Harvard Apparatus Pump Controller

USER MANUAL

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Warranty & Repairs

Manual Description

This manual provides all operational information required to operate the Harvard Apparatus Pump Controller.

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, 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 1–800–272–2775, or outside the U.S. call 508-893-8999. Our E-mail address is support@hbiosci.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. 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 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 products should refer to the serial number of the unit, located on the rear panel.

Calibrations

Calibration is not required for the Harvard Apparatus Pump Controller. The pump mechanisms that the controller is driving do require calibration. Please refer to the pump user manual for that model for calibration recommendations.

⚠️ **For research use only. Not for clinical use on patients.**

⚠️ **PLEASE REFER TO SAFETY INFORMATION BEFORE SETTING UP AND PLUGGING IN THE CONTROLLER.**

Safety Information

Please read the following safety precautions to ensure proper use of your syringe pump controller. 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
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 HAPC is 100-240 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.

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 RS485 HAPC-to-pump communication cable).

USE PROPER FUSE
Use only specified fuses with product.

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.

SAFETY ALARMS
Visual and audible alarms for end of run, near end of run (nominally 75% of run) and motor stall.

OBSERVE ALL WARNING LABELS ON PRODUCT
Read all labels on product to ensure proper usage.

Product Overview

The Harvard Apparatus Pump Controller (HAPC) is a leap forward in syringe pump capability. The Harvard Apparatus Pump Controller (HAPC) allows the user to configure and control up to four independent pumping channels controlled by an intuitive touch screen interface. The controller is compatible with all Harvard Apparatus Nanomite, PHD ULTRA™ and Pump 11 Elite/Pico Plus Elite syringe pump modules and stand alone syringe pumps. Note: Elite pumps must have a serial number starting with **D-3**XXXXX, ULTRA pumps must have a serial number starting with **D-4**XXXXX.

The Harvard Apparatus Pump Controller (HAPC) uses a 7" LCD color touchscreen interface and advanced application software to control operation. The display run screen presents the user with all key dispensing parameters for all active channels in real time.

The controller can be purchased populated with 1–4 channels. Channel modules are field installable for future channel expansion. Channel module installation instructions are included in this manual.

The application software provides convenient selection of common syringe models from a syringe Lookup Table, as well as insertion of custom syringe specifications. Syringe tables containing all major syringe manufacturers allow simple selection of any compatible syringe size. The system is then able to calculate the cross-sectional area of the syringe selected and calibrate the flow rate and volume accumulation, displaying real-time operating characteristics via on-screen graphics.

External I/O interfaces permit external control via an independent computer or device.

Advanced Connectivity

The Harvard Apparatus Pump Controller (HAPC) comes standard with USB for PC communication.
An entire suite of ASCII commands is available to control the HAPC remotely with a PC. The HAPC also contains a footswitch input and digital Input/Output for each independent pumping channel.

Adjustable Motor Force

The Harvard Apparatus Pump Controller (HAPC) allows the linear force of each channel to be properly set. Depending on the Harvard Apparatus pump under control by the HAPC, the force can be sufficient to damage delicate, low-volume syringes, as well as many standard syringes if pumping viscous fluids. The application software provides controls to allow you to set a maximum force value (calculated as a percentage of the maximum value)

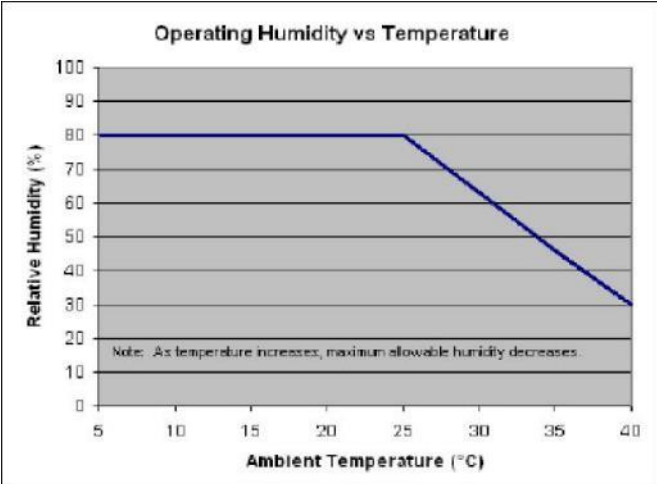# Harvard Apparatus Pump Controller (HAPC)

Controller Specifications

Specifications	Harvard Apparatus Pump Controller (HAPC)
Channels	1 to 4
Display	7" WQVGA TFT Color Display with Touch Screen
Mode of Operation	Continuous with Method and Conditional syringe pump control features
Non-Volatile Memory	Stores all settings
Connectors:	
RS-485	IEEE-1394, 6 pos For connection to Pump 11 Elite, Pump 11 Pico Plus Elite or PHD ULTRA™ Family Modules
USB	Type B
I/O & TTL	15 pin D-Sub Connector, per channel
Footswitch	Mini phono jack (one per channel)
8- Pin Phoenix	For channel connection to Nanomite Module
Dimensions (L X W X H)	8.75 x 10 x 6.25 in (22 x 25.4 x 15.87 cm)
Weight (populated with four channel modules)	2.3 kg (5 lbs)
Atmospheric Conditions	
Operating Temperature	4°C to 40°C (40°F to 104°F)
Storage Temperature	-10°C to 70°C (14°F to 158°F)
Operating Humidity	See Chart Below
Storage Humidity	20% to 80% RH, non condensing
Power	100 to 240 VAC, 50/60 Hz 50 W, 0.5 A fuse
Classification	Class I
Pollution Degree	1
Installation Category	II
Regulatory Certifications	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
EMC Declaration	FCC 47CFR 15B; EN61326-1

Controller Specification Table

Operating Humidity

The following is a chart of operating humidity versus temperature for the Harvard Apparatus Pump Controller. Please note as operating temperature increases, the maximum allowable operating humidity decreases.

Operating Humidity vs. Temperature Chart

Pump Module Specifications

All pump module specifications assume that the module is connected to the HAPC.

| Specifications	Nanomite Injector	Pump 11 Elite Syringe Pump Module	Pump 11 Pico Plus Elite Syringe Pump Module	PHD ULTRA™ Syringe Pump Module	PHD ULTRA™ 4400 Syringe Pump Module	PHD ULTRA™ XF Syringe Pump Module
Item #	70-3601 (Single)	70-4804 (Single) 70-4805 (Dual)	70-4806 (Dual) 70-4807 (Single)	70-3406 (Dual) 70-3408 (Push/Pull)	70-3410 (Single)	70-3514 (Four)
Channels	1	1 or 2	1 or 2	2	1	4
Accuracy	±0.5%	±0.5%	± 0.35%	± 0.25%	± 0.35%	± 0.5%
Syringe (Min./Max.)	0.5 µl / 1 ml	0.5 µl / 60 ml (10 ml dual)	0.5 µl / 60 ml (10 ml dual)	0.5 µl / 140 ml	0.5 µl / 140 ml	20 ml / 200 ml
Flow Rate:						
Minimum	3.66 pl/min (0.5 µl syringe)	1.26 pl/min	0.54 pl/min	3.16 pl/min (0.5 µl syringe)	3.16 pl/min (0.5 µl syringe)	50.7 nl/min (20 ml syringe)
Maximum	3.82 ml/min (1 ml syringe)	88.40 ml/min (26.02 ml/min dual)	39.77 ml/min (11.70 ml/min dual)	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	None	None
Non-Volatile Memory	None (on HAPC)	Stores all settings	Stores all settings	Stores all settings	Stores all settings	Stores all settings
Connectors:						
RS-485	See HAPC specifications	See HAPC specifications	See HAPC specifications	See HAPC specifications	See HAPC specifications	See HAPC specifications
USB	See HAPC specifications	See HAPC specifications	See HAPC specifications	See HAPC specifications	See HAPC specifications	See HAPC specifications
I/O & TTL	See HAPC specifications	See HAPC specifications	See HAPC specifications	See HAPC specifications	See HAPC specifications	See HAPC specifications
Footswitch	See HAPC specifications	See HAPC specifications	See HAPC specifications	See HAPC specifications	See HAPC specifications	See HAPC specifications
RS-232	See HAPC specifications	See HAPC specifications	See HAPC specifications	See HAPC specifications	See HAPC specifications	See HAPC specifications
8-Pin Phoenix	See HAPC specifications	See HAPC specifications	See HAPC specifications	See HAPC specifications	See HAPC specifications	See HAPC specifications
Linear Force (Max) @ 100% Force selection	5 kg (11 lbs)	16 kg (35 lbs)	16 kg (35 lbs)	34 kg (75 lb)	91 kg (200 lb)	455 kg (1000 lb)
Drive Motor	1.8° Stepper Motor	0.9° Stepper 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	Microprocessor with 1/16 microstepping	Microprocessor with 1/16 microstepping
Microsteps/revolution of lead screw	3,200	15,360	20,480	12,800	6,400	32,000
Step Resolution	0.198 µm/µstep	0.069 µm/µstep	0.031 µm/µstep	0.082 µm/µstep	0.082 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	27.5 sec/µstep	27.5 sec/µstep
Maximum	52 µsec/µstep	52 µsec/µstep	52 µsec/µstep	26 µsec/µstep	52 µsec/µstep	52 µsec/µstep
Pusher Travel Rate:						
Minimum	0.433 µm/min	0.15 µm/min	0.068 µm/min	0.18 µm/min	0.36 µm/min	0.18 µm/min
Maximum	228.97 mm/min	159.00 mm/min	71.55 mm/min	190.80 mm/min	190.80 mm/min	91.637 mm/min
Stall Detection	No	Yes	Yes	Yes	Yes	Yes
Input Power*	Powered by HAPC*	Powered by HAPC*	Powered by HAPC*	Powered by HAPC*	Powered by HAPC*	Powered by HAPC*
Dimensions (L X W X H)	2.5 x 2.0 x 7.5 in (6.35 x 5.08 x 19.05 cm)	24.13 x 17.15 x 10.67 cm (9.5 x 6.75 x 4.2 in)	24.13 x 17.15 x 10.67 cm (9.5 x 6.75 x 4.2 in)	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)	16 x 12 x 8.5 in (40.64 x 30.48 x 21.6 cm)
Dimensions: Nanomite Mounting post	Length 3.25 in (8.25 cm) OD: 0.312 in (0.793 cm)	Nanomite Only	Nanomite Only	Nanomite Only	Nanomite Only	Nanomite Only
Weight (injector/module only)	0.54kg (1.2 lb)	2.3 kg (5.08 lbs)	2.3 kg (5.08 lbs)	5.1 kg (11.2 lb)	5.3 kg (11.7 lb)	20 kg (44 lb)
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)	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)	-10°C to 70°C (14°F to 158°F)	-10°C to 70°C (14°F to 158°F)
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	20% to 80% RH, non condensing	20% to 80% RH, non condensing
Method of Operation	Continuous	Continuous	Continuous	Continuous	Continuous	Continuous
Classification	Class I	Class I	Class I	Class I	Class I	Class I
Pollution Degree	1	1	1	1	1	1
Installation Category	II	II	II	II	II	II
Regulatory Certifications	CE, ETL (UL, CSA), WEEE, EU RoHS & CB Scheme	CE, ETL (UL, CSA), WEEE, EU RoHS & CB Scheme	CE, ETL (UL, CSA), WEEE, EU RoHS & CB Scheme	CE, ETL (UL, CSA), WEEE, EU RoHS & CB Scheme	CE, ETL (UL, CSA), WEEE, EU RoHS & CB Scheme	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	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	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
EMC Declaration	FCC 47CFR 15B; EN61326-1	FCC 47CFR 15B; EN61326-1	FCC 47CFR 15B; EN61326-1	FCC 47CFR 15B; EN61326-1	FCC 47CFR 15B; EN61326-1	FCC 47CFR 15B; EN61326-1

Note* The Pump 11 Elite, Pico Plus Elite and PHD ULTRA™ XF are fully PC controllable and come with external power supplies. When used with the HAPC, the power supplies are not required. In cases of extremely high pressure applications using the PHD ULTRA XF, the external power supplier may be required. Please contact Technical Support for additional application questions.

Connections & Syringe Loading

The rear of the Harvard Apparatus Pump Controller (HAPC) contains all of the physical connections required to connect syringe pumps to the controller.
* Note: Only one pump can be connected per channel.
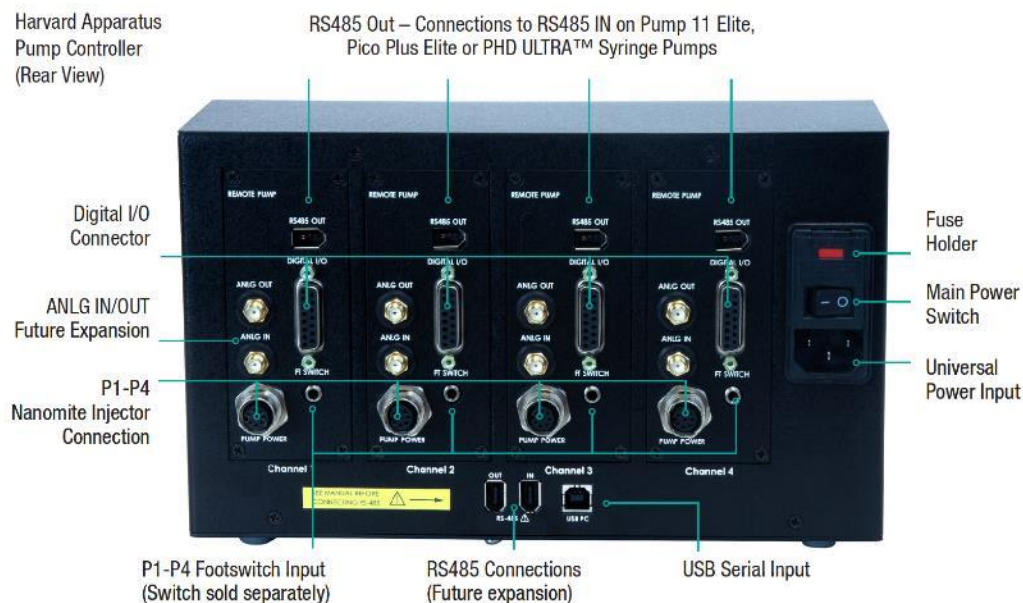
HAPC Rear View Connections

The operating voltage range for the is 100 to 240 VAC, 50/60 Hz. Use only the specified line cord for this product and make sure line cord is certified for country of use.

1. Plug the power cord into the Universal Power Input connector on the rear of the HAPC.
2. Connect syringe pumps to the appropriate channels before powering on the HAPC. The HAPC will only recognize newly connected modules upon power up. The following gives instructions for connection to the compatible Harvard Apparatus pump families. The controller is compatible with all Harvard Apparatus Nanomite, PHD ULTRA™ and Pump 11 Elite/Pico Plus Elite syringe pump modules and stand alone syringe pumps. Note: Elite pumps must have a serial number starting with D-3XXXXX, ULTRA pumps must have a serial number starting with D-4XXXXX.

Nanomite Injector

Connection to HAPC: The Nanomite injector contains a molded 8-pin male Phoenix connector.

1. Connect the male Phoenix connector end to the Nanomite Injector Connection on the required channel (P1-P4). **Please be aware of the pin configuration and match the black connector tab on male connector to the open tab on the Nanomite Injector connection. Incorrect insertion of the connector can cause the pins to bend.** When connected properly, the connector can be tightened by hand by turning the connector clockwise.
2. Power on the controller.
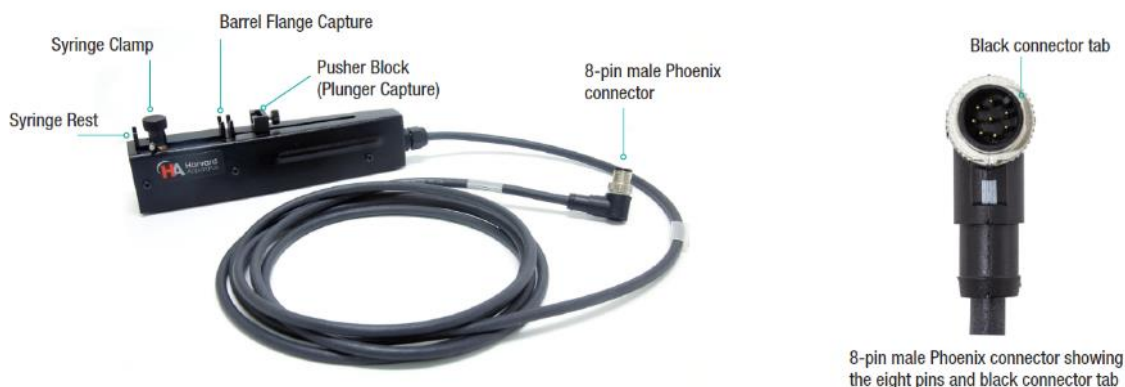
Nanomite Injector Setup

Syringe Loading

1. Raise the spring loaded syringe clamp and rotate to the side, away from the syringe rest.
2. Turn On the HAPC control box, use the Fast Forward / Fast Reverse buttons for the selected channel to adjust the pusher block to the approximate length of the syringe.
3. Place the syringe on the syringe rest, ensuring that the barrel flange is positioned within its capture and plunger rests in the pusher block.
4. Lift and rotate the syringe clamp, placing it on the syringe barrel to secure the syringe in place

Pump 11 Elite/Pico Plus Elite and PHD ULTRA™ Family

Connection to HAPC:

1. Using an RS485 Pump Cable (cable sold separately, please see order information in the Ordering Information section of this manual), connect the RS485 located at the top of the selected HAPC channel and connect the other end to the RS485 IN on the Pump 11 Elite/Pico Plus Elite or PHD ULTRA™ syringe pump.
2. On the connected syringe pump, there is a POWER SOURCE switch. On the Pump 11 Elite/Pico Plus Elite pumps, the switch has the choice of either DC-IN or RS-485. On the PHD ULTRA™ family, the switch has the choice of either AC-IN or RS-485. In both cases, please make sure the switch is set to RS-485. Note: The HAPC will power all connected pumps. In the case of high force applications using the PHD ULTRA™ 4400 or PHD ULTRA™ XF, external power to the pump may be required. In this case, please contact Technical Support for application assistance.
3. Power on the controller

Pump 11 Elite/Pico Plus Elite (left) & PHD ULTRA™ (right) syringe pumps showing RS-485 IN connection and POWER SOURCE switch.

Syringe Loading:

Please see the following manual for PHD ULTRA™ family syringe installation.
PHD ULTRA™, PHD ULTRA™ 4400 and PHD ULTRA™ XF (modules): PHD ULTRA™ Syringe Pump Module Manual publication 5419-006
Please see manual Pump 11 Elite / Pico Plus Elite 5420-007 or Pump 11 Elite OEM Series publication 5420-007 for syringe loading instructions.
Manual publications are available on the Harvard Apparatus website at the following location.

https://www.harvardapparatus.com/technical-support/manuals

Channel Module Installation

The Harvard Apparatus Pump Controller (HAPC) is available in one, two, three or four channel configurations. Additional channel modules can be added to units with less than four channels and are field installable. You can also request a return material authorization from our Support Team and have the channel modules installed at the Harvard Apparatus factory. Labor charges will apply. The following are instructions to install a channel module in the field. All four channels use the same installation procedure with the exception of the Channel Number switch setting (SW2) explained below.

1. The channel module requires a mechanical switch setting to be properly recognized by the unit. The following is the procedure to set the Channel Number switch (SW2) on the 4-CH Motor Card. The Channel Number switch (SW2) is called out by the red arrow in the graphic below.

    a. Set Channel to 1: by setting SW2 position 1 to ON as shown below.
    b. Set Channel to 2: by setting SW2 position 2 to ON as shown below.
    c. Set Channel to 3: by setting SW2 position 1 and 2 to ON as shown below.
    d. Set Channel to 4: by setting SW2 position 3 to ON as shown below.

Module Switch Setting for Channel 1 (P1)
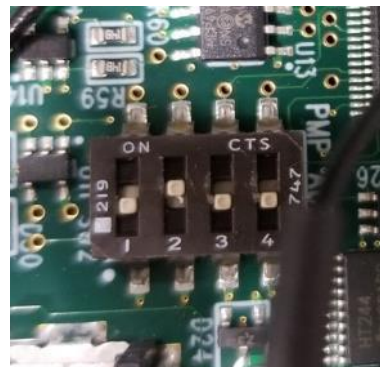
Module Switch Setting for Channel 2 (P2)
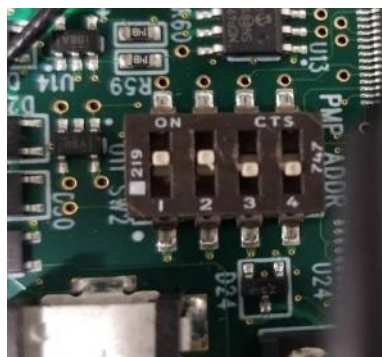
Module Switch Setting for Channel 3 (P3)
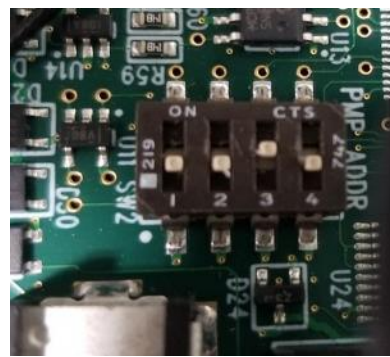
Module Switch Setting for Channel 4 (P4)

For additional reference, a table of the switch configuration can be found below.

Motor Card	SW2 Dip-Switch Position			
	1	2	3	4
Channel 1	ON	OFF	OFF	OFF
Channel 2	OFF	ON	OFF	OFF
Channel 3	ON	ON	OFF	OFF
Channel 4	OFF	OFF	ON	OFF

SW2 Switch Truth Table

2. Power off the HAPC using the main power switch located on the read of the HAPC.

3. On the rear of the HAPC, remove the four screws holding the blank panel onto the intended channel slot. Remove the blank panel. On the rear of the blank panel, there is a white wire holder that holds a grey ribbon cable with grey connector and a black and red power cable with a white connector. Both connectors need to be plugged into the channel module.

4. Plug the grey connector into the location marked by a grey arrow in the picture below. Plug the white connector into the location marked with a white arrow in the picture below.

5. Place the module into the channel slot and align the four screw holes, insert the four screws and tighten.
6. Power on the unit. The HAPC will now recognize the channel module.

Harvard Apparatus Pump Controller (HAPC)

Navigating the HAPC User Interface

Introduction

The HAPC uses a high resolution 7" WQVGA TFT Color Display with touchscreen that offers an icon-enabled graphical user interface and an advanced methods architecture to streamline simple to complex pumping protocols. There are setup and run screens for all channels and operating conditions. There are small functional differences for each individual condition based on the features that condition supports.

HAPC showing touchscreen interface

When you first turn on the unit after delivery from the Harvard Apparatus factory, three startup screens will appear. The first is the Initialization screen where the HAPC performs a self check, then the Harvard Apparatus splash screen containing software revision information followed by the "Pumps Found" screen that shows the properly connected pumps. Once the "Pumps Found" Screen appears, either select the Green check mark or wait 2 seconds and the Pump Controller interface will appear.
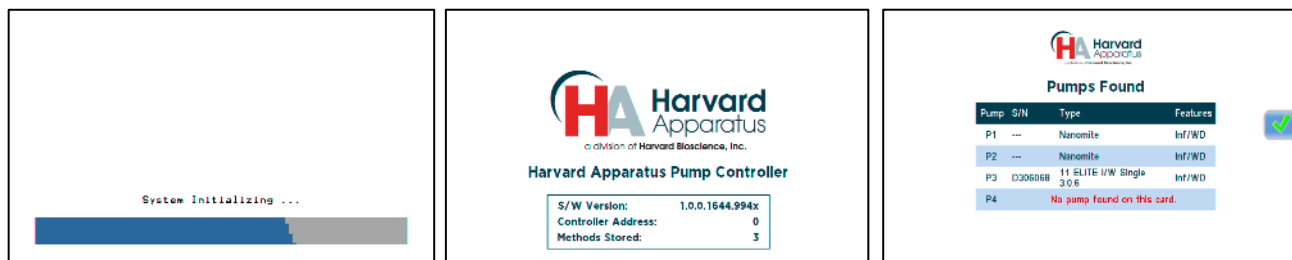
HAPC Initialization Screen, Harvard Apparatus Splash Screen and Pumps Found Screen

Graphical User Interface Screen/Button Glossary

The following gives a glossary of the screens and icons used in the HAPC graphical user interface. Please familiarize yourself with the buttons and screens. They will be referred to throughout this section.

The HAPC touchscreen with allows you to navigate through all menu selections and data entry by gently touching the onscreen buttons with a finger or the tip of a soft, non-sharp object such as a pencil eraser.

The software is organized into three main navigational branches:

- Quick Start Operations
- Preloaded/User-Defined Methods
- Systems Settings

The Quick Start screens are the primary "home" for the applications. From those screens, you can access all the commands needed to operate the HAPC, as well as the main system settings.

Harvard Apparatus Pump Controller (HAPC)

From anywhere in the applications, you can return to the Quick Start or Method Main screens by:

- Choosing the Cancel or Home/Back buttons one or more times until you reach the Method Main or Quick Start screens.
- Choosing Method Select and making a selection from the Method options available.

The HAPC touchscreen interface is divided into three basic areas:

- Operations Display: this section of the screen is used to display pump operations, method information, general parameter settings and the real-time display of data while the pump is running.
- Message Area: this section is used to display the pump name, the time/date display and the message box which contains operational messages while the pump is running. It is used to display useful information while entering parameters. The Message Area is displayed in blue when one of these helpful operational messages are displayed. It is also used to display error or warning messages to indicate problem conditions in a Method or error conditions during pump operation. The Message Area is displayed in yellow when one of these warning messages is displayed.

