the wizard.

RS-232 Specifications



Pin #	Signal
2	TXD
3	RXD
5	GND
1, 4, 6-9	N/C

RS-232 9-Pin D-Sub Male



Baud Rates:

- 9600
- 19200
- 38400
- 57600
- 115200

Word Size – 8

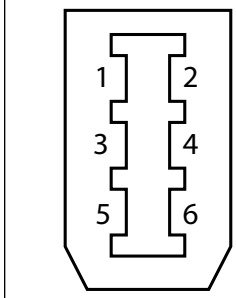
Parity – None

Stop Bits – 1

RS-232 Specifications.

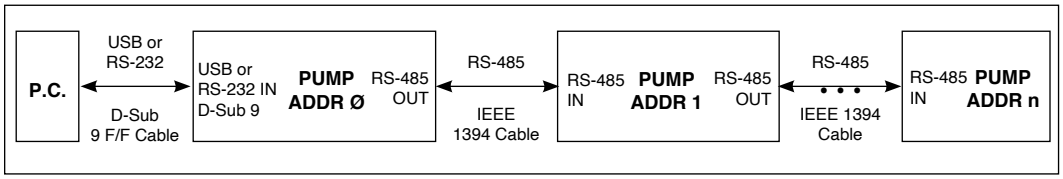
PUMP-TO-PUMP CONNECTION RS-485

CAUTION: DO NOT CONNECT TO FIREWIRE PORTS ON A PC. DAMAGE MAY OCCUR TO PUMP AND/OR PC.



Mating Face	Pin #	RS-485 In Signal	RS-485 Out Signal	Notes
	1	PWR IN	PWR OUT (+30V)*	* Protected by resettable fuse
	2	GND	GND	
	3	RS-485 A	TIED TO PIN 4**	** 100 Ω ½ w to GND termination
	4	RS-485 B	TIED TO PIN 3**	
	5	TIED TO PIN 6**	RS-485 A	
	6	TIED TO PIN 5**	RS-485 B	

RS-485 In/Out - IEEE-1394 Sockets



Daisy chaining via RS-485.

NOTE: When daisy-chaining with RS-485, at a minimum, every 4th pump in the daisy-chain must be self-powered (i.e. another stand-alone unit). This can be affected by force selection.

NOTE: When applying power to pumps in a daisy chain, apply power to the last group in the chain first and work backwards.

NOTE: When removing power, be aware that power removed from a stand-alone unit will cause power to be removed from all RS-485 powered units deriving power from that stand-alone unit.

NOTE: Power may be removed from any group of pumps, except the first group, without affecting communications "downstream"

NOTE: Each pump in the daisy-chain must have a unique address. The first pump must be set to address 00.

APPENDIX F: MAINTENANCE

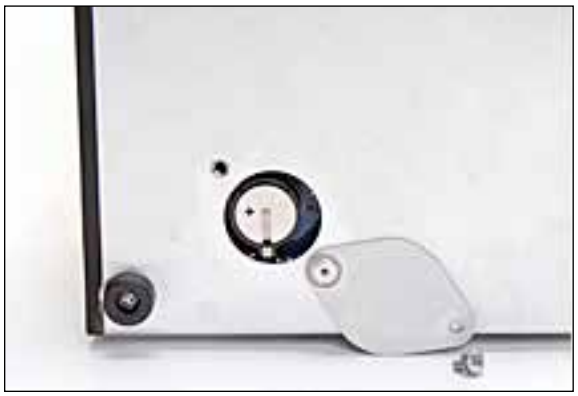
Maintenance

PHD ULTRA™ series pumps require no special maintenance other than keeping them clean by avoiding accidental spills of pumped material.

The two guide rods and the lead screw should be sparingly lubricated periodically; every 100 hrs the pump will remind you. The guide rods should be oiled using light-weight machine oil and the lead screw should be lubricated with Super Lube Synthetic Grease provided with the pump.

