



## SmartFlo Manual

iPad version

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Flow control for ExiGo, UniGo & 4U Pumps

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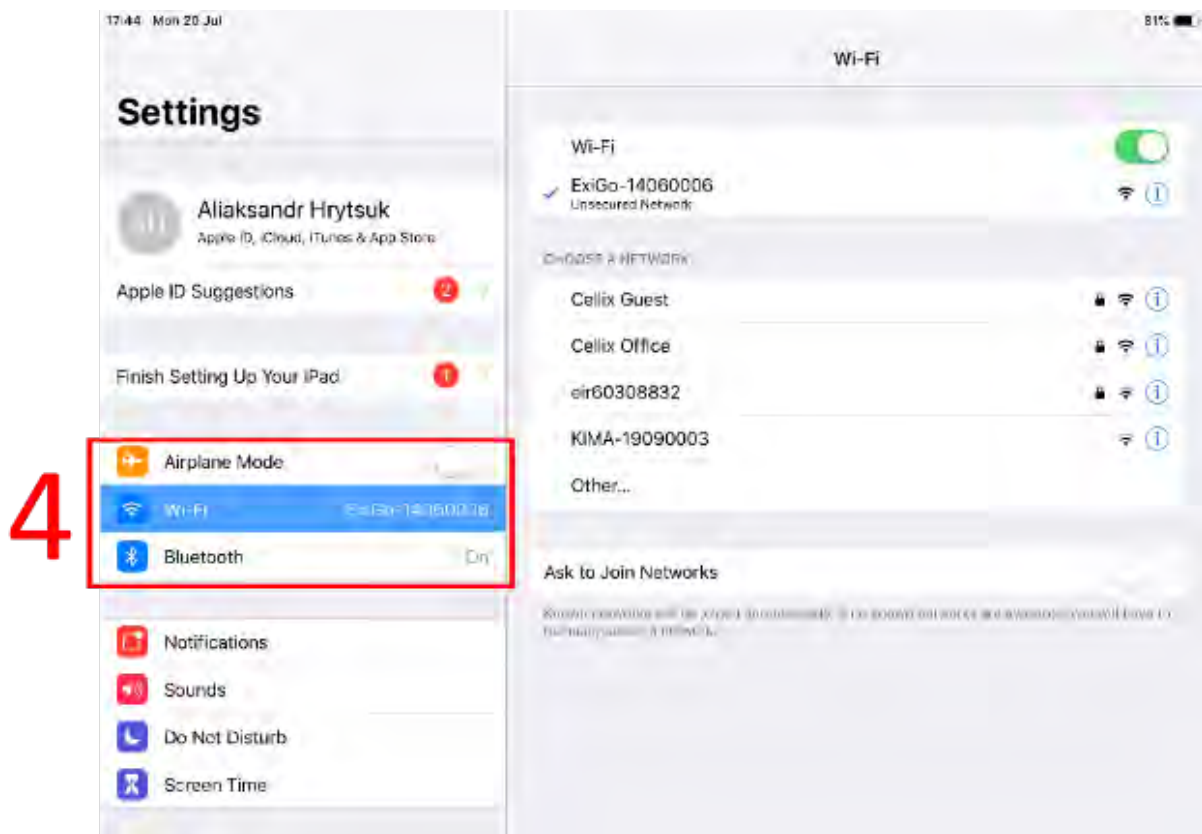
## 1 SmartFlo installation

### 1.1 Connecting to WiFi

The communication between the iPad the pump is done by means of a WiFi network. Once the pump is powered up, it will create a WiFi network (SSID by default) containing the serial number of the pump, e.g. for ExiGo pump, SSID = ExiGo-14060006 or for 4U, SSID = 4U-17040003.

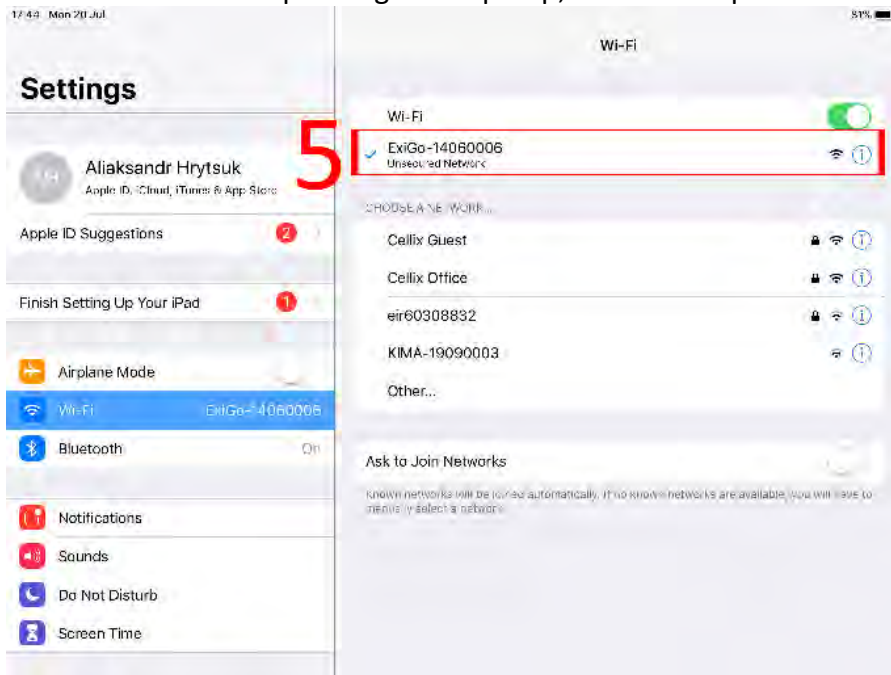
It is required to connect to this network prior to establishing the communication with the pump. To connect to the WiFi network, please complete the following steps:

1. Connect the power cable to the pump and press the power switch.
2. Wait until the colour of the lights changes from white to orange or yellow.<sup>1</sup>
3. On the iPad, tap on settings.
4. Within the settings tab, tap WiFi.



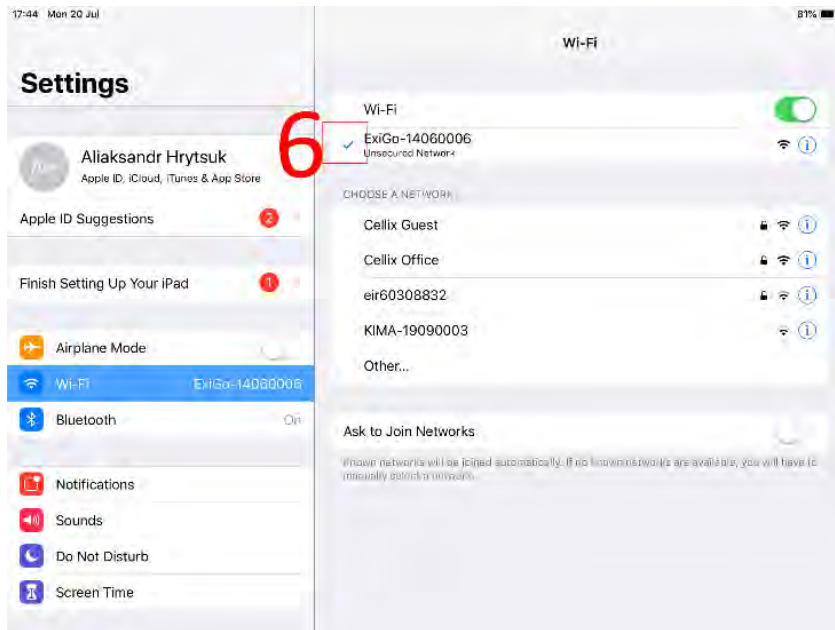
<sup>1</sup> White colour is only shown during booting process.