The HAPC graphical user interface provides complete control over connected syringe pumps. An overview of the navigation buttons and channel setup tabs can be found below.

- Navigation Buttons: this area of the touchscreen contains the buttons used to navigate through the software menus and to start/stop pump operations. **The function of the various navigation buttons will be explained throughout this manual.**
- Channel Setup Tabs: Selects the desired channel for pump setup. There are four channel setup tabs labeled P1 (for channel 1), P2 (for channel 2), P3 (for channel 3) and P4 (for channel 4). The color of selected channel tab will be white while the remaining channel tabs remain blue. All channels can run independently through the HAPC graphical user interface or be triggered by TTL or software triggering.
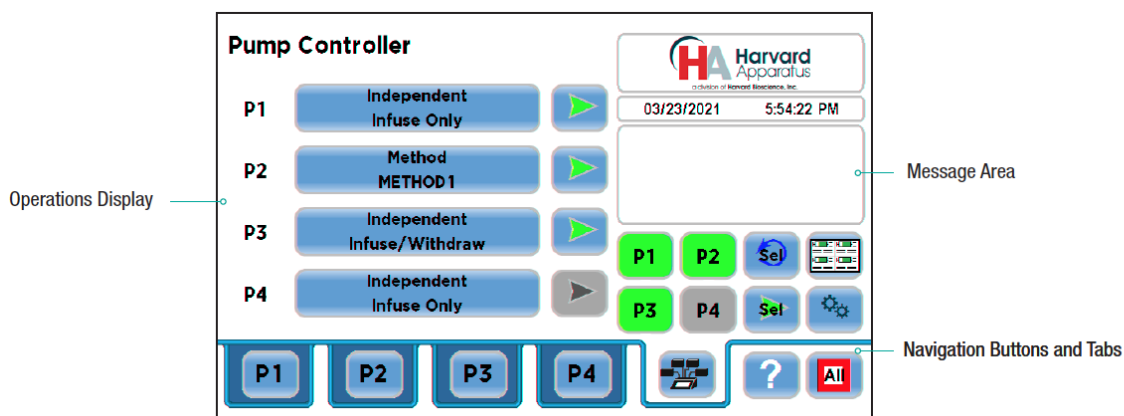
**Pump Controller Screen Showing the three basic GUI areas**
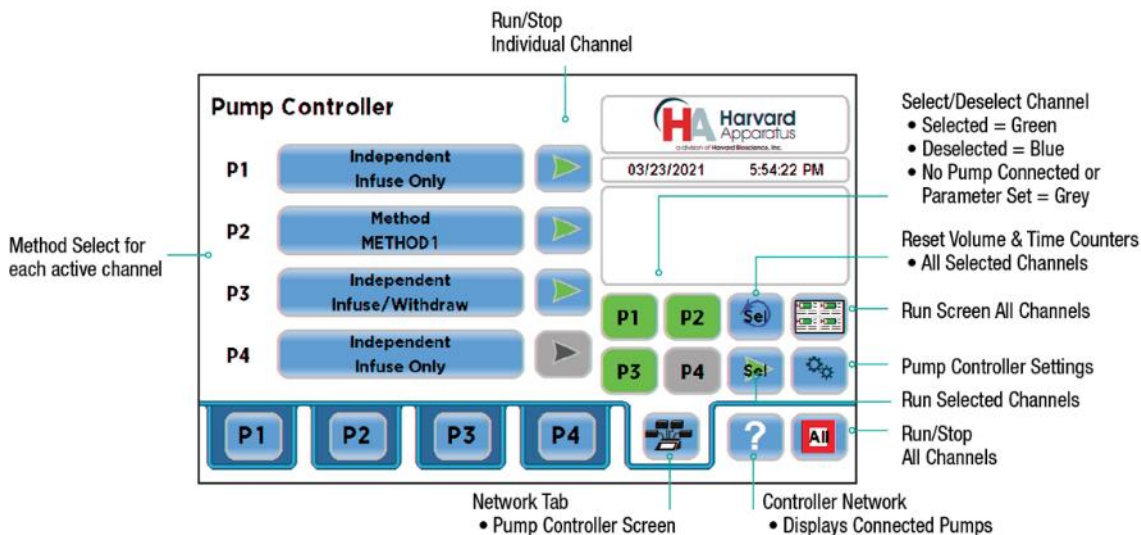
Pump Controller Screen with button function labels

- Network Tab: The Network Tab brings the user to an overview screen with all four channels and their chosen Method. The ability to run selected channels, edit Methods, reset counters for selected channels, access settings and the controller run screen. To run all or one pump from this screen, press the P1, P2, P3, P4 buttons to enable the desired pumps. When the button is bright green, the pump is selected. Press the Run Selected button to start the highlighted pumps. Method Select: Allows the selection of the syringe pump channel mode. There are six mode selections. New Method, Infuse Only, Withdraw Only, Infuse/Withdraw, Withdraw/Infuse and Twin or Reciprocating. The following gives an overview of the Method Selection screen.

Quick Start Screen

The Quick Start screen allows the user to set the parameters for the syringe pump operation, adjust syringe position and run stop one or all set pump channels. The following gives an overview of the functions of this screen.

Quick Start Screen
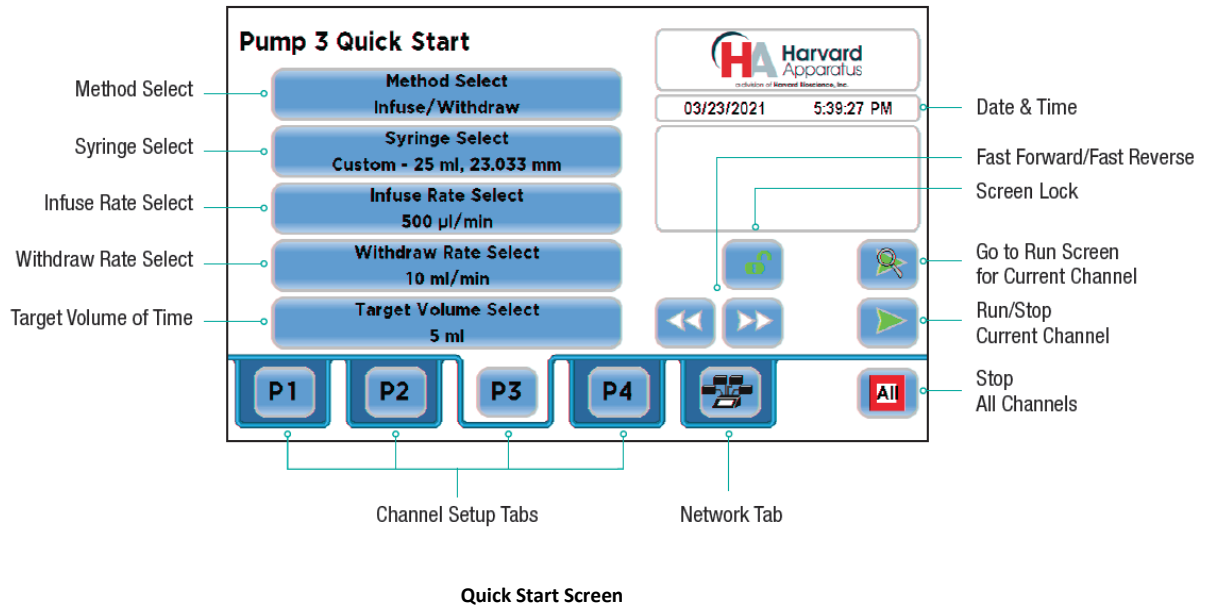
Harvard Apparatus Pump Controller (HAPC)

Method Select

Method Select: The Method Select button opens a selection menu.
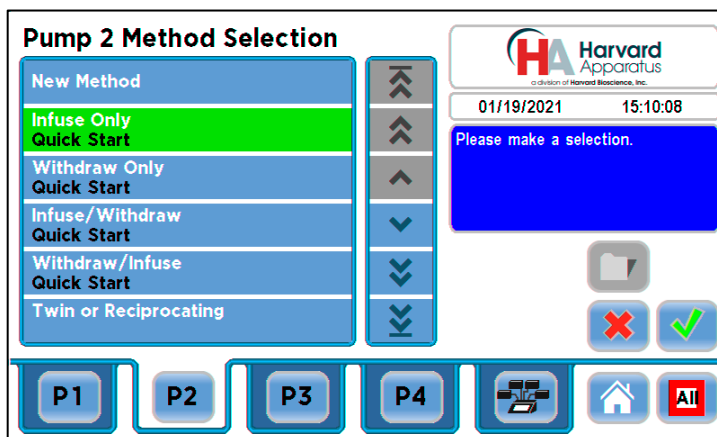
Method Selection Screen

- New Method: Allows the creation of pump flow profiles containing detailed parameters required to control the pump for infuse or withdraw. Multi-step methods can be created and stored on the unit. **Details on Method creation are provided later in this section.**
- Infuse Only: The selected channel syringe will operate in infuse mode only. The pusher block will push the syringe plunger at the set flow rate and volume/time.
- Withdraw Only: The selected channel syringe will operate in withdraw mode only. The pusher block will pull the syringe plunger at the set flow rate and volume/time.
- Infuse/Withdraw: The selected channel syringe will operate in Infuse/Withdraw mode. The pusher block will push the syringe plunger at the set flow rate and volume while infusing and will then pull the syringe plunger at the set flow rate while withdrawing. The infuse and withdraw flow rates can be different. For example: An experiment may require a low flow rate for infusion but require a fast withdraw rate for quick syringe refill.
- Withdraw/Infuse: The selected channel syringe will operate in Withdraw/Infuse mode. The pusher block will pull the syringe plunger at the set flow rate and volume while refilling and will then push the syringe plunger at the set flow rate while withdrawing. The infuse and withdraw flow rates can be different. For example: An experiment may require a low flow rate for infusion but require a fast withdraw rate for quick syringe refill.
- Twin or Reciprocating: The Twin Condition allows 2-4 syringes to operate in the same mode using the exact same syringe type, syringe size, force, target (volume or time) and flow rate settings. The pump also allows the user to combine both flows through the Ganging feature which supports loading multiple syringes concurrently.
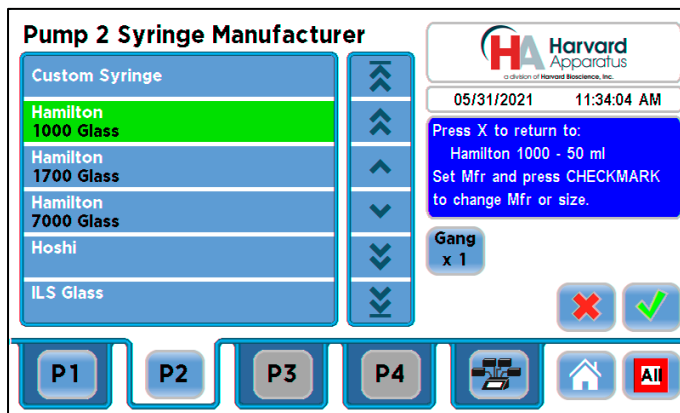
Syringe Select

Syringe Select: In order to accurately control the flow rate or volume delivery of the pump, the HAPC requires that each method include accurate setting of the syringe diameter and volume. All Methods require a syringe definition, either by selecting from the installed syringe specifications list or by defining a new (Custom) syringe in the application.

The built-in Syringe Lookup Table provides a convenient lookup function that allows users to select from a wide variety of syringes from major manufacturers, including: Air-Tite, Becton Dickinson, Hamilton, Harvard Apparatus, Cadence Science, SGE Scientific Glass Engineering, Sherwood — Monoject, and Terumo.

1. To select a syringe from the Quick Start or Method Main screen, choose the Syringe Select button to bring up the Syringe Manufacturer Selection screen.

Syringe Select Screen with selection highlighted.

2. From the Syringe Manufacturer Selection Screen, scroll through, find and double tap (or tap once and select the green arrow) the Manufacturer/Model button for the desired syringe manufacturer. You can scroll through listed syringe manufacturers by using the scroll arrows found to the right of the syringe manufacturer list shown in the screen above. This will bring up the Syringe Dimensions screen below and list the available syringe sizes for that manufacturer/model.
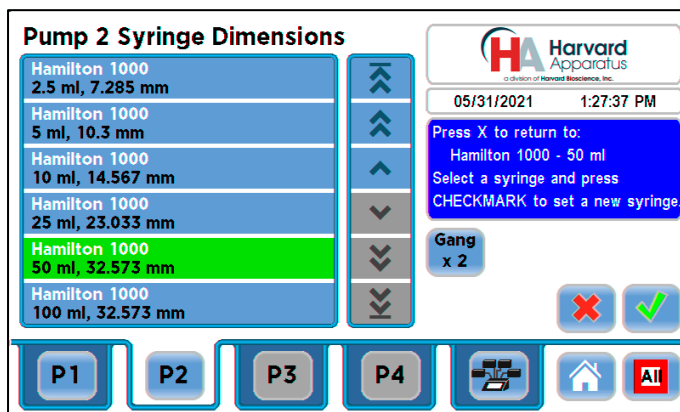

Syringe Size Selection screen showing barrel dimensions and syringe capacity.

3. Double tap the syringe you are selecting to select and return to the Quick Start Screen. You can also select the syringe by tapping once to highlight and then selecting the green check mark button.

The Syringe Select screen also allows you to enter a custom syringe that may not be listed in the syringe manufacturers tables.

1. From the Quick Start or Method Main screen, choose the Syringe Select button.
2. From the Syringe Manufacturer menu, double tap the Custom Syringe option at the top of the syringe selection menu. You can also select the Custom Syringe menu by tapping the Custom Syringe button once to highlight and then selecting the green check mark button to accept.
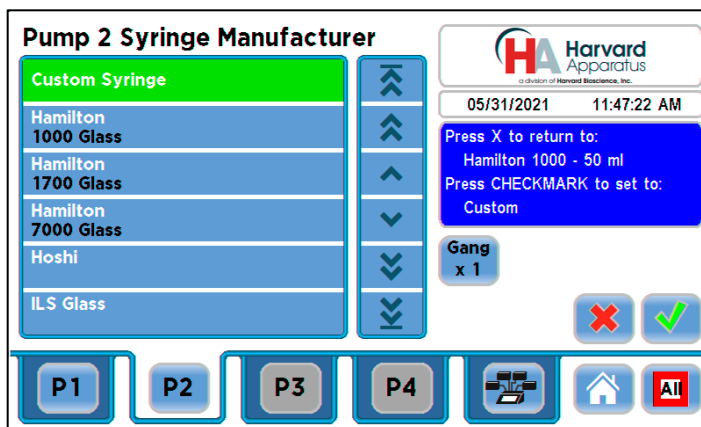
**Syringe Selection Menu showing the Custom Syringe highlighted.**

3. On the Syringe Dimension Entry screen, the Diameter (mm) entry box should be highlighted by default. If it is not, choose the Diameter (mm) button.
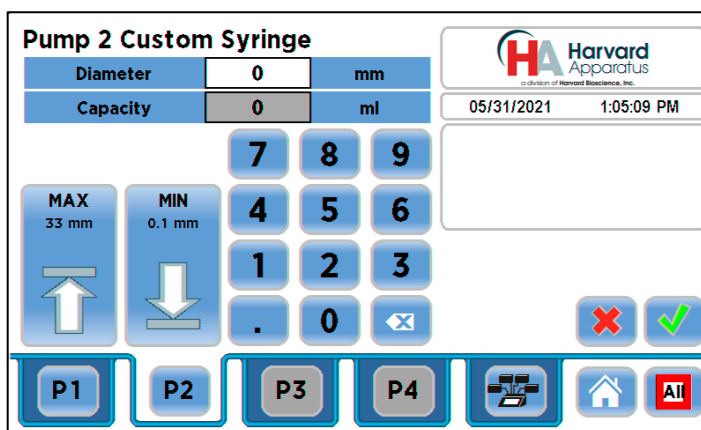
Custom Syringe Screen

4. Enter the diameter of your syringe using the keypad.
5. Choose the Volume button and enter the total volume of your syringe.
6. If the Volume unit of measure is not correct, choose the Unit of Measure button.
7. On the Units Selections screen, select the Units button appropriate to your syringe, then choose Accept. You are automatically returned to the Syringe Dimension Entry screen.
8. When all parameter entries are correct, choose the Accept button (green check mark) to return to the Quick Start or Method Main screen.
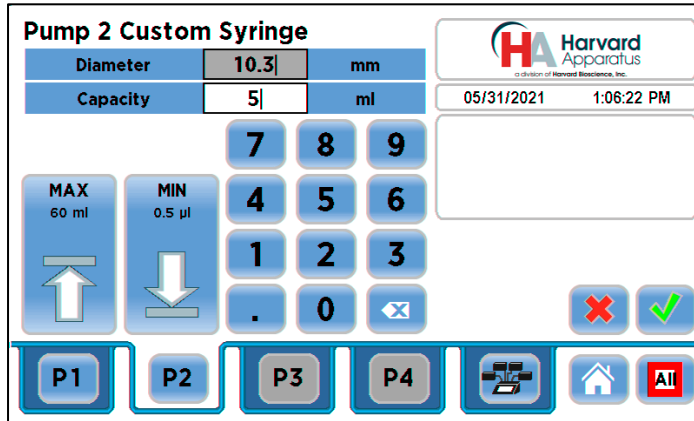
Custom Syringe Screen with Diameter and Capacity entered.

Syringe Selection Gang Feature

The Gang feature is available in the Syringe Dimensions screen and allows multiple syringes to be combined into one common output on each individual pump connected to the HAPC that offers more than one syringe position. Example: The PHD ULTRA™ or Pump 11 Elite Dual syringe pumps.

1. From the Quick Start Screen, choose syringe select and select the syringe you wish to use. You can also use the Custom Syringe option explained above with the Gang feature.
2. Choose the Gang button to enter the Syringe Count screen.
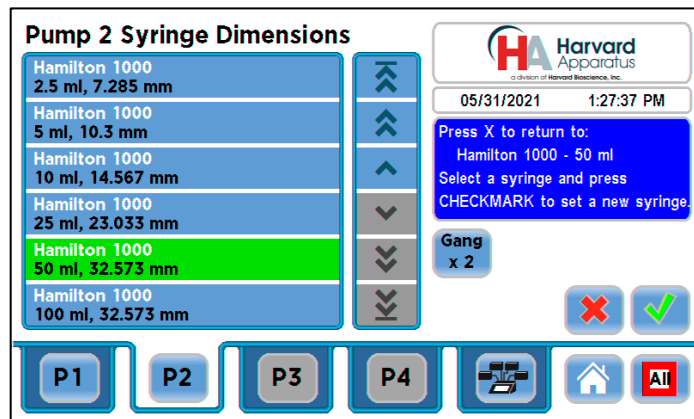
Syringe Dimension Screen showing Gang button.

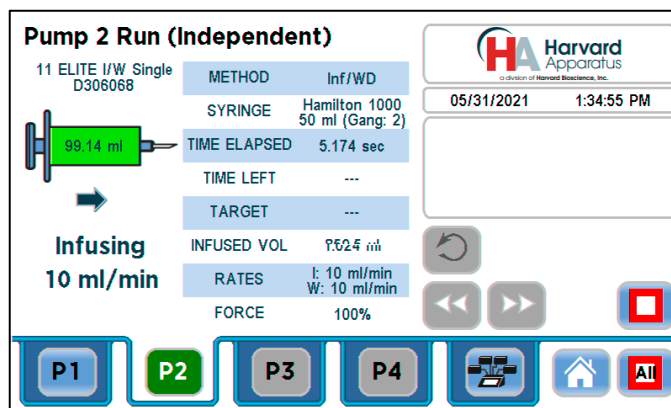3. Enter the number of syringes being used then press the Accept button (green check mark).
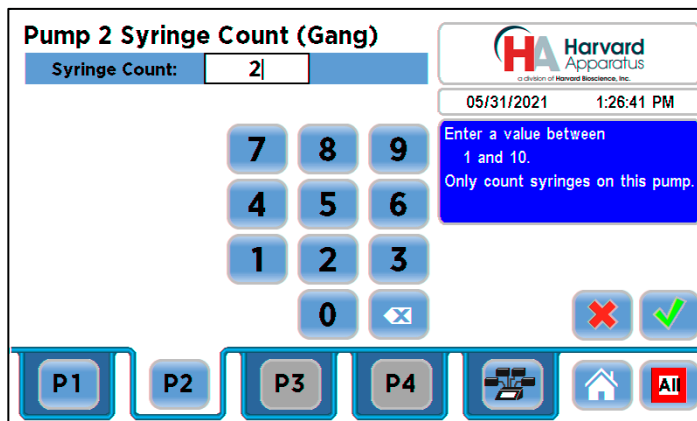
4. The Syringe Select button on the Quick Start screen for this pump channel will list the Gang parameters that were entered. Select the Go To Run screen button to review the settings.
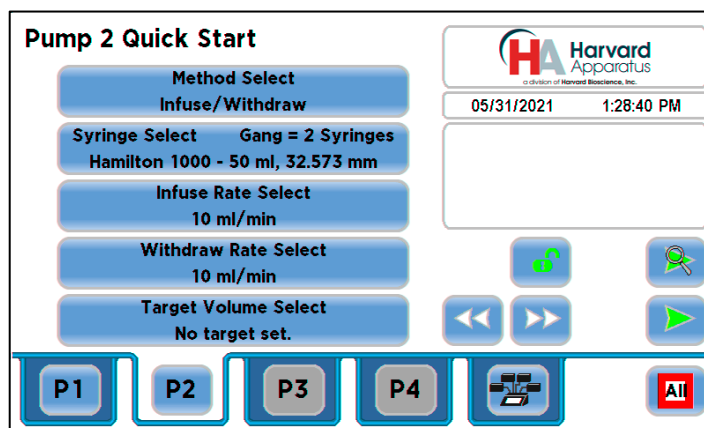
5. The Run Screen for this pump channel will also list the Gang setup in the SYRINGE section.


Infuse/Withdraw Rate Select and Target Time/Volume

The Infuse and Withdraw buttons allow you to access and enter the flow rate parameters depending on the method chosen. The Target Time/Volume Select options differ based on the method chosen.

Infuse Only: The selected channel syringe will operate in infuse mode only. In this case, the Withdraw Rate Select button will not be available. The pusher block of the pump being controlled will push the syringe plunger at the set flow rate and volume/time.