To clean the exterior surfaces, use a lint-free cloth to remove loose dust. For more efficient cleaning, use a soft cloth dampened [not soaked] with water, an aqueous solution of 75% isopropyl alcohol, or a mild detergent.

Battery Replacement



1. Remove screw and swing cover to the side.
2. Slide battery out from under clip.
3. Install Lithium Coin Battery: 3V, 16mm CR1620 (Harvard Part No. 5155-288 or equivalent) by sliding under clip with positive side facing out

CAUTION: USE ONLY SAME TYPE & RATED BATTERY. OBSERVE POLARITY WHEN INSTALLING.

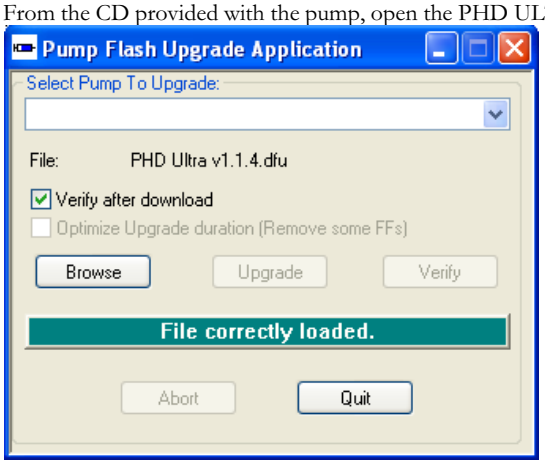
Upgrading EZ PRO™ Software

1. Upload the latest software version to your desktop (format is ***filename.dfu***).
2. Connect the pump to PC using a USB cable.
3. In Hyperterminal type "Boot". The pump's light should be flashing.

NOTE: To exit bootloader mode without upgrading the software, power cycle the pump.

NOTE: Prior to upgrading software, users will need to install the PHD ULTRA™ USB driver as well as the bootloader driver file (PHDUltra-Bootloader.inf). Reference "USB Virtual Comport Driver Installation".

4. Disconnect then reconnect the USB cable.
5. From the CD provided with the pump, open the PHD ULTRA™ Flash Upgrade Application.



6. Check "Verify after download" then click browse. Browse to the file previously saved on your desktop and click open.
7. Click upgrade. The previous software will first be erased, the new software will be loaded, and finally the software will be verified.
8. Disconnect the USB cable and power cycle the pump.

Troubleshooting

Infusion Accuracy

To ensure infusion accuracy always use new syringe(s) and measure syringe bore diameter and enter actual dimensions in millimeters (mm) using the Custom Syringe entry option. Additionally, make sure that the guide rods and lead screw are properly lubricated.