5. Select the network corresponding to the pump; in this example: ExiGo-14060006:<sup>2</sup>



4

6. Wait until the iPad connects to the network<sup>3</sup>.

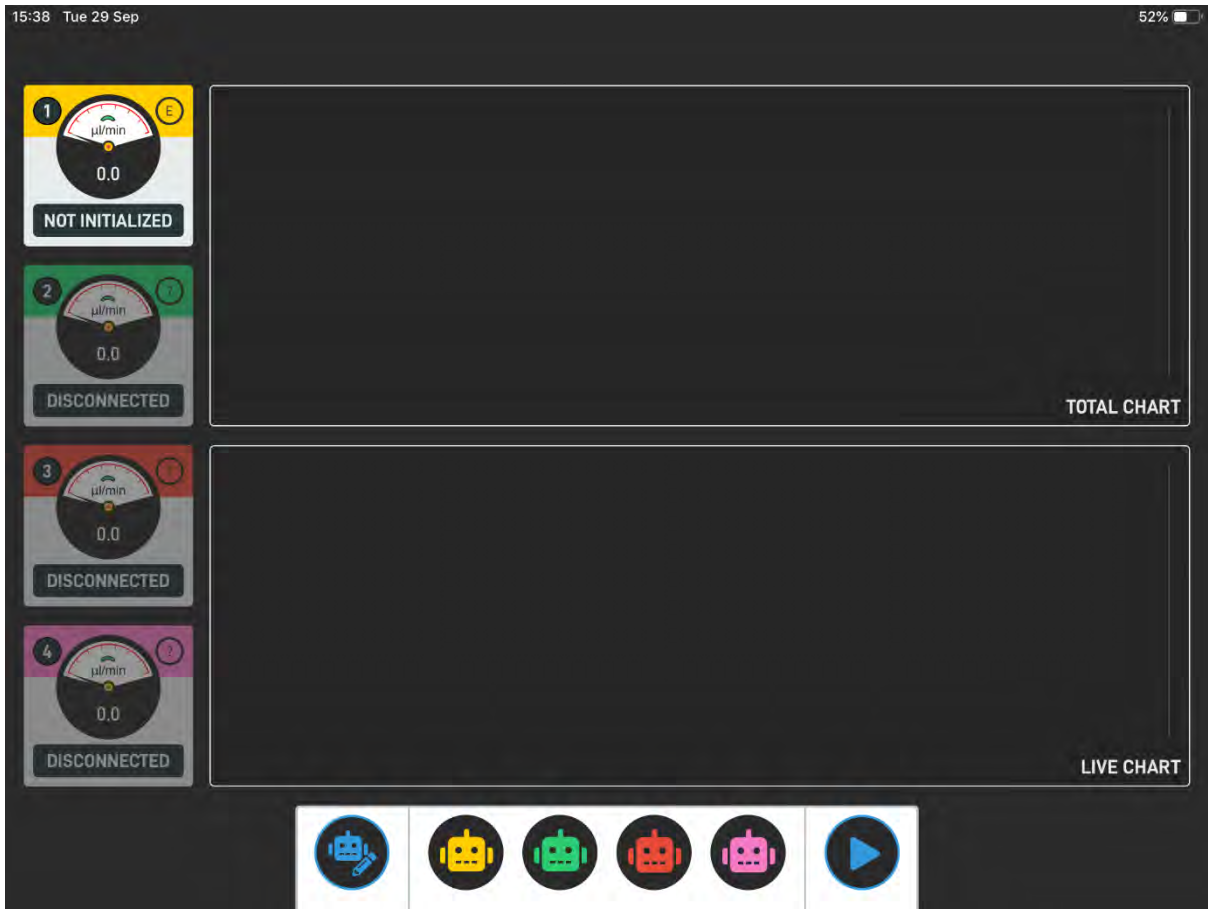


7. Now you can open the SmartFlo app.

<sup>2</sup> Exceptionally, the pump may take longer to bring up the network. If after one minute, the WiFi is not visible, try switching OFF and ON the WiFi on the iPad. If after this, the network is still not visible, please turn OFF and ON the pump and try again.

<sup>3</sup> A blue tick symbol should appear beside the pump network name after the connection is established.

## 2 SmartFlo Overview



SmartFlo iPad interface


SmartFlo is comprised of three main sections:

	<h2>HOME</h2> <p>This window allows the user to:</p> <table border="1"> <thead> <tr> <th>ExiGo Pump</th> <th>UniGo or 4U pump</th> </tr> </thead> <tbody> <tr> <td> <ul style="list-style-type: none"> <li>• Monitor the status of the pump(s).</li> <li>• Initialize the pump(s).</li> <li>• Set the syringe(s).</li> <li>• Move the pump(s) plunger to the initial position required by the assay.</li> </ul> </td> <td> <ul style="list-style-type: none"> <li>• Monitor the status of the pump(s).</li> <li>• Monitor the pressure(s) readings.</li> </ul> </td> </tr> </tbody> </table> <h2>MANUAL</h2> <p>This window allows the user to:</p> <ul style="list-style-type: none"> <li>• Run the pump(s) in manual mode.</li> <li>• Visualize the measured flow rate(s)/pressure(s).</li> <li>• Record the measured flow rate(s)/pressure(s).</li> <li>• Set PID parameters and other options.</li> </ul> <h2>PROGRAM</h2> <p>This window allows the user to:</p> <ul style="list-style-type: none"> <li>• Create custom flow profile(s).</li> <li>• Program the pump(s).</li> <li>• Visualize the running assay(s) status.</li> </ul>	ExiGo Pump	UniGo or 4U pump	<ul style="list-style-type: none"> <li>• Monitor the status of the pump(s).</li> <li>• Initialize the pump(s).</li> <li>• Set the syringe(s).</li> <li>• Move the pump(s) plunger to the initial position required by the assay.</li> </ul>	<ul style="list-style-type: none"> <li>• Monitor the status of the pump(s).</li> <li>• Monitor the pressure(s) readings.</li> </ul>
ExiGo Pump	UniGo or 4U pump				
<ul style="list-style-type: none"> <li>• Monitor the status of the pump(s).</li> <li>• Initialize the pump(s).</li> <li>• Set the syringe(s).</li> <li>• Move the pump(s) plunger to the initial position required by the assay.</li> </ul>	<ul style="list-style-type: none"> <li>• Monitor the status of the pump(s).</li> <li>• Monitor the pressure(s) readings.</li> </ul>				

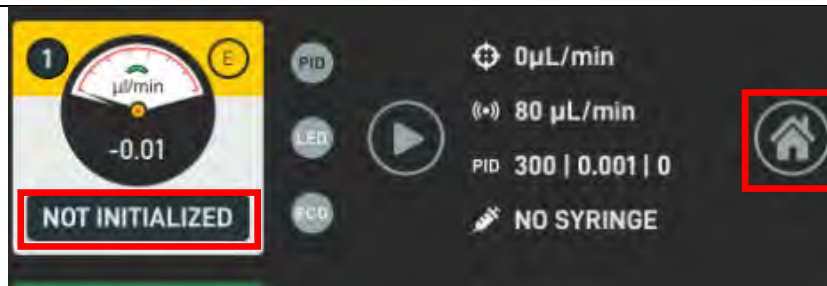
### 3 Controlling an ExiGo pump

#### 3.1 How to initialize the pump

The NOT INITIALIZED status means that the pump MUST be initialized prior to starting the assay. To initialize the pump, please follow the next steps:

1. Tap  and initialize the pump.
2. Remove any installed syringe on the pump<sup>4</sup>. Then tap on the pump's plunger image to begin the initialization.
3. The user interface will ask for confirmation and then it will move the pump drive to the home position. Once the pump is initialized, the status will change to STOPPED.

1



7

3



Figures 1.1 – 1.3: ExiGo pump initialization

<sup>4</sup> **Warning:** Failure to remove any installed syringe may cause the pump to malfunction during the initialization.

### 3.2 How to set the Syringe type

The type of syringe to be used during the experiment must be defined prior to starting the assay. To set the syringe, please complete the following steps:

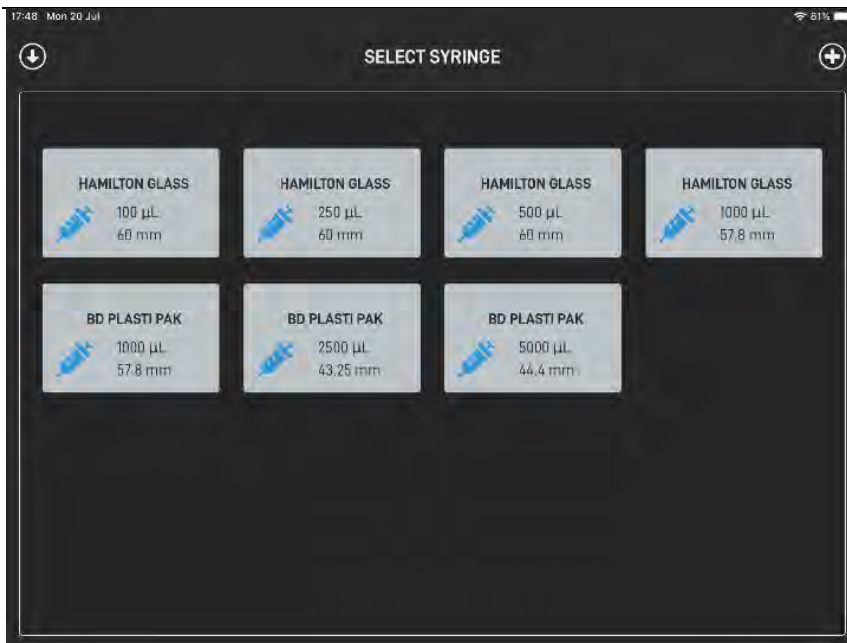
1. Tap on the syringe image in the user interface.
2. A Syringe Selector window will appear. Compatible syringes are pre-loaded.
3. Select the desired syringe and tap SET or tap on the selected syringe to set it.

