Flow Control

User's Guide

Programmable Dosing Pumps for
Liquid Delivery,
Solutions Application & Switching

- From Single Unit to Multi-Channel Systems
- Manual and Software controls for Automated Operation
- Compatible with Imaging & Data Acquisition systems
- No electrical noise during operation
- Easy calibration

Contents

Specifications CFPS-2

Flow Rate Range:	8 µl/min to 7.3ml/min (depends on tubing configuration)
Number of Channels:	2/4 (with manual, analog and digital signal control)
Remote control	wireless, activates and closes channels independent on other controls
Timer:	x4 channels, can be used for sequencing and continuous loops
Dosing:	timers can be activated by specifying dispensing volumes
Analog Inputs:	x4 10-bit channels
Digital input:	x4 channels, TTL
RS232 Port:	115,200 baud (USB adapter is available)
Power:	120-240 VAC input.
Dimensions:	Controller 14 x 6 x 8 in, drive unit 4 x 2.5 x 2 in. can be mounted on a 0.5in rod

Specifications CFPS-1U/1

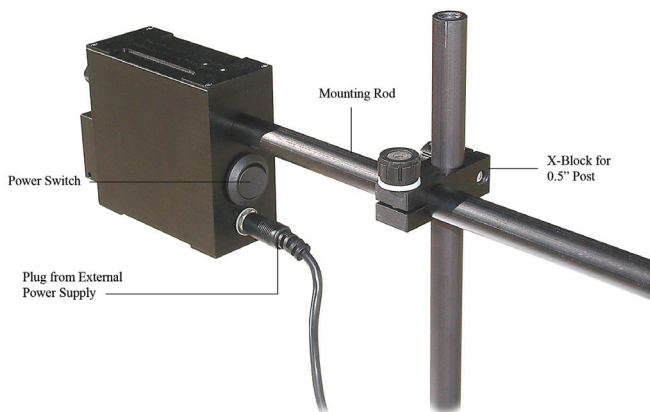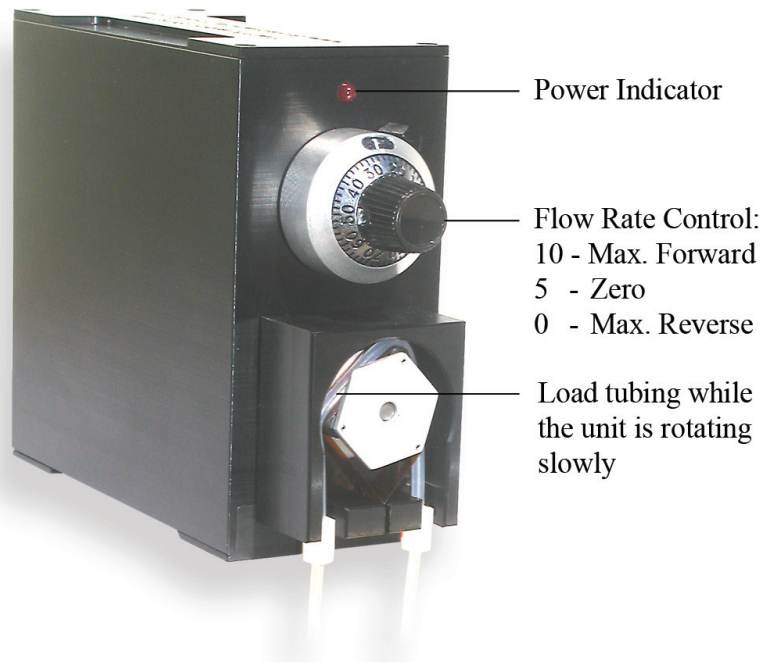|	
Flow Rate Range:	8 µl/min to 7.3ml/min (depends on tubing configuration)
Power:	12VDC, external power adapter for 120-240 VAC input.
Remote control	wireless, activates and stops dispensing independent on other controls, up to 16 different units can be controlled by the same remote (CFPS-1U only)
Timer:	1sec precision, can be used for continuous loops (CFPS-1U only)
Dosing:	timer can be activated by specifying dispensing volumes (CFPS-1U only)
Analog Inputs:	0-10V (CFPS-1U only)
Digital input:	+5V TTL (CFPS-1U only)
RS232 Port:	CFPS-1U only (USB adapter is available)
Dimensions:	37x77x82mm (without mounting X-block)

CE

Introduction

The flow control systems are based on miniature precision pumps, which can deliver stable flow through soft tubing. Due to miniature size, stable operation and small diameter of tubing, the pulsation is minimized to provide smooth perfusion. The flow control systems can be also used for solution aspiration/suction during perfusion. The flow rate can be controlled by front panel dials or by analog signals, and by software commands.

CFPS-1 Micro pump - Installation Guide

1 Attach the unit to the provided mounting rod and mount on a 0.5" post using provided mounting X-block, or simply place the unit on a desktop. Insert the power plug from the power supply, which should be connected to a 120/240VAC main power . Turn the power switch ON. The LED on the front panel should be GREEN. By rotating the dial, you can adjust the flow rate. Rotating the dial below 5 indicator, will reverse the flow.