1. Select the Infuse Rate Select button.
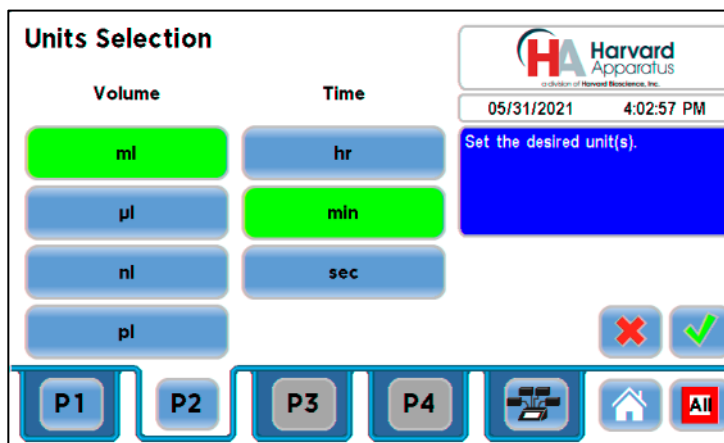
Harvard Apparatus Pump Controller (HAPC)
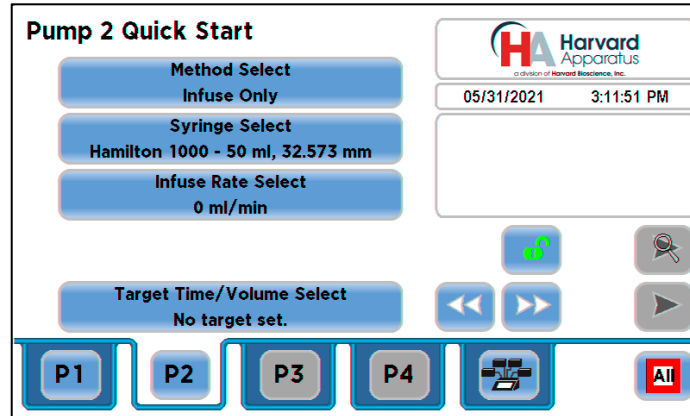
Pump 2 Quick Start Infuse Only

2. The flow rate maximum and minimum are calculated based on the syringe size chosen. The units can be changed by pressing on the units (in this case pressing on the ml/min) and bringing up the Units Selection screen (shown after the Set Infuse Rate screen below). On the left hand side of the screen there are MAX and MIN buttons placed for your convenience. Selecting one of these buttons chooses the maximum or minimum flow rate for that chosen syringe. Enter the required Infuse Rate parameters and press the green check mark button to accept the selections.
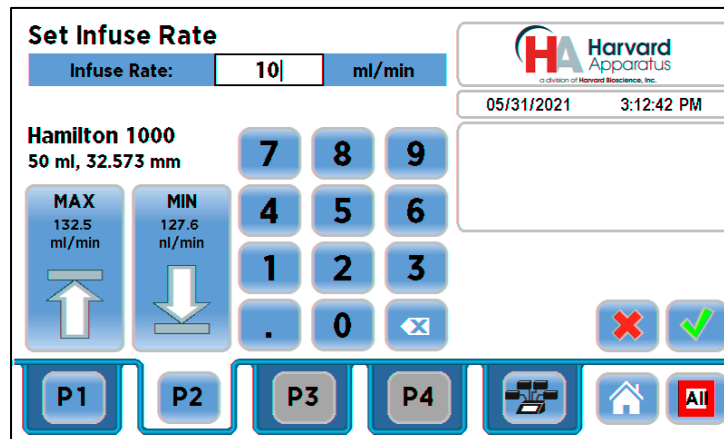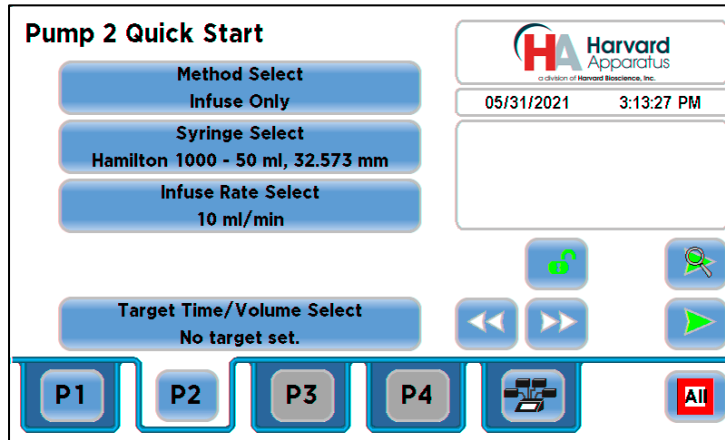

**Set Infuse Rate Screen**

Units Selection Screen

3. The Quick Start screen for the selected channel will display the selected infusion rate.

Quick Start Screen with infusion parameters

4. The HAPC allows you to select a Target Volume or Target Time. Target Time is available in the Infuse Only and Withdraw Only Quick Start methods. To enter a Target volume for your infusion, select the Target Time/Volume Select button to access that screen. To enter a target volume, select the space to the right of the Target Volume label. Use the keypad to enter the desired volume up to the volume of the selected syringe and accept the volume by pressing the green check mark button. The Set Target Volume or Time screen below shows the volume being entered. You can change the units by selecting the unit (ml in screenshot below) and using the unit selection screen to select a different volume unit (ml, µl, nl & pl).
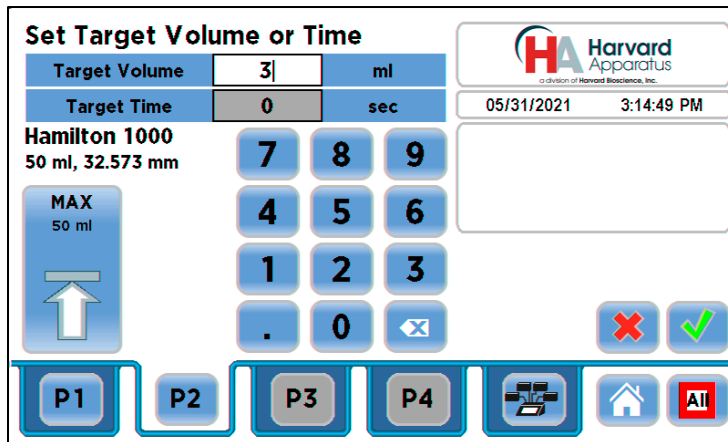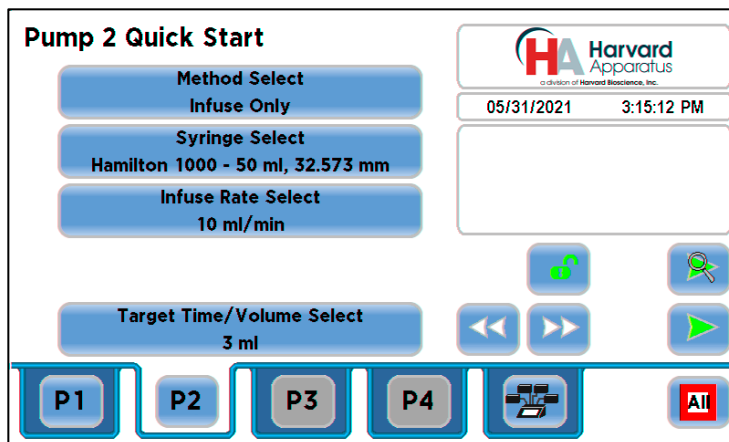

Set Target Volume
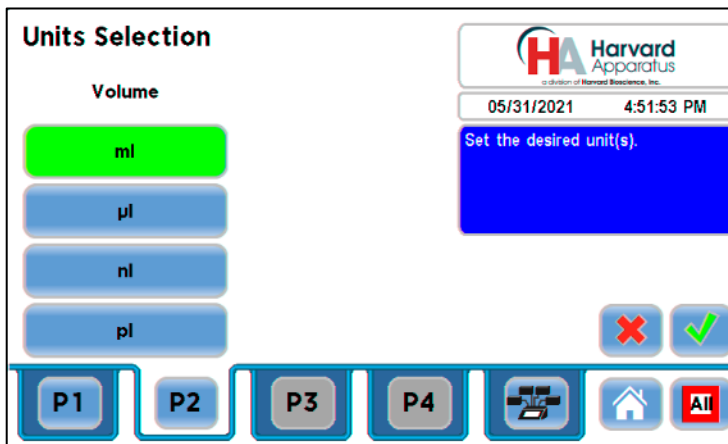
**Units Selection Screen for Target Volume**

Quick Start Screen

5. To run your infusion using Target Time instead of Target Volume, select Target Time on the Set Target Volume or Time screen. You can choose units in seconds (sec) or hours:minutes:seconds (HH:MM:SS).

Withdraw Only: The selected channel syringe will operate in withdraw mode only. The pusher block will pull the syringe plunger at the set flow rate and volume/time. The setup instructions are the same for Withdraw Only with the exception that the Withdraw Rate Select button will be available instead of the Infuse Rate Select button

Infuse/Withdraw: The selected channel syringe will operate in Infuse/Withdraw mode. The pusher block will push the syringe plunger at the set flow rate and volume while infusing and will then pull the syringe plunger at the set flow rate while withdrawing. The infuse and withdraw flow rates can be different. For example: An experiment may require a low flow rate for infusion but require a fast withdraw rate for quick syringe refill.

The setup for Infuse/Withdraw is similar to the Infuse method above. Setup the Syringe Select to set up your desired syringe. Enter the Infuse rate and Withdraw Rate using the Select buttons for those features. Target Time is only available when using the Infuse Only or Withdraw Only methods and is not available in the Infuse/Withdraw or Withdraw/Infuse methods as shown in the screen below.

In the Target Volume selection for both Infuse/Withdraw and Withdraw/Infuse, there is an added feature called "Continuous Operation". Selecting Continuous Operation allows the syringe to infuse and withdraw the full contents of the syringe continuously. To set Continuous Operation, press the "Continuous Operation" button found to the right of the number keypad on the "Set Target Volume" screen.
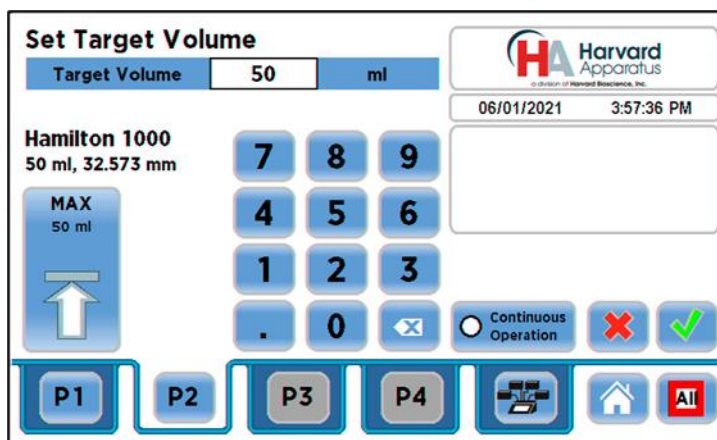
Set Target Volume Screen

Pressing the "Continuous Operation" button will automatically set the Target Volume to the maximum volume for the set syringe as shown in the screenshot below.
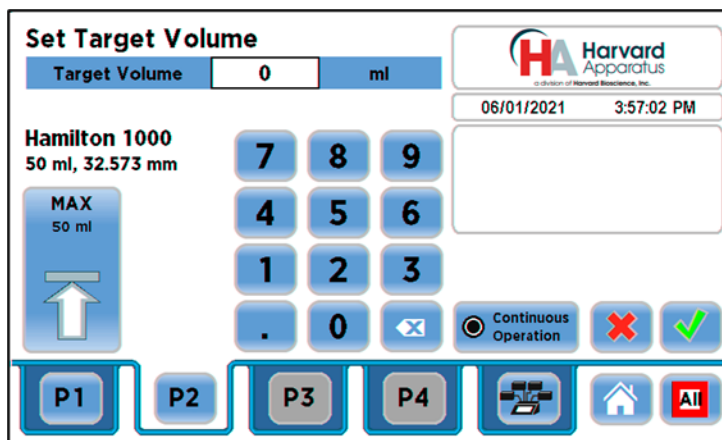
**Set Target volume Screen showing Continuous Operations Engaged**

Withdraw/Infuse: The selected channel syringe will operate in Withdraw/Infuse mode. The pusher block will pull the syringe plunger at the set flow rate and volume while withdrawing and will then push the syringe plunger at the set flow rate while infusing. The infuse and withdraw flow rates can be different. For example: An experiment may require a low flow rate for infusion but require a fast withdraw rate for quick syringe refill. The setup is the same as Infuse/Withdraw with exception that the pump will start in Withdraw mode.
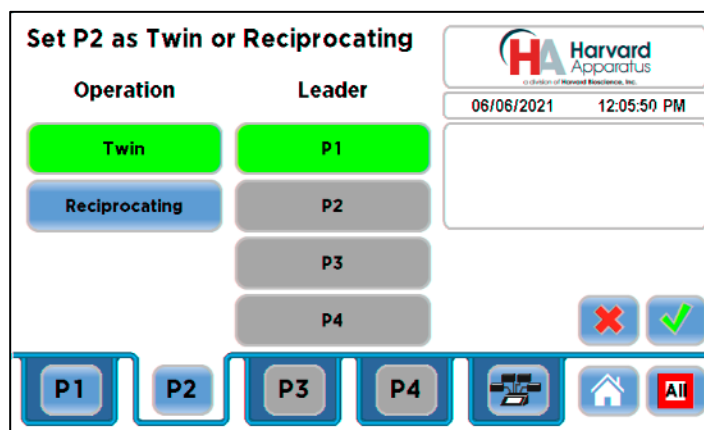
Twin or Reciprocating

The Twin Condition allows up to three additional pump channels to operate in the same mode using the exact same syringe type, syringe size, force, target (volume or time) and flow rate settings. **Note: All channels used in Twin or Reciprocating mode must be the same pump type using the same size and type of syringe.** The HAPC also allows the user to combine both flows through the Ganging feature for when multiple syringes are loaded on a given pump. The Twin Condition Setup follows the same setup procedure as discussed for the methods above with one exception. The user only needs to select the Mode Select, Syringe Select, Rate Select and Target Select for the leader pump channel and the selected Twin or Twins will be automatically set.

1. To setup a Twin method, select the channel/channels that you would like to pair with the lead channel. In the example screen below we show two of the same type of syringe pump connected to the HAPC (Channel P1 & P2). We will show an example setup of P2 being set as the Twin of P1. Setup P1 with the parameters you wish to run using the instructions covered above.
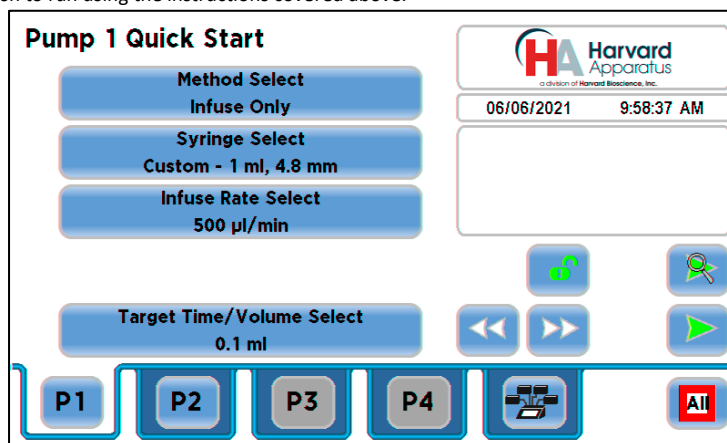

Example P1 Channel Setup

2. Select the P2 tab to bring up the P2 Quick Start Screen.
3. Select the Twin or Reciprocating button on the P2 Quick Start Method Selection screen by double tapping the Twin or Reciprocating button or by selecting that button and then pressing the green check mark button. The "Set P2 as Twin or Reciprocating" screen will appear. Select the Twin button. The button will turn green when selected. Select the leader pump you would like to use. In the example below the screenshot shows Twin and P1 selected, and both are highlighted. Press the green check mark button to accept the settings. The HAPC will enter the Pump Controller Screen.

Set Channel as Twin or Reciprocating Screen — Twin

4. The Pump Controller screen below shows that P2 is set as the Twin of P1. To run this setup, press the Run/Stop button for P1 or press the Run/Stop Selected button. Please make sure the P1 button is selected and is green before running.
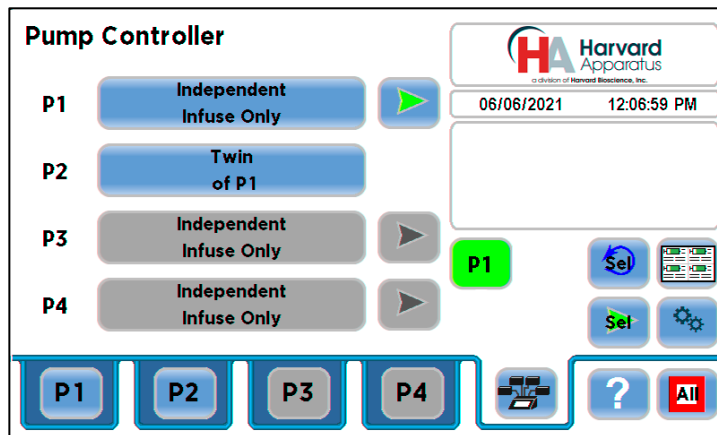
Pump Controller Screen Set for Twin
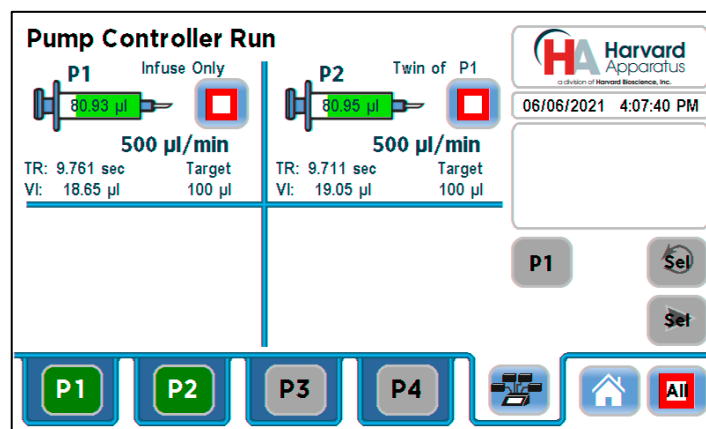
Pump Controller Run Screen — Twin Example

5. In Reciprocating method, the two syringe channels operating the same type of syringe pump will move in opposite directions at the same rate using the same syringe size and type. For example, when P1 is infusing, P2 is withdrawing at the same rate. When combined with a valve box, the reciprocating condition can provide the continuous fluidic delivery of a peristaltic pump with the accurate, smooth, low flow rates provided by a syringe pump.
6. To setup a Reciprocating method, select the channel/channels that you would like to pair with the lead channel. In the example screen below we show two of the same type of syringe pump connected to the HAPC (Channel P1 & P2). We will show an example setup of P2 being set as the Reciprocating pump of P1.
7. Setup P1 with the parameters you wish to run using the instructions covered above. Select the P2 tab to bring up the P2 Quick Start Screen.
8. Select the Twin or Reciprocating button on the P2 Quick Start Method Selection screen by double tapping the Twin or Reciprocating button or by selecting that button and then pressing the green check mark button. The "Set P2 as Twin or Reciprocating" screen will appear. Select the Twin button. The button will turn green when selected. Select the leader pump you would like to use. In the example below the screenshot shows Twin and P1 selected, and both are highlighted. Press the green check mark button to accept the settings. The HAPC will enter the Pump Controller Screen.
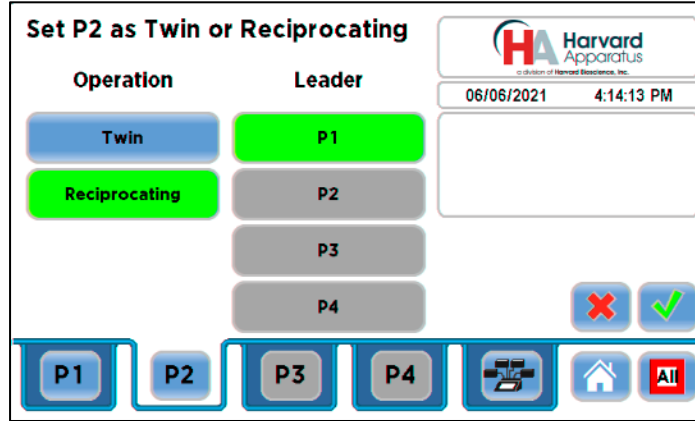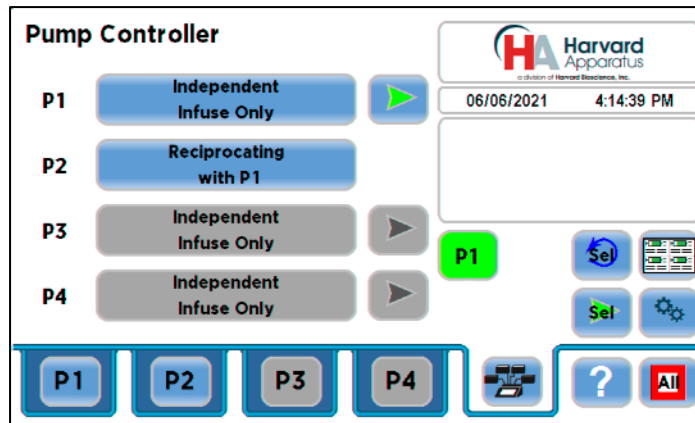
Set Channel as Twin or Reciprocating Screen — Reciprocating

9. The Pump Controller screen below shows that P2 is set as the Reciprocal of P1. To run this setup, press the Run/Stop button for P1 or press the Run/Stop Selected button. Please make sure the P1 button is selected and is green before running.

Pump Controller Screen Set for Reciprocating

10. Alternatively, you can run this Reciprocating method (and the previous Twin method) from the lead pump tab. In this example, the lead pump is P1. Select the P1 tab to enter the P1 Quick Start Screen.
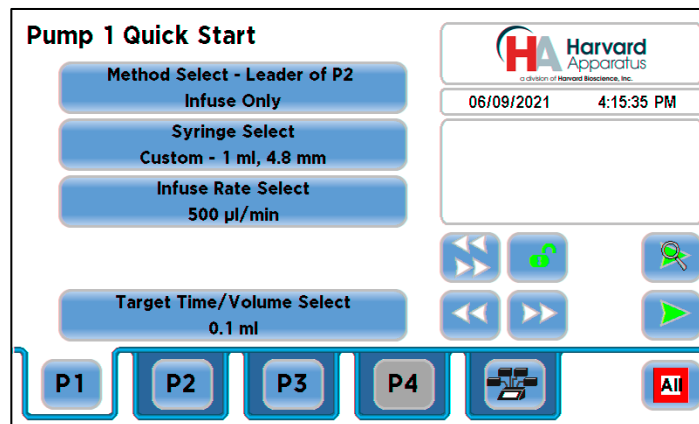
Quick Start – P1 Reciprocating Method

11. The Reciprocating (and Twin) Quick Start screen contains an additional button called Position Syringes. Selecting this button allows you to adjust the position of any active syringe pump connected to the HAPC. This is a convenient feature when setting up Reciprocating, Twin and Custom Methods. Press the Position Syringe Button to bring up that screen.

Quick Start Screen Showing Position Syringes Button
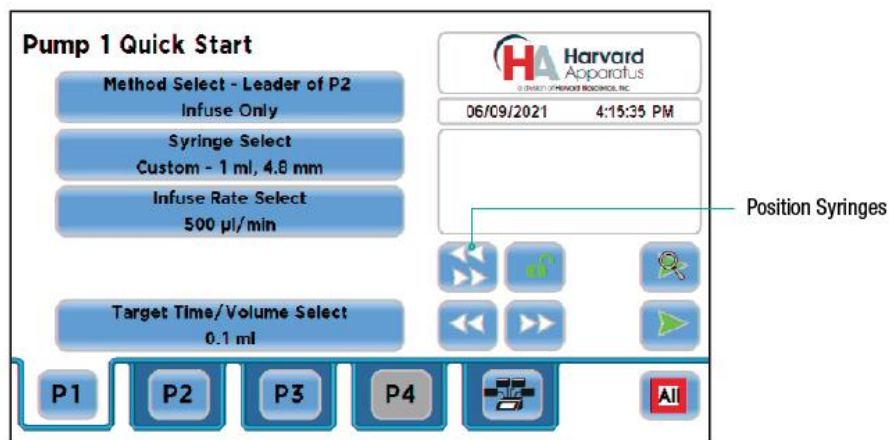
12. Use the Fast Forward/Fast Reverse buttons to adjust the position of the syringe plunger for any active syringe pump. Select the green check mark to exit the Position Syringes Screen.
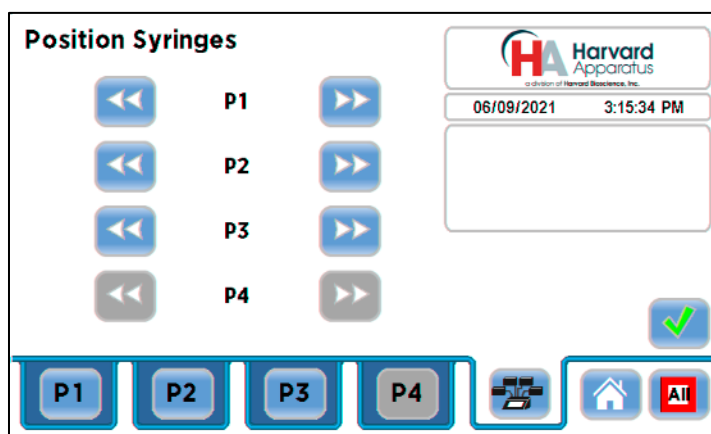
Position Syringes Screen

13. Press the Run/Stop Selected Channel button to start the Reciprocating method. Pressing the Run/Stop All pumps button would indeed start the Reciprocating method. However, it would also start any other setup and active pump channels. In the example above, P3 is active on the controller. It is not part of the Reciprocating method but would start if the Run/Stop All button is used. This is an example of the true versatility of the HAPC.
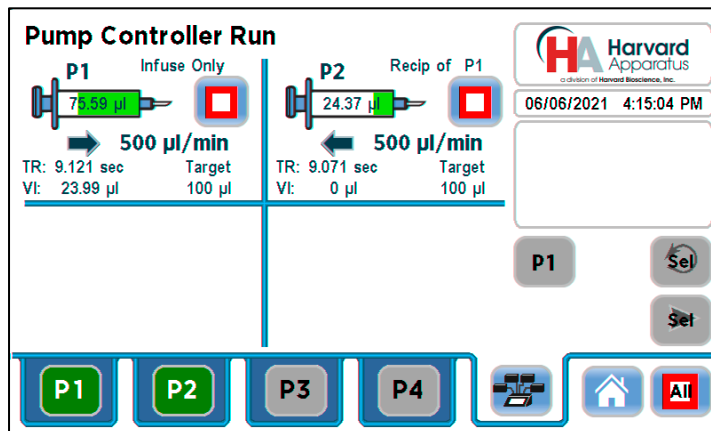
Pump Controller Run Screen — Reciprocating Example

Custom Pump Method Programs

The HAPC has the capability to create custom user-defined flow methods using preloaded method steps and store them on the controller. Custom Methods can also be transferred off of the HAPC and stored on a PC using the HAPC pump applications (for more information see the section on Pump Application Programs found later in this manual).

The Harvard Apparatus Pump Controller offers a menu of advanced pumping profile method steps, including:

- Constant Rate: A single continuous rate of flow.
- Ramped Rate: A linearly changing flow rate between a starting and ending flow rate.
- Stepped Rate: An evenly stepped, changing flow rate between a starting and ending flow rate.
- Pulsed Flow: An oscillating flow rate varying between a starting and a target rate.
- Bolus Delivery: An infusion operation to occur for a specified volume and time. The Infusion Rate is automatically calculated.
- Concentration Infusion: A measured flow rate based on delivery of a specific dosage to a recipient based on the recipient's weight.
- Gradient: Combined flow streams from multiple pumps into a common output stream.
- Autofill Cycling: Continuous infuse/withdraw or withdraw/infuse operation.
- Commands, Triggers and Events: Advanced commands and triggering options.

In addition, you have access to a variety of commands along with triggers & events to repeat, loop back or jump forward in a Method, as well as send signals to external devices or react to signals received from external devices. This package of pumping profiles and commands provides users with an extremely broad array of applications that can be easily configured without the use of complex external programming.