1



Figures 2.1: Tap to open the Syringe selector

2



Figures 2.2: Syringe selector main page



3



Figures 2.3: Syringe set

SmartFlo program pre-loaded syringes include:

Hamilton Syringes	
700 Series	
Part Number	Description
80601	100 µL, Model 710 LT SYR
80701	250 µL, Model 725 LT SYR
80801	500 µL, Model 750 LT SYR
1000 Series	
Part Number	Description
81301	1mL, Model 1001 LT SYR
BD Plastipak Syringes	
Part Number	Description
300013	1 mL Syringe. Luer tip
300185	2.5 mL Syringe. Luer tip
302187	5 mL Syringe. Luer tip

### 3.3 Clamping the syringe

1

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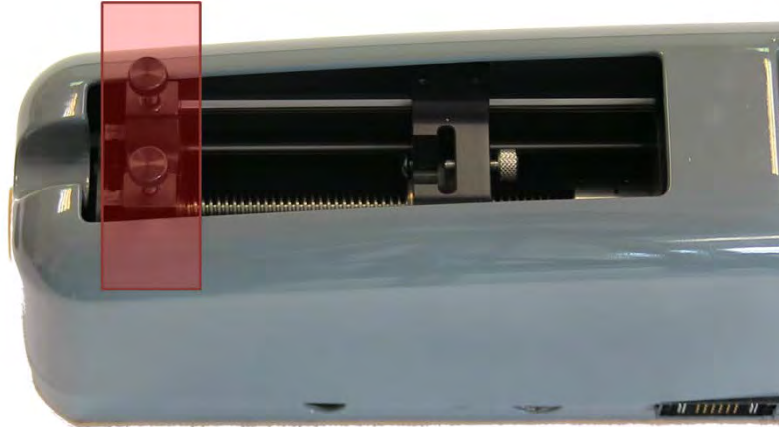


Figure 3.1: Syringe clamp

Remove the syringe clamp.

10

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2

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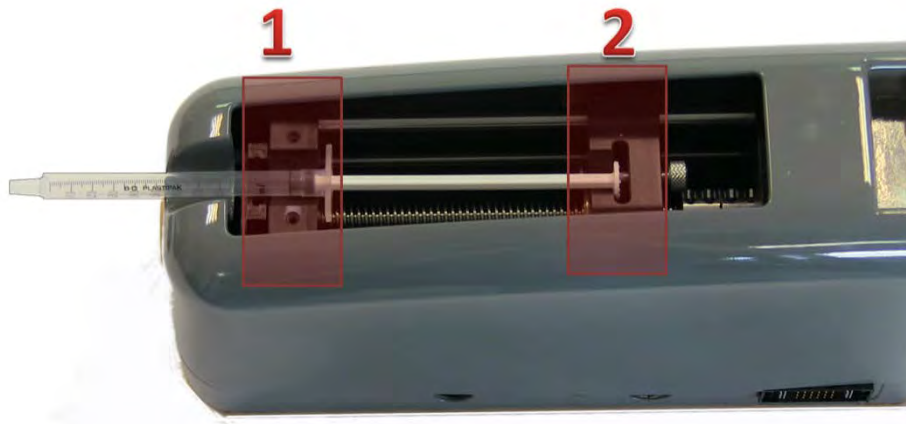


Figure 3.2: Clamping points: 1 for the barrel and 2 for the plunger.

Place the syringe in the pump with the body resting on the front of the pump (position 1 in Figure 7) and the plunger resting in position 2. Move the position of the pump's plunger if required (see section 4.4).

3

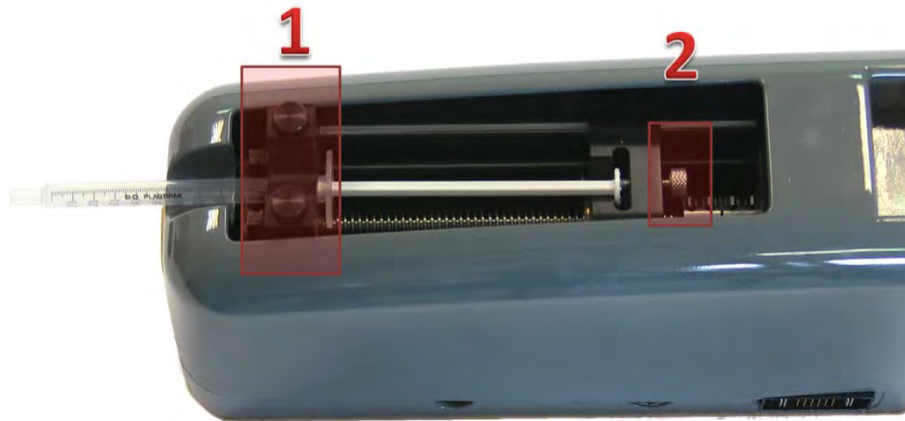





Figure 3.3: Syringe clamped using the clamp (1) and the thumb screw (2)

Put the syringe clamp back in place (Figure 8 position 1) and tighten the screws firmly. Tighten the thumb screw (Figure 8 position 2) to secure the syringe plunger.

Please note that the syringe clamp is reversible, depending on the syringe to be installed. See table below:

5ml Syringe	Smaller Syringes	Clamping Direction
		

### 3.4 Move the plunger to the initial required position

In most cases, the position of the pump after initialization will not be suitable for placing the syringe. To move the pump, simply drag the pump plunger on the user interface and drop it to the required position. An indicator of the approximate volume displaced during the pump movement will appear.

1

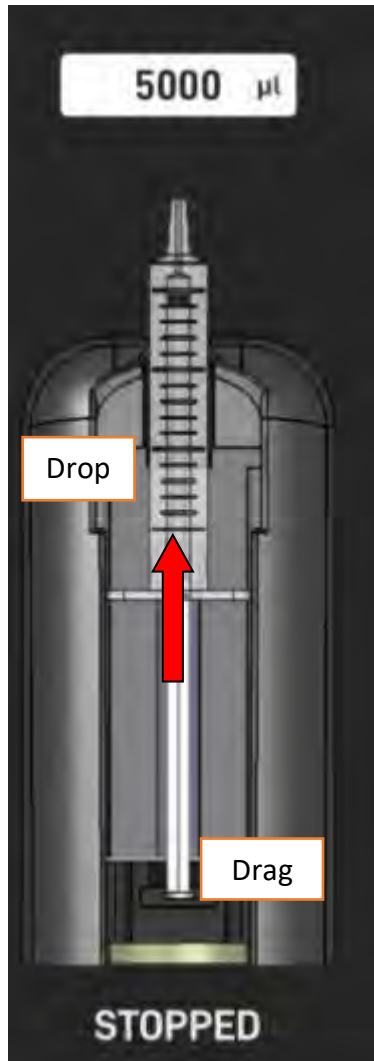


Figure 4.1: Drag and drop the plunger to move it to the initial position

2



Figure 4.2: Final position

### 3.5 Manual mode: How to set the flow rate

You may choose to set the flow rate manually in Flow Rate Units (L/min).





1. Tap  in the flow rate indicator.
2. Then tap .
3. Set the desired flow rate value by typing in the number. Tap  to accept the changes.
4. Once the flow rate has been set, tap the  button to start the assay.



Figure 5.1 – 5.4: Manual mode flow rate set

### 3.6 ECO mode



Figure 6: ECO mode

If the ExiGo pump is overheating, it is possible to set the ECO mode to reduce the torque and thus, reducing the heat generated by the motor.

This is only recommended if the heat generated by the motor is affecting your sample or having an impact on your setup. The recommended option is to have the ECO mode disabled.

To change the pump to ECO mode:

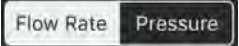
1. In the Manual Tab, tap  ECO mode ON or OFF

## 4 Controlling a UniGo or 4U pump

The UniGo or 4U pumps do not require an initialization. A manual flow rate or a custom flow profile can be applied and executed directly after booting up.