Power Indicator

Flow Rate Control:
10 - Max. Forward
5 - Zero
0 - Max. Reverse

Load tubing while the unit is rotating slowly

Mounting Rod

X-Block for 0.5" Post

Power Switch

Plug from External Power Supply

CFPS-1U Units - Installation Guide

1 Mount the unit on a 0.5" post using provided mounting X-block, or place the unit on a desktop. Insert the power plug. Turn the power switch ON. The display on the front panel should be GREEN. Turning the DIAL clockwise will turn the unit drive, which will be indicated by small GREEN LED. By rotating the dial, you can adjust the flow rate. After 5sec, the display will show the unit address, flow rate (in absolute numbers from 1 to 127, or in volume/min), and the direction of the flow - clock-wise or antic lock-wise. Turning the DIAL anti clock-wise at this point will stop the drive - GREEN LED is OFF. You can also turn the drive ON/OFF by pressing the button, that corresponds to the unit address, on the REMOTE.
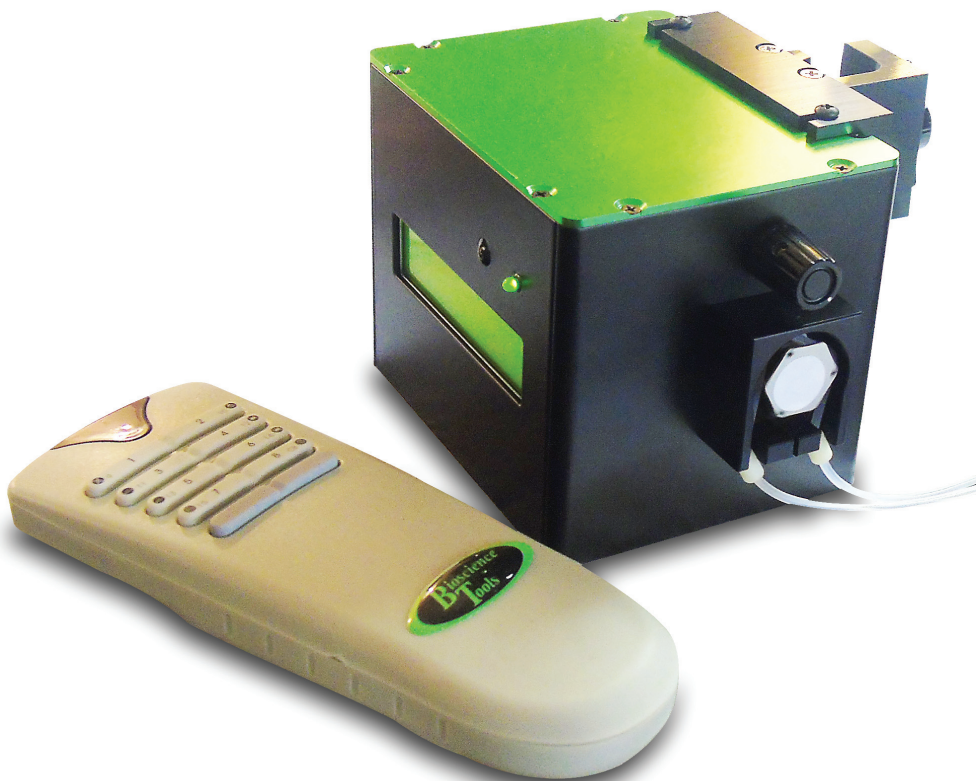
I.D.	flow rate
0.015"	8-170 μl/min
0.020"	20-340 μl/min
0.031"	50-920 μl/min
0.062"	170-3400 μl/min
0.093"	370-7300 μl/min

Depending on the diameter of tubing used and configuration purchased, the system can be calibrated to provide flow rates in the range from 8 μl/min to 7/3 ml/min.

The system comes with a tubing with different inside diameters: 0.015, 0.020, 0.031, 0.062, 0.093". The table above shows flow rates that can be achieved with different diameter tubing.

2 Select tubing for the required flow rate and insert it into the unit. This step is easier to perform if the pumps are slowly rotating. Using the dial on the front, adjust the speed so that it is not too fast to load tubing. Use provided or optional fitting from CFPS-FIT or PS-KIT to connect to extension tubing, which should be long enough to reach your sample and sources of solution.

3 Below are examples of possible connection to the microbore extension tubing using fitting from CFPS-FIT kit.
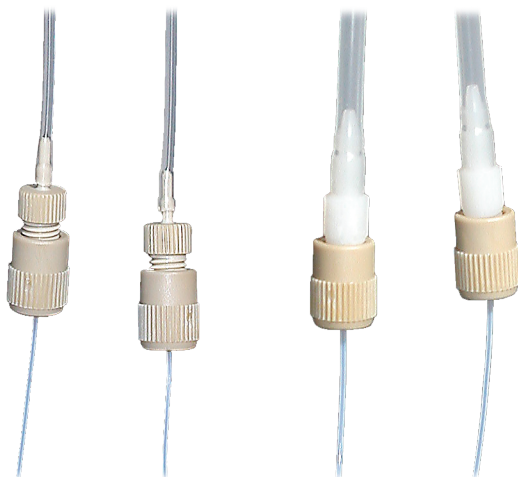
Operation

The unit can be also controlled by adjusting the system settings using MENU parameters, which can be shown on the DISPLAY by pressing and, to adjust parameters, rotating dial DIAL. The adjusted parameters will be stored in system memory for subsequent use. By pressing DIAL, you can browse through the following parameters:

ON/OFF   turns the drive to deliver liquid ON/OFF manually. By setting the drive ON, the unit will start liquid delivery every time you turn the power ON. This can be used as a simple way to initiate the unit - through one touch. REMOTE and software controls will continue toggle the drive ON/OFF. MENU example:

        OFF/ON------------------->OFF

FLOW RATE this parameter sets the liquid delivery flow rate. It can be shown in absolute numbers - digital CODE, or in volume/min (ml/min for example). Digital CODE can be in the range from 1 to 127, the higher the number the higher flow rate. The actual flow rate will be determined by the tubing I.D. (0.015, 0.020, 0.031, 0.062 or 0.093") and the pump configuration (GREEN, YELLOW, RED or WHITE). MENU examples:

        code ---------------------->127

        ml/min ------------------>1.0

DIRECTION determines the pump rotating direction FORWARD or REVERSE. MENU example

        REV/FWD --------------->FWD

UNITS   sets flow rate units to display. MENU example:

        code/rate ----------------->RATE

COLOR   should correspond to the unit color marking on the front of the pump. Example:

        color --------------------->GREEN

TUBING ID should correspond to the tubing I.D. installed. Tubing I.D. and color are important only if actual flow rate or dispensing volume will be defined. Example:

        tubing-ID ----------------->0.015"