Creating a Custom Pump Method

1. To create a Custom Pump Method, enter the Method Select screen for the pump channel you wish to use. The HAPC will enter the Method Main screen for the selected Channel. Select the New Method button and the selection will turn green, press New Method again or press the green check mark button to advance to the Method Name screen.
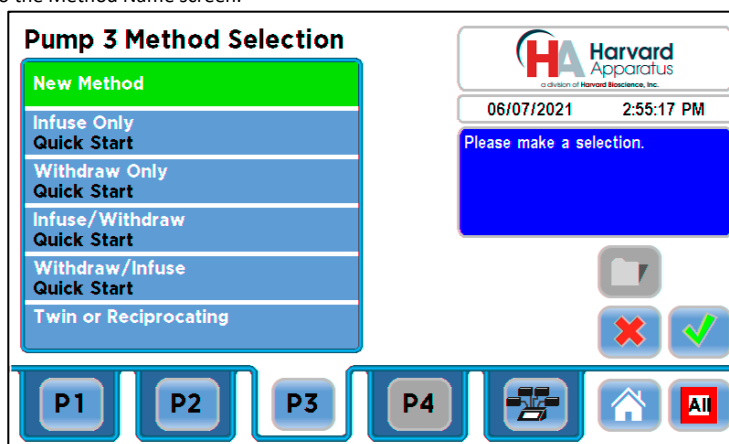
Method Selection with New Method Highlighted

2. Enter a name for your method (up to 15 characters) and select the green check mark to accept.
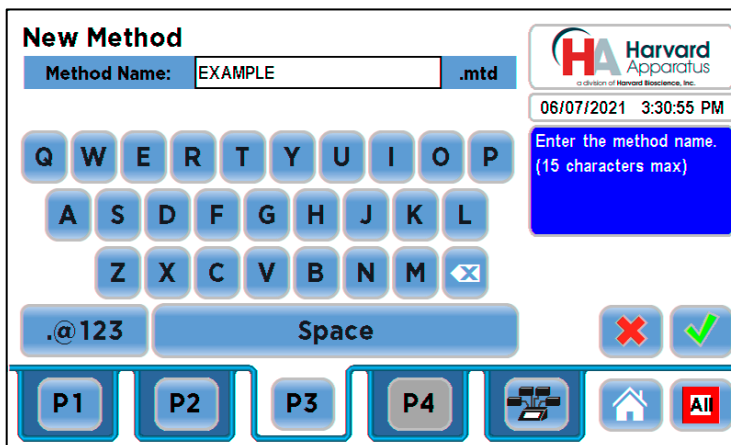
New Method — Method Name Screen

3. Once the Custom Method is named. The HAPC will return to the Method Main screen.
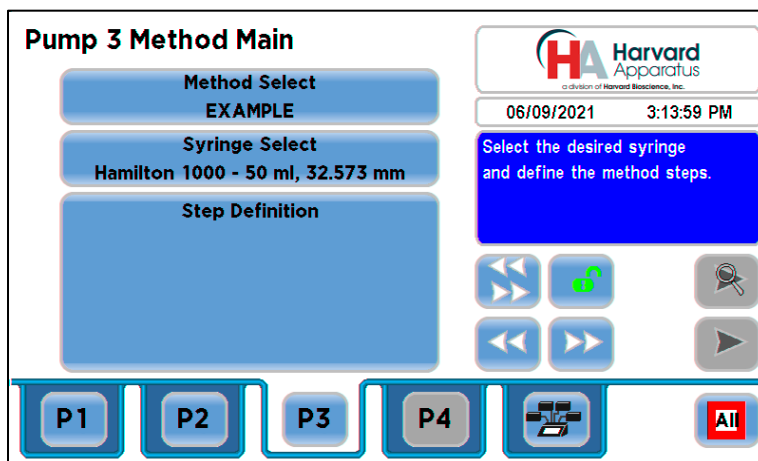
Method Main Screen

Note: The useful Position Syringes button and feature explained in the Reciprocating example apply here as well.

4. Enter the desired syringe into the Syringe Select screen.
5. Once the Method is named and the proper syringe is selected, you can start to create your custom method. Press the Step Definition button to enter the Edit Method Screen. The Edit Method screen allows you to select method steps using the available advanced pumping profiles to create your own custom flow program that can be saved for later use on the HAPC.
6. The following screenshot defines the available buttons on the Edit Method screen.
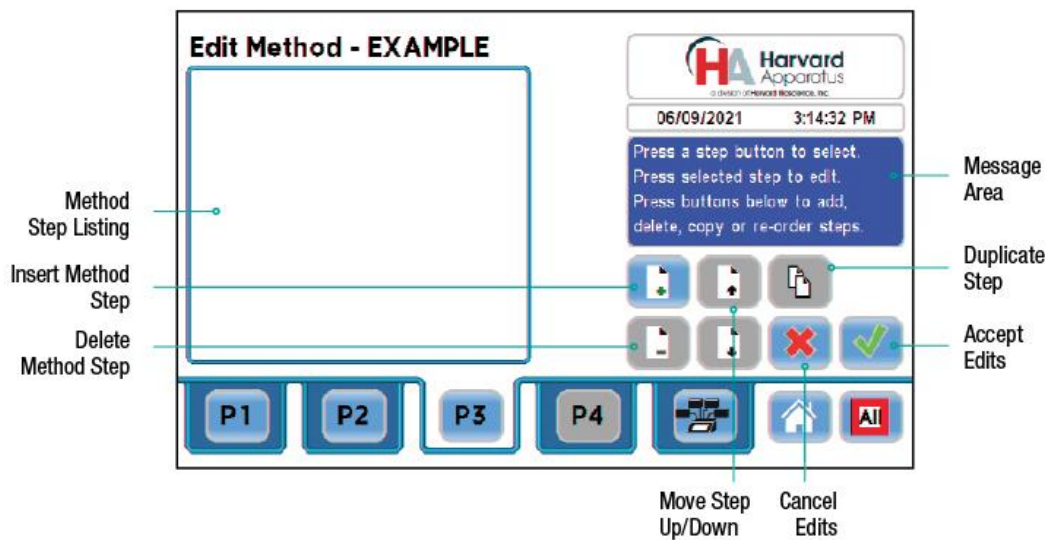
Edit Method Screen

The Edit Method screen contains buttons and features to allow you to create a custom method flow profile. To start creating a custom method flow profile, select the Insert Method Step button. This will bring up a screen listing the flow profiles listed above.

The following are the available pump profiles and instructions on setting up each feature. Editing and running a custom method program will be covered at the end of this section. Press the appropriate button for the operating profile that you wish to use.
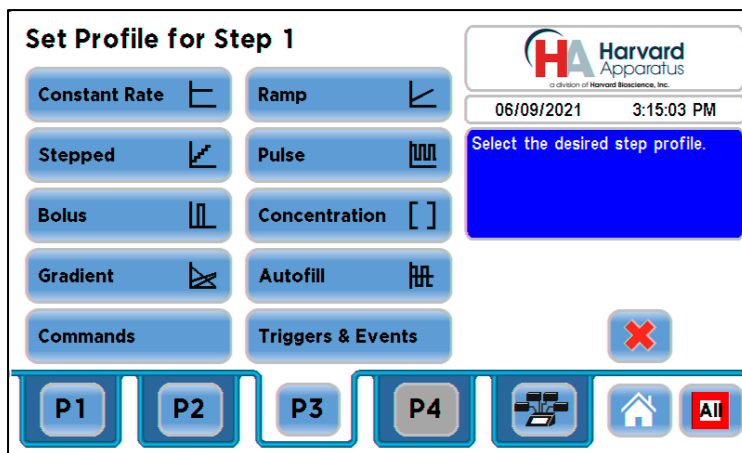
Set Profile Screen

Constant Rate Profile

The Constant Rate profile is used to run the pump at a defined flow rate and for a specific pumping mode (infuse or withdraw) up to a target volume or for a defined time period.
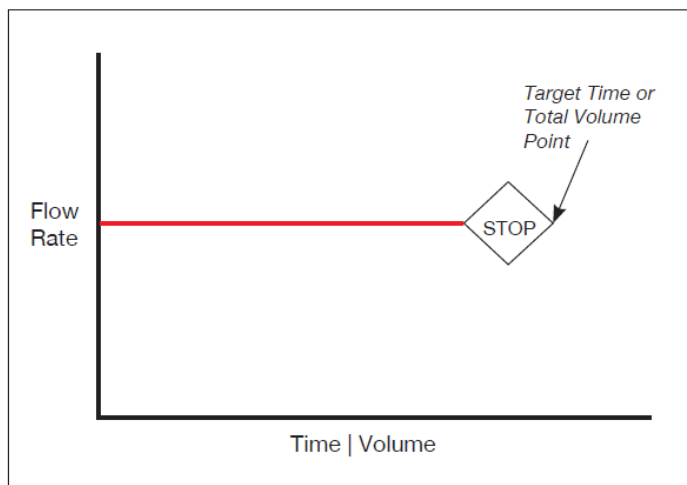
Constant Rate Operating Profile

When creating or editing a Constant Rate profile, you will define three primary operating parameters:

- The Flow Mode defining the direction of flow: infuse or withdraw.
- The Flow Rate to define the rate of uptake or dispensing.
- The Target Volume or Target Time that determine how long the pump will operate at the set rate.

When creating or editing a Constant Rate profile, you can set the rate in ml, µl, nl or pl units of volume and using sec, min or hr as the units of time. The system automatically calculates a minimum and maximum flow rate based on the syringe selected or custom-defined. The min/max values are made available as button selection options on the Set Infuse and Withdraw Rate screens**.**
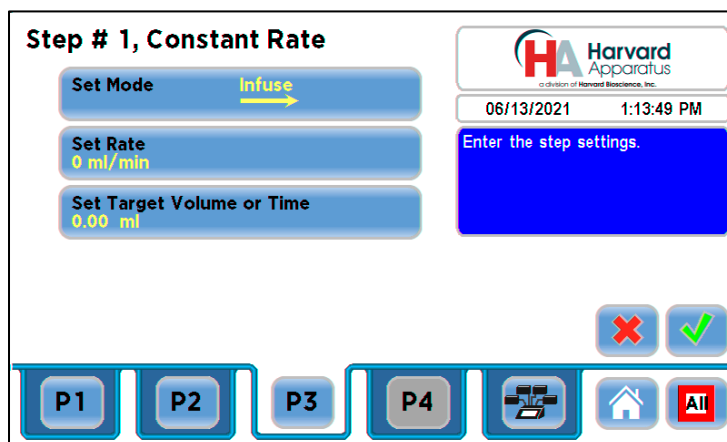
Constant Rate Step Definition Screen

To set up/edit a Constant Rate profile:

1. From the Step Definition screen for a Constant Rate profile, choose the Set Mode button to toggle the Flow Mode between Infuse and Withdraw operation.
2. Choose the Set Rate button to enter the Set Rate screen.
3. Enter the flow rate value desired using the keypad or select the Minimum Rate or Maximum Rate button. If the Units of Rate are not correct for your application, choose the Units button.
4. On the Units Selection screen, select the unit of measure (ml, µl, nl or pl) and the unit of time (sec, min, hr) as appropriate, then choose Accept to confirm your selections.
5. When all parameters are correctly set on the Set Rate screen, choose Accept to confirm your settings and return to Step Definition screen.

6.   Choose the Set Target Volume or Time button to enter the Set Volume or Time screen.

7.   On the Set Volume or Time screen, select the Volume or Time button, as desired.

8.   Enter the desired value using the keypad or select the Maximum Volume button.

9.   If the Units of Volume/Time are not correct for your application, choose the Units button to the right of the parameter entry box. For the Units of Volume, this choice takes you to the Units Selection screen. For the Units of Time option, this choice will toggle the button between sec (seconds) and h:m:s (hours:minutes:seconds). To use the h:m:s option, enter your time value in hours, minutes and seconds, separating each value with a colon.

10.   If you are changing the Units of Volume, on the Units Selection screen, select the unit of measure (ml, µl, nl or pl) as appropriate, then choose Accept to confirm your selection.

11.   When all parameters are correctly set on the Set Target Volume or Time screen, choose the Accept Edits button to confirm your settings and return to the Step Definition screen. Press green checkmark button to accept the newly-created step. The updated Edit Method screen will be displayed.

Ramp Rate Profile

The Ramp Rate profile is used to create a linearly increasing or decreasing flow rate for a single pumping mode (infuse or withdraw) over the course of a defined time period.
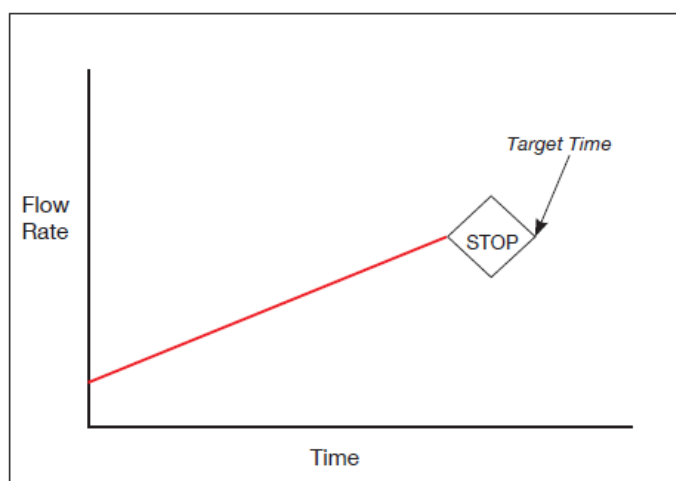
**Ramp Rate Operating Profile**

When creating or editing a Ramp Rate profile, you will define three primary operating

- The Flow Mode defining the direction of flow: infuse or withdraw
- The Flow Rate at the beginning and end of the pumping cycle
- The Target Time that determines the total length of time over which the ramp will be calculated

During a Ramp Rate profile, the HAPC varies the flow rate linearly between the starting rate and ending rate over the full time period entered. A Ramp Rate profile can be applied to an increasing or decreasing rate application.

When creating or editing a Ramp Rate profile, you can set the rate in ml, µl, nl or pl units of volume and using sec or h:m:s (hours:minutes:seconds) as the units of time. The system automatically calculates a minimum and maximum flow rate based on the syringe selected or custom-defined. The min/max values are made available as button selection options on the Set Infuse and Withdraw Rate screens.

To set up/edit a Ramp Rate profile:

1.   From the Step Definition screen for a Ramp Rate profile, choose the Set Mode button to toggle the Flow Mode between Infuse and Withdraw operation.
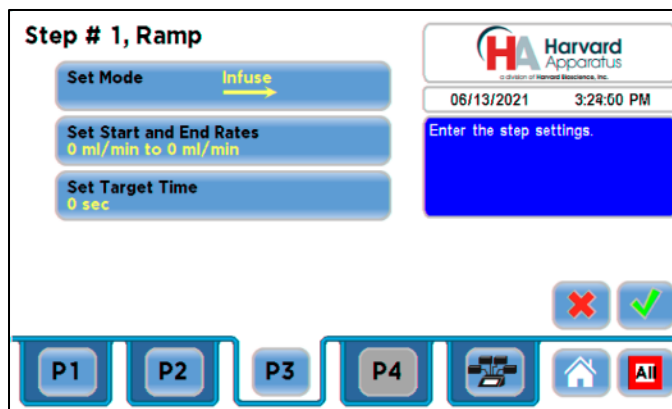
Ramp Step Definition Screen

2. Choose the Set Start & End Rate button to enter the Set Start & End Rates screen.
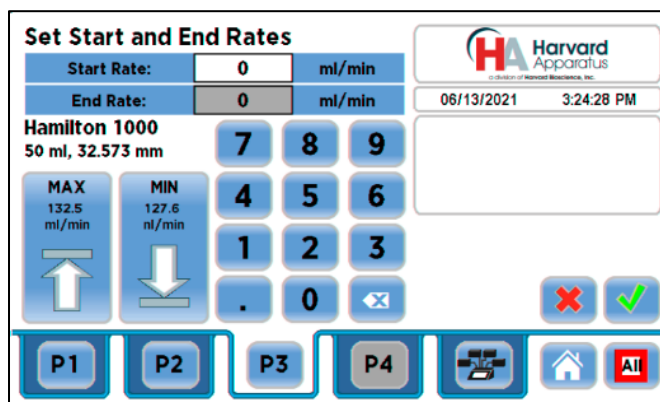
Ramp Set Start & End Rate Screen

3. Select the Start Rate button (it should be selected by default as indicated by the active data entry box to the right of the button). Enter the flow rate value desired using the keypad or select the Minimum Rate or Maximum Rate button.
4. If the Units of Rate are not correct for your application, choose the Units button.
5. On the Units Selection screen, select the unit of measure (ml, µl, nl or pl) and the unit of time (sec, min, hr) as appropriate, then choose Accept to confirm your selections.
6. Repeat Steps 3 to 5 for the End Rate by selecting the End Rate button and continuing data entry.
7. When all parameters are correctly set on the Set Rate screen, choose Accept to confirm your settings and return to Step Definition screen.
8. Choose the Set Target Time button to enter the Set Time screen.
9. Enter the desired Time value using the keypad.
10. If the Units of Time are not correct for your application, select the Units button to toggle between sec (seconds) and h:m:s (hours:minutes:seconds). To use the h:m:s option, enter your time value in hours, minutes and seconds, separating each value with a colon.
11. When all parameters are correctly set on the Set Target Time screen, choose Accept to confirm your settings and return to the Step Definition screen. Press green checkmark button to accept the newly-created step. The updated Edit Method screen will be displayed.

> **NOTE:** Ramps ≤ 2 seconds from min to max rates may cause motor stalls.

Harvard Apparatus Pump Controller (HAPC)

STEPPED PROFILE

The Stepped Rate profile is used to create an increasing or decreasing flow rate that varies in a series of equal steps between a starting and ending flow rate.
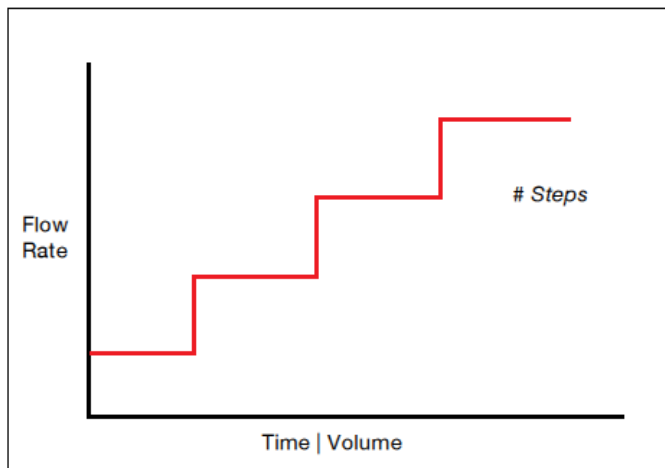
Stepped Flow Operating Profile

When creating or editing a Stepped Rate profile, you will define four primary operating parameters:

- The Flow Mode defining the direction of flow: infuse or withdraw
- The Flow Rate at the beginning and end of the pumping cycle
- The Target Time that determines the total length of time over which the stepped profile will be calculated
- The Number of Steps that will be created in the profile

During a Stepped Rate profile, the HAPC calculates a series of equal rate increases that will vary the flow from the starting value to the ending value. You enter the Number of Steps you want to use. The Target Time defines the total length of pumping time, with the Target Time value divided equally into each stepped rate. A Stepped Rate profile can be applied to an increasing or decreasing rate application.

When creating or editing a Stepped Rate profile, you can set the rate in ml, μl, nl or pl units of volume using sec or h:m:s (hours:minutes:seconds) as the units of time. The system automatically calculates a minimum and maximum flow rate based on the syringe selected or custom-defined. The min/max values are made available as button selection options on the Set screen.

To set up/edit a Stepped Flow profile:

1. To set up/edit a stepped rate profile, from the Step Definition screen for a Stepped Rate profile, choose the Set Mode button to toggle the Flow Mode between Infuse and Withdraw operation.
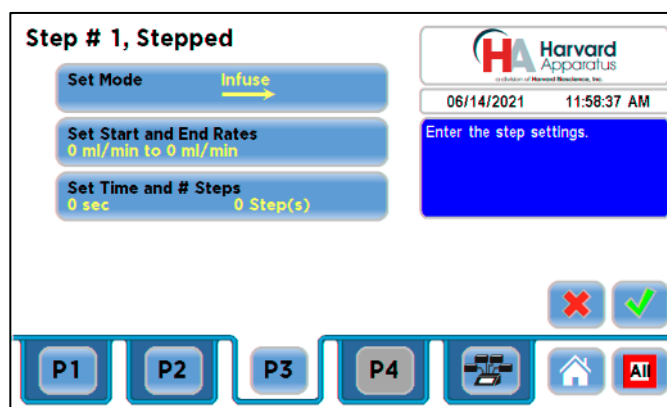
Stepped Flow Step Definition Screen

2. Choose the Set Start & End Rate button to enter the Set Start and End Rates screen.

Set Start and End Rates Screen

3. Select the Start Rate button (it should be selected by default as indicated by the active data entry box to the right of the button). Enter the flow rate value desired using the keypad or select the Minimum Rate or Maximum Rate button.
4. If the Units of Rate are not correct for your application, choose the Units button.
5. On the Units Selection screen, select the unit of measure (ml, µl, nl or pl) and the unit of time (sec, min, hr) as appropriate, then choose Accept to confirm your selections.
6. Repeat Steps 3 to 5 for the End Rate by selecting the End Rate button and continuing data entry.
7. When all parameters are correctly set on the Set Rate screen, choose Accept to confirm your settings and return to Step Definition screen.
8. Choose the Set Time and # Steps button to enter the Set Time & Steps screen.
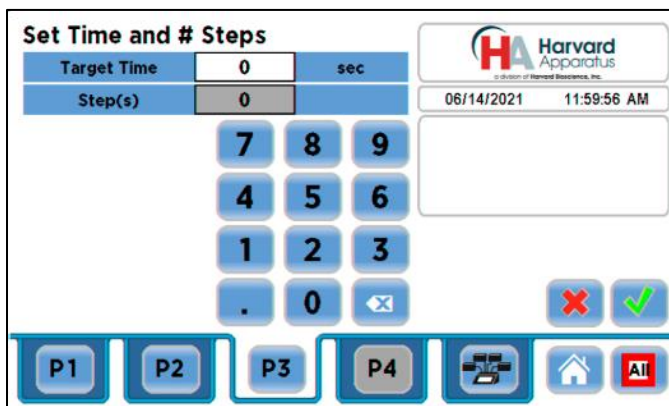
Set Time and # Steps Screen

9. Select the Total Time button (it should be selected by default as indicated by the active data entry box to the right of the button). Enter the desired value using the keypad.
10. If the Units of Time are not correct for your application, select the Units button to toggle between sec (seconds) and h:m:s (hours:minutes:seconds). To use the h:m:s option, enter your time value in hours, minutes and seconds, separating each value with a colon.
11. Select the Number of Steps button and enter the desired value using the keypad.
12. When all parameters are correctly set on the Set Target Time screen, choose Accept to confirm your settings and return to the Step Definition screen. Press green checkmark button to accept the newly-created step. The updated Edit Method screen will be displayed.

PULSE PROFILE

The Pulse Flow profile is used to create an oscillating infusion or withdrawal profile that varies between a starting flow rate and a second rate that can be either higher or lower than the start rate. The flow rate is constant within each segment of the pulsed flow profile and the user defines the total number of repetitions (pulses) for the oscillating pattern. Each segment of the profile must be set to run for either a specific length of time or to deliver a set volume.
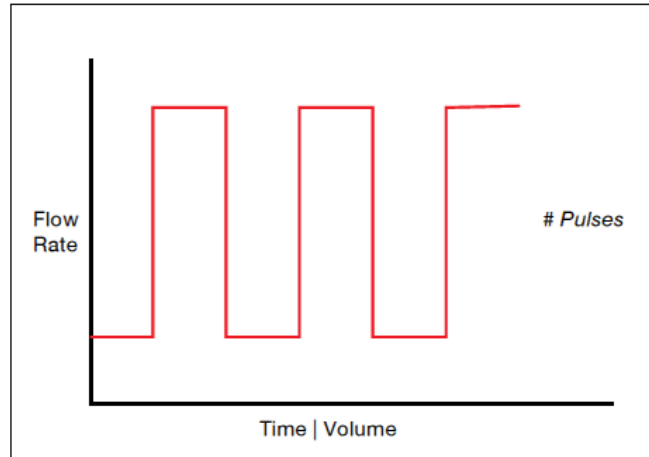
Pulse Flow Operating Profile

- When creating or editing a Pulse Flow profile, you will define four primary operating parameters:
- The Flow Mode defining the direction of flow: infuse or withdraw
- The Flow Rate to be used at each level of the pulsed profile within the pumping cycle
- The length of Time that each segment of the profile will run or the specific Volume to be infused/withdrawn during each segment of the profile
- The Number of Pulses (repetitions) that will be executed during the pumping cycle

During a Pulse Flow profile, the HAPC calculates a series of equal length pumping stages at two user-defined flow rates: a starting rate and a "pulse" rate. You enter the Number of Pulses (repetitions) that you want to use, along with how you want the system to calculate the length of each stage — by time or by volume pumped. A Pulse Rate profile can be applied to pulses that are higher in rate or lower in rate than the starting flow rate.