### 4.1 **Setting the feedback**

The recommended option is to use Flow rate as a feedback parameter for your UniGo or 4U pump. However, advanced users have the option to switch to a pressure control by selecting pressure as the feedback parameter.<sup>5</sup>

To change the feedback parameter: In the window tab, tap  to switch between flow rate/pressure.

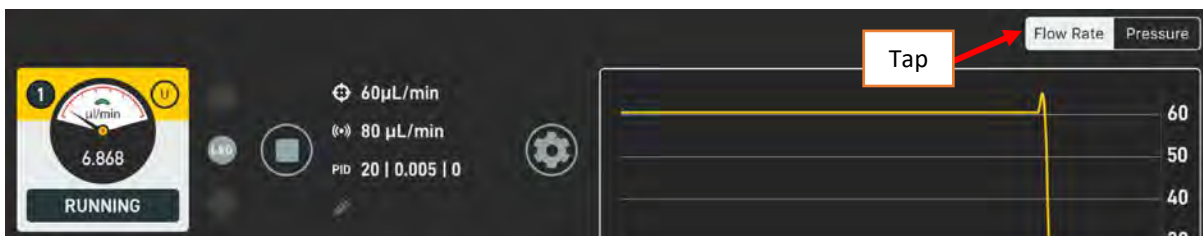

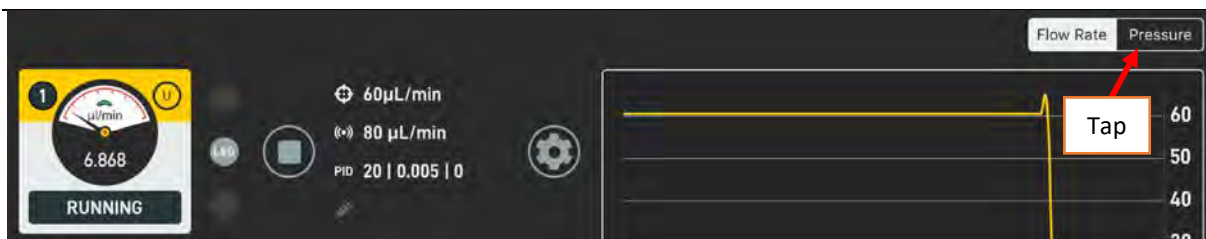


Figure 7: Feedback selector

#### 4.1.1 **View the Pressure reading**

1. In the window tab, tap  to switch to the pressure reading.
2. The pressure reading will be visible in mbar.

1



<sup>5</sup> Cellix recommends keeping flow rate as the feedback parameter. Using pressure as the feedback control may result in different flow rates than expected as this will depend on the fluidic resistance of your setup, viscosity of the media, etc.

2

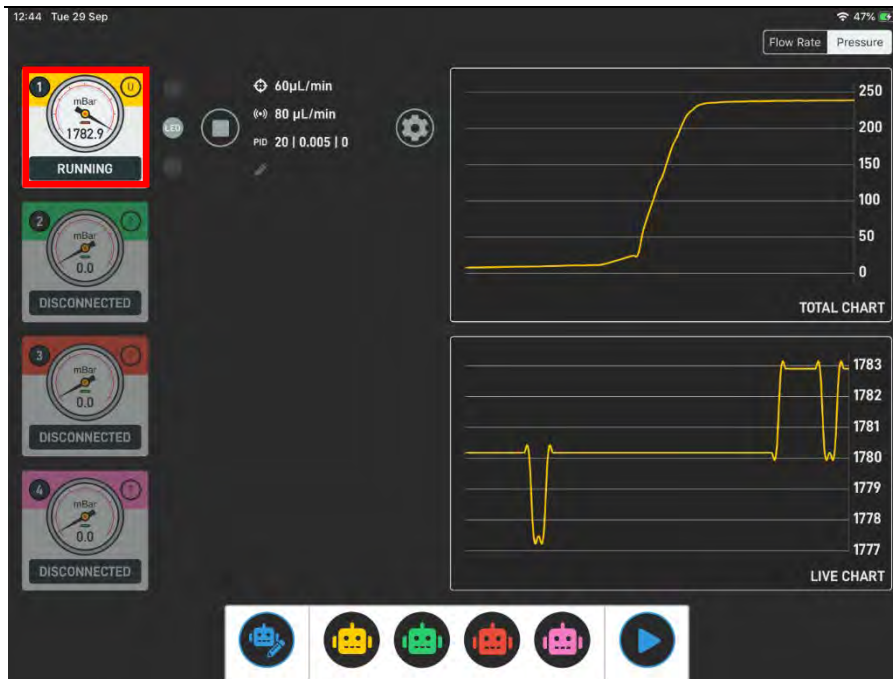







Figure 8.1 – 8.2: Feedback selector

 Note that when pressure is selected as a feedback, all the units are automatically updated from nL/min to mbar. In iPad version there is no option to manually set or program the pressure option.

#### 4.2 Manual mode: How to set the flow rate

Depending on the selected feedback parameter, the set-point can be specified in flow rate (L/min):

1. Tap  in the flow rate indicator
2. Then tap 
3. Set the desired flow rate value. Tap  to accept the changes
4. Once the flow rate has been set, tap the  button to start the assay.



1



2



3



Figures 9.1 – 9.3: Manual mode flow rate setting

## 5 Flow Sensor: Visualizing the flow rates

The performance of the pump(s) can be significantly increased by using a flow sensor to obtain real-time flow rate feedback. The flow sensor can be connected to ExiGo pump (optional) and it is compulsory for UniGo/4U pumps.

Each flow sensor is plug-and-play; therefore, it can be connected to the pump(s) at any moment. Once the sensor is connected, it is automatically recognized by the pump and a “Flow Sensor” indicator will appear in SmartFlo.

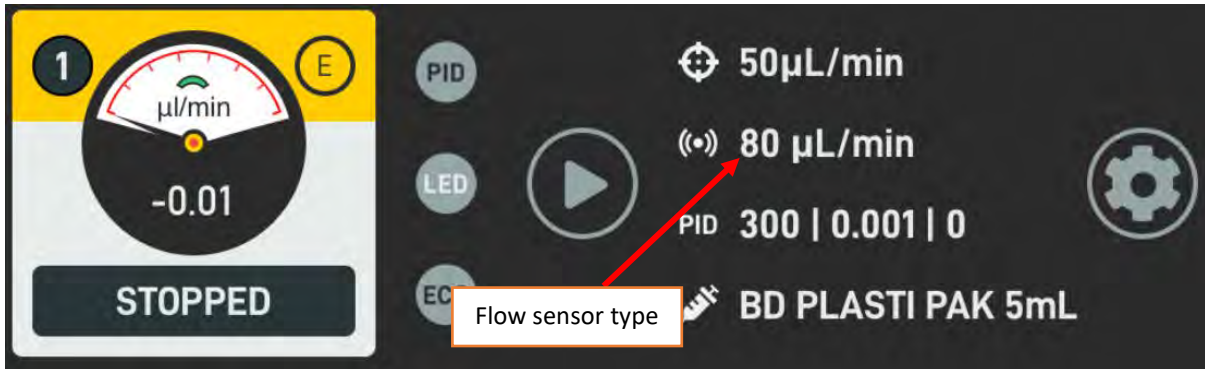


Figure 10: Flow sensor automatically detected

Immediately after plugging-in the flow sensor, the real time flow rate measurements will appear within the Manual Tab.