        CALIBRATION used to determine the actual flow rate for precise volume dosing. Since the flow rate is determined not only by the pump but by your setup - connecting tubing length, diameter, liquid viscosity, pressure and so on - you can calibrate your setup, if precise dosing is required

for your setup. The calibration is performed by setting the flow rate to the maximum by adjusting CODE value to 127, and timing the dispensed volume. These can be done using by measuring weight of regular water dispensed during certain time, which can be set using TIMER described later, 10min for example. IMPORTANT: much longer dispensing time might be required to accurately measure volume dispensed at very low flow rates. Changing this parameter back to DEFAULT will erase MEASUREd flow rate value and restore the default value, which is defined by the system according to the TUBING ID and COLOR of the pump. Setting this parameter to MEASURE will let you to adjust the flow rate by entering the measured value at the next MENU step - MAX FLOW RATE. Example:

calibrate MEASURE

MAX FLOW RATE is set after calibration procedure described above. MENU example:

ml/min ------------> 0.9

TIMER   can be used only after dispensing time or volume are entered at the following MENU step. If time and volume are set to zero, the timer will be disabled after the attempt to enable it. Example:

timer --------------> ON

DISPENSE TIME can be entered in HOUR.MIN.SEC format by selecting time unit first. Rotate dial to select time unit to adjust. The unit selected will be shown by arrow pointing next to the selection <---:

min <--------------- 00.00.00

by pressing DIAL again, the arrow will be pointing to ---->value. Rotate DIAL to set the unit value:

sec ------------------>00.00.10

press DIAL again to set the value, and to adjust another time unit. Instead of time, dispense volume can be set by selecting the volume:

ml <--------------- 0.0

press DIAL again and adjust the volume:

ml ---------------->10.0

if volume is set above zero, it will be used to control TIMER - the timer will stop after the dispensed volume reaches the set value. After dispensing time or volume are set, TIMER can be enabled through the previous MENU step. TIMER will be initiated every time you turn the drive ON,

manually, through software or by REMOTE. If you turn the drive OFF during TIMER operation, TIMER and dispensing will stop, but turning the drive ON again will resume TIMER and dispensing.

PERIOD   is used to enable continuous liquid delivery by initiating TIMER again after waiting time expired, every 24hours for example. PERIOD can be enabled only after actual period time is set at the next MENU step, similar to setting TIMER. MENU example:

period -----------> ON

TIMER PERIOD sets actual period in HOUR.MIN.SEC format by selecting time unit first:

min <-------------00.00.00

and then unit value:

min ------------->00.02.00

PERIOD will not be enabled if the actual period length is shorter than time set by TIMER, regardless if it is set through volume or time units.

ADDRESS   sets the unit address for REMOTE control from 1 to 16. To operate units with address from 9 to 16, the GREY button needs to be pressed to turn REMOTE light RED, and then by pressing the corresponding button, 1 for address 9 for example. MENU example:

address------------>01

ANALOG   enables ANALOG input to control the flow rate. Input range is from 0 to +10V. This input is applied to pin 2 in female DB-9 connector on the back panel. The input is translated into digital code from 1 to 127, with +5 value resulting to CODE equal 0. Values from 0 to +5 will result to REVERSE rotation of the pump with the maximum rate at 0V. ANALOG input will not initialize dispensing until the drive is turned ON manually, through software or by REMOTE. Example:

ANALOG
OFF/ON ---------> ON

Using Wireless Remote Control PC-16-RC

1. The remote control unit requires three AAA type batteries (included).

2. Eight push-buttons will activate/de-activate the first eight units directly: push once to activate, push again to de-activate.

3. The grey unlabeled, CONTROL, button will activate/de-activate channels from 9 to 16, when used in conjunction with buttons 1 to 8. Pushing the control button will make the remote LED turn red. Pushing the numerical button, while LED is red, will activate/de-activate the corresponding units according to the table below.

| BUTTON	ADDRESS	ADDRESS CONTROL (grey)
1	1	9
2	2	10
3	3	11
4	4	12
5	5	13
6	6	14
7	7	15
8	8	16

Troubleshooting

If the remote unit stops activating some units, press the control button until LED starts blinking and push button 1 to restore the settings.

Software Control

Any software package, which is capable to send commands to a serial RS232 port of your computer, can control the flow rate. If your computer has a USB port only, use an optional adapter CFPS-USB to convert it into a serial port. The RS232 port should be configured as 9600 baud – 8 bit words – 1 stop bit – NO parity. Use a NULL-MODEM cable to connect the unit to your computer. Below is the list of commands available to build a flexible automated system:

Flow Rate Control

VAddd<CR>   uses decimal data (ddd) to control flow rate. Values can range from 0 to 255. Values below 128 will result to REVERSE rotation of the pump, with 0 corresponding to maximum flow rate. Values above 128 will result to FORWARD rotation. Digital CODE for FORWARD rotation can be determined as CODE = ddd - 128, and for REVERSE rotation: CODE = 128 - ddd. Value of 128 will turn the drive OFF, and any value not equal 128 will turn the drive ON.
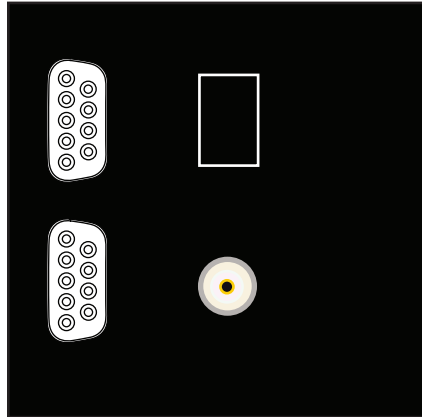
Front Panel LED