When creating or editing a Pulse Flow profile, you can set the rate in ml, µl, nl or pl units of volume using sec, min or hr as the units of time. The system automatically calculates a minimum and maximum flow rate based on the syringes elected or custom-defined. The min/max values are made available as button selection options on the Set Pulse Rates screens.
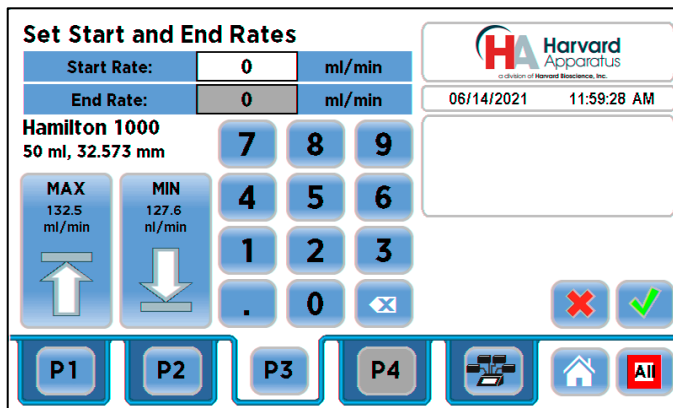
To set up/edit a Pulse Flow profile:

1. From the Step Definition screen for a Pulse Rate Flow choose the Set Mode button to toggle the Flow Mode between Infuse and Withdraw operation.
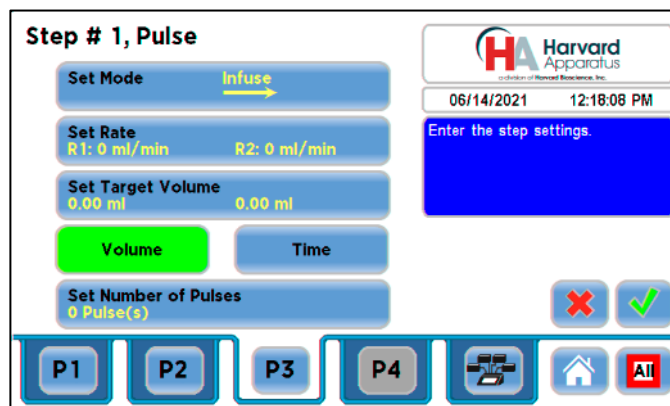

Pulse Flow Step Definition Screen
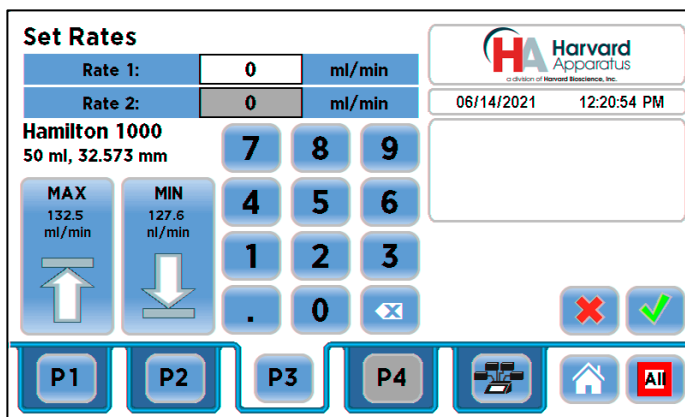
2. Choose the Set Rates button to enter the Set Pulse Rates screen.

Set Pulse Rates Screen

3. Select the Rate 1 button (it should be selected by default as indicated by the active data entry box to the right of the button). Enter the flow rate value desired using the keypad or select the Minimum Rate or Maximum Rate button.
4. If the Units of Rate are not correct for your application, choose the Units button.
5. On the Units Selection screen, select the unit of measure (ml, μl, nl or pl) and the unit of time (sec, min, hr) as appropriate, then choose Accept to confirm your selections.
6. Repeat Steps 3 to 5 for the second flow rate by selecting the Rate 2 button and continuing data entry.
7. When all parameters are correctly set on the Set Pulse Rates screen, choose Accept to confirm your settings and return to Step Definition screen.
8. Select the Volume or Time button to determine how the pump cycle length will be managed. Volume calculates each cycle stage by pumping for the length of time needed to pump the specified volume. Time manages each cycle stage by pumping for the amount of time specified. The selected button will turn green.
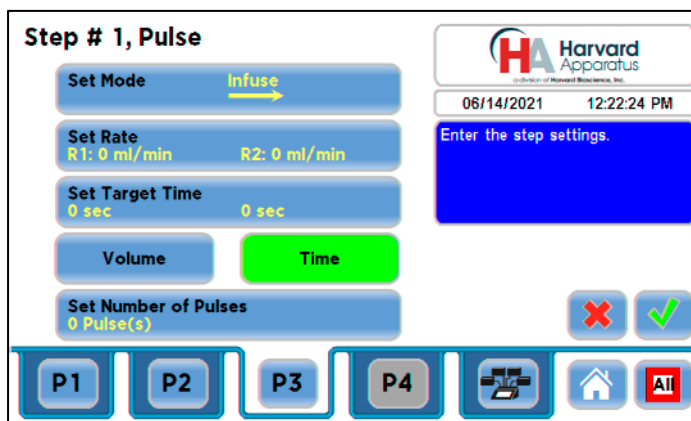
Pulse Flow Step Definition Screen — Time Selected

9. Depending on whether you have selected the Volume or Time button in the preceding step, choose the Set Time or the Set Volume button to enter the Set Pulse Times or the Set Pulse Volumes screens.
10. If you selected Set Time, continue with Step 11. If you selected Set Volume, proceed to Step 14.
11. On the Set Target Times screen, select the Time 1 button (it should be selected by default as indicated by the active data entry box to the right of the button). Enter the desired value using the keypad. Repeat for Time 2.

Set Target Times Screen

12. If the Units of Time associated with Time 1 or Time 2 are not correct for your application, select the Units button associated with either parameter to toggle between sec (seconds) and h:m:s (hours:minutes:seconds). To use the h:m:s option, enter your time value in hours, minutes and seconds, separating each value with a colon.

13. When both Time parameters are set to the correct values, choose the Accept button to return to the Step Definition screen.

14. Enter the Set Target Volume screen, select the Volume 1 button (it should be selected by default as indicated by the active data entry box to the right of the button). Enter the desired value using the keypad. Repeat for Volume 2.

Pulse Flow Step Definition Screen — Volume Selected

Set Target Volume Screen

15. If the Units of Volume associated with Volume 1 or Volume 2 are not correct for your application, choose the Units button associated with either parameter to enter the Units selection screen. Select the unit of measure button (ml, μl, nl, pl) applicable to your application, then choose the Accept button to return to the Set Pulse Volumes screen.
16. When both Volume parameters are set to the correct values, choose the Accept button to return to the Step Definition screen.
17. Select the # of Pulses button to enter the Set # Pulses screen.
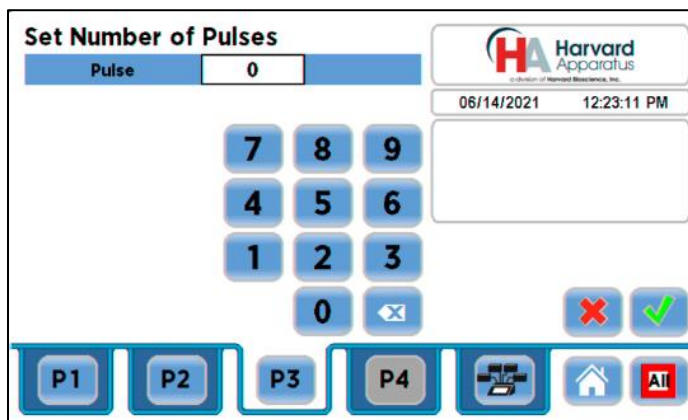
Set Number of Pulses Screen

18. On the Set # Pulses screen, enter the desired value using the keypad, then choose the Accept button the duration of each pulse is defined by the pulse volume or pulse time that was previously set. Press green checkmark button to accept the newly-created step. The updated Edit Method screen will be displayed.

BOLUS PROFILE

The Bolus Delivery profile is used to infuse a defined dose of fluid controlled by the total volume and the total time the pump operates. Bolus profiles are used for infusion only. In a bolus profile, you set both the time the pump operates and the total volume to be delivered. The pump automatically calculates the flow rate based on the syringe selected. The flow rate is constant during a Bolus Delivery profile
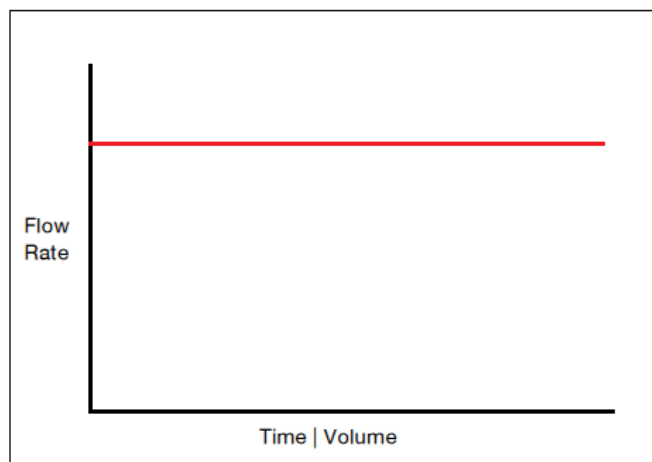
Bolus Delivery Operating Profile

When creating or editing a Bolus Delivery profile, you will define the following operating parameters:

- The Target Volume to be infused.
- The Target Time value which is the total time the pump will operate.
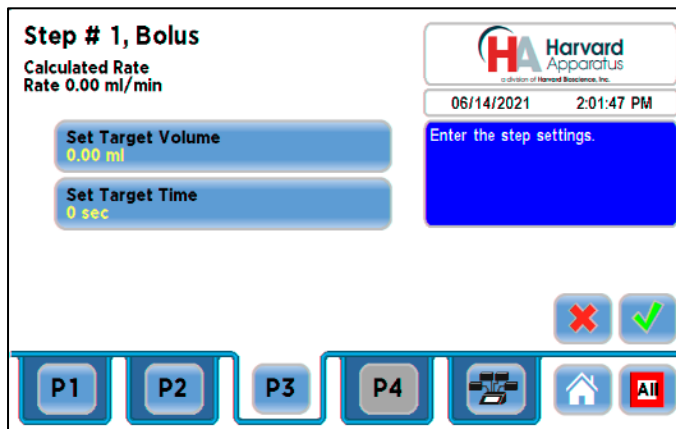
To set up/edit a Bolus Delivery profile:

1. From the Step Definition screen for a Bolus Delivery profile, choose the Set Target Volume button.
2. On the Set Target Volumes screen, enter the desired value using the keypad.
3. If the Units of Measure are not correct for your application, choose the Units button to enter the Units selection screen. Select the unit of measure button (ml, µl, nl, pl) applicable for your application, then choose the Accept button to return to the Set Target Volumes screen.
4. When the Volume parameters are correctly set, choose the Accept button to return to the Step Definition screen.
5. Select the Target Time button.
6. On the Set Target Times screen, enter the desired value using the keypad.
7. If the Units of Time are not correct for your application, select the Units button to toggle between sec (seconds) and h:m:s (hours:minutes:seconds). To use the h:m:s option, enter your time value in hours, minutes and seconds, separating each value with a colon.
8. When the Time parameters are correctly set, choose the Accept button to return to the Step Definition screen. The pump will automatically calculate the flow rate based on the entered Target Volume and Time. Press green checkmark button to accept the newly-created step. The updated Edit Method screen will be displayed.

CONCENTRATION PROFILE

The Concentration Delivery profile is used to manage infusion of a defined concentration of drug or other liquid to a set dosage level based on the subject's weight.
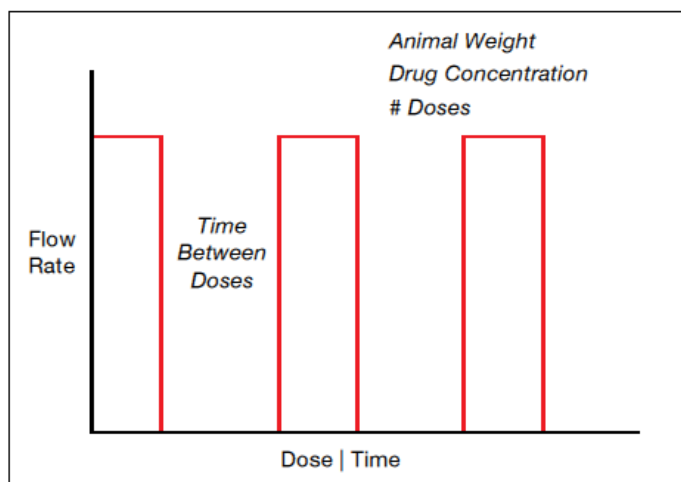
Concentration Delivery Pump Operation Profile

When creating or editing a Concentration Delivery profile, you will define the following operating parameters:

- The Weight of the target subject
- The Flow Rate to be used during infusion

- The concentration of the drug or other liquid being infused
- Either the target dosage or the target infusion time — the pump automatically calculates whichever value you do not enter.
- If you wish to infuse multiple doses to the target, you can specify the number of doses along with a delay between dosings.

During a Concentration profile, the HAPC operates at a constant infusion rate and automatically stops when the target dosage rate is reached. When creating or editing a Concentration flow profile, you can set the rate in ml, µl, nl or pl units of volume using sec, min or hr as the units of time. The system automatically calculates a minimum and maximum flow rate based on the syringe selected or custom-defined. The min/max values are made available as button selection options on the Set Rate and Concentration screen. The ingredient concentration is entered in mg/ml or percent.

Concentration Step Definition Screen

1. From the Step Definition screen for a Concentration profile, choose the Animal Weight button to enter the Set Animal Weight screen.

Set Animal Weight Screen

2. Enter the Weight then choose the Accept button to return to the Step Definition screen.
3. Choose the Set Rate and Concentration button to enter the Set Rate and Concentration screen.
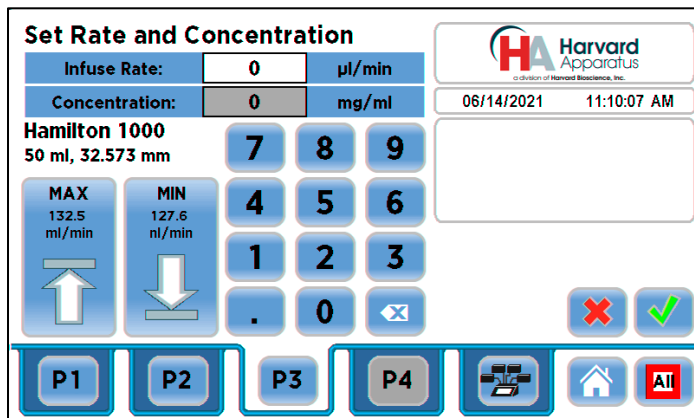
Set Rate and Concentration Screen

4. Select the Infuse Rate (it should be selected by default as indicated by the active data entry box to the right of the button). Enter the desired rate using the keypad or select the Min Rate or Max Rate button.
5. If the Units of Rate are not correct for your application, choose the Units button.
6. On the Units Selection screen, select the unit of measure (ml, µl, nl or pl) and the unit of time (sec, min, hr) as appropriate, then choose Accept to confirm your selections.
7. Select the Concentration button and enter the concentration of the active ingredient in the infusion fluid in mg/ml or percent. The units of concentration may be toggled between mg/ml and precent by pressing the concentration units button.
8. When all parameters are correctly set on the Set Rate and Concentration screen, choose Accept to confirm your settings and return to Step Definition screen.
9. Choose the Set Dose or Duration button to enter the Set Dose or Duration screen.
10. On the Set Dose or Duration screen, select either the Dose button (if you wish to enter the target dosage value in which case the HAPC will calculate the required pumping duration) or Duration (if you wish to infuse for a specific time period in which case the HAPC will calculate the delivered dose).
11. As appropriate enter either the Dose in mg/ml or percent or the Duration using the keypad.
12. If the Units of Time associated with Duration are not correct for your application, select the Units button to toggle between sec (seconds) and h:m:s (hours:minutes:seconds). To use the h:m:s option, enter your time value in hours, minutes and seconds, separating each value with a colon.
13. When all parameters on the Set Dose or Duration screen are correct, choose the Accept button to return to the Step Definition screen.
14. Choose the Set # Doses & Doses Interval button to enter the Set # Doses & Dose Interval screen.
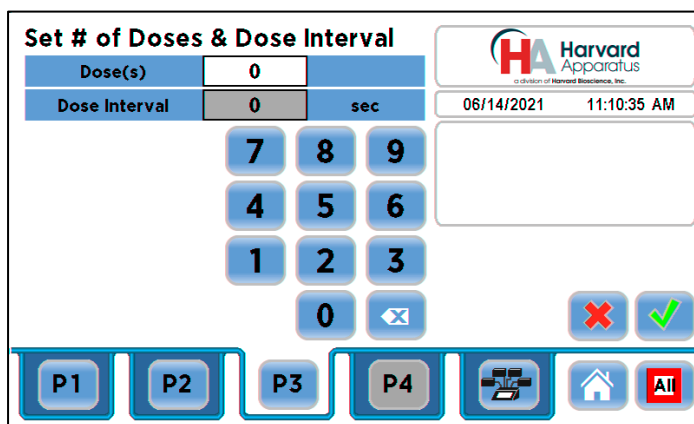
Set # Doses & Dose Interval Screen

15. Select the Doses button (it should be selected by default as indicated by the active data entry box to the right of the button). Enter the desired number of doses using the keypad.
16. If the # Doses is greater than one, select the Dose Interval button and enter the desired length of time between individual doses.
17. If the Units of Time associated with Dose Interval are not correct for your application, select the Units button to toggle between sec (seconds) and h:m:s (hours:minutes:seconds). To use the h:m:s option, enter your time value in hours, minutes and seconds, separating each value with a colon.
18. When all parameters on the Set # Doses & Dose Interval screen are correct, choose the Accept button to return to the Step Definition screen. Press green checkmark button to accept the newly-created step. The updated Edit Method screen will be displayed.

GRADIENT PROFILE

The Gradient profile is used to combine multiple flow streams from different pumps (Nanomite, Pump 11 Elite/Pico Elite & PHD ULTRA into a common output stream. The flow profiles can be defined as constant rate, as a smooth (linear) ramp, or to execute in a stepped format

Note: The HAPC allows you to use different pump mechanisms. However, the same syringe size & type must be used in all connected pumps. That syringe must be compatible with all connected pumps. For example: If a Nanomite, Elite & PHD ULTRA were connected to the HAPC, the largest available syringe size would be 1 ml. The reason for that is that all syringes have to be the same because when a method is defined, only one syringe can be selected.
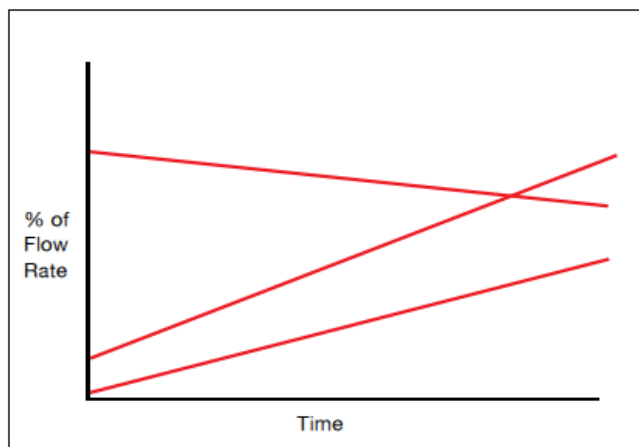
Gradient Delivery Pump Operation Profile

When creating or editing a Gradient profile you will define 4 primary operating parameters:

- The combined Flow Rate
- The Target Starting and Ending Percentages for each pump in the system.
- The Target Time that determines the total length of time over which the Gradient profile will be calculated
- The Number of Steps that will be created in the profile

To set up/edit a Gradient Profile

1. From the Step Definition screen for Gradient, choose the Set Combined Flow Rate button to enter the Set Combined Flow Rate screen.
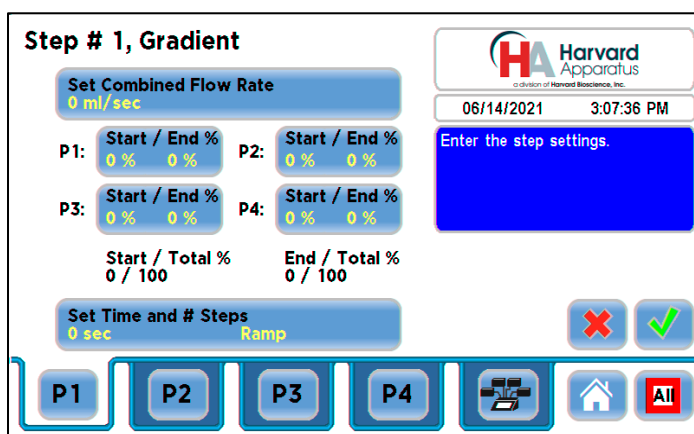
Gradient Step Definition Screen

2. Enter the desired combined flow rate value for all pumps using the keypad or select the Minimum Rate or Maximum Rate button.
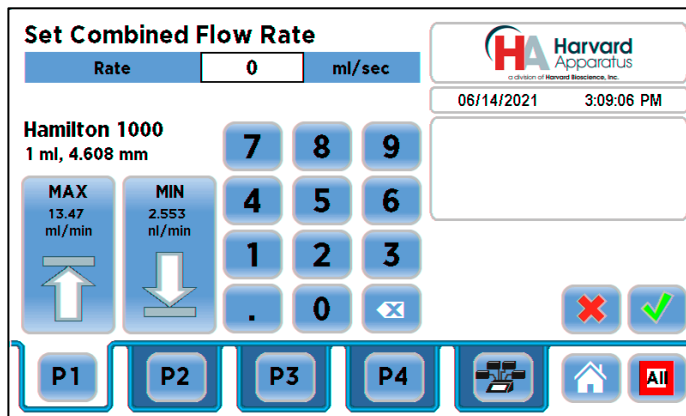
Set Combined Flow Rate Screen

3. If the Units of Rate are not correct for your application, choose the Units button.
4. On the Units Selection screen, select the unit of measure (ml, μl, nl, or pl) and the unit of time (sec, min, hr) as appropriate, then choose Accept to confirm your selections.
5. When all parameters are correctly set on the Set Rate screen, choose Accept to confirm your settings and return to the Gradient Step Definition screen.
6. Set the gradient percentages for all pumps to be included in the gradient. Once the first pump is set, the HAPC will adjust the percentages on the remaining pumps in relation to the set combined flow rate. Once your settings are complete, select Accept and the HAPC will return to the Gradient Step Definition screen.
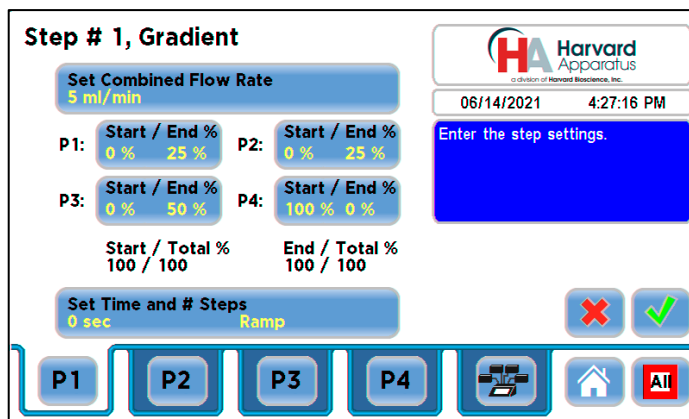
Gradient Step Definition Screen with set combined flow rate & pump gradient percentages

7. Select the Set Time and # Steps button to enter the duration of the gradient and to set the proper steps and press Accept. Press green checkmark button to accept the newly-created step. The updated Edit Method screen will be displayed.

> **NOTE:** For a Constant rate ⊏ or Ramp ∠ profile choose 0 steps. For a Stepped profile ⌐ select the number of steps desired.
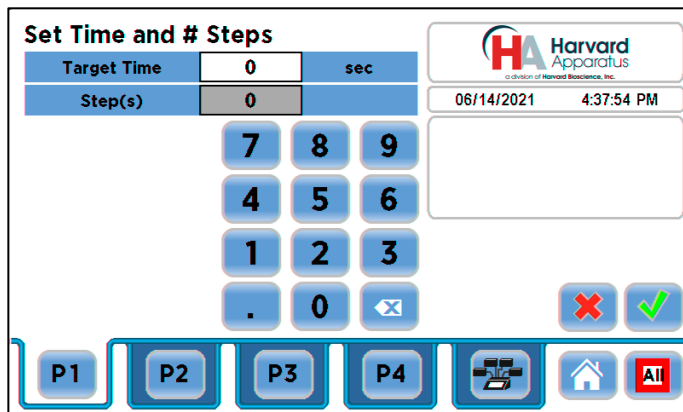
Set Time and # Steps Screen

AUTOFILL CYCLING PROFILE

The Autofill Cycling Profile is an automated Infuse/Withdraw or Withdraw/Infuse step that operates at constant, but separately defined, flow rates for the withdraw and infuse operations. The Autofill profile is designed to work in conjunction with an autofill valve that controls the switching of flows from a reservoir for refilling the syringe, to the target infusion subject. Note: Pin 8 of the 15-pin I/O connector adapter for the required channel on the rear of the HAPC will actuate to control a Harvard Apparatus Valve Box used in conjunction with the Autofill Pump Profile. Please contact our Technical Support department for additional information. Technical Support toll free number 1–800–272–2775, or outside the U.S. call 508-893-8999. Our E-mail address is support@hbiosci.com.
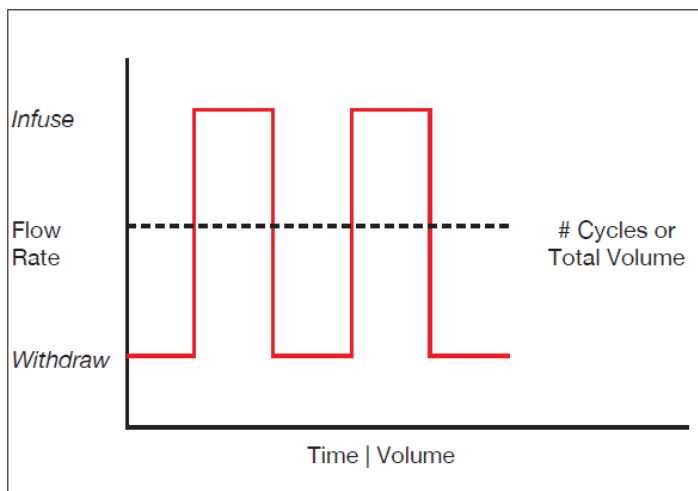
Autofill Cycling Profile

When creating or editing an Autofill Cycling profile, you will define the following operating parameters:

- The Flow Mode defining the cycle: Infuse/Withdraw (INF/WD) or Withdraw/Infuse (WD/INF)
- The Flow Rates to be used during infuse/withdraw operations
- The infusion volume to be delivered during each pump cycle
- The total volume to be delivered during all cycles or the total number of Infuse/Withdraw or Withdraw/Infuse cycles that you want the pump to execute. For example, if you want to pump 100 ml using a 10 ml syringe, the pump will execute 10 Infuse/Withdraw or Withdraw/Infuse cycles, depending upon the chosen flow mode.