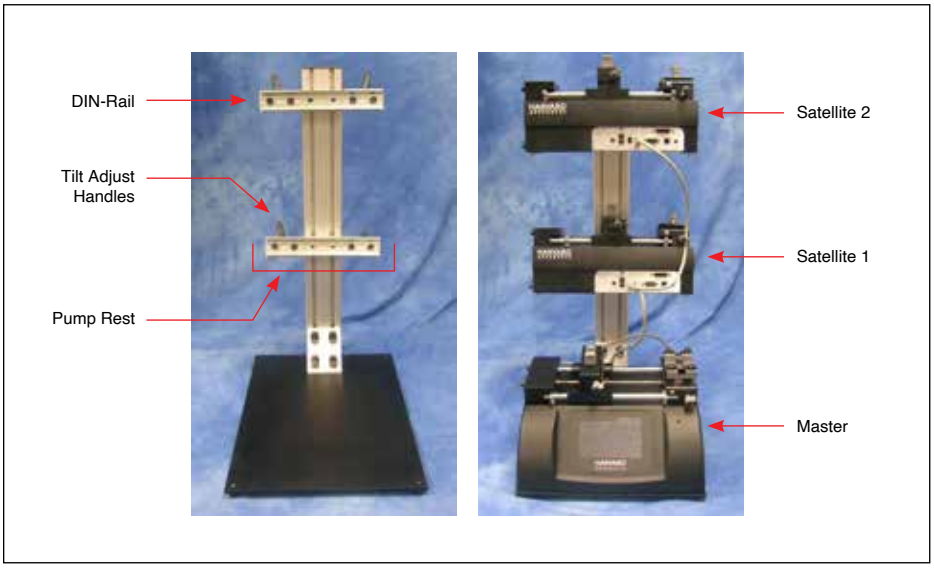
RS-232 Difficulties

Verify that the baud rates, data framing parameters, data bits, parity, and stop bits on all devices are the same. Verify flow control (handshaking) is set to None. If an address is set to other than address Ø, make sure commands and queries are prefixed with the address. Make sure straight-through pinning is used for the cables; do not use null-modem cables.

APPENDIX G: REMOTE STAND

NOTE: Remote stand will not support HPSI or XF mechanisms.

The Remote Stand accessory allows the user to maximize bench space by mounting two satellite / remote Syringe Pump Modules with a Master Stand Alone pump at the stand's base.

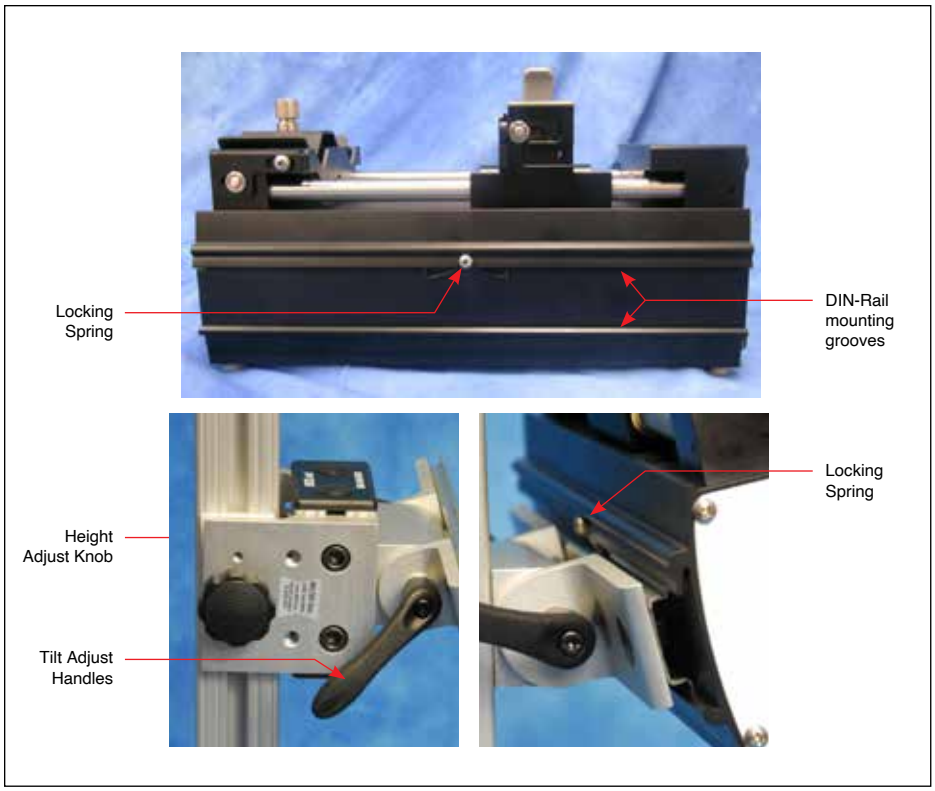


Adjusting DIN-Rail Height

1. Loosen both Height Adjust Knobs located on the sides of the Pump Rest.
2. Slide the Pump Rest to your desired height.
3. Tighten both Height Adjust Knobs securely.