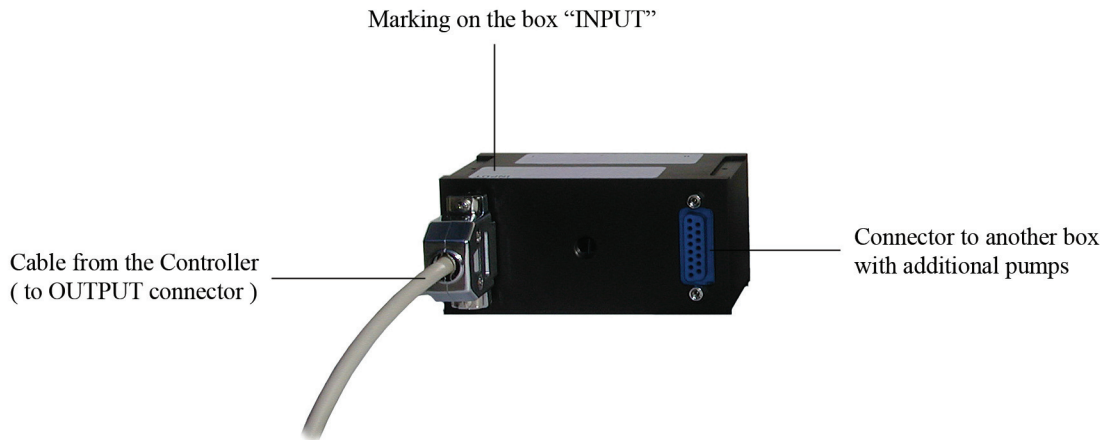| LED	The GREEN LED will indicate if the pump is rotating
TIMER	If TIMER is operating GREEN LED will turn ON/OFF every sec
PERIOD	GREEN LED will be slowly changing intensity up and down (sleeping) while TIMER is OFF and waiting for the next dispensing cycle

Back Panel

Power Jack	Connects to an external power supply 9-12V DC
Power Switch	Turns power to the unit ON/OFF
DB-9 connectors	Male connector: RS232 port, 9600, 8bit, 1stop, NO parity Female connector: pin 1 - analog output -3.5 to +3.5V, NEGATIVE for REVERSE direction, 0V when the drive is OFF; pin 2 - ANALOG input, 0 - 10V; pin 3 - digital output, +5V when the drive is ON, 0V - OFF; pin 4 - digital input, +5V turns the drive ON, 0V - OFF; pin 9 - system GROUND

The flow control system can be connected to a solution switch system PS-8H to apply different solutions through the same tubing in sequence. In this case your system might look similar to the setup shown below.

CFPS-2 System - Installation Guide

1 Connect the drive unit to the controller using cable with DB-9/15 connectors on both sides. There two connectors on the drive box: INPUT is the female connector, and OUTPUT to the second box is the MALE connector. For more than 2-channel system, multiple boxes should be connected using a DB-15 cable (included if 4-channel system or channel upgrade is purchased).

Marking on the box "INPUT"

Cable from the Controller
(to OUTPUT connector)

Connector to another box
with additional pumps

2 Plug the power cord into 120/230VAC power outlet and into the controller on the back panel. Turn the controller ON using the switch on the back panel.

Power switch

output   input   RS232

TTL

1   2   3   4

analog

120-240 VAC
input
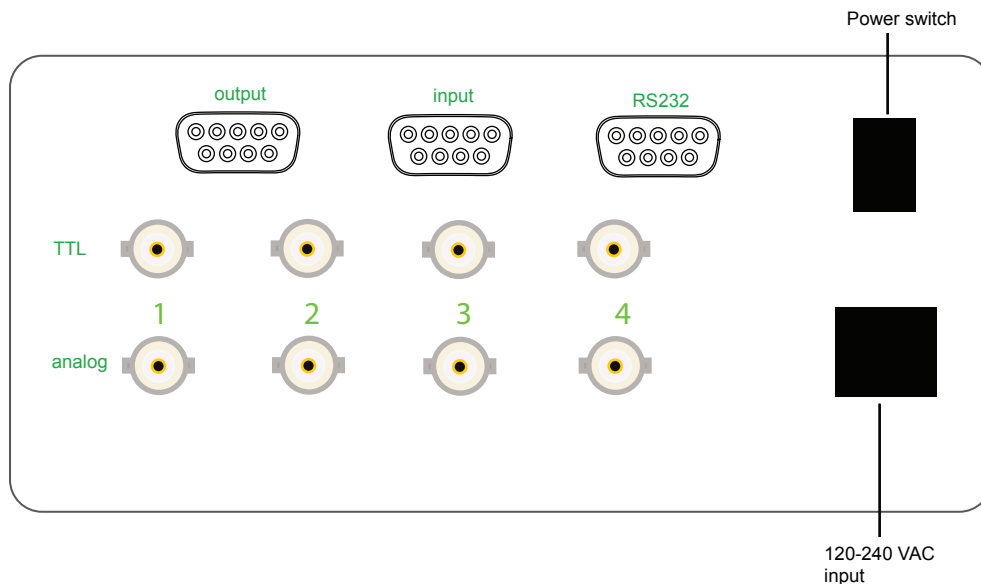
3 Start operating the system by switching channels by touching the appropriate button rotating STANDBY knobs clock-wise all way. If solutions flow is in the wrong direction, switch the direction using REV/FOR button on SET screen to switch into FORWARD/REVERSE settings.
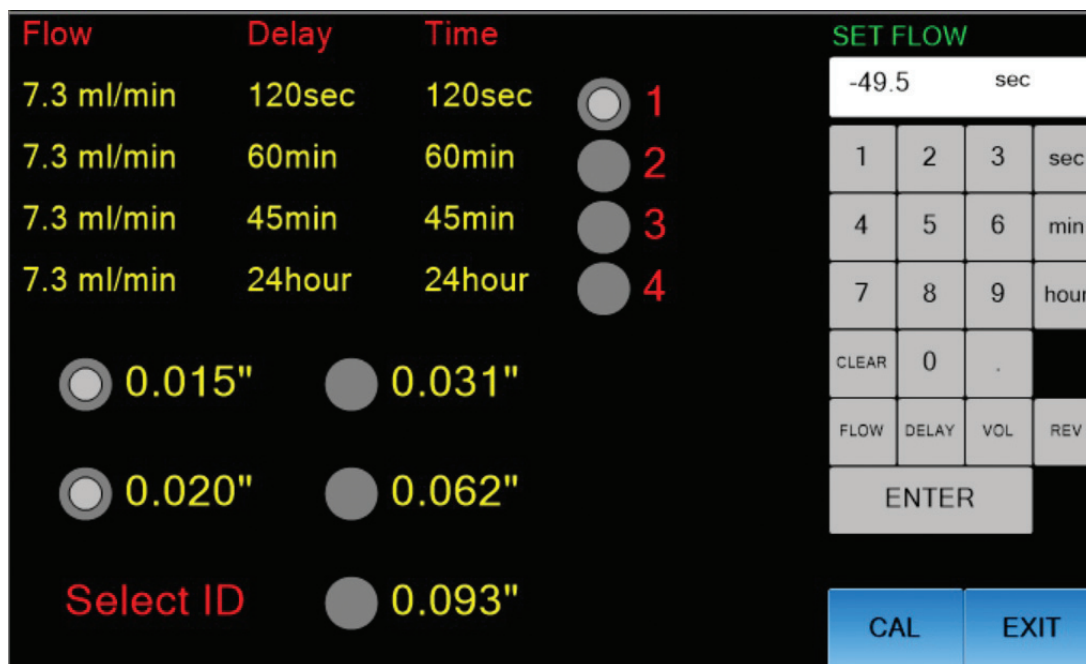