During an Autofill profile, the HAPC operates at a constant pump rate during the infusion and withdrawal stages, although the rate can be different for each direction (i.e. infuse vs. withdraw). When creating or editing an Autofill Cycling profile, you can set the rate in ml, µl, nl or pl units of volume using sec, min or hr as the units of time. The system automatically calculates a minimum and maximum flow rate based on the syringe selected or custom-defined. The min/max values are made available as button selection options on the Set Rate screen.
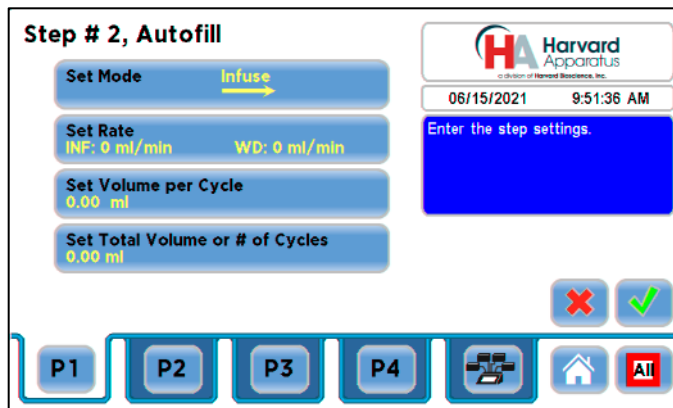
Autofill Step Definition Screen

To set up/edit an Autofill Cycling Profile:

1. From the Step Definition screen for an Autofill Cycling, choose the Set mode button to toggle between the Withdraw/Infuse (WD/INF) and Infuse/Withdraw (INF/WD) modes. Withdraw/Infuse begins by withdrawing into the syringe, following by infusing into the target.
2. Choose the Set Rates button to enter the Set Infuse/Withdraw Rate screen.
3. Select the Infuse Rate (it should be selected by default as indicated by the active data entry box to the right of the button). Enter the desired rate using the keypad or select the Minimum Rate or Maximum Rate button.
4. If the Units of Rate are not correct for your application, choose the Units button.
5. On the Units Selection screen, select the unit of measure (ml, μl, nl or pl) and the unit of time(sec, min, hr) as appropriate, then choose Accept to confirm your selections.
6. Select the Withdraw Rate and enter the desired rate using the keypad or select the Minimum Rate or Maximum Rate button.
7. When all parameters are correctly set on the Set Infuse/Withdraw Rate screen, choose Accept to confirm your settings and return to Step Definition screen.
8. Choose the Set Volume per Cycle button to enter the Set Volume per Cycle screen.
9. Enter the Volume using the keypad.
10. If the Units of Measure associated with Volume are not correct for your application, choose the Units button to enter the Units selection screen. Select the unit of measure button (ml, μl, nl, pl) appropriate for your application, then choose the Accept button to return to the Set Target Volumes screen.
11. When all parameters on the Set Volume per Cycle screen are correct, choose the Accept button to return to the Step Definition screen.
12. Choose the Set Total Volume or # Cycles button to enter the Set Total Volume or # Cycles screen.
13. Select either Total Volume or # Cycles to define how the pump will control pumping activity. Total Volume will cycle the pump the correct number of times to deliver the total volume according to the Volume per Cycle setting. For example, if you set a 10 ml Volume per Cycle and set 100 ml in Total Volume, the pump will cycle 10 times.
14. If you select Total Volume, enter the volume desired using the keypad. If you select # Cycles, enter the total number of Infuse/Withdraw or Withdraw/Infuse cycles that you wish to perform.
15. If the Units of Measure associated with Volume are not correct for your application, choose the Units button to enter the Units selection screen. Select the unit of measure button (ml, μl, nl, pl) appropriate for your application, then choose the Accept button to return to the Set Target Volumes screen.
16. When all parameters on the Set Total Volume or # Cycles screen are correct, choose the Accept button to return to the Step Definition screen. Press green checkmark button to accept the newly-created step. The updated Edit Method screen will be displayed.

Note: Using maximum rate may not be appropriate during the Withdraw stage of an Autofill profile, since air can be drawn into the syringe, or a high vacuum pressure can be produced depending on the syringe and /or tubing being used, or the fluid viscosity.

Incorporating Advanced Options (Commands and I/O) Into A Method

HAPC Methods can incorporate a variety of commands that expand the versatility of the system by permitting convenient looping, chaining of events, sending signals to external devices, or accepting inbound signals from external devices. These Command controls are described in this section of the Guide.

To access the Command options, choose Commands from the Select Profile screen.
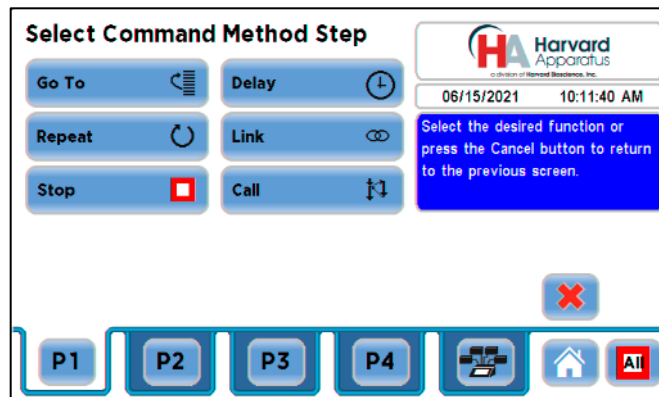
Select Command Method Step Screen

GO TO STEP

The Go To Command is used to instruct the HAPC to jump to a particular Step in a Method. This can be used to help you loop back or jump forward in a Method protocol and can be used in conjunction with I/O Events to make the pump respond to a trigger from an external device.

When defining a Go To jump in a Method, the Command targets the Step sequence position and not the function that currently occupies that position. For example, if you create a Go To jump to Step 4 in a Method and Step 4 is currently a Bolus Pump Operation Profile) and subsequently move a Constant Rate profile into the Step 4 position, the Go To jump will then connect to the Constant Rate operation and not to the Bolus operation.

To insert a Go To jump step:

1. From the Method Main screen, choose Step Definition to enter the Edit Method Steps Summary screen.
2. Highlight (select once) the Method Step that you want the Go To jump to follow.
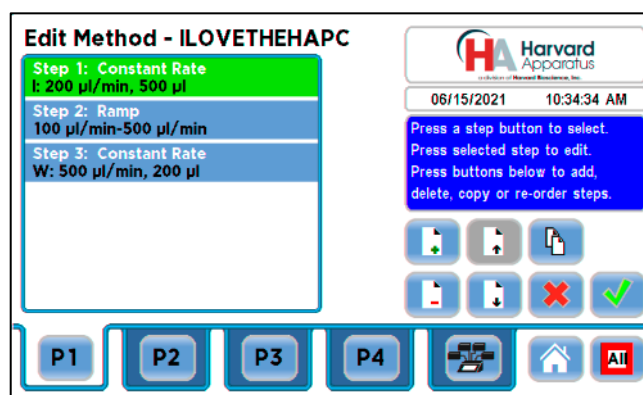
Edit Method Steps Screen with Highlighted Method Step

3. Choose the Add Step button to access the Method Steps Menu screen.
4. Choose Commands to enter the Set Command Method Step screen.
5. Choose Go To to insert the Go To Step and view an updated list of all current Steps in the Method.
6. Double tap the Step that you want to jump to with the Go To Command. The system automatically returns to the Edit Method Steps Summary screen which now shows the Go To Step inserted in the Method.

Edit Method Steps Screen showing Go To step

DELAY

The Delay Command is used to insert a time delay in a procedure. You can program a time delay between 0.2 seconds up to 99:59:59 (99 hours, 59 minutes, 59 seconds).

To insert a time delay in a method:

1. From the Method Main screen, choose Step Definition to enter the Edit Method Steps Summary screen.
2. Highlight (select once) the Method Step that you want the time delay to follow.
3. Choose the Add Step button to access the Method Steps Menu screen.
4. Choose Commands to enter the Commands screen.
5. Choose Delay to enter the Set Delay screen.
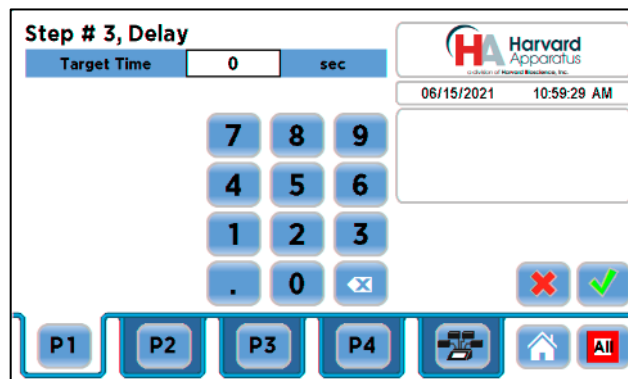
Delay Screen

6. Enter the desired Time using the keypad.
7. If the Units of Time associated with Time are not correct for your application, select the Units button to toggle between sec (seconds) [0.2 seconds minimum allowable value] and h:m:s (hours:minutes:seconds). To use the h:m:s option, enter your time value in hours, minutes and seconds, separating each value with a colon. You can enter a value up to 99:59:59.
8. When your Time entry is correct, choose the Accept button to insert the Delay Step in the Method and return to the Edit Method Steps Summary screen.

REPEAT STEP

The Repeat Command is used to repeat Steps in a procedure a defined number of times. To use this Command, you will tell the application what Steps you want to Repeat and how many times you want them repeated. The Repeat Step command creates a "jump" back to a specific Step in a Method that executes the defined Step plus all following Steps up to the Repeat command (i.e. it creates a Method loop).

When defining a Repeat jump in a Method, the Command targets the Step sequence position and not the function that currently occupies that position. For example, if you create a Repeat jump to Step 4 in a Method (currently a Bolus Pump Operation Profile) and subsequently move a Constant Rate profile into the Step 4 position, the Repeat jump will then connect to the Constant Rate operation and not to the Bolus operation.

To insert a Step Repeat sequence into a method:

1. From the Method Main screen, choose Step Definition to enter the Method Steps Summary screen.
2. Highlight (select once) the Method Step that you want the repeat step to follow.
3. Choose the Add Step button to access the Method Steps Menu screen.
4. Choose Advanced Options to enter the Set Advanced Options screen.
5. Choose Repeat to insert the Repeat Step function into the Method.
6. Select the Step(s) you would like to repeat from by selecting the Step button twice or selecting once and then choosing Accept.
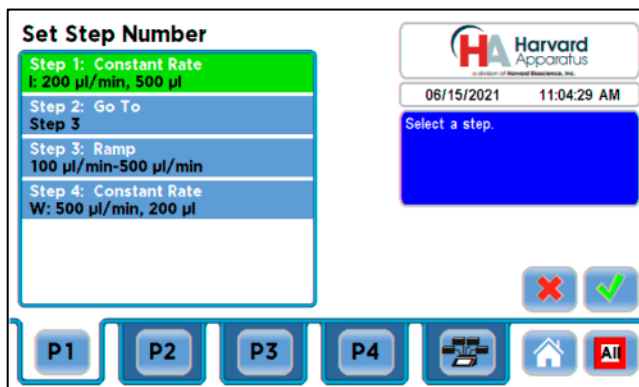
Set Step Number Screen

7. Enter the number of repeats using the keypad then choose the Accept button to save your changes and return to the Method Steps Summary screen.
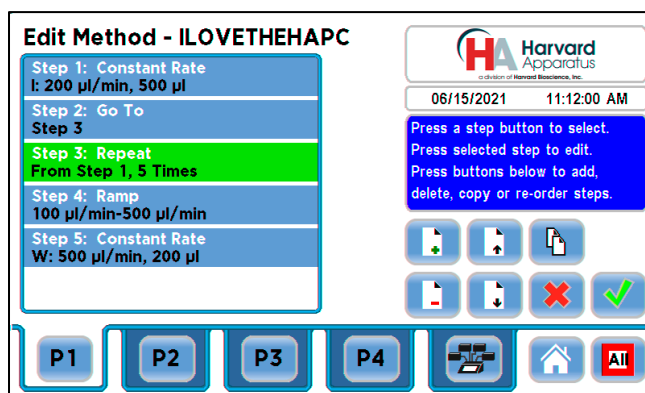
Edit Method Steps Screen Showing Repeat step

8. This command creates a loopback to the designated Step in a Method, executing the selected Step, plus all subsequent Steps up to the point of insertion of the Repeat command. For example, in the above figure, Steps 1 and 2 will be executed once, and, due to the Repeat command on Step 3, the system will loop back to Step 1 and execute both Steps 1 and 2 five additional times.

LINK METHOD

The Link Command is used to insert a link to another stored Method into the operating sequence of a Method. You can Link a Method any place in the Method sequence. The Linked Method will run and will not return to the Main Method that the methods was linked from. To return to the Main Method after linking, please use the Call Method defined below.
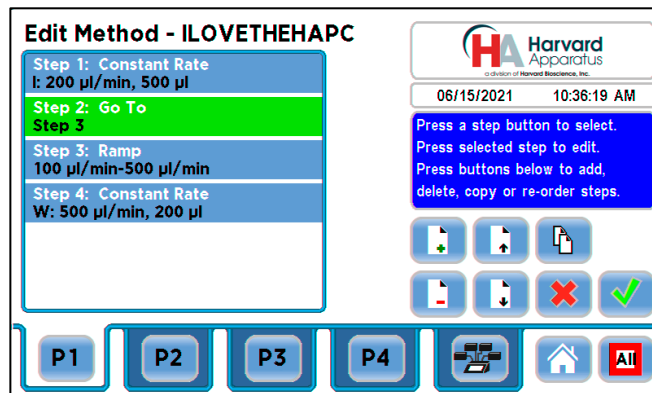
To Link to a stored method:

1. From the Method Main screen, choose Step Definition to enter the Edit Method Steps Summary screen.
2. Highlight (select once) the Method Step that you want the Link Command to follow.
3. Choose the Add Step button to access the Method Steps Menu screen.
4. Choose the Commands button to enter the Commands screen.
5. Choose Link to enter the Link Selection screen and display a list of the saved Methods available.
6. Double tap the Method that you want to link to in the current Method. If the desired Method is not listed on the screen, use the Scroll Up/Scroll Down or Page Up/Page Down buttons to scroll through the Method List. Upon selection you are returned to the Method Steps Summary screen.
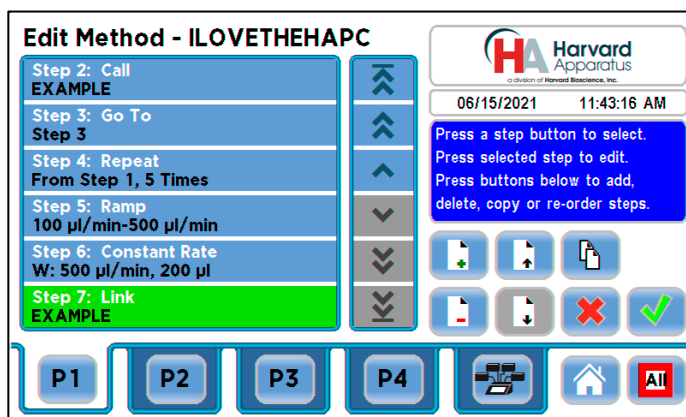
Edit Method Screen Showing Linked Method Named "EXAMPLE"

Call Method
Call Method works in the same way that the Link Method works with the same setup procedure above. The difference is that the Call Method will bring the HAPC back to the original Method and continue with the next step after the "called" Method is finished.

STOP Method
The Stop Command is used to instruct the pump to stop operation. This Command can be used in conjunction with I/O Events (see next section) to control pump operation based on external events.

To insert a Stop command into a method:

1. From the Method Main screen, choose Step Definition to enter the Method Steps Summary screen.
2. Highlight (select once) the Method Step that you want the Stop Command to follow.
3. Choose the Add Step button to access the Method Steps Menu screen.
4. Choose Commands to enter the Commands screen.
5. Choose Stop to insert the Stop Command into the Method.

I/O EVENT TRIGGERS

The HAPC permits easy connection to external I/O devices per pump channel via a variety of interfaces, including a built-in 15-pin D-sub connector. The HAPC software contains simple commands for incorporating I/O controls into your pump Methods. Integrated commands for control of an external valve, multi-pump synchronization, and general trigger signals are integrated in the software. The following procedure describes the use of the Advanced Options I/O commands. Following the procedure is a description of the selection menu options for each of the I/O command types. Details for the electrical connection controls and pin-out description for the 15-pin User I/O Connector are provided later in this manual.

The HAPC manages trigger events through specific pins on the I/O Connector port on the back of each pump channel. The following details define pin logic:

- Triggers are communicated via Pin 4, 5 or 6.
- Event signals are communicated via Pin 2.

I/O TRIGGER (OUT)

The I/O Trigger (out) command is used to send a signal to an external device when the Step in the Method is reached.

The following options are available when setting an I/O Trigger (out) command:

- Trigger 1: Specifies output via the Trigger 1 (Pin 4) port. When selected, you must also specify whether the signal to be sent is High Signal or Low Signal.
    - High Signal: Sets the output signal to logic high.
    - Low Signal: Sets the output signal to logic low.

- Trigger 2: Specifies output via the Trigger 2 (Pin 5) port. When selected, you must also specify whether the signal to be sent is High Signal or Low Signal.
    - High Signal: Sets the output signal to logic high.
    - Low Signal: Sets the output signal to logic low.

- Trigger 3: Specifies output via the Trigger 3 (Pin 6) port. When selected, you must also specify whether the signal to be sent is High Signal or Low Signal.
    - High Signal: Sets the output signal to logic high.
    - Low Signal: Sets the output signal to logic low.

- Valve: Select automatic or manual valve control (automatic is controlled by pumping). [pin 8]
    - Valve On: Activates the valve.
    - Valve Off: De-Activates the valve.
    - Valve Auto: Returns the pump to Automatic valve control.

To insert an I/O Trigger Command:

1. From the Method Main screen, choose Step Definition to enter the Method Steps Summary screen.
2. Highlight (select once) the Method Step that you want the I/O Trigger (Out) to follow.
3. Choose the Add Step button to access the Method Steps Menu screen.
4. Choose Triggers & Events to enter the Select Triggers & Events screen.
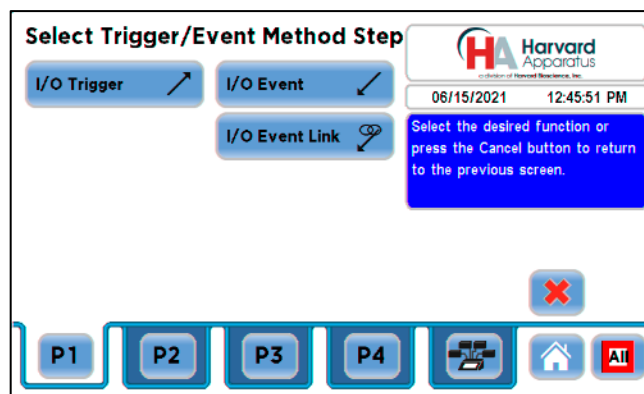
Select Trigger/Event Method Step

5. Choose the I/O Trigger button to enter the Select Trigger/Event Method Step Definition Screen.
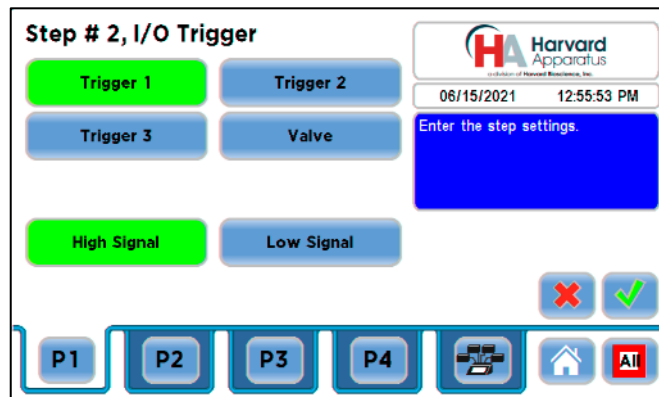
I/O Trigger Screen

6. Set your Trigger settings by choosing the appropriate option from the following sub-procedures:

    a. To send a Trigger signal to an external device via Pin 4, select the Trigger 1 button. To send a Trigger signal via Pin 5, select the Trigger 2 button. Then select whether the signal will be High or Low by selecting the appropriate button. To send a Trigger signal via Pin 6, select the Trigger 3 button.
    b. To send a trigger signal to an external valve, select Valve. Then select whether the trigger will actuate (On button) or close (Off button) by selecting the appropriate button. This overrides the 'Valve Auto' setting, which means that the valve is controlled by a direction change. The valve will default back to 'auto' after leaving the Method Run screen.

7. Choose the Accept button to save your changes and return to the Edit Method Steps Summary screen.

I/O EVENT

The I/O Event command is used to have the pump pause and wait for a signal from an external device or for a manual user input at the touchscreen. These external signals are communicated via Pin 2 on the 15-pin I/O connector port.
The following options are available when setting an I/O Event (in) command.

- Input High-to-Low: Sets the pump to wait for a logic low input signal falling edge.
- Input Low-to-High: Sets the pump to wait for a logic high input signal rising edge.
- User Press: Sets the pump to wait for manual input from the user at the touchscreen (screen touch).

To insert an I/O Event:

1. From the Method Main screen, choose Step Definition to enter the Method Steps Summary screen.
2. Highlight (select once) the Method Step that you want the I/O Event (in) to follow.
3. Choose the Add Step button to access the Method Steps Menu screen.
4. Choose Triggers & Events to enter the Select Advanced Options screen.
5. Choose the I/O Event button to enter the Event Step Definition Screen.
6. Select either Input High, Input Low or User Press, as appropriate.
7. Choose the Accept button to save your changes and return to the Method Steps Summary screen.

I/O EVENT LINK

The I/O Event Link command is used to have the pump jump to a linked method if the signal is received. The external signals are communicated via Pin 2 on the 15-pin I/O Connector of the selected pump.
The following options are available when setting an I/O Event Link (in) command. This command requires that you have a method set with the specific actions (steps) you want to perform if the event occurs so that you can choose the Method name being linked by this command.

- Input High-to-Low: Will link to the desired method upon a logic low input signal falling edge.
- Input Low-to-High: Will link to the desired method upon a logic high input signal rising edge.
- User Press: Will link to the desired method upon a manual input from a selected pump.
- Motor Stall: Will link to the desired method upon a Motor Stall event from a selected pump.

Managing Methods

All User-Defined Custom Methods are stored in the Method List for ongoing use. Over time, you may want to manage previously created Methods to keep your Method List easy to navigate. In addition, the HAPC allows you to export Method information to an externally connected pump or to a computer that will be used to control operation. This section of the Guide describes the file management facilities available on the HAPC.

Saving a Copy of a Method

Follow these instructions to save a copy of a Method under a new name:

1. From the Quick Start or Method Main screen, choose the Method Select button to enter the Method Selection screen.
2. From the list of available Methods, select (press once) the Method you want to save a copy of, then choose the File Options button to enter the File Options screen. The File options button is the folder button located above the Cancel button on the method Main screen.
3. Choose Save As/Copy to access the Method Name Entry screen. The current Method Name will be displayed in the text entry box.
4. On the Method Name screen, type the new name for your Method (up to 15 characters) using the onscreen keyboard. Choose the Symbols/Numbers button (.?123) to display the list of available numbers and symbols that can be included in the Method Name. To switch the keyboard back to letters mode, choose the Letters button (ABC)
5. When finished entering the new Method Name, choose Accept to save your changes and return to the File Options screen.
6. Choose Back to return to the Method Selection screen.

Renaming a Method

Follow these instructions to rename a previously saved Method:

1. From the Quick Start or Method Main screen, choose the Method Select button to enter the Method Selection screen.
2. From the list of available Methods, select (press once) the Method you want to rename, then choose the File Options button to enter the File Options screen.
3. Choose Rename Method to access the Method Name Entry screen. The current Method Name will be displayed in the text entry box.
4. On the Method Name screen, type the new name for your Method using the onscreen keyboard. Choose the Symbols/Numbers button (.?123) to display the list of available numbers and symbols that can be included in the Method Name. To switch the keyboard back to letters mode, choose the Letters button (ABC).
5. When finished entering the new Method Name, choose Accept to save your changes and return to the File Options screen.
6. Choose Back to return to the Method Selection screen.

Appending a Method

Follow these instructions to Append a previously created Method into a new Method:

1. From the Quick Start or Method Main screen, choose the Method Select button to enter the Method Selection screen.
2. From the list of available Methods, select (press once) the Method you want as the base Method.
3. Choose the File Options button to enter the File Options screen.
4. Choose Append to access the Method to Append screen.
5. Choose (press twice) the Method you would like to Append (attach) to your base Method. The pump will return you to the File Options screen and display a confirmation that the Method was copied.
6. Choose Back to return to the Method Selection screen.

Deleting A Method

Follow these instructions to delete a previously saved Method:

1. From the Quick Start or Method Main screen, choose the Method Select button to enter the Method Selection screen.
2. From the list of available Methods, select (press once) the Method you want to delete, then choose the File Options button to enter the File Options screen.
3. Choose Delete Method. The application will display a warning message in the Message Area asking you to confirm your deletion request.
4. Choose Delete Method again to confirm the deletion and return to the Method Selection screen.

Managing Methods

The HAPC is compatible with our HAPC Method Manager program which allows you to import/export methods to/from your PC. Please see the section named "PC USB Drivers and Application Programs" for more information about the Method Manager.