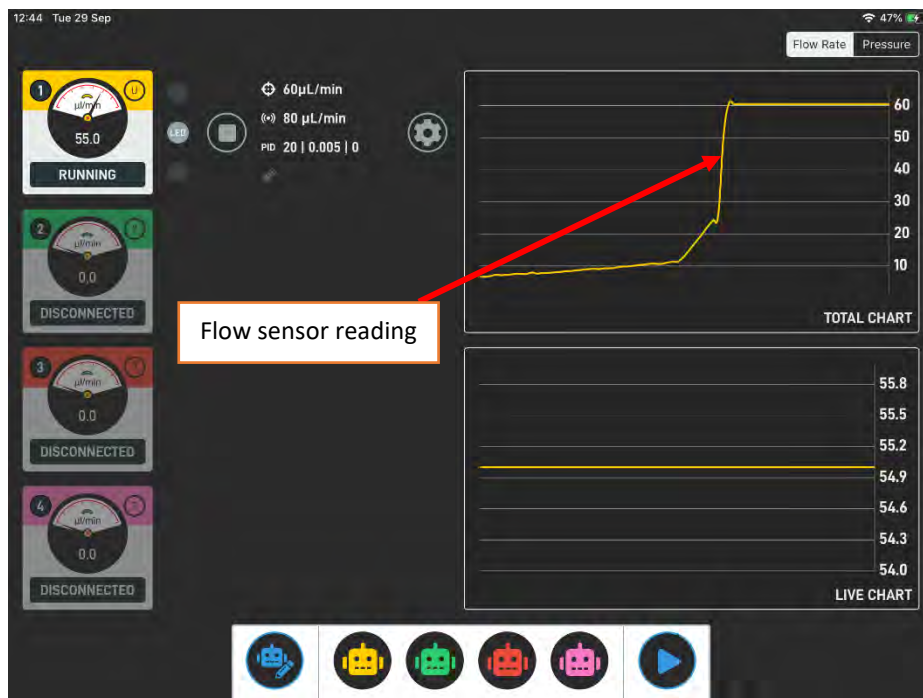


Figure 11: Flow sensor reading

When running a UniGo or 4U pump, it is possible to switch to pressure readings at any time. Just switch between flow rate and pressure by tapping Flow Rate Pressure

## 6 Setting the PID parameters

In order to get the best performance and accuracy of the ExiGo/UniGo/4U pumps as well as a fast dynamic response, the PID controller must be turned on.<sup>6</sup>



Figure 12: Setting PID parameters

**Proportional (Kp):** The proportional gain defines how quickly the system will change its output to reduce the existing error (Flow rate set point minus current flow rate). Therefore, the proportional parameter will increase the speed of the control system response. However, if the proportional value is too large, the system will begin to oscillate. Using **P** parameter on its own may lead to a Steady-State error (offset) between desired flow rate and current flow rate.

**Integral (Ki):** The integral term sums the instantaneous flow rate error over time and gives the accumulated offset that should have been corrected. Thus, its main purpose is to drive the flow rate Steady-State error to zero. A large value of the Integral parameter may cause the system to overshoot the set point value and even oscillate.

**Derivative (Kd):** The derivative term is proportional to the rate of change of the system output (pump flow rate). Therefore it “predicts” the system behaviour decreasing the system output if the flow rate is changing rapidly. This parameter helps to reduce overshoot and settling time but an incorrect value may cause the system to become unstable.

<sup>6</sup> If controlling an ExiGo pump, the PID can only be turned on when a flow sensor is connected. If you purchased an ExiGo pump without a flow sensor you can still use the pump without the PID controller. Please contact Cellix if you wish to purchase one.

### 6.1 How to tune in the PID:

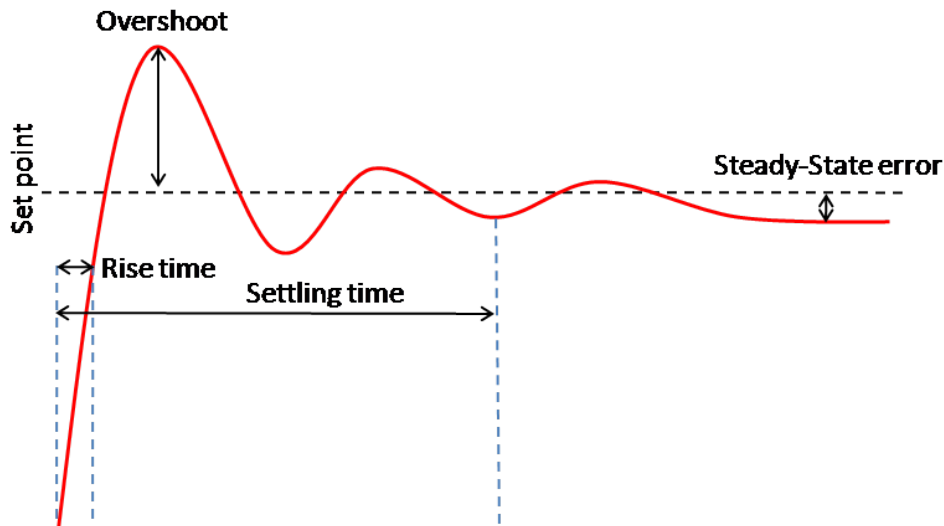







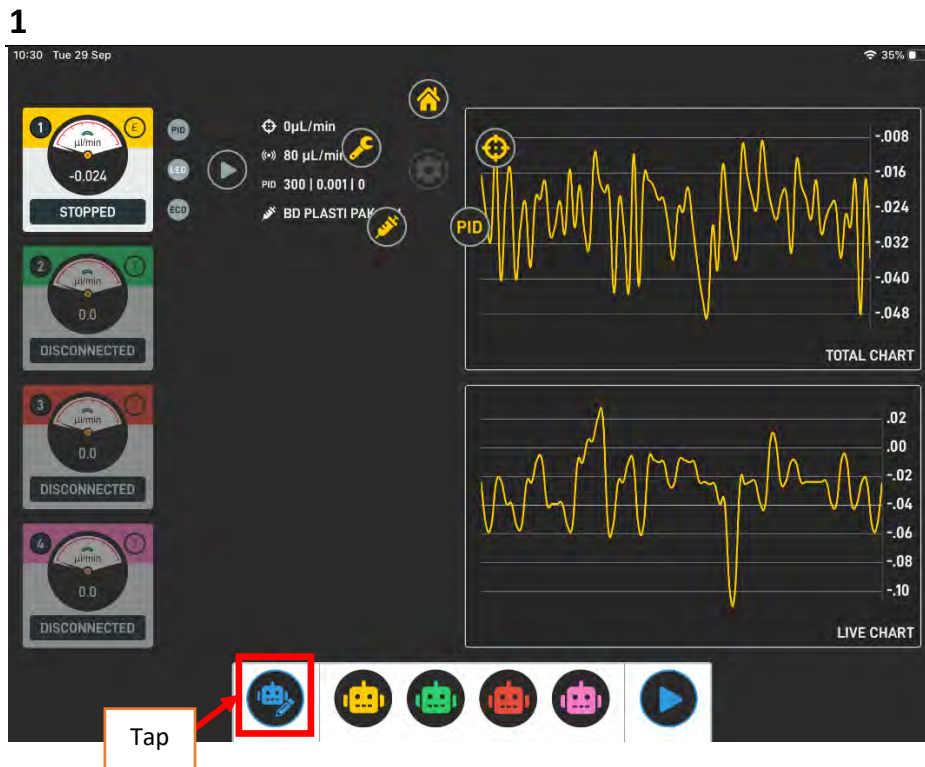
Figure 13: Typical response to a set point change

1. Set all parameters to 0.
2. Increase **P** and change the set point until the dynamic response of the pump is fast enough without oscillating.
3. Increase gradually **I** value in order to minimize the Steady-State error. Integral parameter can be any value between 0 and 1 but it is very sensitive and may cause the system to oscillate. Therefore it is recommended to start using a value of 0.001. A value over 0.1 will probably lead the system to become unstable.
4. In case of a large overshoot when changing the set point, increase the **D** value gradually until the optimal ratio overshoot/response time is achieved. However, a large value of **D** may slow down the dynamic response of the system.

## 7 Program mode: Defining a custom flow profile

It is possible to program a pump with a custom flow profile in order to have a precise control of the flow rates and duration of a certain experiment.

1. Tap  to open the Waveform Editor.
2. Enter your waveform elements: 
3. Tap  button to program the selected pump.
4. Tap  to run a particular pump.
5. For multi pump programming repeat steps 1 to 3 for the remaining pumps.
6. To run all pumps simultaneously tap 



2

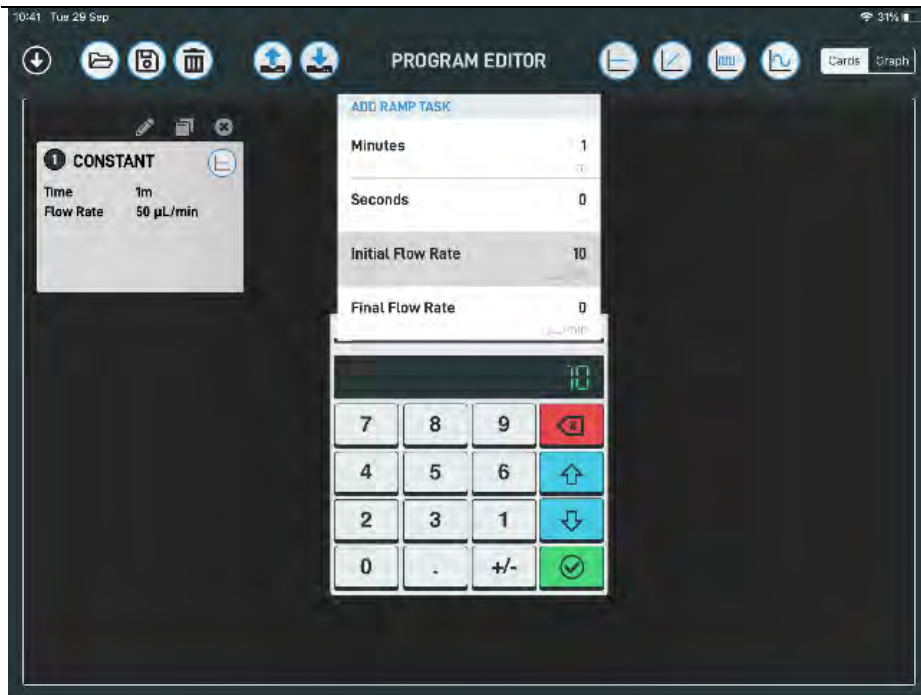


Figure 14.1 – 14.2: Defining a custom flow profile

## 8 Waveform Editor

The waveform Editor allows you to create a custom flow profile for your pump(s).