Flow Rate

Depending on the diameter of tubing used, the standard CFPS-2 system can provide flow rates in the range from 0.008 to 7.3 ml/min.

The system comes with a 0.093in. I.D. tubing (or optional different diameter). The table below shows flow rates achieved in standard configuration and upgrades depending on tubing diameter.

In order to SET the flow rates for each channel, touch button SET to go to the settings screen:

Flow | Delay | Time

SET FLOW

-49.5 sec

Flow	Delay	Time		
7.3 ml/min	120sec	120sec	●	1
7.3 ml/min	60min	60min	●	2
7.3 ml/min	45min	45min	●	3
7.3 ml/min	24hour	24hour	●	4

1	2	3	sec
4	5	6	min
7	8	9	hour
CLEAR	0	.	
FLOW	DELAY	VOL	REV

ENTER

● 0.015"   ● 0.031"

● 0.020"   ● 0.062"

Select ID   ● 0.093"

CAL   EXIT

If the numeric keypad does not show SET FLOW or SET VOLUME, touch button FLOW to start editing the flow rates. To switch between different channels, select the appropriate channel number 1. 2. 3 or 4:
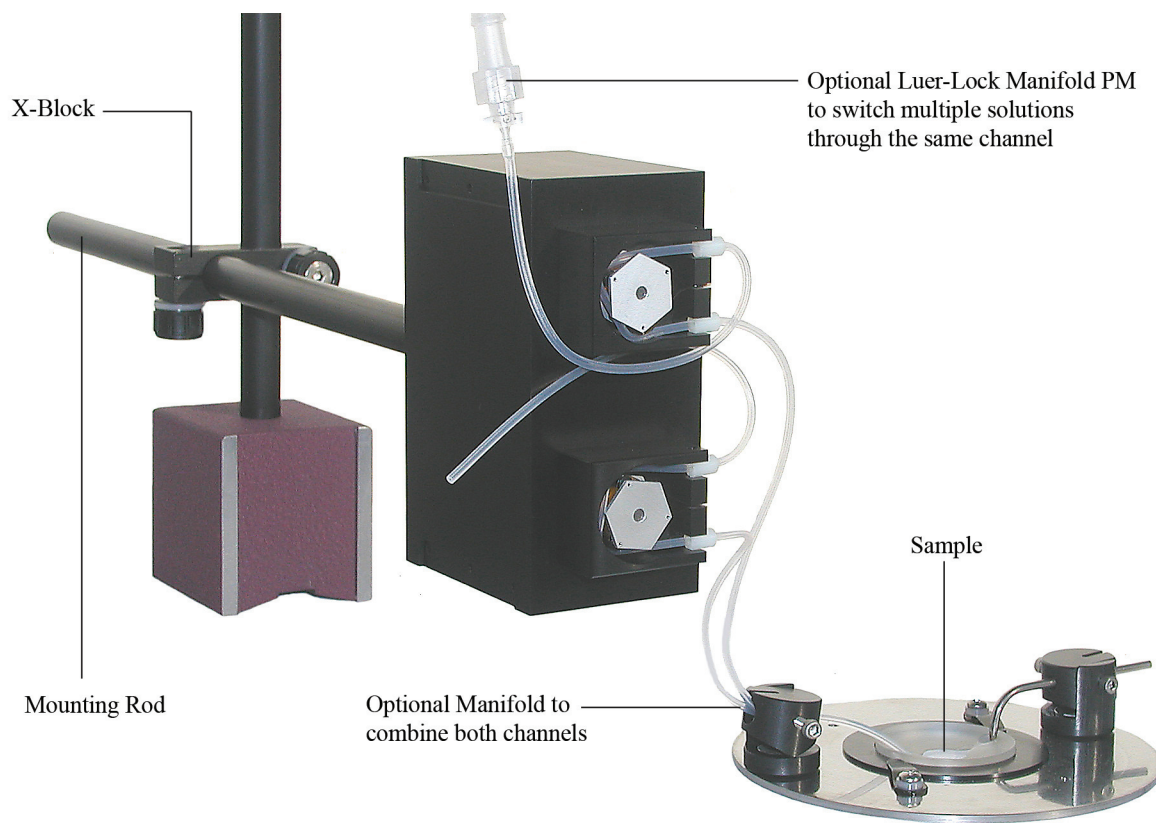
The flow rate can be entered as a digital CODE from 0 to 127. This is the easiest way to program the flow rate, independent off tubing ID. Touch button CLEAR first, and enter 127, and then touch button ENTER to move the flow rate into memory/

To enter the flow rate as a volume, touch button VOL, select units "ul" or ml, and ENTER the flow rate into the memory as ul/min or ml/min.