PC USB Drivers and Application Programs

The HAPC is compatible with the Harvard Apparatus Pump Method Manager and Firmware Updater. You will need the Harvard Apparatus Pump Windows 7 & 10 USB drivers to establish communications with the HAPC. The USB drivers and forementioned programs can be downloaded in a compressed file named "HAPC Application Programs.zip". You can access this file by visiting the Harvard Apparatus Pump Controller webpage found on www.harvardapparatus.com and navigate to the "Related Files" section at the bottom of the webpage. Once you download and open the file "HAPC Application Programs.zip" there will be three directories available named USB Drivers, Method Manager for HAPC and Firmware Updater.

- **USB Drivers**

    In the folder "USB Drivers", there is a subfolder named "HBIO USB Drivers". Please run the application file "Driver Setup" to load the HAPC USB drivers.

- **Method Manager for HAPC**

    Connect a USB cable from the HAPC to your PC. Please make sure to install the HBIO USB Drivers before running the application "Method Manager for HAPC".

1. Run the "Method Manager for HAPC" application. The following program will open on your PC.
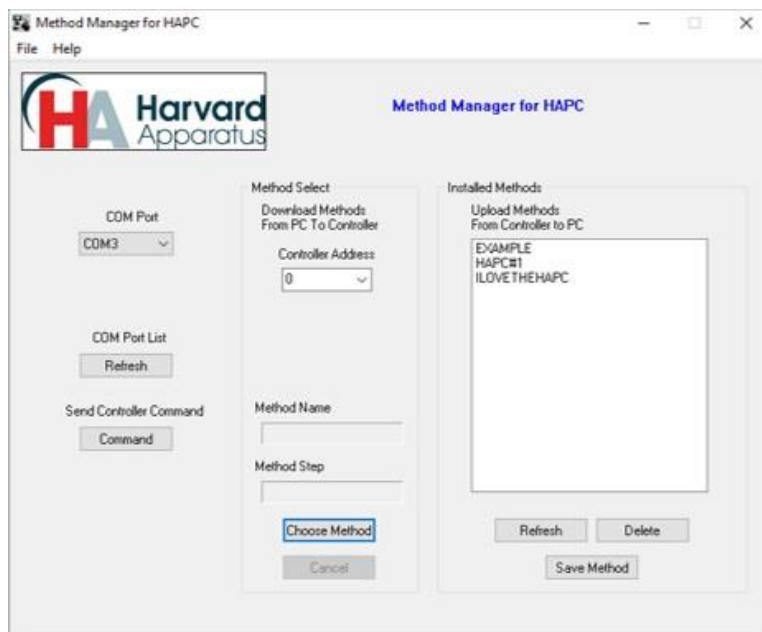
Method Manager for HAPC

2. The Method Manager for HAPC allows you to connect your PC to the HAPC through a USB cable and allow you to upload and download Methods that you created on the HAPC.
3. Select the COM port pull down to select the port that the HAPC is connected. The Com Port List Refresh button will refresh the available COM ports if necessary. Once connected, the Methods available on your HAPC will be listed under the Installed Methods section.
4. Select Save Method to save the selected method on your PC.
5. To upload Methods stored on your PC, select "Choose Method" and navigate to the method file on your PC. Note: The HAPC can store dozens of multi- step programs. It is not necessary to move them off of your HAPC unless you wish to use them on another HAPC system or store for later use.
6. The Command button allows you to send pump commands to control the HAPC from a PC. Pump commands can be found later in this manual.

- **Firmware Updater**

    The Firmware Updater is only required if the application software on the HAPC requires an update. The HAPC and associated modules are shipped with the latest application software. If you require a software update to your HAPC or pump modules, please contact Harvard Apparatus Technical Support at 508-893-8999.

Harvard Apparatus Pump Controller (HAPC)

Pump Controller Settings

The HAPC Pump Controller Settings menu is used to control basic system operations. This section describes the options available in this section of the application software.
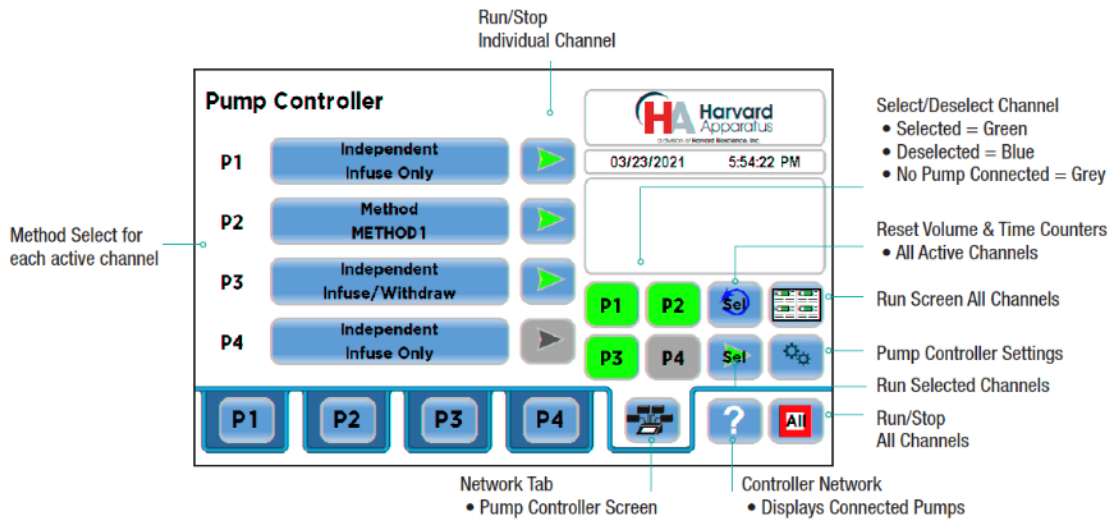
Pump Controller Screen with button function labels

Navigate to the HAPC Pump Controller screen and press the Pump Controller Settings button. (See button layout above.) The Pump Controller Settings screen will open.
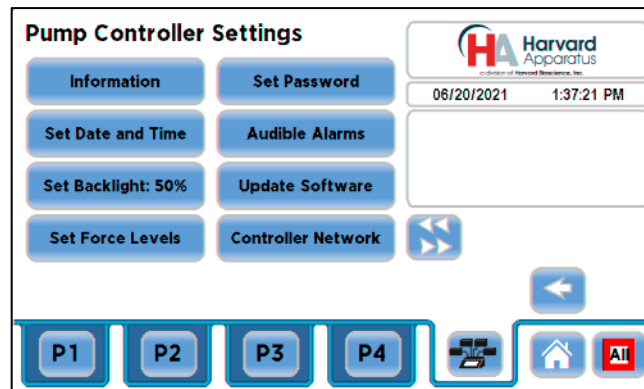
- **Information:** Pressing this button brings up the Pump Controller Information screen. The model name, serial number of the HAPC unit and the ability to set the controller address are all available on this screen.
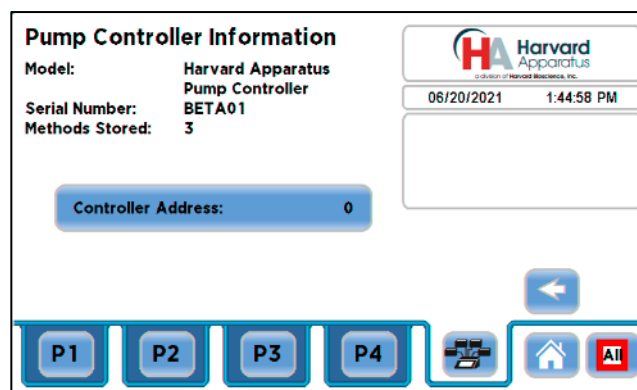
Information Screen

Set Password: The Set Password button sets the password for the HAPC screen lock. Press the Set Password button to access that screen. A password can be any number sequence from 1-999999. Setting the password for 0 will disable the Set Password feature. NOTE: If you forget your password contact Harvard Apparatus Technical Support at 508-893-8999.
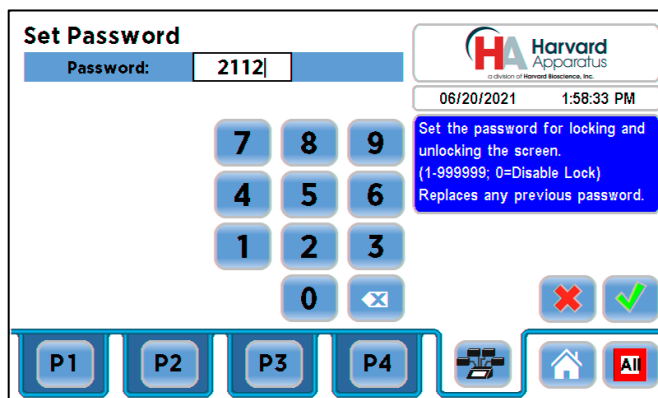
Set Password Screen
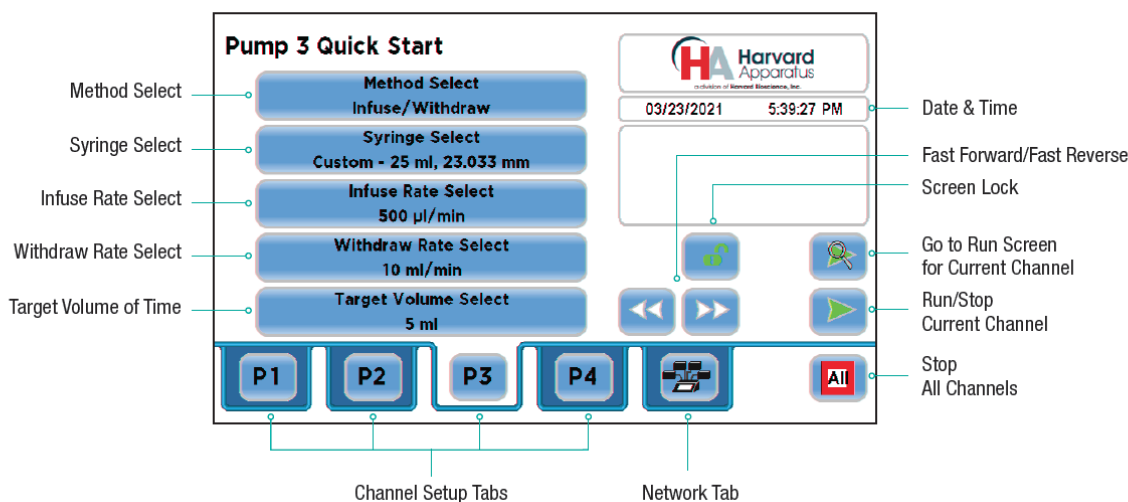
Quick Start Screen

- o **Screen Lock:** Screen Lock locks the settings for all pump channels and only allows the pump channel to be run/stopped. To use the Screen Lock, navigate to the Quick Start Screen for the channel you are working with and press the Screen Lock button twice. To unlock press the Screen Lock button and enter the password you set above.

- **Set Date and Time:** The HAPC displays the date and time on each screen in the user interface. Built-in battery backups maintain the date and time even if the pump loses power or is unplugged for a period of time. If it is necessary to set the date and time values, follow the instructions below.

    1. To change the Date, select the Date button and enter the Date values using the keypad in the format defined by the date Format button to the right of the Date entry box. You can toggle between m/d/y (Month/Day/Year), d/m/y (Day/Month/Year) and y/m/d (Year/Month/day) display by successive selection of the Date Units.
    2. To change the Time, select the Time button and enter the current time in hh:mm:ss (hours:minutes:seconds) format. Select the Time Format button to toggle between AM, 24 Hour and PM values for the Time.
    3. When the Date and Time values are correct, choose the Accept button to save your changes and return to the Settings screen.
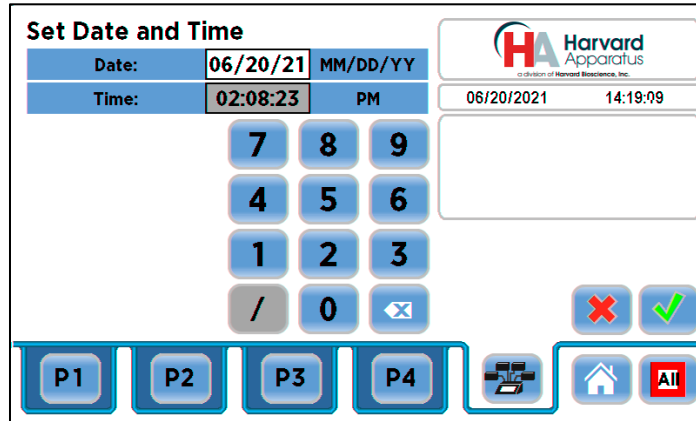
Set Date and Time

- **Audible Alarms:** The HAPC incorporates an Audible Alarm feature that can be used to warn the operator about various operating conditions, errors and power outages. The following alarms are user configurable in the Settings section of the application. Alarm buttons shown in green generate audio (see screenshot below); Those shown in blue are currently muted.
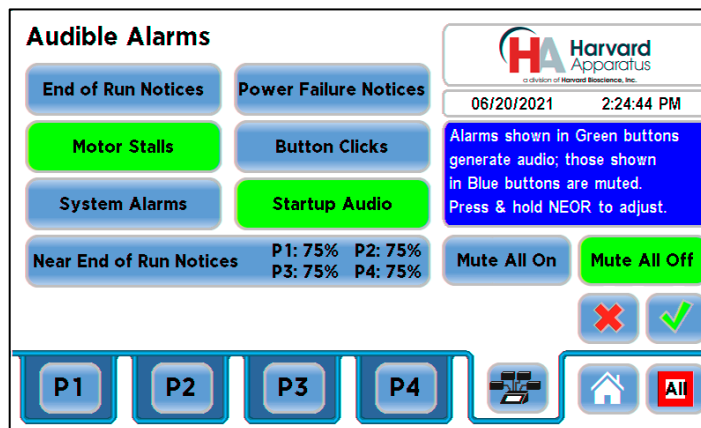
Audible Alarms

- End-of-Run: An alarm will sound when a Method run is completed. Touch anywhere on touchscreen to silence the alarm.
- Power Failure Notices: An alarm will sound on subsequent controller powerup if controller power is lost while any pump was running. Pressing the notification clears the alarm and the controller proceeds through power-up.
- Motor Stalls: An alarm will sound to notify the operator of any motor stall on any operating channel.
- Button Clicks: A soft beep indicates a positive touch on any button on the screen.
- Mute All On/Mute All Off: Selecting Mute All On button will mute all alarms. The inverse is true for the Mute All Off button.
- Near End-of-Run: This alarm can be custom configured to notify the operator that a Method is near-completion. The user can set a custom value using the touchscreen. When blue, press, hold & release the Near End of Run button to bring up the Set Near EOR Alarm Pct screen to set the end of run percentage for each active channel.
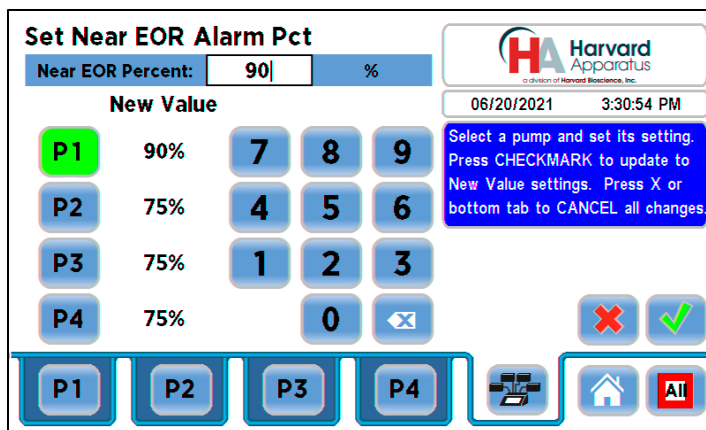
Set Near End of Run Alarm

- **Set Backlight:** Sets the backlight intensity of the HAPC touchscreen. The backlight can be set in increments of 10%. The factory default is 50% and the current setting is listed on the Set backlight button.
- **Set Force Levels:** Sets the force level for any active pump. Select the Set Force Levels button to open the Set Force Level Screen. Select the required pump by selecting P1 – P4. The button for the selected pump will be green. Set the required force level and press accept to return to the Pump Controller Screen. The force levels for Follower (Twin/Recip) pumps are adjusted to match changes in Leader force levels.
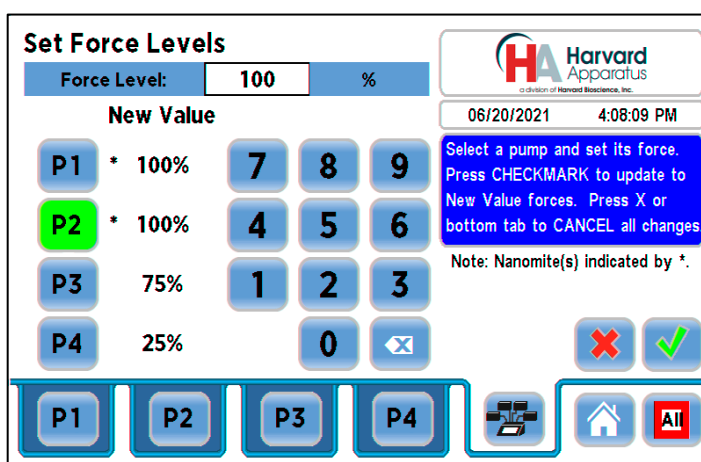
Set Force Levels Screen

- o Recommended force levels for common syringes are listed in a table below. Note: Suggested force levels are for the PHD ULTRA™ and Pump 11 Elite/Pico Plus Elite modules. The recommended linear force setting for the Nanomite injector is 100%. The Nanomite has a much lower linear force and is only intended for glass and plastic syringes.

Suggested Max Force Settings for Syringes on Connected Pumps							
		Max Force Setting					
Syringe Type/Material	Capacity	Nanomite	Pump 11 Elite Pump 11 Pico Plus Elite Pump 11 Elite OEM	PHD Ultra	PHD Ultra 4400	PHD Ultra HPSI	PHD ULTRA XF
Stainless Steel	All	100%	100%	100%	100%	100%	100%
Plastic	< 1 ml	100%	50%	50%	35%	N/A *	N/A *
Glass/Glass Glass/Plastic	>= 1 ml to 5 ml	100%	100%	50%	50%	N/A *	N/A *
	> 5 ml, <= 10 ml	100%	100%	100%	50%	N/A *	N/A *
	> 10 ml	100%	100%	100%	100%	100%	100%

*These entries are N/A because these pumps do not include any syringes in these sizes in their syringe tables. The user still has the option of setting a Custom syringe, which will result in the generic "make sure your force setting does not exceed the limit of your syringe" message.

Suggested Force Settings for Common Syringes

- **Controller Network:** Displays all connected pumps. PHD ULTRA and Elite pumps list their software versions. The Nanomites do not have internal software.

Controller Network

- **Position Syringes Button:** This button is found to the right of the Controller Network button on the Pump Controller Settings Screen. This useful feature that allows you to position syringes on any active channel is explained in the Twin or Reciprocating section.
- **Update Software:** This feature updates the application software on the HAPC controller only. NOTE: If you require a software update to your HAPC or pump modules, please contact Harvard Apparatus Technical Support at 508-893-8999.

Additional Syringe Pump Information

The Pump 11 Elite/ Pico Plus Elite and PHD ULTRA syringe pump modules are world class syringe pumps that each have their own Operational Manual with additional syringe pump, syringe volume/diameter reference tables and syringe mounting instructions.

Please review the following manual publications for additional syringe pump module information. Manual publications are available on the Harvard Apparatus website at the following location. **https://www.harvardapparatus.com/technical-support/manuals**

Pump 11 Elite / Pico Plus Elite: 5420-007; PHD ULTRA™ Syringe Pump Module Manual publication 5419-006.

Controller "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 the HAPC from a single computer interface. HAPC commands are communicated to the HAPC via USB port interface through a terminal program of your choice.

Note: Setting up initial Addresses:

When using the Controller, you will need to assign the Controller to address 0 using the Pump Address screen in the Settings menu or the 'Address' command. 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.

Each connected OEM pump will need to be assigned an address of 1. To set the addresses for these pumps, connect to each of their USB ports and enter the command "addr 1".

In addition, there is one motor controller card installed in the main Controller unit. The dipswitches on these cards will be preconfigured with settings for Channel 1, 2, 3, and 4. Refer to section Channel Module Installation for details.

The Pump commands allow all pump control information to be managed from one external computer source routed through the Controller base. These commands can control attached pumps (up to 4) from a single USB interface on a computer.

Pump Controller commands are communicated to the Controller via the USB port interface through a terminal program.

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 'rsave off' command to turn off write of rate to memory.

Commands may be abbreviated to the first four letters. For example, "address" could be abbreviated "addr". A space must follow the command if arguments are included.

Commands targeted to particular channels include the channel designator <chan>, where <chan> includes letters corresponding to the Controller channels (Channel 1=a, 2=b, 3=c, 4=d). For example, a channel designator of "b" would send the command to channel 2 only, and a channel designator of "abcd" would send the command to all four channels.

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
<chan>	Controller channel identifier.

When present, this will include any combination of:
- 'a' for channel 1/P1
- 'b' for channel 2/P2
- 'c' for channel 3/P3
- 'd' for channel 4/P4

<prompt>   Prompt: a four-character prompt showing the status of each channel of the Controller. One of the following characters will be displayed indicating the status of P1, followed by another indicating the status of P2, another for P3, and another for P4.

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

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

If the pump is in Poll ON mode, an XON character is added after the prompt.

In the following list of commands:

- The general format of the response is
  <lf><prompt> unless otherwise noted.

Error messages: Error messages are displayed if the entered command cannot be executed for some reason. The error message may be displayed on multiple lines. No line will be longer than 80 characters.

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 (e.g., using the IRUN command if the Infuse Rate is not set).

Argument Errors: Argument errors are displayed when a command argument is unrecognized or missing. 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]

<lf><sp><sp><sp>{error message}

<lf><prompt>

Range Errors: Range errors are displayed when a numeric argument is out of range. The argument in question will be displayed.

The range error has the following format:
<lf>Range error: {bad argument}
<lf><sp><sp><sp>{error message}
<lf><prompt>

System Commands

ADDRESS

Sets or displays the Controller address. The Controller address should be set to 0. Although the valid range is 0 to 255, the expanded range is allowed for future expansion.

Command format:
address[<sp>[0-255]]

Response to command "address":
<lf>{#}
<lf><prompt>

Response to command "address {<new addr>}":
<lf><prompt>

Example:
address<sp>0

BRIGHT

Sets or displays the backlight brightness level in percent. Valid range is 0 to 100. Note that specifying 0 will turn the backlight off so that the screen will not be visible.

Command format:
bright[<sp>0-100]

Response to command "bright":
<lf>{#%}   *Where # is the current Brightness setting*
<lf><prompt>

Response to command "bright {new bright level}":
<lf><prompt>

Example:
bright<sp>100

CATALOG

Displays a catalog of methods stored on the Controller.

Command format:
cat

Response to command "cat":
<lf>Method Files
<lf> ------------------------------
<lf>"{method name}"   *This line is repeated for each method*
<lf>
<lf># method(s)   *Where # is the number of methods stored on the Controller*
<lf><prompt>

Example:
cat

CMD

Displays the Command Set name. The Controller uses the command set "MCC".

Command format:
cmd

Response to command "cmd":
<lf>MCC
<lf><prompt>

Example:
cmd

Harvard Apparatus Pump Controller (HAPC)

ECHO

Sets or displays the USB echo state. Valid states are on or off.

Command format:
echo[<sp>[on|off]]

Response to command "echo":
<lf>{Off|On}
<lf><prompt>

Response to command "echo {Off|On}":
<lf><prompt>

Example:
echo<sp>off

Note:
If polling mode is set to "Remote", the response to "echo" will be:
<lf>Off in remote polling mode

FAST

Allows fast-forward/fast-reverse motion of one or more channels.
The "i" parameter initiates fast motion in the "Infuse" direction;
the "w" parameter initiates fast motion in the "Withdraw" or "Refill" direction;
the "s" parameter stops any fast-forward or fast-reverse motion that is underway.

Command format:
fast<sp>{<chan>}<sp>{i|w|s}

Example:
fast<sp>ab<sp>i   *Starts channel 1 & 2 fast-forward (infuse direction)*
fast<sp>ab<sp>s   *Stops fast-forward movement of channels 1 & 2 started with command above*

Command response:
<lf><prompt>

FORCE

Sets or displays the infusion force level, in percent, for one or more channels. Valid range is 1 to 100.

Command format:force<sp>{chan}[<sp>[1-100]]

Response to command "force {chan}":
<lf><A|B|C|D>:<sp>#%   *This line is repeated for each requested channel*
<lf><prompt>

Response to command "force<sp>{chan}<sp><newValue>":
<lf><prompt>

Examples:
force<sp>a<sp>90   *Sets force for Channel 1 to 90%*
force<sp>ab<sp>95   *Sets force for Channels 1 & 2 to 95%*

Note: since this command adjusts each channel's force setting individually, care must be taken when using this command when channels are paired with Twin or Reciprocating mode. Use of this command can override the force matching normally performed automatically for paired channels, allowing users to use different force settings for paired channels.

FTSWITCH

Sets or displays the foot switch setting for one or more channels. Each channel may be set independently. Each foot switch may be used in a toggle on or off mode (Momentary, in which case each press of the foot switch toggles the procedure between running and paused), a press to run mode (Falling edge/active low), or a release to run mode (Rising edge/active high). Setting a foot switch channel setting to ignore (i) results in ignoring presses and releases of the foot switch for that channel.

Command format (get setting(s)):
ftswitch<sp>{chan}

Command response (get setting(s)):

The first line will be repeated for each requested channel.

<lf><A|B|C|D>:<sp><Momentary|Active low (falling)|Active high (rising) | Ignored>
<lf><prompt>

Example:
ftsw abcd
A: Momentary
B: Ignored
C: Active low (falling)
D: Active high (rising)

Command format (change setting(s)):
ftswitch<sp>{chan}<sp>[m|r|f|i]

Command response (change setting(s)):
<lf><prompt>

Example:
ftsw abcd m

MDEL

Delete a method from the Controller.