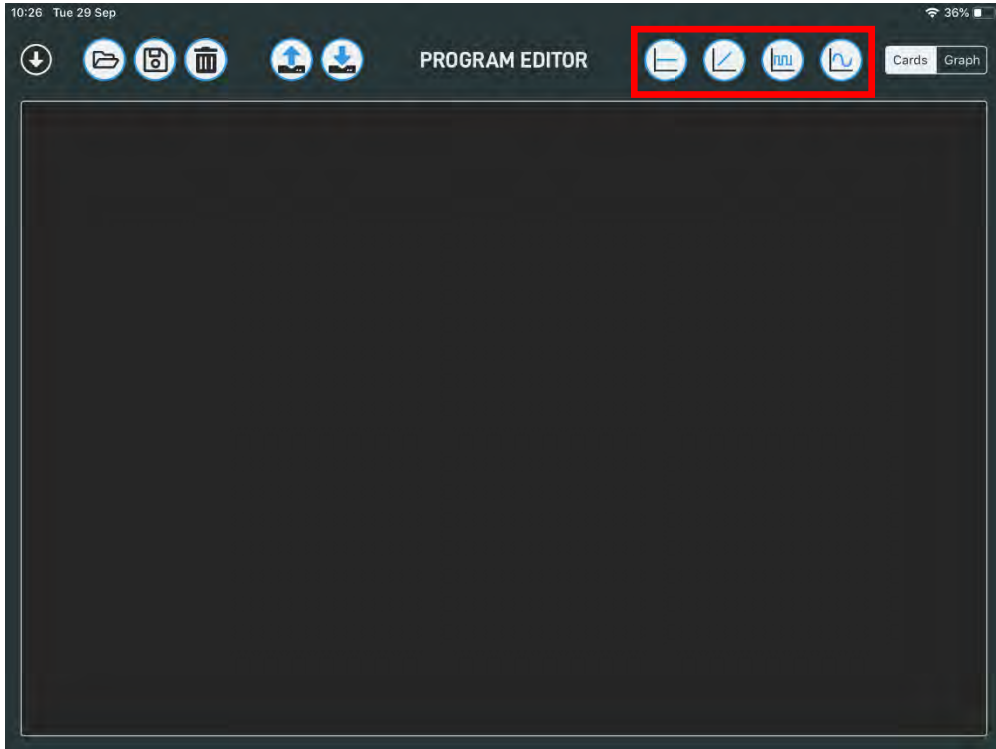






Figure 15: Program editor

You can add 4 different elements to your waveform:

- Constant Flow/Pause: 
- Ramp: 
- Pulse wave: 
- Sine wave: 

**Constant Flow**

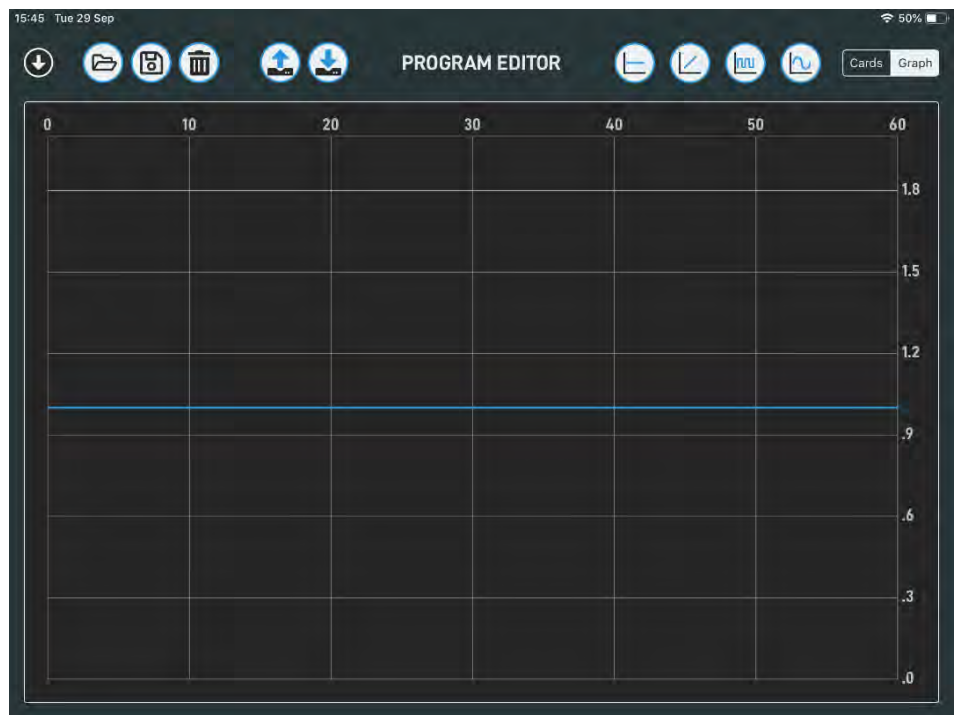
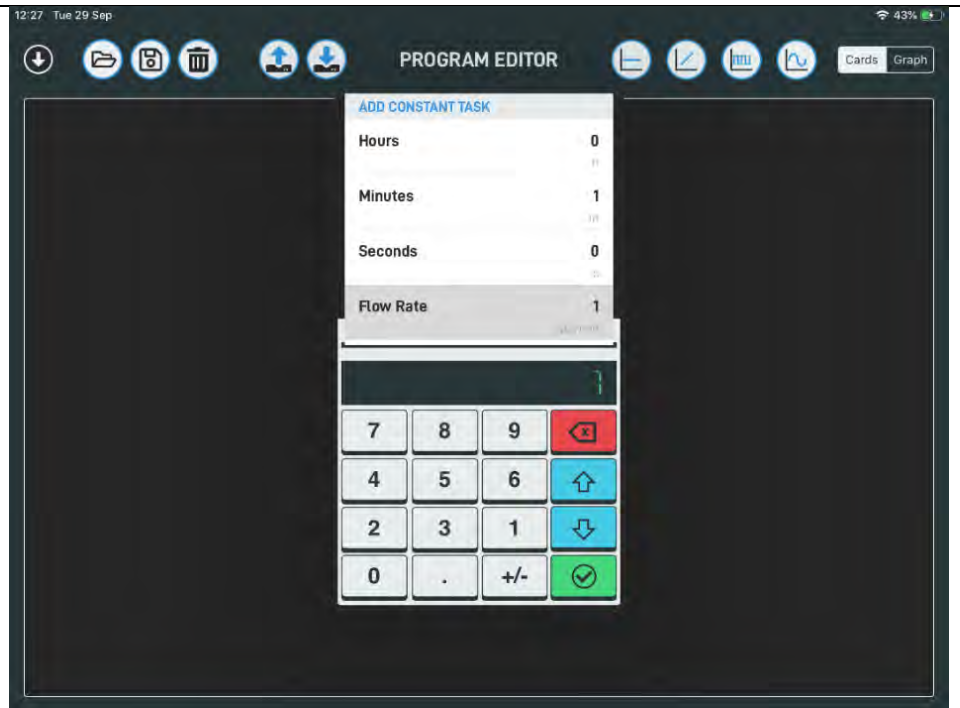
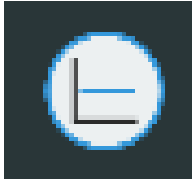


Figure 16.1 – 16.2: Program editor for Constant Flow

<b>Flow Rate</b>	Flow rate set point for the constant step. Set to 0 if you would like to create a pause.
<b>Duration</b>	Duration of the constant step in minutes and seconds.