Every time a new setting is entered, the screen will be updated to show the new value. IMPORTANT, before entering new settings, the display has to be cleared first by touching button CLEAR.

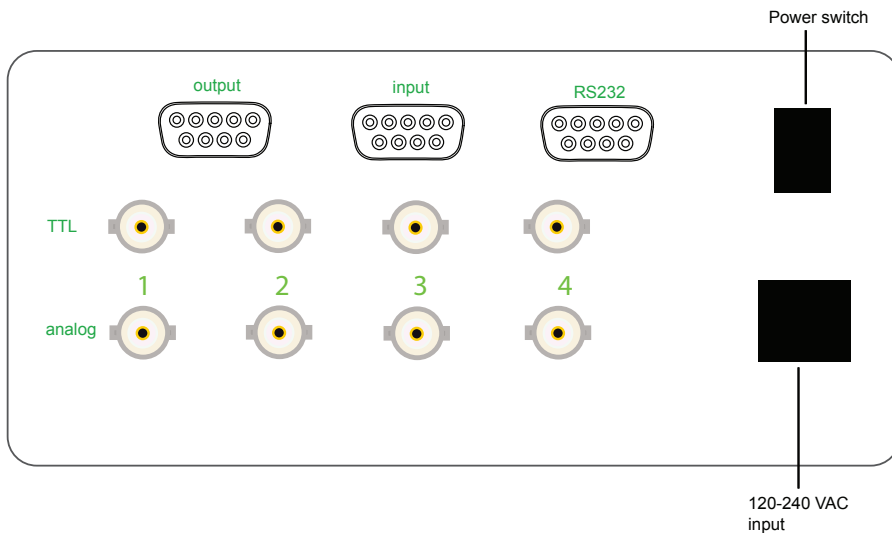| I.D.	Catalog No.	flow rate
0.015"	CFPS-TS-15	8-170 µl/min
0.020"	CFPS-TS-20	20-340 µl/min
0.031"	CFPS-TS-31	50-920 µl/min
0.062"	CFPS-TS-62	170-3400 µl/min
0.093"	CFPS-TS-93	370-7300 µl/min

4 Arrange and mount the box with tubing. For more than 2-channel system, multiple boxes can be connected to each other using included mounting brackets, to form a single unit. You can use the provided mounting rod and x-block to position tubing closer to your sample to minimize the dead space inside tubing.

X-Block

Optional Luer-Lock Manifold PM to switch multiple solutions through the same channel

Sample

Mounting Rod

Optional Manifold to combine both channels

Using Wireless Remote Control

1. The remote control unit requires three AAA type batteries (included).

2. Four push-buttons will activate/de-activate the four channels of CFPS-2 controller directly: push once to activate, push again to de-activate.

3. The grey unlabeled, CONTROL button**:** If the remote unit stops activating some channels, press the control button until the unit's LED starts blinking and push button 2 to restore the settings.

Back Panel

120-240VAC Input	Connects to 120-240 VAC power supply
OUTPUT DB-9 Connector	Connects to the drive unit to provide control signals and power.
Analog 1...4 BNC Connectors	Inputs to control flow rate by a source of analog signal. This operates independently from front panel settings.
TTL 1...4 BNC Connectors	Digital signal inputs to switch channel 1...5 by a +5V TTL or a digital pulse. The length of the pulse determines duration of the channel operation. Flow rate is determined by the front panel dials.
INPUT DB-9 Connector	Digital Inputs - in parallel with TTL 1...4 connectors, and Analog inputs - in parallel with Analog 1...4 inputs.
RS232	Connects to a serial port of a computer through a regular DB-9 NULL MODEM cable. Can be used with USB connector through optional USB adapter.
POWER switch	Turns the controller ON/OFF.

Operation

After connecting all tubing to your samples, sources of solution, optional manifolds and automatic solution switches PS-8H, and to a container for waist solution, fill the tubing with solutions at higher flow rates - change direction of solution flow by REVERSE switches, if required. Note: for low flow rate units, tubing can be pre filled (primed) with solution first, and then connected to the drive units. After tubing lines are primed with solution you can control flow rates and exchange solutions in your systems by a combination of the following controls:

MANUAL: By using knobs 1, 2, 3, and 4 from STANDBY into ACTIVE modes (this also controls flow rates but not precisely).

AUTO memory: The controller can use independent TIMERs for both ACTIVE state and WAIT states between different channels, to turn them in sequence from Channel 1, to Channel 2, then Channel 3 and then Channel 4.. Note: programming WAIT/DELAY timer for Channel 1 will make the controller work in a loop indefinitely. Making WAIT time 0sec for any channel will stop the sequence, and can be used to program the Channel individually, without sequence. An individual channel can run in its own loop, if the DELAY for this channel is more than 0sec.

IMPORTANT: the TIMERs and WAIT states, as well as ON/OFF states for each channel are stored in the controller memory after the controller turned OFF (or looses power). Next time the controller is ON, it starts operating from exactly the same state of TIMERs and WAIT delays. It is recommended to put channels into STANDBY modes before turning the controller OFF, so the controller does not start dispensing solutions unpredictably when the controller is turned ON again.