Command format:
mdel<sp><methodname>

Command response:
<lf><prompt>

Example:
mdel abc   *Deletes method abc if it exists.*

Example response:
<lf><prompt>

Error response:
Argument error: Error processing command.   *Displayed if method does not exist*

MDIR

Displays a list of methods stored on the Controller.

Command format:
mdir

Command response to "mdir":
<lf>{<method name>}   *This line is repeated for each method*
<lf><prompt>

NEOR

Sets or displays the "Near-end-of-run" warning level, in percent, for one or more channels. Valid range is 0 to 99.

Command format:neor<sp>{chan}[<sp>[0-99]]

Response to command "neor {chan}":
<lf><A|B|C|D>:<sp>#%   *This line is repeated for each requested channel*
<lf><prompt>

Response to command "neor<sp>{chan}<sp><newValue>":
<lf><prompt>

Examples:
neor<sp>a<sp>75   *Sets Near-end-of-run warning for Channel 1 to 75%*
neor<sp>ab<sp>50   *Sets Near-end-of-run warning for Channel 1 to 50%*

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 an XON character is output when the pump is ready for another command.

When polling mode is remote (the default state), the following occurs:

- Prompts are not displayed

- Echo is forced off and the echo command is illegal

Command format:
poll[<sp>[on|off|remote]]

Command response:
<lf>Off
<lf><prompt> or:
<lf>On
<lf><prompt><xon> or:
 Remote

Examples:
poll<sp>off

RSAVE

Turns On or Off saving rate changes to memory. Without the On/Off parameter, the current setting is displayed. With the parameter, continually writing rate changes to memory is turned on or off accordingly.

Command format: rsave[<sp>{On|Off}]

Command response:
<lf>{On|Off}
<lf><prompt>

NOTE: This command should be used when sending commands quickly to avoid damage to the pump memory.

TIME

Sets or displays the date and time.

Command format: time[<sp>{mm/dd/yy|dd/mm/yy|yy/mm/dd}{<sp>}
{hh:mm:ss}]

Command response:
<lf>##/##/#### ##:##:## [#M] *or* <lf>####/##/## ##:##:## [#M]
<lf><prompt>

The date field order format is dependent on the settings made when setting the date from the touch screen. It may appear as MM/DD/YYYY, DD/MM/YYYY, or YYYY/MM/DD. In 12-hour format, the "[#M]" will show either AM or PM. In 24-hour format, this field is omitted.

Example 1 (display current date and time):
time

Example 2 (set date and time):
time<sp>01/02/21<sp>13:14:15

Note:
If date format has been set to MM/DD/YY, this commandsets the time and date to 13:14:15 (01:14:15 PM) on January 2, 2021.

If date format has been set to DD/MM/YY, this command sets the time and date to 13:14:15 (01:14:15 PM) on February 1, 2021.

If date format has been set to YY/MM/DD, this commandsets the time and date to 13:14:15 (01:14:15 PM) on February 21, 2001.

TOUCH

Gets or sets the touchscreen On/Off status. This command can be used to disable and re-enable touchscreen input. If the {on|off} parameter is omitted, the current On/Off setting is returned.

Command format:
touch[<sp>{on|off}]

Command response for "touch":
<lf>{On|Off}
<lf><prompt>

Command response for "touch {on|off}":
<lf><prompt>

VALVE

Displays or sets the valve state for one or more channels. When the valve is set to auto, the motor direction determines the valve state. When set to auto, OFF = Infuse and ON = Refill.

Command format:
valve<sp>{chan}[on|off|auto]

Command response for "valve<sp>{chan}":   *(one of these three lines is shown for each requested channel)*
<lf><A|B|C|D>:<sp>On   *or*

<lf><A|B|C|D>:<sp>Off   *or*
<lf><A|B|C|D>:<sp>Automatic
<lf><prompt>   *(this line follows the last channel displayed)*

Command response for "valve<sp>{chan}{setting}":
<lf><prompt>   *(this line follows the last channel displayed)*

Example:
valve<sp>ab<sp>auto

VER

Displays the short version string.

Command format:
ver

Command response:
<lf>Harvard<sp>Apparatus<sp>Pump<sp>Controller<sp>#.#.#
<lf><prompt>

VERSION

Displays the full version string.

Command format:
version

Command response:
<lf>Harvard<sp>Apparatus<sp>Pump<sp>Controller
<lf>Display<sp>boot<sp>loader:<sp>#.#.#
<lf>Display<sp>application:<sp>#.#.#
<lf>
<lf>Board<sp>#<sp>boot<sp>loader:<sp>#.#.#   *These two lines are repeated for each*
<lf>Board<sp>#<sp>application:<sp>#.#.#   *motor card present in the Controller.*
<lf>
<lf>Serial number: P4#####
<lf><prompt>

Syringe Commands

DIAMETER

Sets or displays the syringe diameter (in mm) for one or more channels.

Command format:
diameter<sp>{<chan>}[<sp>{syringe diameter}]

Command response to diameter<sp>{<chan>}:
<lf><A|B|C|D>:<sp>#   *Displays one line per requested channel.*
<lf><prompt>

Command response to diameter<sp>{chan}<sp>{syringe diameter}:
<lf><prompt>

Note: an error response will occur if an attempt is made to change the syringe diameter if the motor is running. However, care must be taken to not change the syringe diameter with this command when a method is underway and the motor is stopped (such as when a DELAY step is active). Doing so will cause the motor to run at an incorrect rate.

Note: since this command adjusts each channel's force setting individually, care must be taken when using this command when channels are paired with Twin or Reciprocating mode. Use of this command can override the diameter matching normally performed automatically for paired channels, resulting in incorrect volume infusion.

GANG

Sets or displays the syringe gang count for one or more channels.

Command format:
gang<sp>{<chan>}[<sp>{gang count}]

Command response to gang<sp>{<chan>}:
<lf><A|B|C|D>:<sp># syringes   *Displays one line per requested channel.*
<lf><prompt>

Command response to gang<sp>{chan}<sp>{ gang count }:
<lf><prompt>

Note: an error response will occur if an attempt is made to set the gang count when the motor is running or to set the gang count to greater than 10. However, this count may exceed the maximum gang count allowed for a channel. Care must be taken to not change the gang count with this command when a method is underway and the motor is stopped (such as when a DELAY step is active) and to not exceed the maximum allowed gang count for the particular pump on each channel.

Note: since this command adjusts each channel's gang setting individually, care must be taken when using this command when channels are paired with Twin or Reciprocating mode. Use of this command can override the gang count matching normally performed automatically for paired channels, resulting in incorrect volume infusion.

SVOLUME

Sets or displays syringe volume (capacity) for one or more channels.

Command format:
svolume<sp>{chan}[<sp>{syringe volume}<sp>{ul|ml}]

Command response to svolume<sp>{chan}
<lf><A|B|C|D>: # xl   *Displays one line per requested channel.*
<lf><prompt>   *Displayed after the line for the last channel line.*

Command response to svolume<sp>{chan}<sp>{syringe volume}<sp>{ul|ml}
<lf><prompt>

Note: since this command adjusts each channel's syringe capacity setting individually, care must be taken when using this command when channels are paired with Twin or Reciprocating mode. Use of this command can override the syringe matching normally performed automatically for paired channels, resulting in incorrect volume infusion.

SYRINGE

Sets or displays the selected syringe setting for one or more channels. Quick start only. Valid 3-character manufacturer codes are shown in the table below.

Command format:
syringe<sp>{chan}[<sp><?|<code>[<sp><?|<index>]>]

Typing 'syringe' with only the channel specifier displays the current syringe setting(s) for the specified channel(s).

Typing 'syringe<sp >{chan}<sp>?' displays a list of manufacturers for the given channel(s) with their associated 3-letter codes: see table below.

Typing 'syringe<sp>{chan}<sp><code>< sp>?' shows a list of syringe sizes associated with the specified manufacturer. This includes an index, a volume, and a diameter for each syringe available in manufacturer list <code>.

Typing 'syringe<sp>{chan}<sp><code><sp><index>' selects the syringe in index <index> of the list of syringes associated with the manufacturer determined by <code>.

Example 1:
Command:
syringe<sp>abcd

Command response: *The following line is displayed for each requested channel*
<lf>A:<sp>{mfr},<sp>{vol}<sp>[ml|ul],<sp><diam><sp>mm
<lf><prompt>

Example 2:
syringe<sp>ab<sp>?

Command response:

<lf>A:
<lf>{code}<sp>{manufacturer}   *One line is displayed for each manufacturer for channel 1*
<lf>B:
<lf>{code}<sp>{manufacturer}   *One line is displayed for each manufacturer for channel 2*
<lf><prompt>

Example 3:
syringe<sp>ac<sp>sst<sp>?

Command response:

<lf>A: Argument erroror: sst

      Unknown manufacturer code *Indicates this channel does not support Stainless Steel syringes*

<lf>C:
<lf> #   Volume   Diameter<cr>
<lf><index>:<sp><vol><sp><ul|ml><sp><diam>   *one line is displayed for each syringe*
<lf><prompt>

Example 4:
syringe<sp>c<sp>sst<sp>0   *Sets channel 3 to the first Stainless Steel syringe*

Command response:
<lf><prompt>

air	Air-Tite, HSW Norm-Ject
bdg	Becton Dickinson, Glass (all types)
bdp	Becton Dickinson, Plasti-pak
cad	Cadence Science, Micro-Mate Glass
cma	CMA Microdialysis
h07	Hamilton 700, Glass
h10	Hamilton 1000, Glass
h17	Hamilton 1700, Glass
h70	Hamilton 7000, Glass
hos	Hoshi
ils	ILS, GLass
nip	Nipro
sge	SGE (Scientific Glass Engineering)
smp	Sherwood-Monojet, Plastic
sst	Stainless Steel
tej	Terumo Japan, Plastic
top	Top

Note: The system disallows changes to the syringe setting if the motor is running, but care must be taken to not change this setting when a method is running.

Note: since this command adjusts each channel's syringe setting individually, care must be taken when using this command when channels are paired with Twin or Reciprocating mode. Use of this command can override the syringe matching normally performed automatically for paired channels, resulting in incorrect volume infusion.

Run Commands

IRUN

Runs the pump on one or more channels in the infuse direction if the current settings (e.g., IRATE must be set; TVOL or TTIM must be set).

Command format:
irun<sp>{<chan>}

Command response:
<lf><A|B|C|D>: Mode changed to Infuse Only   *This line will be displayed for each channel*
                                                                              not already set to Infuse Only mode.

<lf><prompt>

RRUN

Runs the pump on one or more channels in the opposite direction if the current settings (e.g., xRATE must be set; TVOL or TTIM must be set).

Command format:
rrun<sp>{<chan>}

Command response:
<lf><A|B|C|D>: Mode changed to Infuse Only   *One of these two lines will be displayed*
<lf><A|B|C|D>: Mode changed to Withdraw Only *for each channel.*
<lf><prompt>

RUN

Runs the motor(s) for one of more channels at their current rates in their current directions. This can be used to restart multiple channels at the same time. For example, if the pump on channel P1 has started infusing and the pump on channel P2 has started withdrawing, and then motors are paused, typing "run ab" will restart both motors at the same time, in their original directions (channel P1 infusing and channel P2 refilling).

Command format:
run<sp>{<chan>}

Command response:
<lf><prompt>

STOP

Stops the pump(s) on one or more channels.
Command format:
stop<sp>{chan}

Command response:
<lf><prompt>

NOTE: If the pump is running in 'fast' mode, the 'FAST<sp>{chan} s' is required.

WRUN

Runs the pump on one or more channels in the withdraw/refill direction if the current settings (e.g., WRATE must be set; TVOL or TTIM must be set).

Command format:
wrun<sp>{<chan>}

Command response:
<lf><A|B|C|D>: Mode changed to Withdraw Only *This line will be displayed for each channel*
not already set to Withdraw Only mode.

<lf><prompt>

Rate Commands

NOTE: In the descriptions for Rate commands, the text "xl/xxx" is used as a placeholder to indicate the actual flow rates. For commands requiring rate units, use the following format:

{ml|ul|nl|pl}/{hr|min|sec}
which may be abbreviated to: {m|u|n|p}[/]{h|m|s}
Ex: m/m or mm= milliliter/minute n/s or ns= nanoliter/second

CRATE

Displays the current rate(s) at which the motor(s) is/are running for one or more channels. A valid response is returned only in dynamic situations (while the pump is running).

Command format:

crate<sp>{chan}

Command response:

<lf><A|B|C|D>: Infusing at # xl/xxx

or: *One of these two lines is shown for each requested channels.*

<lf><A|B|C|D>: Withdrawing at # xl/xxx

<lf><prompt> *This line follows the info for the last displayed channel.*

IRATE

Sets or displays the infusion rate for one or more channels. The rate argument may be replaced with "max" or "min" to set the rate to the maximum or minimum rate, respectively. "lim" may be used to display the range limits.

Command format:

irate<sp>{chan}[<sp>max|min|lim|<rate><sp>{rate units}]

Command response:
<lf><A|B|C|D>:<sp>Infuse at # xl/xxx   *Displays one line per requested channel.*
<lf><prompt>

or (if "lim" argument is used):

<lf><A|B|C|D>: # xl/xxx to # xl/xxx   *Displays one line per requested channel.*
<lf><prompt>

Example:
irate<sp>ab<sp>10<sp>ml/min

RATE

Sets or displays the rate for the current direction (infuse or withdraw/refill) for the specified channel(s). It can be used in place of "IRATE" if the current direction for the given channels is Infuse or "WRATE" if the current direction is Withdraw. Quick Start mode only. The rate argument may be replaced with "max" or "min" to set the rate to the maximum or minimum rate, respectively. "lim" may be used to display the range limits.

Command format:
rate<sp>{chan}<sp>[max|min|lim|<rate><sp>{rate units}]

Command response:
<lf><A|B|C|D>:<sp><Infuse|Refill> at # xl/xxx   *Displays one line per requested channel.*
<lf><prompt>

or (if "lim" argument is used):
<lf><A|B|C|D>: <sp><Infuse|Refill> at # xl/xxx to # xl/xxx   *Displays one line per requested channel.*

Example:
rate<sp>ab<sp>10<sp>ml/min

WRATE

Sets or displays the withdraw/refill rate for one or more channels. The rate argument may be replaced with "max" or "min" to set the rate to the maximum or minimum rate, respectively. "lim" may be used to display the range limits.

Command format:

wrate<sp>{chan}[<sp>max|min|lim|<rate><sp>{rate units}]

Command response:
<lf><A|B|C|D>:<sp>Refill at # xl/xxx   *Displays one line per requested channel.*
<lf><prompt>

or (if "lim" argument is used):

<lf><A|B|C|D>: # xl/xxx to # xl/xxx   *Displays one line per requested channel.*
<lf><prompt>

Example:
wrate<sp>ab<sp>10<sp>ml/min

Volume Commands

CIVOLUME

Clears the infused volume for one or more channels.

Command format:
civolume<sp>{chan}

Command response:
<lf><prompt>

CTVOLUME

Clears the target volume for one or more channels.

Command format:
ctvolume<sp>{chan}

Command response:
<lf><prompt>

CVOLUME

Clears both the infused and withdrawn volumes.

Command format:
cvolume<sp>{chan}

Command response:
<lf><prompt>

CWVOLUME

Clears the withdraw/refill volume for one or more channels.

Command format:
cwvolume<sp>{chan}

Command response:
<lf><prompt>

IVOLUME

Displays the infused volume for one or more channels.

Command format:
ivolume<sp>{chan}

Command response:
<lf><A|B|C|D>: # xl   *Displays one line per requested channel.*
<lf><prompt>   *Displayed after the line for the last channel line.*

TVOLUME

Sets or displays the target volume for one or more channels.

Command format:
 tvolume<sp>{chan}[<sp>{target volume}<sp>{volume units}]

Command response to tvolume<sp>{chan}:   *Displays one line per requested channel.*
<lf><A|B|C|D>: Target volume not set
<lf><A|B|C|D>: x xl
<lf><prompt>   *Displayed after line for last channel.*

Command response to tvolume<sp>{chan}<sp>{target volume}<sp>{volume units}:
<lf><prompt>

WVOLUME

Displays the withdraw/refill volume for one or more channels.

Command format:
wvolume<sp>{chan}

Command response:
<lf><A|B|C|D>: # xl   *Displays one line per requested channel.*
<lf><prompt>   *Displayed after the line for the last channel line.*

Time Commands

CITIME

Clears the infused time for one or more channels.

Command format:
citime<sp>{chan}

Command response:
<lf><prompt>

CTIME

Clears both the infused and withdraw/refill times for one or more channels.

Command format:
ctime<sp>{chan}

Command response:
<lf><prompt>

CTTIME

Clears the target time for one or more channels.

Command format:
cttime<sp>{chan}

Command response:
<lf><prompt>

CWTIME

Clears the withdraw/refill time for one or more channels.

Command format:
cwtime<sp>{chan}

Command response:
<lf><prompt>

ITIME

Displays the infused time for one or more channels.

Command format:
itime<sp>{chan}

Command response:
<lf><A|B|C|D>: <time in sec>   *Displays one line per requested channel.*
<lf><prompt>   *Displayed after line for last channel.*

TTIME

Sets or displays the target time for one or more channels.

Command format:
ttime[<sp>{chan}<sp>{target time}]

Command response to ttime<sp>{chan}:   *Displays one line per requested channel.*
<lf><A|B|C|D>: Target time not set   *or*
<lf><A|B|C|D>: #   *or*
<lf><A|B|C|D>: ##:##:##   *Displayed after line for last channel.*
<lf><prompt>

Command response to ttime<sp>{chan}<sp>{target time}:
<lf><prompt>

WTIME

Displays the withdraw/refill time for one or more channels.

Command format:
wtime<sp>{chan}

Command response:
<lf><A|B|C|D>: <time in sec>   *Displays one line per requested channel.*
<lf><prompt>   *Displayed after line for last channel.*

Digital I/O Commands

INPUT

Reads and displays the trigger input port (Pin 2) status from one or more channels.

Command format:
input[<sp>{chan}]

Command response to "input<sp>{chan}":
<lf><A|B}C|D><sp>Low|High   *Displays one line per requested channel.*
<lf><prompt>   *Displays after line for last requested channel.*

OUTPUT

Sets the level on one of the output ports {1|2|3} for one or more channels. A port selector of 1 is used for Trigger 1 Out (Pin 4); 2 is used for Trigger 2 Out (Pin 5); 3 is used for Trigger 3 Out (Pin 5).

Command format:
output<sp>{chan}<sp>{1|2|3}<sp>{high|low}

Command response:
<lf><prompt>

Internal Commands

STATUS

Displays the raw status of all channels, for use with a controlling computer.

Command format:
status

Command response:

<lf><RATEA><sp><TIMEA><sp><VOLA><sp><MDA><LA><SA><IA><DPA><TA>

<lf><RATEB><sp><TIMEB><sp><VOLB><sp><MDB><LB><SB><IB><DPB><TB>

<lf><RATEC><sp><TIMEC><sp><VOLC><sp><MDC><LC><SC><IC><DPC><TC>

<lf><RATED><sp><TIMED><sp><VOLD><sp><MDD><LD><SD><ID><DPD><TD>

The output displays data elements for each channel, separated by spaces and terminated by a carriage return / linefeed pair. The data for each channel consists of three integer fields and one flag field, all separated by spaces. For each channel, the first integer (<RATEn>) is the current rate in femtoliters per second, the second integer (<TIMEn >) is the infuse time in milliseconds (granularity of 1 millisecond), and the third integer (<VOLn>) is the infused volume in femtoliters. All three values are for the current direction.

Each channel flag field consists of six flags:

- Flag one (<MDn>) is the motor direction and will be "i or I" if the pump is infusing and "w or 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 (<Ln>) is the limit switch status. If the infuse limit switch was hit, "i or I" is displayed. If the withdraw limit switch was hit, "w or W" is displayed. If no limit switch was hit or the pump does not have limit switches, "." is displayed.

- Flag three (<Sn>) is the stall status and will be "S" if the pump has stalled. Otherwise it will be ".".

- Flag four (<In>) is the trigger input state and will be "T" if high and "." if low.

- Flag five (<DPn>) is the direction port state and will be "I" for infuse and "W" for withdraw.

- Flag six (<Tn>) is the target reached status. It will be "T" if the target time or volume was reached, or "." if not.

Maintenance

Fuse Replacement
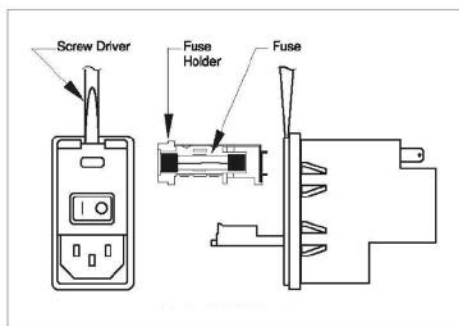
Key Information

1.   Make sure the power cord is disconnected from the main supply before servicing the fuse.

2.   Use only Type 3AG, 1/4" x 11/4, ½ amp, 250 volt; Type T (time delay) fuses (Harvard Apparatus Part No. 5146-037 or equivalent).

Turn off power and remove power cord from power module. Use a straight blade screwdriver to pry open the access door. Remove the fuse holder and then remove the fuses from this holder as shown in figure below. Replace fuses, and then replace the fuse holder.

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.
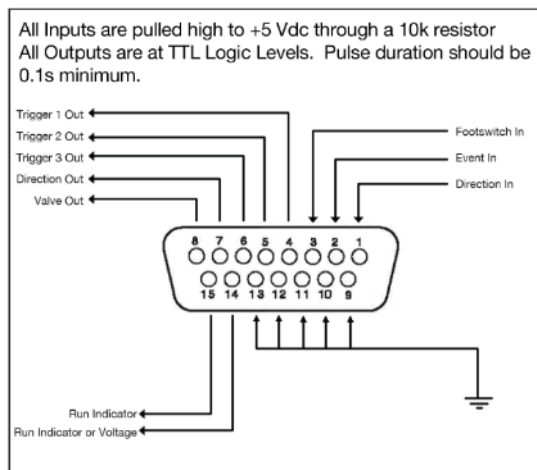

CAUTION: Use only same type & rated battery. Observe polarity when installing.

External Connections

User I/O Connector Specifications

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.

Trigger 1 Out
Trigger 2 Out
Trigger 3 Out
Direction Out
Valve Out

Footswitch In
Event In
Direction In

8 7 6 5 4 3 2 1
15 14 13 12 11 10 9

Run Indicator
Run Indicator or Voltage

NOTE: For remote pumps, I/O connection must be made at the remote box. (Not the control box)

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. **Trigger 3 Output**
   TTL Logic Output-Default = Low Control thru method or serial comm
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 set to 'auto'.
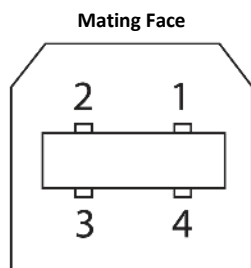
9–13. Signal Return / Ground

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)

Electrical Specifications:

Inputs:	$V_{IH} \geq 2V$	$I_{IH} \leq 20\mu A$
	$V_{IL} \geq 0.4V$	$I_{IL} \leq 0.5mA$

Outputs:	$V_{OH} \geq 3.8V$	$I_{OH} \leq 6mA$
	$V_{OL} \geq 0.4V$	$I_{OL} \leq 6mA$

USB Connection

Mating Face
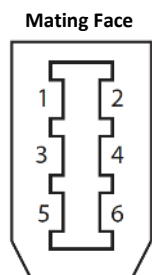
Pin #	Signal
1	+5V
2	- Data
3	+ Data
4	GND

HAPC to Pump RS-485 Connection

CAUTION: Do not connect to firewire ports on a PC. Damage may ocur 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**	** 100 Ω, ½ w to GND termination
5	TIED TO PIN 6**	RS-485 A	
6	TIED TO PIN 5**	RS-485 B	

Harvard Apparatus Pump Controller (HAPC)

Ordering Information

Catalog #	Description
704400	HAPC-M: 1 Channel Module, no controller, for future expansion
704401	HAPC-1: Controller populated with one channel module.
704402	HAPC-2: Controller populated with two channel modules.
704403	HAPC-3: Controller populated with three channel modules.
704404	HAPC-4: Controller populated with four channel modules.
Pump Modules*	
Catalog #	Description
703602	Nanomite Injector, Single Syringe, Black
704804	Pump 11 Elite Single Syringe Pump Module, Black
704805	Pump 11 Elite Dual Syringe Pump Module, Black
704806	Pump 11 Pico Plus Elite Dual Syringe Pump Module, Black
704807	Pump 11 Elite Pico Plus Single Syringe Pump Module, Black
703406	PHD ULTRA™ Sattelite Syringe Pump Module
703408	PHD ULTRA™ PUSH/PULL SATELLITE MODULE
703410	PHD ULTRA™ 4400 SATELLITE MODULE
703514	PHD ULTRA™ XF SYRINGE PUMP MODULE
Accessories	
Catalog #	Description
702215	Footswitch (with Phono Plug)
704405	HAPC-B: Controller Blank Panel
704021	RS-485 Cable, HAPC Channel to pump, 1 m (3.3 ft)
704001	RS-485 Cable, HAPC Channel to pump, 2 m (6.6 ft)
704020	RS-485 Cable, HAPC Channel to pump 9 m (29 ft)

Note: The Pump 11 Elite, Pico Plus Elite and PHD ULTRA™ XF are fully PC controllable and come with external power supplies. When used with the HAPC, the power supplies are not required. In cases of extremely high pressure applications using the PHD ULTRA™ XF, the external power supplier may be required. Please contact Technical Support for additional application questions.

For additional items such as valve boxes, syringes, tubing and connectors are also available. Please visit www.harvardappartus.com.