Ramp

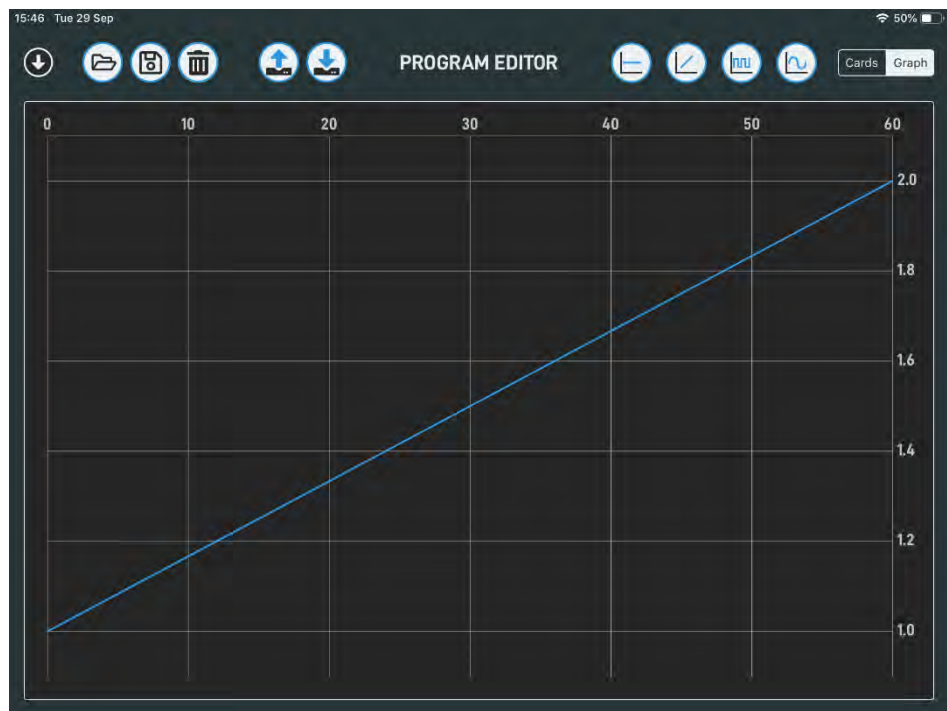
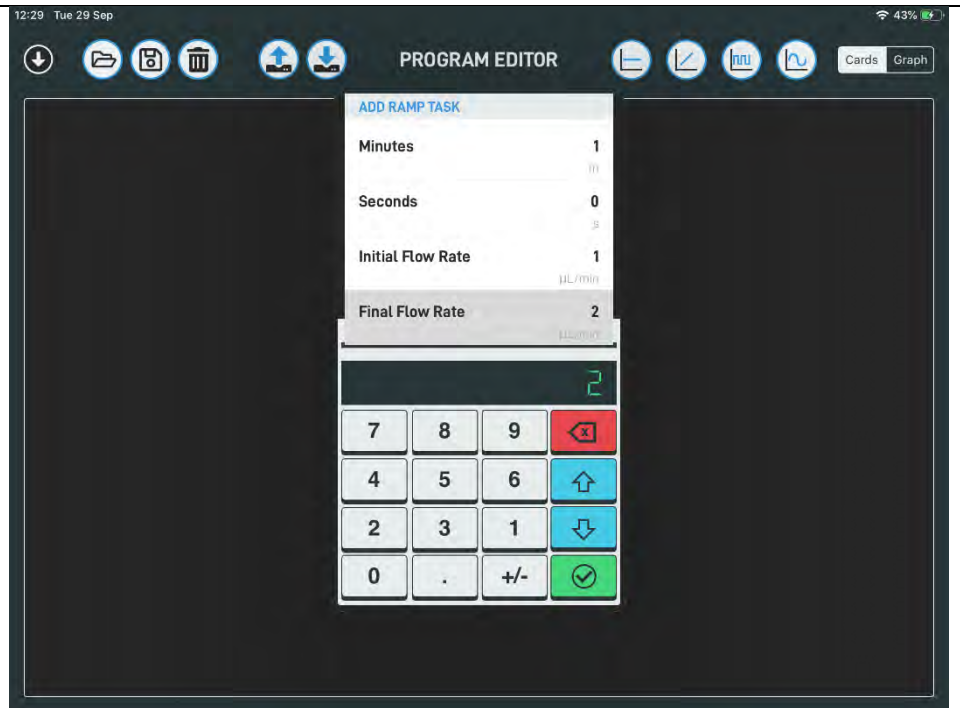
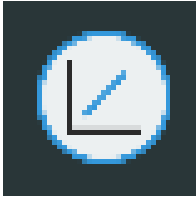


Figure 17.1 – 17.2: Program editor for Ramp

<b>Initial Flow Rate</b>	Initial Flow Rate of the Ramp
<b>Final Flow Rate</b>	Final Flow Rate of the Ramp
<b>Duration</b>	Duration of the ramp in minutes and seconds

**Pulse wave**

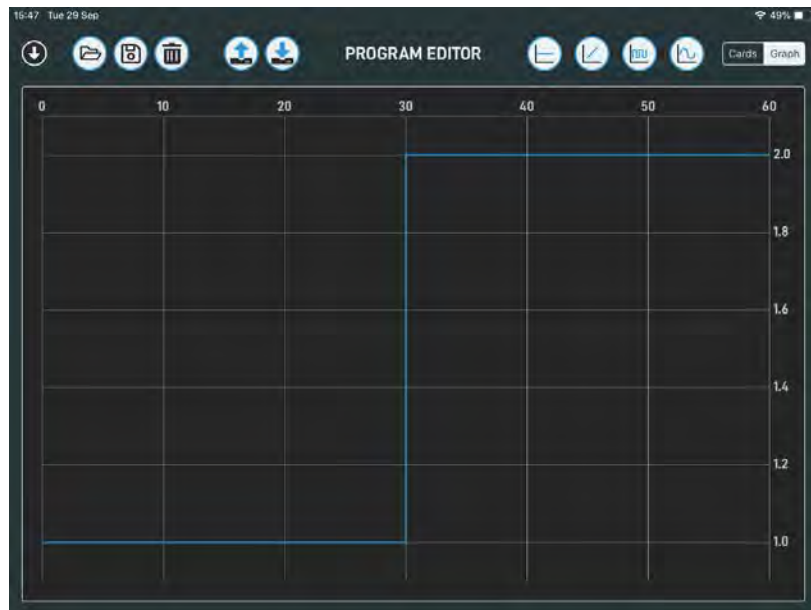
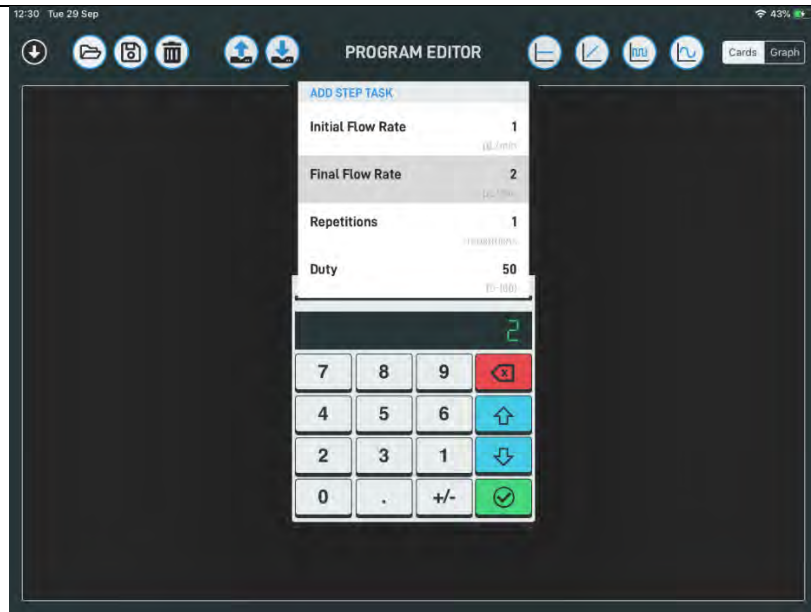


Figure 18.1 – 18.2: Program editor for Pulse wave

<b>Initial Flow Rate</b>	Maximum flow rate of the Pulse(s)
<b>Final Flow Rate</b>	Minimum flow rate of the Pulse(s)
<b>Repetitions</b>	Number of Pulses of the Train Pulse Step
<b>Duty Cycle</b>	Ratio between the maximum and minimum flow rate of the Pulse(s). For example, Duty Cycle = 60 means that the Pulse(s) will remain 60% of the period on minimum flow rate and 40% of the period on maximum flow rate
<b>Period</b>	Duration of <b>one</b> full cycle of the Pulses in minutes and seconds