To stop the sequence running, the active channels can be stopped by touching the appropriate buttons (1, 2, 3, or 4). To stop the sequence permanently, the TIMERS and DELAY times has to be programmed as 0sec. This will stop the TIMERS, and clear WAIT states.

DIGITAL INPUT: Using standard digital or TTL pulses generated by external computers or other devices, you can switch the channels ON/OFF. The digital signal should be provided either through BNC connectors or DB-9 connector (Input) on the back of the controller. The short TTL pulse can be also used to start TIMER for the channel if programmed more than 0sec/

ANALOG SIGNAL: If you have a source of calibrated analog signal in the range from 0 to +10V, you can change the flow rate independent from flow rate settings. Analog signals are supplied to BNC connectors or DB-9 connector (Input) on the back of the controller. The signal has to be above 0.5V to change the flow rate. The analog INPUT is converted into CODE according to this formula:

$$CODE = ((INPUT * 1023 / 10V) - 50) * 255 / 983$$

If the CODE is less than 127, the drives will rotate in REVERSE directions, 128 results to STOP, and if more that 128 - rotate in FORWARD directions.

PROGRAMMING THE CONTROLLER: By touching SET button, the screen will show a number of settings that can be programmed. FLOW rates, DELAY and duration TIME.

To program the flow rate touch button FLOW. The numerical keypad will be renamed to SET FLOW, and the button will change into TIME button.

FLOW rate can be programmed as numerical CODE or as a volume in ml/min (or ul/min). To switch between the units touch button VOL (the button will change into CODE button), and then touch "ul" button or "ml" button. To switch back into CODE programming, touch CODE button.
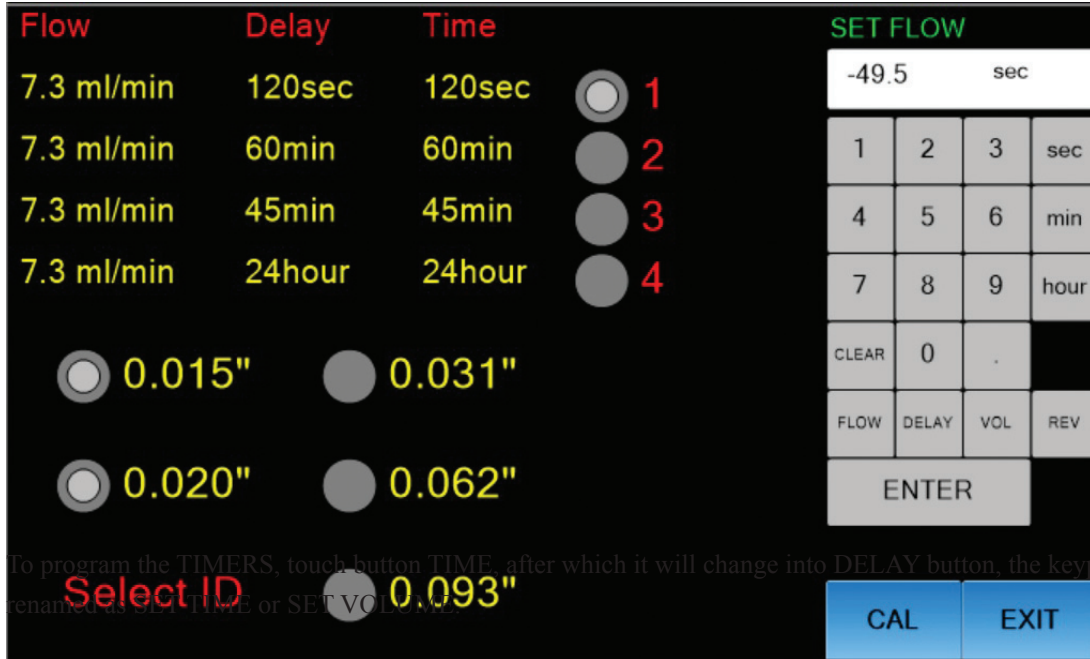
The duration time can be programmed in seconds, minutes, and hours, or in microliters, milliliters and liters. To switch to volume programing, touch VOL button, which will change into TIME button and unit buttons will change into "ul", "ml" and "L" buttons. The keypad will also change into SET VOLUME. To switch back into time units, touch button TIME.

To program WAIT TIMERS, touch TIME button first to show DELAY button. The keypad will be renamed SET DELAY. The WAIT TIMERS cab programmed only in seconds, minutes or hours, which can be switched by touching buttons "sec", "min" or "hour".

The rotating direction of the pumps can changed by touching button REV to switch into REVERSE or FOR button - for FORWARD. The settings for the flow rate will change color to GREEN for FORWARD, or RED for REVERSE.

Tubing
The appropriate tubing diameter (ID), can be selected by touching shown ID. This will set maximum flow rates available for each tubing. This, however, will not affect maximum rates, if the flow rate was calibrated (see below).

Calibration

The default flow rate for the tubing can be changed after calibration procedure, which can be performed if the timer for the channel is programmed as well. By measuring water volume dispensed (μg is μl, and mg is ml)

First, program the TIMER in seconds or minutes. Then, touch button CAL, which will change into START button. After touching START button, it will change into STOP button and the water start dispensing. After the TIMER stops (or after touching STOP button), the button will change into VOL button. The dispensed volume needs to be measured and entered in microliters or milliliters. The settings for the flow rate on the screen will change into calculated flow rate in "ul/min" or "ml/min" VOL button will change into DEF button to indicate that this channel was calibrated. To switch back to DEFAULT flow rates, touch DEF button, which will change into CAL button again.