NOTE: If adjusting the height with a pump attached, loosen one Height Adjust Knob, then use one hand to support the pump while loosening the second Height Adjust Knob.

NOTE: Slot covers, provided as stops to prevent the Pump Rests from colliding, are located in the slots on the side of the stand. The stops can be trimmed to provide more traveling room for the Pump Rests. To trim: pop out the cover using a screw driver, cut to desired length with scissors, then snap back into place.



Adjusting DIN-Rail Tilt

1. Loosen both Tilt-Adjust handles by turning counter-clockwise. To increae the handles range of motion, pull the handle out and twist clockwise then allow the handle to click bback into place.
2. Once both handles have loosened, tilt the DIN-rail to your desired angle and tighten into place using the Tilt-Adjust handles.

NOTE: Ensure that the DIN-Rail is tightened securely using the Tilt-Adjust handles to prevent any movement when the pump is attached.

Mounting a Pump

1. The rear side of a Satellite/Remote pump has a groove with a locking spring for DIN-rail mounting. Position the pump's top groove and locking spring over the top edge of the DIN-rail.
2. Push the top of the pump down against the spring while pushing the bottom of the pump back until the bottom groove locks under the DIN-rail.

Dismounting a Pump

1. Holding both sides of the pump, push down on the top of the pump to depress the locking spring.
2. Tilt the bottom of the pump out to relese the bottom groove from the DIN-rail.
3. Fift the pump off of the DIN-rail.

APPENDIX H: ORDERING INFORMATION

ENCLOSED OEM MODULES (power supply included)

Catalog Number	Description
70-3506	PHD ULTRA™ Infusion/Withdrawal
70-3508	PHD ULTRA™ Push/Pull Infusion/Withdrawal
70-3510	PHD ULTRA™ 4400 Push/Pull Infusion/Withdrawal
70-3514	PHD ULTRA™ XF Infusion/Withdrawal

OPEN BASEPLATE OEM MODULES (power supply not included)

Catalog Number	Description
70-3610	PHD ULTRA™ 4400 Open Baseplate Single Syringe
5005-070	Power Supply (AC/DC Apapter), 30VDC, 50W

ACCESSORIES (ENCLOSED AND OPEN BASEPLATE MODULES)

Catalog Number	Description
70-2215	Footswitch (w/phono plug connection)
70-4000	RS-485 Cable for Pump-to-Pump Communication, 0.5 m (2 ft)
70-4021	RS-485 Cable for Pump-to-Pump Communication, 1 m (3 ft)
70-4001	RS-485 Cable for Pump-to-Pump Communication, 2 m (7 ft)
70-4020	RS-485 Cable for Pump-to-Pump Communication, 5 m (16 ft)
70-4002	USB Cable for PC-to-Pump Communication, 2 m (7 ft)
70-4003	USB Cable for PC-to-Pump Communication, 5 m (16 ft)
70-4004	RS-232 Cable for PC-to-Pump Communication, 9 pin D-sub, 2 m (7 ft)
55-7760	Cable Assy, Daisy-chain, Legacy RS-232 RJ-11, 0.6 m (2 ft)
72-2478	Cable Assy, Daisy-chain, Legacy RS-232 RJ-11, 2 m (7 ft)
70-4005	Adapter, PHD Digital I/O
70-4006	Adapter, D-sub 15 to Terminal Block
70-4013	Lubricant, SuperLube, 1cc
70-4019	Stand (Holds 1 controlling pump plus two enlosed satellites)
55-7002	Auto Fill Valve Box, Normal Pressure, 30 psi
55-7004	Auto Fill Valve Box, High Pressure, 200 psi
55-8000	Adapter for 10-100ml Hamilton GasTight™ syringes
5012-005	Hex Key, 3/32 (for stop collar adjustment)
5005-070	Power Supply (AC/DC Apapter), 30VDC, 50W