Sine wave

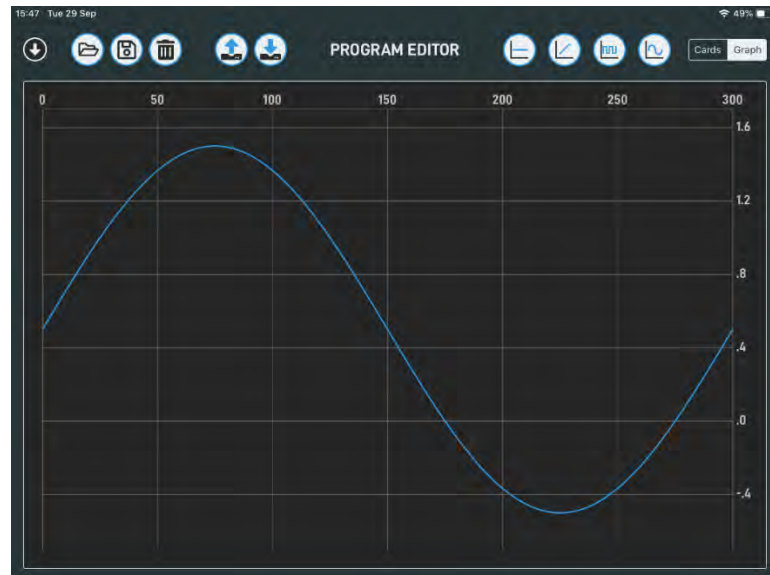
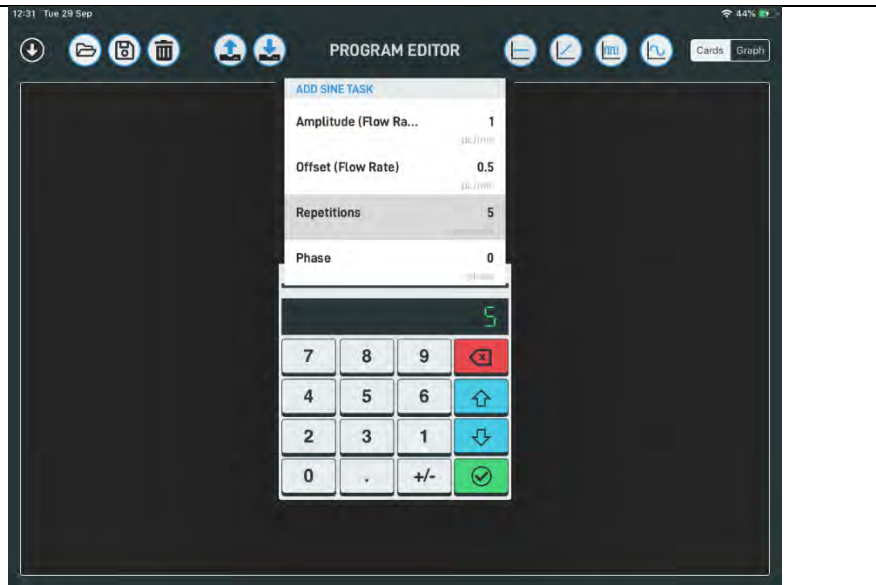
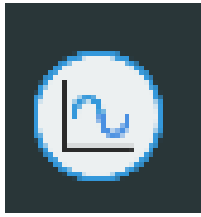


Figure 19.1 – 19.2: Program editor for Sine wave

<b>Amplitude</b>	Amplitude is measured between the centre of the sine wave and its maximum value
<b>Offset</b>	Defines the position of the centre of the sine wave regarding the zero position.
<b>Repetitions</b>	Number of full cycles of the sine wave step
<b>Phase</b>	The starting angle of the sine wave cycle (from 0 to 360 degrees)
<b>Period</b>	Duration of <b>one</b> full cycle of the sine wave in minutes and seconds <sup>7</sup>

<sup>7</sup> The full duration of the sine wave is determined by Period x Repetitions

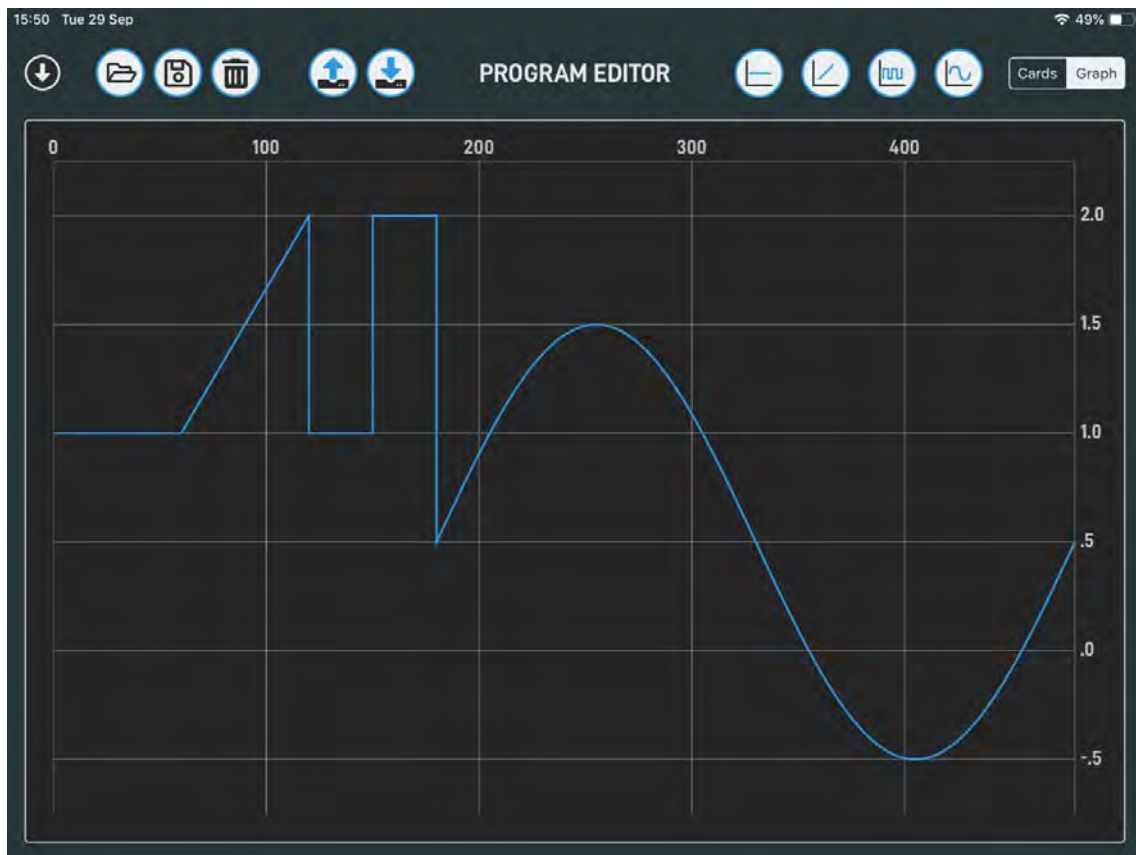


Figure 20: Example of different elements in the same waveform

### 8.1 Open/Save custom waveforms

You can load and/or save a custom waveform into your iPad using the following buttons:



To load a previously saved protocol and program it into your pump.

Open







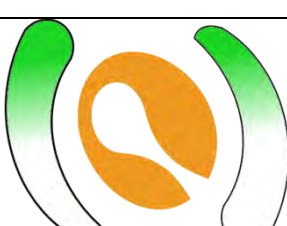

To save your custom waveform into your computer.

Save



If your pump is currently programmed with a custom waveform, you can retrieve it and modify it.

9 LED Status colours explanation

Color	Effect	Meaning
	Flashing	Pump is booting up. Please wait until Status LED changes its colour prior to connect the pump.
	2 Flashes and fades out	Pump not initialized and <b>no sensor detected</b> at boot time.
	2 Flashes and fades out	Pump not initialized and <b>sensor detected</b> at boot time.
	Flashing	Initializing Pump
	Static	Pump ready with no assay programmed.
	Rotating	Pump running in manual mode.
	Static	Pump ready with assay programmed.

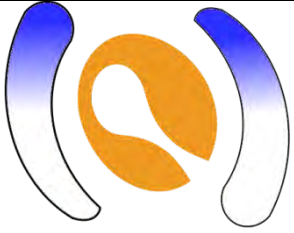

	Rotating	Pump running in assay programmed mode.
	Flashing	Critical error. Please contact Cellix technical support.

Figure 21: LED Status