CFPS-1/2 Calibration

After choosing appropriate size tubing for the required flow rate range, it is advisable to calibrate each unit if delivery of precise amounts of solution is required during your experiment. The calibration procedure is based on timing the system's operation and measuring the resulting solution output. In order to do this, you should have a scale available. Below are two examples of calibrating the standard configuration and slow CFPS-10K upgrade. An external source of analog signal was used to drive the channel, and the output was measured using a scale with 0.01g accuracy. TIMER was set for 1min duration for higher flow rates and 2min for slower in the standard configuration. In CFPS-10K upgrade, TIMER lasted from 2 to 4 min. From 2 to 4 different measurement were taken for each point. If you have an ultra stable and precise scale, one measurement might be enough. Instead of weight, you can measure volume, if you have means to do this. The examples below show linear dependence of the flow rate from applied digital CODE. This allows to calibrate the unit by measuring only flow rate at maximum CODE setting of 127.

Calibration Examples
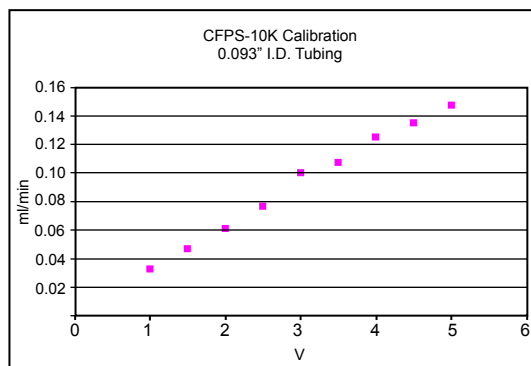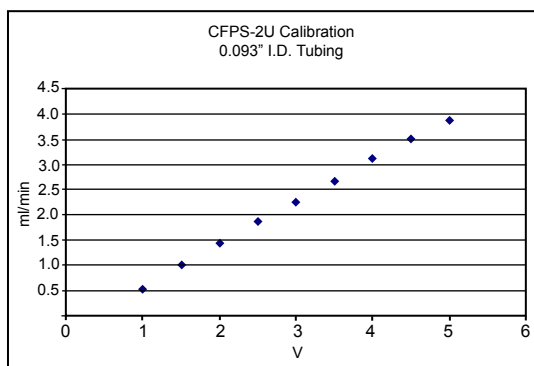
Software Control

Any software package, which is capable to send commands to a serial RS232 or USB port of your computer, can control the flow rate. If your computer has a USB port only, use an optional adapter CFPS-USB to convert it into a serial port. The RS232 port should be configured as 115,200 baud – 8 bit words – 1 stop bit – NO parity. Use a regular DB-9 cable to connect the Controlled Flow system to your computer. No special RS232 cable is required. Below is the list of commands available to build a flexible automated system:

Flow Rate Control

VAddd<CR>   uses decimal data (ddd) as analog output to channel 1 (128 = OFF, flow rate = 0 results
                   to REVERS CODE 127; 255 results to the highest flow rate FORWARD 127). Example:
                   VA239<CR>, sends 239 -128 to channel 1 output, which results to FORWARD CODE 111.
VBddd<CR>   outputs decimal data (ddd) as analog output to channel 2

VCddd<CR>   outputs decimal data (ddd) as analog output to channel 3

VDddd<CR>   outputs decimal data (ddd) as analog output to channel 4

Each command has to be followed by <CR> code (carriage return byte, decimal)

Tubing Replacement

Pump Tubing Installation:

1. Slide tubing into the slot so that one of stoppers is positioned under the slot.
2. Actuate the pump.
3. With the rotor turning slowly, guide the tube between the rotor and the interior wall of the pump head, until the other end of tubing inside the opposite slot with the stopper positioned under the slot.

Pump Tube Removal:

1. Actuate the pump.
2. With the rotor turning, lift the input side of the tube from its slot and wait until it has fully disengaged.

The pumps have a Kapton strip around the rotor. Although the unit can operate without the strip, this amber strip reduces tube wear and minimizes the tendency for peristaltic action to push the tube through the pump, which can stretch the tube and alter the flow rate calibration. The strip should never be tight around the rotor.

Additional Channel Upgrade

The 4-channel controller can operate up to four pumps. The control of individual channels can be achieved through the digital interface on the front panel and by providing ANALOG, DIGITAL signals and through SOFTWARE application capable of sending commands via serial RS232/USB computer port.

Additional pumps can be connected to other pumps in sequence using a cable with DB-15 connectors (provided with upgrades). The pump boxes could be connected together using included mounting brackets to form a single unit.
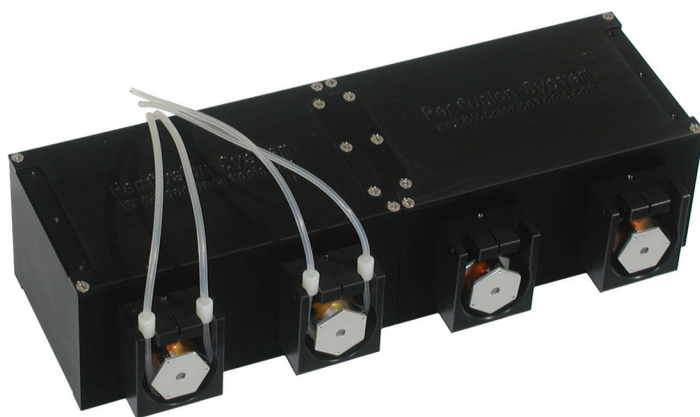
Warranty Service and Repair Information

The Flow Control system is warranted to be free from defects in construction caused by materials and workmanship for a period of one year from the date of purchase. During this period, the manufacturer will service your instrument at no charge. A phone call to us can usually provide enough data to confirm the problem. We will immediately ship to you the replacement parts that are necessary to fix the instrument. If your problem is more serious, or if you prefer that we replace any faulty cards, please call us first. We will issue you a return authorization number. You must put this return number on the outside of the box and on the packing slip or instruction sheet accompanying the instrument. We will immediately repair all instruments that are accompanied by an authorization number and return them to you.